The Botanical and Chemical Distribution of Hallucinogens*

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Out of the vast array of species in the plant kingdom — variously estimated at from 200,000 to 800,000 — a few have been employed in primitive societies for millennia to induce visual, auditory, tactile, and other hallucinations. Because of their earthly effects that often defy description, they have usually been considered sacred and have played central roles as sacraments in aboriginal religions (Schultes 1969a).

Scientific interest in hallucinogenic agents has recently been intense, partly because of the hope of finding potentially valuable drugs for use in experimental or even therapeutic psychiatry and also for use as possible tools in an explanation of the biochemical origins of mental abnormalities (Hoffer & Osmond 1967).

While psychoactive species are widely scattered throughout the plant world, they appear to be concentrated more or less amongst the fungi and angiosperms. The bacteria, algae, lichens, bryophytes, ferns, and gymnosperms seem to be notably poor or lacking in species with hallucinogenic properties (Schultes 1969-1970). These hallucinogenic properties can be ascribed, likewise, to only a few kinds of organic constituents, which may be conveniently divided into two broad groups: nitrogenous and non-nitrogenous compounds (Der Marderosian 1967a; Farnsworth 1968 & 1969; Hofmann 1961a & 1968; Taylor 1966; Usdin & Efron 1967). See Figure 1 for basic chemical skeletons.

The nitrogenous compounds play by far the greater role and comprise, for the most part, alkaloids or related substances, the majority of which are, or may be classified into the following groups: 1. β-carbolines; 2. ergolines; 3. indoles; 4. isoquinolines; 5. isoxazoles; 6. β-phenylethylamines; 7. quinolizidines; 8. tropanes; 9. tryptamines. Non-nitrogenous compounds which are the active principles in at least two well-known hallucinogens include: 1. dibenzopyrans; and 2. phenylpropenes; other compounds, such at catechols and alcohols, may occasionally play a role.

In the study of hallucinogenic plants, two considerations must be borne in mind. One consideration reminds us that there are some of these psychoactive plants used in primitive societies for which the active chemical principles are as yet not known. The other emphasizes that man undoubtedly has utilized only a few of the species that actually do possess hallucinogenic principles: we are, as yet, far from knowing how many plants are endowed with psychotomimetic constituents, but there are certainly many more than the few employed by man as hallucinogens (Schultes 1967).

While almost all hallucinogenic compounds are of vegetal origin, a few may be wholly or partly synthetic. The potent hallucinogen, lysergic acid diethylamide (LSD), although very closely allied chemically to the naturally occurring ergolines, has not been found in the plant kingdom.

NON-NITROGENOUS PRINCIPLES

1. Dibenzopyrans

Cannabaceae

Cannabis. — The most important of the non-nitrogenous hallucinogens are the dibenzopyrans in *Cannabis sativa*, source of marijuana, hashish, bhang, ganja, and other narcotic products. *Cannabis*, a monotypic genus sometimes placed in the *Moraceae* but

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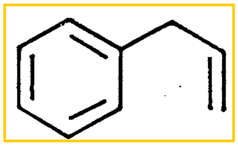
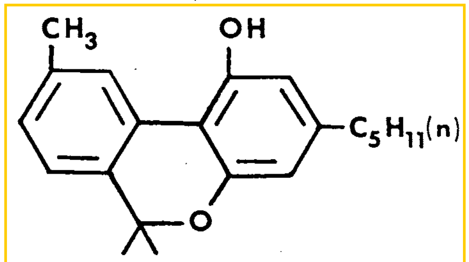
BASIC CHEMICAL SKELETONS OF PRINCIPAL HALLUCINOGENS

Non-nitrogenous compounds

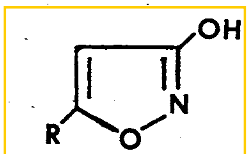


Phenylpropenes

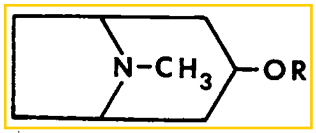


Dibenzopyrans

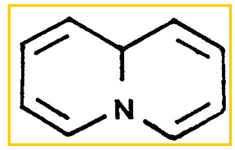
Nitrogenous compounds



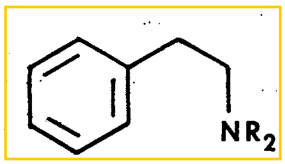
Isoxazoles



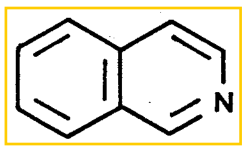
Tropanes



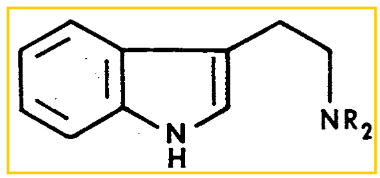
Quinolizidines



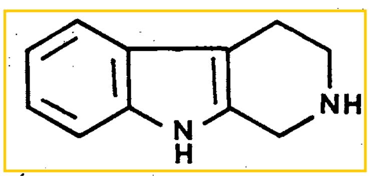
Phenylethylamines



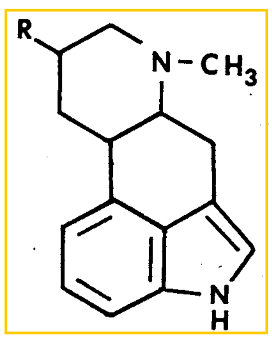
Isoquinolines



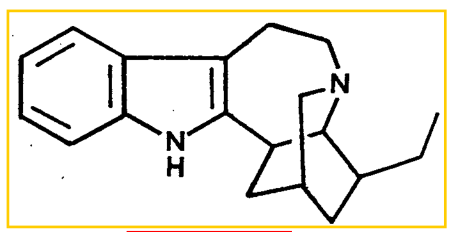
Tryptamines



β-Carbolines



Ergolines



Iboga-indoles

FIGURE 1

often allocated, together with the hops plant (*Humulus*), in a separate family, *Cannabaceae*, represents perhaps one of the oldest and certainly the world's most widespread hallucinogen. The source also of hempen fibres and of an edible seed-oil, the plant is native probably to central Asia but is now found cultivated or spontaneous in most parts of the world. It is represented by many agricultural varieties and ecological races or strains, some of which are rich, some poor, some even lacking in the intoxicating principles.

The biodynamic activity of *Cannabis* is due to a number of constituents contained in a red oil distilled from the resin, mainly to a mixture of stereoisomers collectively called tetrahydrocannabinols and sundry related compounds, including cannabinol, cannabidiol, cannabidiolic acid, cannabigerol, and tetrahydrocannabinolcarboxylic acid (Hofmann 1968; Korte & Sieper 1965; Schulz 1964). The compound Δ^1-tetrahydrocannabinol has recently been shown to be the principal biologically active constituent of *Cannabis* (Mechoulam et al. 1967; Mechoulam & Gaoni 1965). Cannabichrome has likewise been reported as active. Cannabinol and cannabidiol are devoid of euphoric properties, although cannabidiol, when heated with an acidic catalyst, may be converted into an active mixture of tetrahydrocannabinols, a conversion that may be effected during the smoking of *Cannabis*. Cannabigerol and cannabidiolic acid are sedative, and the latter compound has antimicrobial properties (Farnsworth 1968; Hofmann 1968). Cannabinol and the tetrahydrocannabinols have been synthesized. The first biologically active principle to have been structurally elucidated and synthesized was Δ^1-2,3-*trans* tetrahydrocannabinol (Hofmann 1968).

The widely recognized and extreme variation in psychoactive effects of *Cannabis* is due possibly to the instability of some of the constituents which, upon aging or maturation of the plant, may be converted from active to inactive compounds or vice versa. It is believed that some of these conversions take place more readily and rapidly in the drier tropics than in temperate climates. Many phytobiotic factors seem to have effects on the chemical composition of the resin.

This variability and the absence of controlled experiments — almost all experimentation has been done with crude plant material of unknown chemical constitution — have led to a disturbing lack of uniformity of opinion on the physiological effects of *Cannabis*, a situation that has seriously handicapped social and legal control of the use or abuse of the drug (Weil 1969b).

2. Phenylpropenes

Myristicaceae

Myristica. — The tree that yields the spices nutmeg and mace — *Myristica fragrans* — is thought to have been employed aboriginally as a narcotic in southeastern Asia, where it is native. It is sometimes used as an hallucinogen in sophisticated circles in Europe and North America and has occasionally become a problem in prisons in the Unites States (Weil 1965, 1967 & 1969a).

Although its toxicology has not yet been wholly elucidated, the psychoactive principles are contained probably in the essential oil of the seed and aril. The composition of nutmeg oil is highly variable, both qualitatively and quantitatively, but it does contain fatty acids, terpenes, and aromatics. The psychopharmacological effects may be attributable to several phenylpropenes. Elemicine, myristicine, and safrol have been suggested as the active constituents of the oil, which may also contain eugenol, isoeugenol, methylisoeugenol, methyleugenol, and isoelemicine. It seems doubtful that myristicine or safrol are responsible for a significant part of the hallucinogenic effects. While these properties may be attributable largely to elemicine, no studies on the psychopharmacological activity of pure elemicine or safrol have as yet been made (Shulgin 1967; Truitt 1967).

For hallucinating purposes, ground nutmeg is taken orally in large doses, usually several teaspoonfuls. The effects vary appreciably but are often characterized by distortion of perception of time and space, dizziness, tachycardia, dry mouth, headache, and occasionally visual hallucinations (Weil 1967).

Myristica is a genus of some 120 species of the Old World tropics. The only commercially important species is *M. fragrans*, native of the Moluccas and source of two products: nutmeg from its seed and mace from the aril surrounding the seed.

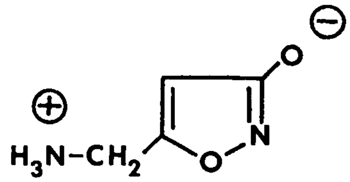
3. Other Compounds: Alcohols

Labiatae

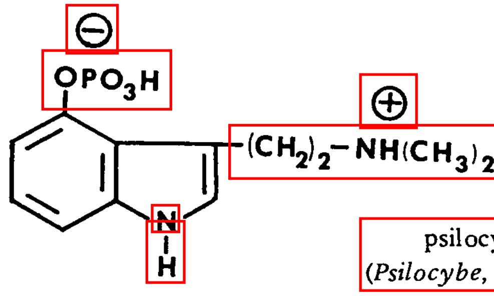
Lagochilus. — For centuries the Tajik, Tartar, Turkomen, and Uzbek tribes of central Asia have used *Lagochilus inebrians* as an intoxicant. The leaves, gathered usually in October, are toasted and made into a tea, sometimes with stems, flowering tops, and the white flowers. Honey or sugar is added to lessen the bitterness (Bunge 1847).

In 1945, a crystalline material called lagochiline, at first thought to be an alkaloid, was isolated. More recent studies, however, have indicated that it is a polyhydric alcohol and that it occurs in concentrations of up to 3%

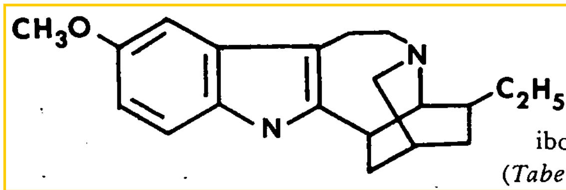
MAIN HALLUCINATING CONSTITUENTS OF PSYCHOTOMIMETIC PLANTS



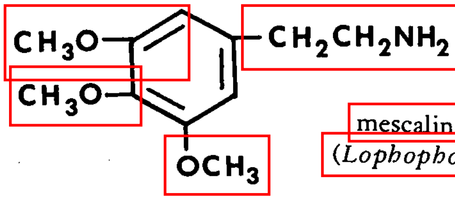
muscimole
(*Amanita*)



psilocybine
(*Psilocybe, Stropharia*)

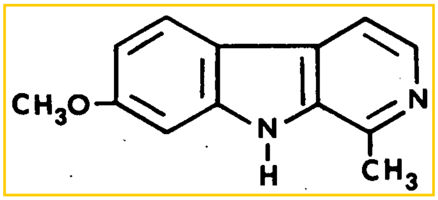


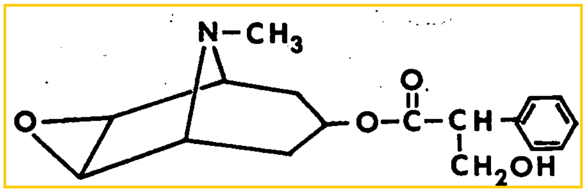
ibogaine
(*Tabernanthe*)



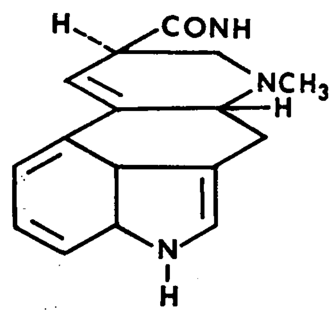
mescaline
(*Lophophora*)

harmine
(*Banisteriopsis*)

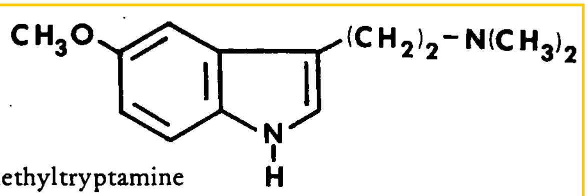




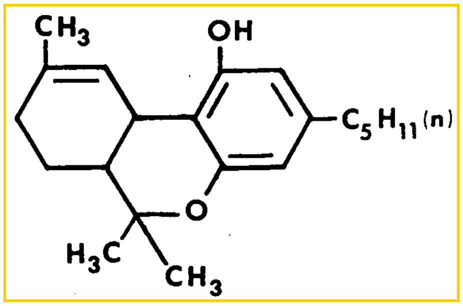
scopolamine
(*Datura*)



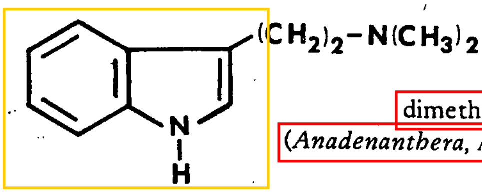
ergine
(*Rivea, Ipomoea*)



5-methoxy-N,N-dimethyltryptamine
(*Virola*)



Δ^1-tetrahydrocannabinol
(*Cannabis*)



dimethyltryptamine
(*Anadenanthera, Mimosa, Banisteriopsis*)

FIGURE 2

of dried plant material (Tyler 1966).

Because of its versatile effects, *Lagochilus inebrians* was made official in the eighth edition of the *Russian Pharmacopoeia*. The recognized sedative activity of the plant is due possibly to the same constituent responsible for the central nervous system activity basic to its folk use as a narcotic (Tyler 1966). The genus *Lagochilus* comprises some 35 species occurring from central Asia to Persia and Afghanistan.

NITROGENOUS PRINCIPLES

1. β-Carbolines

Zygophyllaceae

Peganum. — The *Syrian rue* or *Peganum Harmala* is an herb found in dry localities from the Mediterranean area east to India, Mongolia, and Manchuria. It is a member of a genus of six species distributed in dry areas of Asia Minor and Asia and in southwestern United States and Mexico. Although this and other species of *Peganum* have long been esteemed in folk medicine, its purposeful employment as an hallucinogen is open to question, vague reports notwithstanding, even though it does have psychotomimetic principles (Porter 1962).

The seeds of *Peganum Harmala* contain harmine, harmaline, harmalol, and harman, bases of a typical β-carboline structure of wide botanical and geographical distribution, having been isolated from at least eight plant families of both the New and the Old World (Deulofeu 1967; Willaman 1961).

Malpighiaceae

Banisteriopsis. — In wet tropical forest areas of northern South America, the aborigines use as hallucinogens several species of *Banisteriopsis* containing harmala alkaloids: *B. Cappi, B. inebrians*. An intoxicating drink is prepared from the bark of the stems in the Amazon of Brazil, Bolivia, Colombia, Ecuador, and Peru, the Orinoco of Venezuela, and the Pacific coast of Colombia. It is known variously as *ayahuasca, caapi, yajé, natema, pinde,* or *dapa*. Usually only one species enters the preparation, but occasionally admixtures may be employed (Friedberg 1965; Schultes 1957 & 1961).

A genus of some 100 species of tropical America, *Banisteriopsis* is taxonomically still rather poorly understood. This is true especially of *B. Caapi* and *B. inebrians*, partly because of the lack of fertile material for study of these infrequently flowering jungle lianas, even though the first botanical attention to this drug plant dates from 1854, when it was first encountered in northwestern Brazil by the explorer Spruce (Schultes 1968).

The chemistry of these hallucinogenic species of *Banisteriopsis* has been more critically investigated than the taxonomy, yet failure of chemists to insist upon botanically determined material for analyses has created chaos. Earlier workers isolated alkaloidal constituents from plants probably referable to *B. Caapi* which they named telepathine, yageine, banisterine, all of which were eventually identified as harmine (Henry 1949). More recent examination of botanically authenticated material of this species has established the presence in the bark — and sometimes in the leaves — of harmine as well as occasional lesser amounts of harmaline and Δ-tetrahydroharmine (Chen & Chen 1939; Deulofeu 1967). Recent investigations of *B. inebrians* have isolated harmine from the stems and minute amounts of what appears to be harmaline (O'Connell & Lynn 1953). An interesting chemical study of stems of the type collection of *B. Caapi* has indicated, in spite of passage of some 115 years, the presence of harmine in concentrations matching that of freshly collected material (Schultes et al 1969).

While *Banisteriopsis Caapi* is normally employed as a drink, recent indirect evidence from the northwest Amazon indicates that it may also be used as a snuff. Harmala alkaloids have been reported from snuff powders prepared from a vine said also to be the source of an intoxicating drink, but voucher botanical specimens are lacking (Holmstedt & Lindgren 1967).

Harmine has been isolated from *Cabi paraensis* of the eastern Amazon, a genus closely allied to *Banisteriopsis*. While it is valued in folk medicine, it is apparently not employed as an hallucinogen (Mors & Zaltzman 1954).

2. Ergolines

Convolvulaceae

Ipomoea, Rivea. — The early Spanish chroniclers of Mexico reported that the Indians employed in their religious and magic rites an hallucinogenic seed called *ololiuqui* by the Aztecs. It was also used medicinally, and when applied as a poultice was said to have analgesic properties.

Know as *coatl-xoxouhiqui* ("snake plant"), it was adequately illustrated as a morning glory. Although several Mexican botanists accepted this identification during the last century, not until 30 years ago was a voucher specimen of a convolvulaceous plant, the seeds of which were employed as a divinatory hallucinogen, collected amongst the Mazatecs of Oaxaca and determined as *Rivea corymbosa*. Later field work uncovered similar uses of another morning glory, *Ipomoea violacea* amongst the Zapotecs, also of Oaxaca; this species represents possibly the narcotic *tlitlilzin* of the ancient Aztecs (MacDougall 1960; Schultes 1941; Wasson 1962).

In the interval, ololiuqui had been identified as a species of *Datura*, an identification that gained wide acceptance (Safford 1916b). The reasoning upon which this theory was based held that in four centuries no narcotic used had been observed for a morning glory; the convolvulaceous flowers resembled those of a *Datura* and might have led to confusion; descriptions of ololiuqui-intoxication coincided closely with that induced by *Datura; Datura* had been and still is employed as a divinatory narcotic in Mexico; and, most significantly, no psychoactive principle was known from the *Convolvulaceae*.

Experimental psychiatry indicated that *Rivea* was definitely hallucinogenic, supporting ethnobotanical field work (Osmond 1955). Yet chemists were unable to isolate any inebriating constituents until 1960 and subsequently, when ergot alkaloids related to the synthetic hallucinogenic compound LSD were found in the seeds of both *R. corymbosa* and *I. violacea*.

The main psychotomimetic constituent of the seeds of both species are ergine(*d*Δ-lysergic acid diethylamide) and isoergine(*d*Δ-isolysergic acid diethylamide) which occur together with minor alkaloids: chanoclavine, elymoclavine, and lysergol. Ergometrine appears to be present in seeds of *I. violacea* but absent in *R. corymbosa*. The total alkaloid content of *R. corymbosa* seed is 0.012%; of *I. violacea*, 0.06% — and, indeed, Indians use smaller quantities of the latter than of the former (Hofmann 1961a, 1961b, 1963a, 1963b, 1964, 1966, 1967, 1968; Hofmann & Cerletti 1961).

The discovery of ergot alkaloids — constituents of *Claviceps purpurea*, a relatively primitive fungus — in one of the phylogenetically most advanced angiosperm families was unexpected and is of great chemotaxonomic interest. Suspicion that fungal spores might have contaminated the convolvulaceous seeds was ruled out experimentally (Taber & Heacock 1962); and the discovery of these alkaloids in fresh leaves, stalks, and roots of *I. violacea* and, to a minor extent, in leaves of *R. corymbosa* indicated that these constituents are produced by the tissue of the morning glories themselves, not by infecting fungi (Taber et al 1963a).

Large amounts of a new glycoside, turbicoryn, were likewise isolated from seeds of *R. corymbosa*, but this compound apparently has no part in the psychotomimetic action (Cook & Keeland 1962; Pérezamador & Herrán 1960).

Studies have shown the presence of these ergot alkaloids in a number of horticultural "varieties" of *I. violacea* and other species of *Ipomoea*, as well as in the related genera *Argyreia* and *Stictocardia* (Der Marderosian 1967; Der Marderosian & Youngken 1966; Genest et al 1965; Hylin & Watson 1965; Taber et al 1963b).

There are folklore references to psychotomimetic uses of *I. carnea* in Ecuador, where its common names, *borrachera* and *matacabra*, refer to its inebriating or toxic effects. Ergot alkaloids have been isolated from this species (Naranjo 1969).

The nomenclature and taxonomy of the *Convolvulaceae* are in a state of extreme confusion, especially as to delimitation of genera (Der Marderosian 1965; Schultes 1964; Shinners 1965). *Rivea*, primarily an Asiatic species of woody vines, has five Old World species and one, *R. corymbosa*, in the western hemisphere, occurring in southernmost United States, Mexico, and Central America, some of the Caribbean islands, and the northern coast of South America. *R. corymbosa* has at least nine synonyms, of which *Ipomoea sidaefolia* and *Turbina corymbosa* are most frequently employed. *Ipomoea*, comprising upwards of 500 species in the warm temperate and tropical parts of the hemisphere, is a genus of climbing herbs or shrubs, rarely semi-aquatic. *I. violacea*, often referred to by its synonyms *I. rubro-caerulea* and *I. tricolor*, is represented in horticulture by a number of "varieties," such as Heavenly Blue, Pearly Gates, Flying Saucers, Wedding Bells, Summer Skies, and Blue Stars — all of which contain the hallucinogenic ergot alkaloids (Der Marderosian 1967b).

3. Iboga-Indoles

Apocynaceae

Tabernanthe. — Probably the only member of this alkaloid-rich family known definitely to be utilized as an hallucinogen is *iboga*, the yellowish root of *Tabernanthe iboga*. This narcotic is of great social importance, especially in Gabon and nearby portions of the Congo in Africa. The use of *iboga*, first reported by French and Belgian explorers in the middle of the last century, appears to be spreading. In Gabon, it is employed in initiation rites of secret societies, the most famous of which is the Bwiti cult. Sorcerers take the drug before communicating with the spirit world or seeking advice from ancestors (Pope 1969).

Twelve closely related indole alkaloids have been reported from *iboga*; they comprise up to 6% of the dried material. Ibogaine, apparently the principal psychoactive alkaloid, acts as a cholinesterase inhibitor, a strong central stimulant, and as an hallucinogen (Hoffer & Osmond 1967; Pope 1969). *Tabernanthe* is a genus of about seven species native to tropical Africa.

Sometimes other plants — occasionally as many as 10 — are taken with *iboga*, but few have been chemically investigated. One of the most interesting, the euphor-

...aceous *Alchornea floribunda*, is employed also in the same way as *iboga* in another secret society in Gabon but is apparently not hallucinogenic. Its active principle seems to be the indole yohimbine (Tyler 1966).

Isoquinolines

Cactaceae

Lophophora. — *Lophophora Williamsii*, the *peyote* cactus, has more than 30 bases belonging to the phenylethylamines and the simple isoquinolines (Agurell 1969; Reti 1950 & 1954). The visual hallucinations are due to the phenylethylamine mescaline (see Section 6), but other aspects of the complex *peyote* — intoxication, such as auditory, tactile, and taste hallucinations and other effects, may be due in part at least to the isoquinolines, either alone or in combination. Among the important isoquinolines present are anhalamine, anhalidine, anhalinine, anhalonidine, pellotine, lophophorine, peyoglutam, mescalotam, and several as yet unnamed bases recently isolated (Agurell 1969; Der Marderosian 1966; Kapadia & Fales 1968a & 1968b; Kapadia & Highet 1968; Kapadia et al 1968; Lundstrom & Agurell 1967; McLaughlin & Paul 1965 & 1966; Pallares 1960; Reti 1950 & 1954).

5. Isoxazoles

Agricaceae

Amanita. — While *Amanita muscaria* — the *fly agaric*, a mushroom of the north-temperate zone of Eurasia and North America — may represent one of the oldest of the hallucinogens used by man, only very recently has a clarification of the chemistry of its active principles begun to take shape (Heim 1963b).

The Aryan invaders of India 3500 years ago worshipped a plant, the god-narcotic *soma*, center of an elaborate cult in which the inebriating juice was ceremonially drunk (Wasson 1969). More than 1000 hymns to *soma* have survived in the Rig Veda, describing the plant and its significance in detail. The use of *soma* died out 2000 years ago. Botanists have proposed more than 100 species in attempts to identify *soma*, but none have been satisfactory. The most recent identification of soma as *Amanita muscaria* appears, from the indirect evidence at hand, to be highly probable.

In the 18th Century, Europeans discovered the narcotic use of *Amanita muscaria* among the primitive tribesmen of Siberia. Until very recently it was employed as an orgiastic or shamanistic inebriate by the Ostyak and Vogul, Finno-Ugrian peoples in western Siberia, and the Chukchi, Koryak and Kamchadal of northeastern Siberia. Tradition has established its use among other peoples (Brekhman 1967; Lewin 1964; Wasson 1967 & 1969).

In Siberia, several mushrooms sufficed to induce intoxication — taken as extracts in water or milk, alone or with the juice of *Vaccinium uliginosum* or *Epilobium angustifolium*. A dried mushroom may be held moistened in the mouth, or women may chew them and roll them into pellets for the men to ingest. Since the mushrooms often are expensive, the Siberians practiced ritualistic drinking of the urine of an intoxicated person, having discovered that the inebriating principles were excreted unaltered by the kidneys. Urine-drinking is mentioned also in the Rig Veda hymns to *soma* (Wasson 1969).

Since the discovery in 1869 of muscarine, the intoxicating activity of *Amanita muscaria* has been attributed to this alkaloid. Recent studies, however, have indicated that muscarine represents a minor constituent of the mushroom to which the strong inebriation could hardly be attributed. Trace amounts of bufotenine in the carpophores, likewise, could not be responsible, if indeed it be present. The reported presence of tropane alkaloids has been shown to be due to incorrect interpretation of chromatographic data. Other compounds detected in *A. muscaria* are choline, acetylcholine, and muscaridine (Waser 1967).

Recent chemical and pharmacological studies have shown that the principal biologically active constituents appear to be muscimole, the enolbetaine of 5-aminoethyl-3-hydroxy-isoxazole — an unsaturated cyclic hydroxamic acid which is excreted in the urine; and ibotenic acid, the zwitterion of α-amino-α-[3-hydroxy-isoxazoylyl-5)]-acid monohydrate. The less active musoazone, likewise an amino acid, α-amino-α[2(3H)-oxazolonyl-(5)]-acetic acid, is present in varying but lesser amounts. Structurally related to these isoxazoles is the antibiotic oxamycine which often has psychoactive effects — mental confusion, psychotic depression, abnormal behavior — in man. Other active substances structurally still not elucidated are also known to be present (Eugster 1967; Waser 1967; Wieland 1968).

The widely recognized variability in psychoactivity of *A. muscaria* results probably from varying ratios of ibotenic acid and muscimole in the carpophores. In spite of appreciable variability between individuals and at different times, certain effects are characteristic: twitching of the limbs, a period of good humor and euphoria, macroscopia, occasionally colored visions of the supernatural and illusions of grandeur. Religious overtones frequently occur, and the partaker may become violent, dashing madly about, until exhaustion and deep sleep overtake him.

The genus *Amanita*, of from 50 to 60 species, is cosmopolitan, occurring on all continents except South

America and Australia, but the species occupy definitive areas. A number of the species are toxic, and their chemical constitution, still poorly understood, appears to be variable.

6. Phenylethylamines

Cactaceae

Lophophora. — One of the ancient sacred hallucinogens of Mexico, still in use, is the small, grey-green, napiform, spineless cactus *peyote: Lophophora Williamsii.* It might well be called the "prototype" of hallucinogens since it has been one of the most spectacular psychotomimetics known. It was first fully described by the early Spanish medical doctor Francisco Hernández, but many other colonial Spanish chroniclers detailed the strange story of peyote. Peyote rites persist in several tribes of northern Mexico. It was used in Texas in 1760, was known among American Indians during the Civil War, but came to public attention in the United States about 1880, when the Kiowas and Comanches elaborated a typical Plains Indian vision-quest ritual around its ceremonial ingestion. The peyote cult, organized as the Native American Church, has gradually spread to many tribes in the United States and Canada and counts 250,000 adherents (La Barre 1960 & 1964; Schultes 1937a, pp. 61-88, 129-152; 1937b; 1970). The chlorophyll-bearing crown of the cactus, dried into discoidal "mescal buttons" which are virtually indestructible and can be shipped long distances, is eaten.

The peyote cactus was first botanically described as *Echinocactus Williamsii* in 1845. It has frequently been referred to this genus and to *Anhalonium* in the chemical literature. In 1894, it was placed in the monotypic genus *Lophophora.* Its nomenclature and taxonomy are still confused, and *L. Williamsii* has more than 25 binomial synonyms, most of them referring to age-forms of the variable crown (Schultes 1937b).

Lophophora is placed in the tribe *Cereae*, subtribe *Echinocactacae*, a subtribe of some 28 genera, many of them small or monotypic and once included in *Echinocactus* (*Ariocarpus, Astrophytum, Roseocactus*, etc.). It occurs in central Mexico and near the Rio Grande in southern Texas.

More than 30 alkaloids and their amine derivatives have been isolated from *L. Williamsii*, belonging mainly to the phenylethylamines and the biogenetically related simple isoquinolines (see Section 4). The phenylethylamine mescaline is exclusively responsible for the visual hallucinations; its derivatives, N-methylmescaline and N-acetylmescaline, are apparently not active. Hordenine, another phenylethylamine, is also present in peyote. Peyonine, a novel β-phenylethylpyrrole, was recently isolated from the cactus. The pharmacology of this derivative of mescaline or its precursors has not yet been elucidated (Agurell 1969; Der Marderosian 1966; Kapadia & Fales 1968a, 1968b; Kapadia et al 1968; Lundstrom & Agurell 1967; McLaughlin & Paul 1965 & 1966; Pallares 1960; Reti 1950, 1954).

Trichocereus. — Several species of the South American genus *Trichocereus* have yielded mescaline: *T. macrogonus, T. Pachanoi, T. Terscheckii, T. Werdermannianus* (Agurell 1969). The large columnar *T. Pachanoi* of the dry Andes — called *San Pedro* in Peru, *aguacolla* in Ecuador — is employed in magic and folk medicine in northern Peru (Poisson 1960). Together with another cactus, *Neoraimundia macrostibas* and *Isotoma longiflora, Pedilanthus titimaloides*, and a species of *Datura*, it is the base of a hallucinogenic drink called *cimora* (Friedberg 1964; Gutiérrez-Noriega 1950). There are some 40 species of *Trichocereus* known from subtropical and temperate South America.

7. Quinolizidines

Leguminosae

Cytisus (Genista). — The hallucinogenic use by Yaqui medicine men in northern Mexico of *Cytisus (Genista) canariensis*, a shrub native to the Canary Islands, not Mexico, has recently been reported (Fadiman 1965). It is rich in the toxic alkaloid cystisine (ulexine, baptitoxine, sophorine) which occurs commonly in the Leguminosae (Willaman 1961). About 25 species of *Cytisus*, native to the Atlantic Islands, Europe, and the Mediterranean area, are known, and a number of the species are toxic.

Sophora. — A shrub of dry areas of the American Southwest and adjacent Mexico, *Sophora secundiflora* yields the so-called *mescal beans* or *red beans*. Mexican and Texan Indians formerly employed these beans in the ceremonial Red Bean Dance as an oracular and divinatory medium and for visions in initiation rites (La Barre 1964; Schultes 1937a, 4:129-152). Its use died out in the United States with the arrival of peyote, a much safer hallucinogen. Mescal beans, which contain cytisine, are capable of causing death by asphyxiation (Henry 1949; Howard 1957). Historical reports of the mescal bean go back to 1539, but archaeological remains suggest their ritualistic use earlier than 100 A.D. (Campbell 1958). *Sophora*, with some 50 species, occurs in tropical and warm temperate parts of both hemispheres.

Lythraceae

Heimia. — *Heimia salicifolia* has been valued in Mexican folk medicine since earliest times. Known as *sinicuichi*, its leaves are wilted, crushed in water, and the juice set in the sun to ferment. The resulting drink is mildly intoxicating. Usually devoid of unpleasant aftereffects, it induces euphoria characterized by drowsiness, a sense of shrinkage of the surroundings, auditory hallucinations, and a general removal from a sense of reality (Robichaud & Malone 1964; Tyler 1966).

Alkaloids were first reported from *H. salicifolia* in 1958 (Hegnauer 1958). Recent work has isolated and characterized five alkaloids, of which the major psychoactive one appears to be cryogenine (vertine) (Blomster & Schwarting 1964; Douglas et al 1964). Differing from the usual quinolizidines in having the quinolizidine as part of a larger and complex system of rings, cryogenine has been found only in the Lythraceae. The genus *Heimia* comprises three hardly distinguishable species and ranges from southern United States to Argentina.

Tropanes

Solanaceae

Atropa. — The *belladonna* plant, *Atropa Belladonna*, was utilized as an hallucinogen in Europe in medieval witches' brews. Its principal active constituent has long been known to be scopolamine, but minor tropane alkaloids are also present (Wagner 1969). There are four species of *Atropa*, distributed in Europe, the Mediterranean area, and from Central Asia to the Himalayas.

Datura, Methysticodendron. — *Datura* has a long history as an hallucinogenic genus in both hemispheres (Hoffmann 1968; Lewin 1964; Safford 1920; 1921). The genus, comprising some 15 to 20 species, is usually divided into four sections: (a) *Stramonium*, with three species in the two hemispheres; (b) *Datura*, comprising six species; (c) *Ceratocaulis*, with one Mexican species; (d) *Brugmansia*, South American trees representing possibly six or seven species (Satina 1959).

In Asia and the Mediterranean, *D. Metel* has been a major narcotic and poison, especially in India. *Datura fastuosa* is smoked for pleasure in Asia and Africa, often along with *Cannabis* and tobacco. Other species were valued in early Europe in witchcraft and as ingredients of sorcerers' potions (Lewin 1964; Safford 1920; Wagner 1969).

In the New World, *Datura* was and is even more widely prized. In ancient and modern Mexico and the American Southwest, *toloache* (*D. Meteloides* and *D. innoxia*) is employed medicinally and as an hallucinogen in divination rites among many tribes. The seeds, foliage, and roots, usually in decoction, are taken. The Indians of parts of northeastern North America made limited use of *jimson weed* (*D. Stramonium*) in adolescent rites (Hoffman 1968; Schultes 1969a, 1969b, 1969-70).

All of the South American representatives belong to the subgenus *Brugmansia*, sometimes treated as a distinct genus. They are all arborescent and are native either to the Andean highlands — *D. arborea, D. aurea, D. candida, D. dolichocarpa, D. sanguinea, D. vulcanicola* — or to the warmer lowlands (*D. suaveolens*). Handsome trees, mostly well known in horticultural circles, they all seem to be chromosomally aberrant cultigens, unknown in the wild state. Their classification has long been uncertain. There are six or seven species of this subgenus, although a recent proposal treats them as comprising three species and a number of cultivars (Schultes 1961; 1963a; 1963b; 1965; 1969b).

Some species were of the greatest social and religious importance in ancient Andean cultures. The Chibchas of Colombia, for example, administered potions of *Datura* to wives and slaves of deceased chieftains to induce stupor prior to their being buried alive with the departed master.

The preparation and use of *Datura* differ widely in South America today, but many tribes still employ it for prophecy, divination, and other magico-religious purposes for which the visions are important. The Kamsá of southern Colombia, for example, use several species and numerous named clones, vegetatively propagated and so highly atrophied that they may represent incipient varieties. These monstrous "races" differ, according to witch doctors, in narcotic strength and are, consequently, used for different purposes (Bristol 1966; 1969).

What may possibly represent an extreme variant of an indeterminate species of tree-*Datura* has been described as a distinct genus: *Methysticodendron Amesianum*. Native to a high Andean valley of southern Colombia, it is important to the Kamsá and Ingano Indians as an hallucinogen and as medicine (Schultes 1955).

Chemical work on many of the species of *Datura* has long been carried out, but there is still appreciable variation in results due primarily to failure to insist on authentically vouchered identification of the material analyzed. The principal alkaloids, all tropanes, are hyoscyamine, norhyoscyamine, and scopolamine, present in most of the species; the inactive meteloidine, present in *D. meteloides*; and cusohygrine, found in the roots of several species. It does not contain a tropane ring but biogenetically may be related to the other *Datura*-alkaloids (Henry 1949; Leete 1959; Willaman 1961). There are differences in total alkaloid content and in percentage of scopolamine, according to area of cultivation. In Andean plants of *Datura candida* scopolamine constitutes from 50-60% of the total base content, as contrasted to 30-34% for the same plants grown in England and Hawaii. Aerial portions of typical

D. candida, originally from the Colombian Andes but cultivated in England, yielded scopolamine, norscopolamine, atropine, meteloidine, oscine, and noratropine; roots had these alkaloids as well as 3α-6β-ditigloyloxytropane-7β-ol, 3α-tigloyloxytropane, and tropine. Leaves of the same stock grown in Hawaii contained the same spectrum of alkaloids but varied in total content and amount of scopolamine (Bristol et al 1969). The leaves and stems of South American material of *Methysticodendron* contained scopolamine up to 80% of the total alkaloid content (Pachter & Hopkinson 1960).

Significantly, the alkaloidal content in the cultivars of *D. candida* correlate closely with the reports of their relative toxicity by the Indians of Sibundoy, Colombia. Notwithstanding the great age of their hallucinogenic and medicinal uses, *Daturas* are still the subject of much botanical, ethnobotanical, and phytochemical interest.

Hyoscyamus. – Henbane, a toxic species of the genus, is *Hyoscyamus niger* and was once widely cultivated in Europe as a narcotic. It entered medieval witches' brews as an hallucinogenic ingredient. The psychoactive effects of henbane are attributed mainly to scopolamine (Wagner 1969). *Hyoscyamus* comprises about 20 species of Europe, northern Africa, southwestern and central Asia.

Latua. – A century ago, a spiny shrub of Chile, now called *Latua pubiflora*, the only member of an endemic genus, was identified as a virulent poison inducing delirium and visual hallucinations. It was employed by local Indians, who knew the shrub as *latué* or *arbol de los brujos*, to cause permanent insanity (Murillo 1889). Recent phytochemical studies indicate the presence of atropine and scopolamine (Bodendorf & Kummer 1962; Silva & Mancinelli 1959).

Mandragora. – The famed *mandrake* of Europe, *Mandragora officinarum*, owes its renown mainly to its hallucinogenic toxicity. Its active principles are tropane alkaloids, primarily hyoscyamine, scopolamine, and mandragorine (Wagner 1969). Six species of *Mandragora* are known, native to the region from the Mediterranean to the Himalayas.

9. Tryptamines

Acanthaceae

Justicia. – The Waikás of the Orinoco headwaters in Venezuela and in northern Amazonian Brazil occasionally dry and pulverize the leaves of *Justicia pectoralis* var. *stenophylla* as an admixture to their *Virola*-snuff (Schultes 1966; 1967, pp. 291-306; 1968). There are suspicions that this aromatic herb may contain tryptamines (Holmstedt, personal communication). If the preliminary indications can be verified, it will for the first time establish the presence of these indoles in the Acanthaceae. There are more than 300 species of *Justicia* in the tropical and subtropical parts of both hemispheres.

Agaricaceae

Conocybe, Panaeolus, Psilocybe, Stropharia. – The Spanish conquerors found Mexican Indians practicing religious rites in which mushrooms were ingested as a sacrament permitting them to commune through hallucinations with the spirit world. The Aztecs knew these "sacred" mushrooms as *teonanacatl* ("food of the gods") (Heim & Wasson 1959; Safford 1915).

European persecution drove the cult into hiding in the hinterlands. Notwithstanding the many descriptions in the writings of the early chroniclers, no evidence that the narcotic use of mushrooms had persisted was uncovered until about 30 years ago. Botanists had even postulated that teonanacatl was the same plant as peyote: that the discoidal crown of the cactus, when dried, superficially resembled a dried mushroom and that the earlier writers had confused the two or had been deliberately duped by their Aztec informants. Then, during the 1930s, several investigators found an active mushroom cult amongst the Mazatecs in Oaxaca and collected, as the hallucinogenic fungi, *Panaeolus sphinctrinus* and *Stropharia cubensis*. Later and more intensive work during the 1950s brought to over 24 species in at least four genera the number of basidiomycetes employed currently in six or more tribes of Mexican Indians (Guzman 1959; Heim 1956, pp. 965-68, 1389-95; 1957a; 1957b; 1963; 1966; Heim et al 1967; Schultes 1939; 1940; Singer 1958; Wasson 1957; 1958; 1959; 1963).

It now appears that the mushroom cults are of great age and were once much more widespread. Archeological artifacts, now called "mushroom stones," excavated in great numbers from highland Mayan sites in Guatemala, are dated conservatively at 1000 B.C. Consisting of a stem with a human or animal face and crowned with an umbrella-like top, these icons indicate the existence of a sophisticated mushroom cult at least 3000 years ago.

Perhaps the most important species employed in Mexican mushroom rites are *Psilocybe aztecorum, P. caerulescens, P. mexicana, P. zapotecorum*, and *Stropharia cubensis* (Heim et al 1967; Heim & Wasson 1959). All of these have been found to contain a most extraordinarily psychoactive compound, psilocybine – an hydroxy-indole alkylamine with a phosphorylated side chain: 4-phosphoryloxy-N,N-dimethyltryptamine – and sometimes the unstable derivative, psilocine: 4-hydroxy-N,N-dimethyltryptamine. Psilocybine is the only natural indole compound with a phosphoric acid radical known from the plant kingdom, and both psilocybine and psilocine are novel indoles in having the hydroxy radical substituted in the 4-position. Tryptophan is probably the biogenetic precursor of psilocybine (Hofmann et al 1958a; 1958b; 1959; Hofmann & Troxler 1959; Hofmann & Tscherter 1960).

These two indoles may occur widely in *Psilocybe* and related genera. One or both have been isolated from *P. baeocystis, P. cyanescens, P. fimetaria, P. pelliculosa, P. quebecensis, P. semilanceata, P. semperviva,* and *P. Wassonii*; as well as from *Conocybe cyanopus, C. Smithii* and a species of *Copelandia* (Benedict et al 1962; 1967; Heim et al 1966; Hofmann 1968; Ola'h & Heim 1967). The occurrence of 4-substituted tryptamines (psilocybine or psilocine) has been reported from *Panaeolus sphinctrinus* and this psychoactive mushroom also contains 5-hydroxytryptamine and 5-hydroxytryptophan (Hegnauer 1966; Ola'h 1969; Tyler & Gröger 1964). The closely related *Panaeolus companulatus* does not contain the hallucinogenic constituents (Taylor & Malone 1960).

Early missionaries in Amazonian Peru reported that the Yurimagua Indians employed an intoxicating beverage made from a "tree fungus" (Schultes 1966). Although no modern evidence points to the use of an hallucinogenic fungus in that area, *Psilocybe yungensis* has been suggested as a possible identification of the mushroom (Schultes 1966).

The principal genera of hallucinogenic mushrooms of Mexico are small but widespread: *Conocybe* is cosmopolitan; *Panaeolus* is cosmopolitan, occurring primarily in Europe, North America, Central America, and temperate Asia; *Psilocybe*, almost cosmopolitan, is distributed in North America, South America, and Asia; and *Stropharia*, likewise almost cosmopolitan, ranges through North America, the West Indies, and Europe.

Leguminosae

Anadenanthera. — The New World snuff prepared from beans of *Anadenanthera (Piptadenia) peregrina*, known in the Orinoco basin of Colombia and Venezuela, center of its present use, as *yopo* or *ñopo*, represents probably the *cohoba* encountered in Hispaniola by Columbus' second voyage in 1496. Von Humboldt, Spruce, and other explorers who mentioned it were all astonished at its hallucinogenic potency (Safford 1916a; Schultes 1967, pp. 291-306; Wassén 1964; 1967; Wassén & Holmstedt 1963).

The beans of this medium-sized tree, usually roasted, are crushed and mixed with ashes or calcined shells. The powder is ceremonially blown into the nostrils through bamboo tubes or snuffed individually through birdbone tubes. The intoxication is marked by fury, followed by an hallucinogenic trance and eventual stupors (Granier-Doyeux 1965).

Five indoles have been isolated from *A. peregrina*, chief of which are N,N-dimethyltryptamine and bufotenine (5-hydroxy-N,N-dimethyltryptamine) (Fish et al. 1955; Holmstedt 1967). The beans contain as their main constituent N,N-dimethyltryptamine or bufotenine. Other indoles found in this species are 5-methoxy-N,N-dimethyltryptamine, N-monomethyltryptamine and 5-methoxy-N-monomethyltryptamine.

Indirect evidence suggests that another species, *A. colubrina*, might formerly have been the source of the narcotic snuffs known in southern Peru and Bolivia as *vilca* or *huilca* and in northern Argentina as *cebil* (Altschul 1967). Since this species is closely related to the more northern *A. peregrina* and its chemical constituents are very similar, *A. colubrina* may well have been valued aboriginally as an hallucinogen.

Anadenanthera comprises only the two species discussed above. Native to South America, they are distinguished from the closely allied genus *Piptadenia* both morphologically and chemically (Altschul 1964).

Mimosa. — The allied genus *Mimosa* likewise yields a psychotomimetic, *vinho de jurema*. An infusion of the roots of *Mimosa hostilis* forms the center of the ancient Yurema cult of the Karirí, Pankarurú, and other Indians of Pernambuso State, Brazil (Schultes 1965; 1966). The drink, said to induce glorious visions of the spirit world, was reported to contain an alkaloid called nigerine, now known to be synonymous with N,N-dimethyltryptamine, the active principle (Goncalves de Lima 1946; Pachter 1960).

The genus *Mimosa* comprises about 500 tropical or subtropical herbs and small shrubs, mostly American but a few native to Africa and Asia. It is closely related to *Anadenanthera* and *Piptadenia*.

Malpighiaceae

Banisteriopsis. — One of the numerous admixtures of the *ayahuasca-caapi-yajé* drink prepared basically from bark of *Banisteriopsis Caapi* or *B. inebrians* (which contain β-carboline bases) is the leaf of *B. Rusbyana* known in the western Amazon of Colombia and Ecuador as *oco-yajé*. The natives add the leaf to heighten and lengthen the visions. Recent examination indicates that *B. Rusbyana* has in its leaves and stems, to the exclusion of the harmala alkaloids characteristic of the other two narcotically utilized species, N,N-dimethyltryptamine and traces of other tryptamines: N_3-methyltryptamine; 5-methoxy-N,N-dimethyltryptamine; and N,βmethyl-tetrahydro-β-carboline) (Agurell et al 1968a; Der Marderosian et al 1968; Poisson 1965). Tryptamines have apparently not hitherto been reported from the *Malpighiaceae.*

Myristicaceae

Virola. — Hallucinogenic snuffs are prepared in northwestern Brazil and adjacent Colombia and Venezuela from the reddish bark resin of *Virola*, a genus of 60 to 70 trees of Central and South America. The species employed have only recently been identified as *V. calophylla* and *V. calophylloidea* in Colombia and *V. theiodora* in Brazil (Schultes 1954b; Schultes & Holmstedt 1968; Seitz 1967). The most intense use of this snuff, called *yakee, paricá, epená*, and *nyakwana*, centers among the Waikás of Brazil and Venezuela. In Colombia, only witch doctors employ it, but in Brazil the intoxicant is taken by all adult males, either individually at any time or ritually in excess at endocannibalistic ceremonies amongst the Waikás. The resin, which is boiled, dried, pulverized, and occasionally mixed with powdered leaves of a *Justicia* and bark-ashes of *Theobroma subincanum* or *Elizabetha princeps*, acts rapidly and violently. Effects include excitement, numbness of the limbs, twitching of facial muscles, nausea, hallucinations, and finally a deep sleep; macroscopia is frequent and enters into Waiká beliefs about the spirits resident in the drug.

Contemporary investigations indicate that the snuff prepared from *V. theiodora* contains normally up to 8% 5-methoxy-N,N-dimethyltryptamine, with lesser amounts of N,N-dimethyltryptamine (Agurell 1969; Holmstedt 1965). There is appreciable variation in alkaloid concentration in different parts (leaves, bark, root) of *V. theiodora*, but the content in the bark resin may reach as high as 11%. Two new β-carbolines have likewise been found in *V. theiodora* (Agurell 1968b).

Of other species of *Virola* investigated, *V. rufula* contains substantial amounts of tryptamines and *V. calophylla*, one of the species employed in the preparation of snuff in Colombia, contains high amounts of alkaloids apparently in the leaves alone. *V. multinervia* and *V. venosa* are almost devoid of alkaloids (Agurell et al 1969).

The Witotos, Boras, and Muinanes of Amazonian Colombia utilize the resin of a *Virola*, possibly *V. theiodora*, orally as an hallucinogen. Small pellets of the boiled resin are rolled in a "salt" left upon evaporation of the filtrate of bark ashes of *Gustavia Poeppigiana* and ingested to bring on a rapid intoxication, during which the witch doctors see and speak with "the little people" (Schultes 1969c, pp. 229-240). There are suggestions that Venezuelan Indians may smoke *V. sebifera* as an intoxicant.

Rubiaceae

Psychotria. — Among the sundry admixtures employed to "strengthen" and "lengthen" the effects of the hallucinogenic drink prepared from *Banisteriopsis Caapi* and *B. inebrians* in the western Amazon, one of the most commonly added are leaves of *Psychotria* (Schultes 1967). One species used in Ecuador and Peru, *P. viridis* (reported through a misidentification as *P. psychotriaefolia* (Schultes 1966; 1969c), has recently been shown to contain N,N-dimethyltryptamine (Der Marderosian, personal communication). The same species and another not yet specifically identified are similarly used in Acre Territory, Brazil (Prance, In press). Tryptamines have apparently not hitherto been reported from the *Rubiaceae*. The genus *Psychotria* comprises more than 700 species of the warmer parts of both hemispheres, many of which have important roles in folk medicine or are poisons.

HALLUCINOGENS OF UNCERTAIN USE OR CHEMICAL COMPOSITION

Sundry plants known to possess psychoactive constituents are doubtfully employed as hallucinogens. Others are known to be used for their psychotomimetic properties, but the chemical principles responsible for the effects are of uncertain or undetermined structure.

Lycoperdaceae

Lycoperdon. — Puffballs, *Lycoperdon marginatum* and *L. mixtecorum*, have recently been reported as hallucinogens utilized by the Mixtecs of Oaxaca in Mexico at 6000 feet altitude or higher (Heim et al 1967). There are more than 100 species of *Lycoperdon*, native mostly to the temperate zone in moss-covered forests.

The Mixtecs call *Lycoperdon mixtecorum gi'-i-wa* ("fungus of first quality") and *L. marginatum*, which has a strong odor of excrement, *gi'-i-sa-wa* ("fungus of second quality"). These two hallucinogens do not appear to occupy the place as divinatory agents that the mushrooms hold among the neighboring Mazatecs.

The more active species, *Lycoperdon mixtecorum*, causes a state of half-sleep one-half hour after ingestion of one or two specimens. Voices and echoes are heard, and voices are said to respond to questions posed to them. The effects of the puffballs differ strongly from those of the hallucinogenic mushrooms: they may not induce visions, although definite auditory hallucinations do accompany the intoxication. There is as yet no phytochemical basis on which to explain the intoxication from these two gastromycetes.

Araceae

Acorus. — There is some evidence that Indians of northern Canada chewed the root of *Acorus Calamus* — *flag root, rat root, sweet calomel* — for its medicinal and stimulant properties. In excessive doses, this root is known to induce strong visual hallucinations (Hoffer & Osmond 1967; Sharma et al 1961). The hallucinogenic principle is reported to be asarone and β-asarone (Hoffer & Osmond 1967). There are two species of *Acorus* occurring in the north temperate zone and warmer parts of both hemispheres.

Homalomena. — Natives of Papua are reported to eat the leaves of *ereiba*, a species of *Homalomena*, together with the leaves and bark of *Galbulimima belgraviana*, as a narcotic. The effects are a violent and crazed condition leading to sleep, during which the partakers see and dream about men or animals that they are supposed to kill (Barrau 1957; 1958; Hamilton 1960). It is not yet clear what, if any, hallucinogenic principle may be present in this aroid. Some 140 species of *Homalomena*, native to tropical Asia and South America, are known.

Amaryllidaceae

Pancratium. — The Bushmen of Dobe, Botswana, consider *Pancratium trianthum*, a bulbous perennial known locally as *kwashi*, to be psychoactive (Schultes 1969-70). Rubbing the bulb over incisions on the head is said to induce visual hallucinations. Nothing is known of possible psychotomimetic constituents. Other species of *Pancratium*, a genus of some 15 species, mainly of Asia and Africa, possess toxic principles, chiefly alkaloids. Although some species are employed in folk medicine, several are potent cardiac poisons.

Zinginberaceae

Kaempferia. — Vague reports indicate that in New Guinea, *Kaempferia Galanga*, known as *maraba*, is employed as a hallucinogen (Benedict et al 1962; Hamilton 1960), but phytochemical corroboration is lacking. The rhizome of *galanga*, containing essential oils, is highly prized as a condiment and medicine in tropical Asia. There are some 70 species of *Kaempferia* distributed in tropical Africa, India to southern China, and western Malaysia.

Moraceae

Olmediopperebea. — An Amazon jungle tree, *Olmediopperebea sclerophylla*, represents one of the most poorly understood hallucinogens. The fruits reputedly are the source of an intoxicating snuff employed formerly by Indians of the Pariana region of central Amazonia (Schultes 1961; 1963a; 1963b; 1965; 1966; 1969b). Nothing is known of the chemical constituents. Two species of *Olmediopperebea*, both Amazonian, have been described.

Aizoaceae

Mesembryanthemum. — More than 225 years ago, the Hottentots of South Africa were reported using a narcotic called *kanna* or *channa*. At the present time, this name applies to sundry species of *Mesembryanthemum* (*Sceletium*), especially to *M. tortuosum*, but there is no evidence that these are employed hallucinogenically. Other plants — *Sclerocarya Caffra* of the *Anacardiaceae* and *Cannabis* — have been suggested as possible identifications (Lewin 1964; Schultes 1967; 1970; Tyler 1966).

Several species of *Mesembryanthemum* known to cause a state of torpor when ingested have yielded alkaloids: mesembrine and mesembrenine. Both have a nucleus related to the crinane nucleus in certain amaryllidaceous alkaloids but differ in having an open ring. There are about 1000 species of *Mesembryanthemum, sensu lato*, in the xerophytic parts of South Africa. About two dozen species have been split off into a group often recognized as a distinct genus, *Sceletium*.

Himantandraceae

Galbulimima. — In Papua, the leaves and bark of *agara*, *Galbulimima belgraveana*, are taken with the leaves of a species of *Homalomena* to induce a violent intoxication that progresses into a sleep in which visions and dreams are experienced (Barrau 1957; 1958; Hamilton 1960). Several isoquinoline alkaloids have been isolated from this plant, but the specific pharmacology of the constituents is not clear. Two or three species of *Galbulimima* occur in eastern Malaysia and northeastern Australia.

Gomortegaceae

Gomortega. — *Gomortega Keule*, an endemic of Chile, where it has the Mapuche Indian names *keule* or *hualhual*, may once have been employed as a narcotic (Mariani Ramirez 1965; Mechoulam & Gaoni 1965). Its fruits are intoxicating, especially when fresh, due possibly to an essential oil. There is only this one species in the *Gormortegaceae*.

Leguminosae

Erythrina. — The reddish beans of *Erythrina* may have been valued as hallucinogens in Mexico. Resembling seeds of *Sophora secundiflora*, they are frequently sold in modern Mexican herb markets under the name *colorines* (Safford 1916b; Schultes 1937a; 1969a; 1970). Several species contain indole or isoquinoline derivatives and could be hallucinogenic. The genus occurs in the tropics and subtropics of both hemispheres and comprises some 100 species.

Rhynchosia. — The ancient Mexicans may have valued several species of *Rhynchosia* as a narcotic. Modern Oaxacan Indians refer to the toxic seeds of *R.*

pyramidalis and *R. longeracemosa* by the same name, *piule*, that they apply to the seeds of hallucinogenic morning glories. The black and red *Rhynchosia* beans, pictured together with mushrooms, have been identified on Aztec paintings, thus suggesting hallucinogenic use (Schultes 1937a; 1965; 1969a; 1969-70). An as yet uncharacterized alkaloid has been isolated from this genus, which comprises some 300 species of the tropics and subtropics, especially of Africa and America.

Malpighiaceae

Tetrapteris. — The makú Indians in the northwesternmost sector of the Brazilian Amazon prepare a narcotic drink from the bark of *Tetrapteris methystica*. A cold-water infusion with no admixtures has a yellowish hue and induces an intoxication with visual hallucinations very similar to that caused by drinks prepared from species of the related genus *Banisteriopsis* (Schultes 1954a).

No chemical studies have been made of this species of *Tetrapteris*, but, since it is close to *Banisteriopsis*, it is not improbable that β-carbolines are the active constituents. *Tetrapteris* comprises some 80 species distributed from Mexico to tropical South America and in the West Indies.

Coriariaceae

Coriaria. — Long recognized in the Andes as dangerously toxic to animals, *Coriaria thymifolia* has recently been reported as hallucinogenic, giving the sensation of flight. The fruits, reputedly containing catecholic derivatives, are eaten for inebriation in Ecuador, where the plant is called *shanshi* (Naranjo 1969; Naranjo & Naranjo 1961).

Four toxic picrotoxine-like sesquiterpenes have been isolated from the *Coriariaceae:* coriamyrtine, coriatine, tutine, and pseudotutine (Hegnauer 1962-64; 1966). This genus, the only one in the family, has some 15 species distributed in Eurasia, New Zealand, and highland tropical America.

Cactaceae

Ariocarpus. — The Tarahumare Indians of northern Mexico employ *Ariocarpus fissuratus*, called *sunami* and *peyote cimmarón*, as a narcotic, asserting that it is stronger than true *peyote* (*Lophophora*) (Schultes 1967; 1969-70). Anhalonine has been isolated from an indeterminate species of *Ariocarpus*. There are five species known in this genus, all Mexican (Agurell 1969; Der Marderosian 1967a).

Epithelantha. — The Tarahumare likewise use *Epithelantha micromeris* as a narcotic (Schultes 1963a). Chemical studies apparently have not been carried out on representatives of this genus of three species of southwestern United States and Mexico.

Pachycereus. — Another cactus utilized as a narcotic by the Tarahumare is the gigantic *Pachycereus pecten-aboriginum*, which they call *cawé*. Carnegine has been reported from this species (as *Cereus pecten-aboriginum*) (Agurell 1969). Another species, *P. marginatus*, is said to contain pilocereine (Agurell 1969). There are five species of *Pachycereus*, all native to Mexico.

Ericaceae

Pernettya. — *Pernettya furiens*, known in Chile as *huedhued* or *hierba loca*, is toxic. When consumed in quantity, the fruits induce mental confusion and madness or permanent insanity and exercise a narcotic effect similar to that of *Datura* (Mariani Ramirez 1965). This species has apparently not been chemically investigated. Its activity may be due to andromedotoxine, a resinoid, or to arbutin, a glycoside or hydroquinone — both rather widely distributed in the family. *P. parvifolia*, called *taglli* in Ecuador, is noted as a toxic plant containing andromedotoxine and the fruit of which, when ingested, causes hallucinations and other psychic and motor alterations (Chavez et al 1967; Naranjo 1969). Some 25 species of *Pernettya* are known from Tasmania, New Zealand, the highlands from Mexico to Chile, the Galapagos and Falkland Islands.

Desfontainiaceae

Desfontainia. — It is reported that the leaves of *Desfontainia spinosa* var. *Hookeri* are employed in southern Chile as a narcotic as well as medicinally (Mariani Ramirez 1965). Chemical investigation of this anomalous plant have apparently not been carried out. This genus of two or three Andean species comprises the only genus in the family, which appears to be related to the *Loganiaceae* and which is sometimes placed in the *Potaliaceae*.

Apocynaceae

Prestonia. — The source of the hallucinogenic *yajé* of the western Amazon has been reported as *Prestonia (Haemadictyon) amazonica*, an identification based on misinterpretation of field data and guess work. Although well established in botanical and chemical literature, recent evaluation of the evidence seriously discredits this suggestion (Schultes & Roffauf 1960). A recent report of N,N-dimethyltryptamine in *P. amazonica* (Hochstein & Paradies 1957) was based upon an erroneous identification, without voucher specimens, of an aqueous extract of the leaves of a vine which may have been *Banisteriopsis Rusbyana*.

Labiatae

Coleus, Salvia. — In southern Mexico, crushed leaves of *Salvia divinorum*, known in Oaxaca as *hierba de la Virgen* or *hierba de la Pastora*, are valued by the

Mazatecs in divinatory rites when other more potent hallucinogens are unavailable (Epling & Jativa-M 1962). Although investigators have experimentally substantiated the psychotomimetic effects, a toxic principle is still to be isolated from the plant (Wasson 1962, pp. 77-84, 161-193). It has been suggested that *S. divinorum* represents the hallucinogenic *pipiltzintzintli* of the ancient Aztecs (Wasson 1962). There are some 700 species of *Salvia* in the temperate and tropical parts of both hemispheres, but no other species seems to have been reported as an hallucinogen.

The leaves of two other mints, *Coleus pumila* and *C. Blumei*, both native to southeast Asia, are similarly employed by the Mazatecs (Wasson 1962). Chemical studies of these two species, at least on the basis of the material growing in southern Mexico, have not been done, and a psychoactive principle is not known in this genus of some 150 species of the Old World tropics.

Solanaceae

Brunfelsia. — That species of *Brunfelsia* were once employed narcotically in the western Amazon is probable but not yet corroborated by field evidence. Several vernacular names suggest that the intoxicating properties were valued (Schultes 1967). *B. Tastevini* is reputedly utilized by the Kachinauas of the Brazilian Amazon to prepare an hallucinogenic drink, but this report needs confirmation (Benoist 1928). Containing what appear to be tropanes of undetermined structure and the coumarin compound scopoletin, this genus undoubtedly has psychoactive properties. *Brunfelsia* is a tropical American genus of some 25 species, and is somewhat intermediate between the *Solanaceae* and *Scrophulariaceae*.

Campanulaceae

Lobelia. — *Lobelia Tupa*, a tall, polymorphic herb of the Andean highlands known as *tupa* or *tabaco del diablo*, is a widely recognized poison. Chilean peasants are said to employ the juice to relieve toothache, and while the Mapuches of Chile reputedly smoke the leaves for their narcotic effect, there is as yet no certainty that this effect is hallucinogenic (Mariani Ramirez 1965; Naranjo 1969).

The leaves of *L. Tupa* contain the piperidine alkaloid lobeline and the diketo- and dihydroxy-derivatives, lobelamidine and norlobelamidine (Kaczmarek 1959).

There are some 350 to 400 cosmopolitan species of *Lobelia* mostly tropical and subtropical, especially in the Americas. It is usually classified with several other large genera as a subfamily, *Lobeliodieae*, of the *Campanulaceae*, but the subfamily may sometimes be treated as a distinct family, *Lobeliaceae*.

Compositae

Calea. — A common Mexican shrub, *Calea Zacatechichi*, belonging to a tropical American genus of about 100 species, represents one of the most recently discovered hallucinogens. The Chontal Indians of Oaxaca take the leaves in infusion for divination, calling them *thle-pela-kano* or "leaf of god" and believing them to clarify the senses (MacDougall 1968). Although the plant has long been used in folk medicine, few reliable chemical studies appear to have been carried out (Schultes 1969a). Preliminary investigations have indicated the presence of a possible new alkaloid (Holmstedt, personal communication).

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