

**MEDICINAL PLANTS
OF THE
ARID ZONES**

U N E S C O

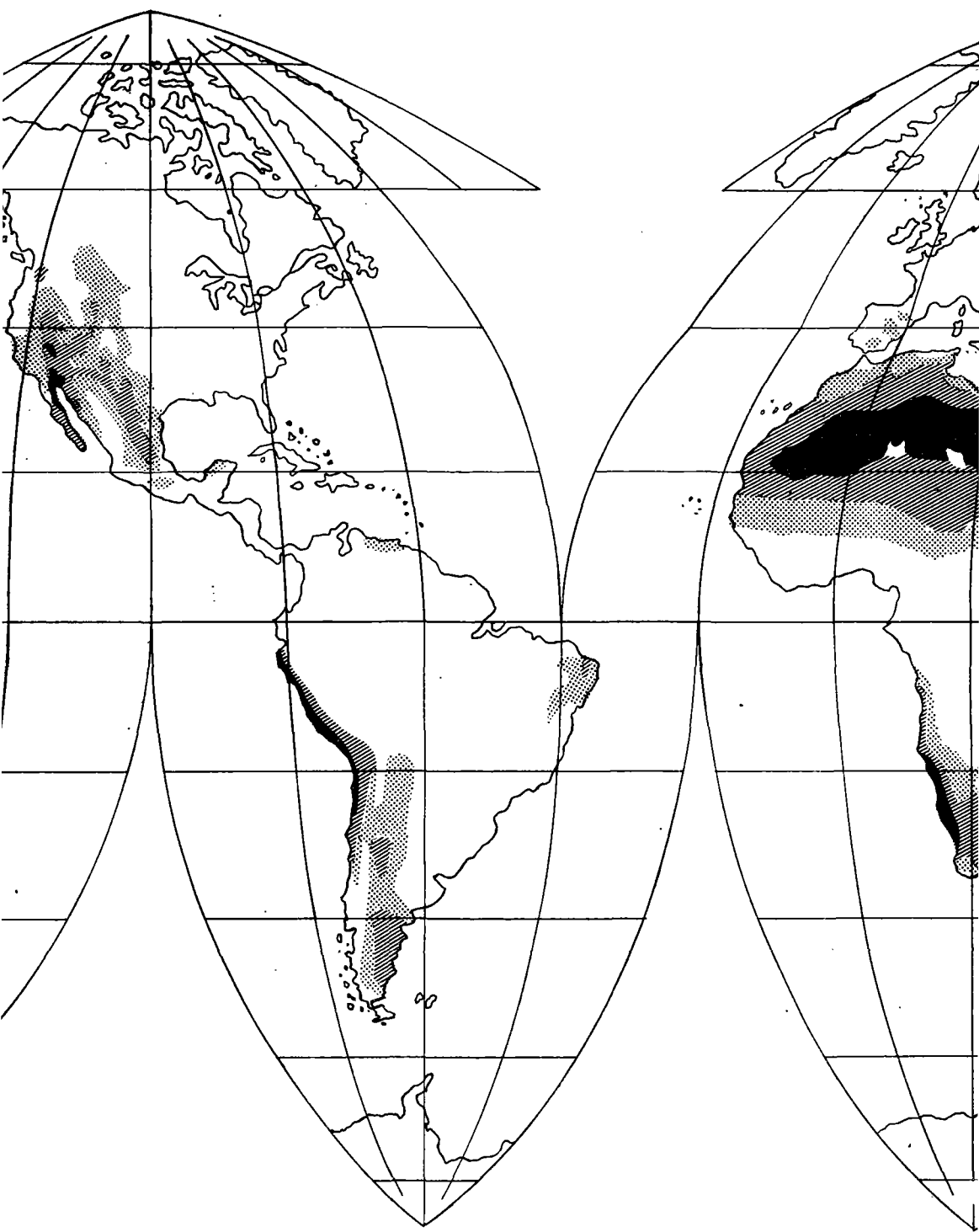
ARID ZONE RESEARCH — XIII
MEDICINAL PLANTS OF THE ARID ZONES

Titles in this series

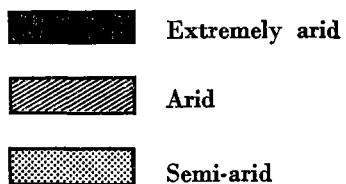
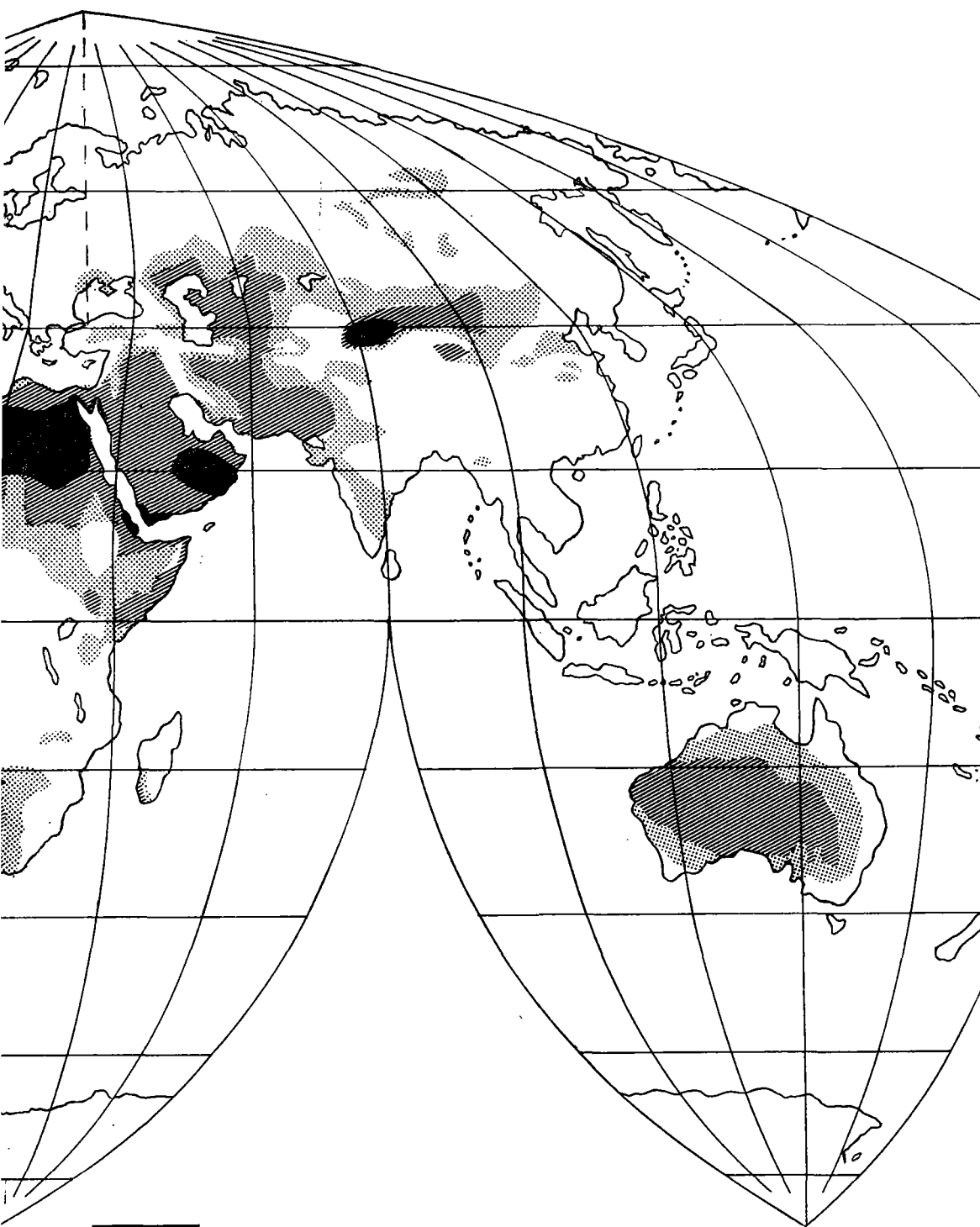
- I. Reviews of research on arid zone hydrology.
- II. Proceedings of the Ankara symposium on arid zone hydrology.
- III. Directory of institutions engaged in arid zone research.
- IV. Reviews of research on problems of utilization of saline water.
- V. Plant ecology. Proceedings of the Montpellier symposium / *Écologie végétale, actes du colloque de Montpellier.*
- VI. Plant ecology. Reviews of research / *Ecologie végétale, compte rendu de recherches.*
- VII. Wind and solar energy. Proceedings of the New Delhi symposium / *Énergie solaire et éolienne, actes du colloque de New Delhi / Energía solar y eólica, actas del coloquio celebrado en Nueva Delhi.*
- VIII. Human and animal ecology. Reviews of research / *Écologie humaine et animale, compte rendu de recherches.*
- IX. Guide book to research data for arid zone development.
- X. Climatology. Reviews of research.
- XI. Climatology and microclimatology. Proceedings of the Canberra symposium / *Climatologie et microclimatologie, actes du colloque de Canberra.*
- XII. Arid zone hydrology. Recent developments.
- XIII. Medicinal plants of the arid zones. Reviews of research.

Since 1955 the reviews of research have been published with yellow covers, and the proceedings of symposia with grey covers.

*Published in 1960 by the United Nations
Educational, Scientific and Cultural Organization
Place de Fontenoy, Paris-7^e
Printed in France by Oberthur, Rennes*



DISTRIBUTION OF ARID HOMOCLIMATES
(After the map prepared for Unesco by Peveril Meigs)



FOREWORD

UNESCO's arid zone programme, drawn up in 1951, was raised to the status of a major project at the ninth session of the General Conference in 1956. While the change has brought a substantial increase in the resources granted to the Organization for the promotion of arid zone research, specifically by direct support for certain institutions in the region extending from North Africa to the Middle East and South-East Asia, the collection and dissemination of scientific information provided by studies on arid zone problems remain essential objectives.

Twelve volumes have so far been published in the *Unesco Arid Zone Research series*. They include digests of research on particular subjects such as hydrology, plant ecology, utilization of saline waters, human and animal ecology, and climatology, and the proceedings of symposia on the same subjects arranged under the programme.

Another class of publication, in the same series but in a reduced format, consists firstly of sequels bringing existing digests up to date, and secondly of monographs on research in certain fields of special importance but where the extent of the work done does not warrant fuller treatment.

Although two important publications have already been issued on the plant ecology of arid and semi-arid regions, it has become apparent that a study dealing specifically with medicinal plants of those regions could be expected to be of considerable interest both to botanists and to pharmacologists; apart from its scientific value, it can provide invaluable indications of the directions in which research on medicinal plants is leading and of the practical possibilities of using such plants in the present-day economy.

Dr. I. C. Chopra, of the Drug Research Laboratory, Jammu (India), and Professor R. Paris of the Faculté de Pharmacie of Paris have kindly agreed to undertake the task with Dr. Chopra concentrating primarily on the botanical aspects and Professor Paris on the pharmacological.

A list of arid zone medicinal plants is given at the end of the book. Plants mentioned in the text can be found by means of this list.

In presenting this work to specialists in this branch of study and to all concerned with arid zone problems, the Unesco Secretariat takes this opportunity of expressing its gratitude to the authors, to all who have supplied suggestions or new information and to the secretariat of the World Health Organization for its valuable advice.

C O N T E N T S

PART ONE. With particular reference to the botanical aspects, by I. C. Chopra, B. K. Abrol and K. L. Handa.	11
PART TWO. With particular reference to the pharmacological aspects, by R. Paris and G. Dillemann.	55
A LIST OF ARID ZONE MEDICINAL SPECIES.	92

PART ONE

With particular reference to the botanical aspects

by

I. C. CHOPRA, B. K. ABROL and K. L. HANDA
Drug Research Laboratory, Jammu (India)

INTRODUCTION

The arid regions of the world occupy very extensive areas of the continental land masses and constitute nearly one-half of the land surface of the Earth. The major portion of the African continent and a great part of the Asian continent are arid. Practically the entire surface of Australia, except the fringes bordering the sea in the north, east and south-east, is arid. The North and South American continents contain large tracts of arid land.

Some parts of Alaska, north-eastern Siberia, the Arctic coast of the Union of Soviet Socialist Republics and the western part of the Tibetan Plateau fall into the semi-arid category. Many of these localities would be classified as tundra by the usual criterion—a mean temperature of less than 10°C during the warmest month. As such areas would not be warm enough for agriculture even if sufficient water were available, it has not been considered advisable to include them in the arid or semi-arid zones as defined by Unesco [2].¹

Although lack of rainfall is a predominant characteristic of the arid regions, this in itself is not an adequate index of aridity. The effectiveness of rainfall depends on its seasonal distribution, the nature and porosity of the soil, and the rate of evaporation. The evaporation rate is in turn determined by the surface temperature, the prevailing winds and the humidity of the air at ground level. The temperature is determined by the latitude of the region north or south of the equator, its elevation above sea-level, hours of sunshine and air movements. The relative humidity of the surface air is affected by the direction and humidity of the prevailing winds.

In general rainfall is unevenly distributed seasonally and there is an enormous range of variation in yearly averages. Absence of rainfall for several years is frequently observed and flood conditions are not uncommon in a certain number of deserts. The rate of evaporation from the surface is high. Variations in the evaporation rate in different regions with similar temperature conditions are due mainly to cloud cover and wind conditions. Strong winds are common, but there are also many calm days in most desert regions.

The average annual rainfall of any particular region is affected by the situation of the region in relation to the continental land masses and by the distribution of forests and mountain ranges. The great Thar Desert in the north-west of the Indian subcon-

1. The numbers in brackets refer to the list of references at the end of each section,

tinents is a desert because it is inaccessible to the south-west monsoon. The aridity of the Great Gobi Desert of Mongolia is due to the massive Himalayan range of mountains in the south which stop the inflow of the moisture-laden winds from the Indian Ocean. There are instances where desert formation is not adequately explained such as in the formation of the Sahara Desert. The great inland drainage basins of Asia, Africa and Australia offer typical examples of arid areas which are below sea level—the Aral and Caspian Sea regions of Central Asia, the Lake Chad region of the Southern Sahara and the Salt Lake region of Australia.

The nature of the surface soil is an important factor determining the nature and density of the vegetation. In deserts, surface erosion is caused chiefly by the rapid and extreme changes in temperature, which are due principally to the lack of cloud cover. Rock surfaces are alternately heated and cooled, resulting in fragmentation and the eventual formation of sand particles. Where the initial rock surface is harder or more resistant to fragmentation or where the range of temperature variation is smaller, stony desert surfaces are commonly formed. Such deserts are the Hamada in Africa, the Gobi in Mongolia and the Gibber Plains in Australia.

According to Peveril Meigs [2] the arid regions of the world can be broadly divided into three main types: (a) extremely arid, (b) arid, and (c) semi-arid zones.

The type of climatic classification adopted depends on the purpose for which it is intended; the above classification is particularly suitable for the examination of agricultural potentialities. Rainfall and temperature are factors of outstanding importance, other factors being correlated. The basis for the distinction between arid and semi-arid regions is the system developed by Thornthwaite [4], which uses an index based upon the adequacy of precipitation in relation to the need of plants. Where the precipitation, analysed month by month, is just adequate to supply all the water that would be needed for maximum evaporation and transpiration in the course of a year, the moisture index would be 0. Climates with an index between 0 and -20 are called sub-humid, between -20 and -40, semi-arid; below -40, arid. The potential evapotranspiration, in centimetres, and the amount of water deficiency or surplus, are worked out for each month with the aid of a series of tables and nomograms, involving the use of precipitation and temperature data, with adjustments for length of month, length of day in relation to latitude and season, and water-holding capacity of an average soil. Although there are certain theoretical deficiencies of this system (lack of allowance for wind and humidity factors and for the water-absorbing capacity of soils), it gives values throughout the world that appear to have more significance to the biological landscape than some other widely used world systems.

In Meigs' classification, regions are designated as extremely arid when at least 12 consecutive months without rainfall have been recorded, and when there is no regular seasonal rhythm of rainfall. Aden at the southern end of the Red Sea, and Themed near the northern end, on the east side of Sinai, and several stations on the Egyptian coast of the Red Sea are typical examples. The Central Sahara and, in the United States of America, parts of the Colorado Desert and Death Valley also fulfil the requirements.

The dry areas of the world occur in five large zones, separated from one another by oceans or by wet equatorial zones. In each of these five zones a core of desert, partly surrounded by semi-arid lands, is found on the west coasts of the continents, chiefly from about 15° to 35° latitude. The North African-Eurasian dry zone is larger than all the remaining dry areas of the world combined. It includes the world's largest desert, the Sahara, and a series of other hot deserts and semi-arid areas, continuing eastward through the Arabian Peninsula and along the Persian Gulf to Pakistan and India. To the north lie the mild or cool winter dry areas of the Mediterranean coast and Iran, while further north and east lie the vast deserts and steppes of the U.S.S.R., Chinese Turkestan, and Mongolia, with sub-freezing winters and warm or hot summers.

To the south is the semi-arid tropical belt of the Sahel. The East African off-shoot includes the intensely hot lowlands of Somaliland.

The North American dry zone resembles the North African-Eurasian zone in the variety of its sub-types, though the subdivisions are much smaller. Dry upland areas, analogous to those of Iran, Turkestan and upland Arabia, make up much of the region in the United States and Mexico, leaving only a small area bordering the Gulf of California and its northward extension in California and Arizona to compare with the hot Saharan climate. The Great Plains of the United States and Canada find their climatic analogues in the Russian steppes.

The South African dry zone consists chiefly of the narrow elongated coastal desert of the Namib and Luanda, and the desert and steppe uplands of the Karroo and Kalahari. The Australian arid zone occupies the entire continent except for a small coastal fringe. Hot climates prevail in the northern half of the region, mild climates in the south, with cool winters in the southern uplands.

The South American arid zone is largely confined to a long narrow strip along practically the entire western coast between the sea and the great Andes mountains. In the south, on the eastern side of the continent, Patagonia and Argentina are dry. In the central Andean plateau a chilly upland desert region forms a link between the western and eastern dry lands.

ADAPTATION OF PLANTS TO ARID ZONE CONDITIONS

Vegetation in the arid zones is very sparse. The general landscape is desolate and barren. Herbs appear only during a short period of the year when the conditions become favourable. The shrubs, herbs and trees have various means of storing water. The trees are rather few and far between. Vegetation if it is to survive, must become adapted to its environment. Since the availability of water is the most important limiting factor, desert plants show morphological adaptations that enable them to withstand the lack of moisture and prolonged periods of drought. These adaptations include increased ability to store water in their succulent stems or leaves; thickening of the leaf cuticle or reduction of leaf surface or the entire absence of leaves to lower the transpiration rate, and the ability to survive as a seed through many years of aridity. Drought-resisting plants may be divided into two groups: Succulents and Ephemerals.

Succulents such as Cactaceae and many species of Euphorbiaceae, store large amounts of water in cavernous leaves or specially adapted stems. They are green all over and even after severe desiccation, can respond to moisture.

Ephemerals, resist long drought periods in a remarkable way. They exist as seeds in the dry spells, germinate only when sufficient rain falls to ensure their growth to maturity; and then set seed for the next dry spell. Such seeds are coated with an inhibitor, which prevents them from germinating until sufficient rain water is available to wash the chemical inhibitor away. In addition, this amount of rain is usually enough to guarantee full growth to maturity. It has been shown that the ability of a cell to resist desiccation, or its effects, depends upon the viscosity of its protoplasm. Both the form of the plant and the properties of its cells may assist drought-resisting plants.

There are also physical differences in the effectiveness of different colours as absorbers of heat. Heating is more effective on dark than on light colours and in shadeless than in shaded areas. This, in effect, means that light-coloured vegetation should induce a lower soil temperature and a more favourable microclimate close to the ground, than should dark vegetation on a light or dark soil. This is indeed the case. But other questions still need to be answered. For example, are pink plants better able to withstand extreme radiation than green plants, or is a mottled surface better

able to do so than a plain surface? Many desert plants are pinkish and their exposed surfaces are mottled, e.g., the melons of arid regions.

When plants whose shoots are exposed to dry air have difficulty in obtaining an adequate or sufficiently rapid supply of water to make good the loss in transpiration they require certain arrangements to diminish the latter process. The ordinary limitation of transpiration by closure of the stomata is not sufficient in the case of plants with exceptionally dry habitats. Plants with such arrangements to diminish the loss of water are termed xerophytes. Desert plants are naturally xerophytes. There are also xerophytes without marked xeromorphy. These are able to obtain water from relatively dry soil owing to their high absorbent power resulting from a concentrated cell sap.

Both morphological and anatomical arrangements are instrumental in diminishing transpiration, and some of these adaptations may at the same time be protective against strong insolation or overheating. The following anatomical features serve to diminish transpiration: thick, cutinized epidermal cell walls and cuticle; reflection of light from the cuticle; formation of waxy or resinous coatings; reduced number of stomata; narrowing of the stomata and their occlusion by resin or wax; sinking of stomata below the general level of the epidermis, either singly or in numbers, in special flask-shaped depressions on the under side of the leaf, or the over-arching of the stomata by adjoining cells so that they come to be situated in cavities protected from the wind. Hairs, whether woolly, stellate, or scaly, which early become filled with air and give the plants a whitish or grey appearance, may serve as protection against the sun's rays. On the other hand evergreen leaves may be small, leathery and relatively poor in sap.

Many xerophytes with small leaves have branches crowded together to form a dense cushion. Not only is transpiration checked by this, but a protection against excessive insolation is also obtained.

A very effective protection against transpiration and light is obtained by the leaf surface being placed vertically; this is often associated with a reduction of the lamina and a flattening of the petiole. Such leaves more or less completely avoid the rays of the sun when it is at its highest.

The most important and most frequent means of protection against excessive transpiration is the reduction of the transpiring surface. This is effected by the dwarfing of the plant by diminished branching, by reduction in the number of leaves, and lastly by reduction of the shoots or leaf-blades. The free surface of leaves is reduced in some cases by inrolling of the surface. The lamina is completely lost in Cactaceae and in some tree-like species of Euphorbiaceae. A striking modification is exhibited by shoots which develop only reduced leaves, while the stems become flat and leaf-like (termed cladodes) and assume the functions of leaves. The marked development of sclerenchyma in the shoots of many xerophytes not only contributes to the rigidity of the plant, but is also associated with the growth of thorns. The thorns are lignified, rigid and pointed structures; they may originate from the modification of leaves or parts thereof, or shoots, or (less commonly) of roots.

Many xerophytes, in addition to controlling the loss of water strictly, also store water when it is obtainable, in special water-storage tissues against periods of shortage. The water-storage tissue often has a more central position and when largely developed gives the character of succulence. In extreme cases the form of the stem or the leaf of succulent plants may approach that of a sphere; this, for a given volume, exposes the minimum surface and thus helps to diminish transpiration. Many xerophytic plants have deep roots enabling them to draw water from considerable depths below the ground surface.

SCOPE FOR CULTIVATION

Attempts to cultivate *Hyoscyamus muticus* in various countries other than Egypt have not met with success—probably because the requisite ecological, edaphic and other environmental conditions were not adequately studied. An excellent study of the conditions under which this important plant grows has now been made by Saber and Balbaa [3]. It is hoped that as a result of this study this plant will now be successfully cultivated elsewhere. There is a great need for such studies on many other plants mentioned in the following pages so that they can be successfully cultivated, particularly for the economic development of backward arid regions.

Many of the *Agave* species can be grown as a means of both checking the deserts and obtaining sapogenins. There is a great demand for aloes and there is no reason why the various species of aloe should not be cultivated in arid regions particularly as they are being successfully grown in such countries as Italy, Sicily, and Malta.

Recent research on *Ammi visnaga* and *A. majus* has brought these two plants, which grow wild in Egypt, into prominence. Preliminary trials in India show that at least the former species can be grown successfully and similar attempts in other countries should be encouraged. *Datura stramonium* and *D. innoxia* are reported to have been grown on land bordering on the desert in Egypt. These two species of *Datura* are in great demand and are worthy of much wider cultivation. *Glycyrrhiza glabra* has persisted in regions with scanty rainfall and can be extensively cultivated in other arid regions. *Balanites aegyptiaca* is worthy of wider cultivation, being admirably suited for places where the drought resistance of a plant is the limiting factor.

Russia is obtaining large revenues from santonin-bearing *Artemisia* and there seems to be every possibility that this herb could be grown in many other arid regions.

Cassia acutifolia which is cultivated only to a small extent in the Sudan and in India could be extended considerably to larger areas to feed the western markets. Similarly *C. angustifolia* which is now cultivated in only one district in India can be grown in other arid regions. According to Drar [1], statistics show that fairly large quantities of senna and squill are imported into Egypt, although both these drugs grow wild in the country. In former times considerable quantities of *Citrullus colocynthis* were exported from Egypt but other countries such as Cyprus and Spain where it is cultivated took over the world market because collection and cultivation in Egypt was neglected. *Ephedra* is cultivated, at present, only in the U.S.A., England, Kenya and Australia and there is every possibility that it could also be cultivated in the arid regions of other countries.

Salvia officinalis, *Pimpinella anisum* and *Lavandula*, among many others, can be cultivated profitably in suitable localities. *Foeniculum vulgare* and *Papaver somniferum* are extensively cultivated in most countries, and many parts of the arid zones are quite suitable for the production of these medicinal plants.

CHEMICAL CONSTITUENTS

A study of the active principles of the medicinal plants of the arid zones shows that a large number contain alkaloids, the family Solanaceae being the richest source of such products. More important alkaloids are the hyoscine and hyoscyamine group of alkaloids contained in *Datura innoxia* and *D. stramonium*, *Hyoscyamus muticus*, *H. albus* and *Physoclaina praealta*. From various species of *Solanum*, such as *S. carolinense*, *S. xanthocarpum*, several steroidal alkaloids, generally also glycosidal in character, have been isolated, the chemistry of which till recently had been obscure. The other important group of alkaloids is found in *Papaver somniferum*. Another important alkaloid is the ephedrine contained in a few species of *Ephedra* of the family Gnetaceae.

A variety of alkaloids is found in *Citrullus colocynthis*, *Descurainia sophia*, *Lophophora williamsii*, *Peganum harmala*, *Pergularia extensa* and *Selenicereus grandiflorus*.

Essential oils constitute the second important group of constituents of the plants of the arid regions. These oils are most prominent in the family Labiatae in plants such as *Salvia officinalis*, *Lavandula officinalis*, *L. latifolia* and *Rosmarinus officinalis* and, in the family Umbelliferae, in *Foeniculum vulgare*, *Pimpinella anisum*, *Ferula alliacea*, *F. asafoetida*, *F. foetida*, *F. galbaniflua*, and *F. narthex*. *F. sumbul* (Umbelliferae) yields oleogum resins which largely contain essential oils. *Ammi visnaga* and *A. majus* (Umbelliferae) contain the coumarin khellin and ammoidin respectively.

The family Leguminosae represented by various species of *Acacia* and *Butea monosperma* yield valuable medicinal gums. *Cassia angustifolia* and *C. acutifolia* of the same family contain glycosides-sennosides. *Glycyrrhiza glabra* contains a characteristic principle glycyrrhizin or glycyrrhizic acid.

The discovery of sapogenins in *Agave* of the family Amaryllidaceae has opened new avenues for the manufacture of steroid hormones.

Various species of *Aloe*, family Liliaceae, contain an aloin-cathartic principle.

The family Compositae is represented by various species of *Artemisia* which contain santonin and volatile oils.

The family Euphorbiaceae is represented by various species of *Euphorbia*, namely, *E. antiquorum*, *E. hirta*, *E. hypericifolia*, *E. neriifolia*, *E. nivulia*, *E. resinifera*, *E. royleana*, *E. tirucalli*, *E. trigona*, etc. Active principles of these species are not confined to one single group and contain alkaloids, resins, volatile matter, caoutchouc, bitter principles, hydrocyanic acid, etc.

The constituents of *Calotropis gigantea* and *C. procera* of family Asclepiadaceae are calotropin, uscharin, colotoxin, resinols, gigantol, etc.

1. DRAR, M. "Plants of raw material in the deserts of Egypt", *Proceedings of the Symposium on Scientific Problems of Land Use in Arid Regions*, Cairo, Egyptian Desert Institute and Unesco, 1954, 222 p.
2. MEIGS, P. Unesco NS/AZ/37 (rev.), Paris, December 1952.
3. SABER, A. H.; BALBAA, S. I. "Hyoscyamus muticus L. in relation to its natural environmental conditions", *Proceedings of the Symposium on Scientific Problems of Land Use in Arid Regions*, Cairo, Egyptian Desert Institute and Unesco, 1954, 222 p.
4. THORNTON, C. S. "An approach towards a rational classification of climate", *Geogr. Rev.*, 1948, 38, 55-94.

SPECIES INVESTIGATED

The prominent families to which the majority of the medicinal plants of the arid zones belong are: Amaryllidaceae, Asclepiadaceae, Cactaceae, Capparidaceae, Chenopodiaceae, Compositae, Cucurbitaceae, Labiatae, Leguminosae, Liliaceae, Solanaceae and Umbelliferae.

The species on which research has been carried out in recent years are discussed below. Other species commonly used are listed in the index at the end of this volume.

Acacia (Leguminosae)

A. arabica Willd. (Babul). A moderate-sized, spiny evergreen tree. Its bark is dark-brown or black, and longitudinally fissured. The spines are straight and sharp-pointed and occur in pairs below the petioles. The bright yellow globose flower heads (June-September) are sweet-scented and the pods contain between 8 and 12 seeds. The tree is indigenous to Sind, the Deccan and tropical Africa; it also occurs in Egypt, Arabia and Natal, and is naturalized in all parts of India.

Seeds collected from goat and sheeps pens are found to be better for artificial sowings than those collected from pods. The moistening and fermentation which they undergo in the alimentary canal of the animals assist germination. Direct sowing, especially ridge-sowing, has proved successful for afforestation. The seedlings and young plants demand plenty of light, moisture, loose soil, and absence of grass and weeds. Where conditions are favourable, they grow to a height of 1.5-2 m. within a year or two.

The babul gum exudes from wounds in the bark, mostly during the period from March to May. Though some trees yield a maximum of about 2 lb. of gum a year, the average yield is only a few ounces. The gum occurs in the form of rounded or ovoid tears, pale yellow, brown or almost black in colour. The darker samples contain tannin. The gum of *A. arabica*, although called gum arabic, is not the true gum arabic which is obtained from *A. senegal*. The gum is very slightly dextrorotatory, whereas that of *A. senegal* is slightly laevorotatory. It is chiefly composed of galactoaraban and on hydrolysis gives *l*-arabinose and *d*-galactose, but no xylose [3]. Babul gum is generally considered inferior to true gum arabic especially for medicinal purposes. Rangaswamy [2] has shown that if proper care is taken in collecting and grading, the gum obtained conforms to the pharmacopoeial requirements for acacia gum, except in regard to optical rotation. Further, under similar conditions its aqueous solutions have higher viscosity and the gum should therefore prove even more useful as an emulsifying and suspending agent. In pharmacy, it is used as a substitute for true gum arabic and in indigenous medicine it is credited with many virtues. It is given for diarrhoea, dysentery and diabetes mellitus. The bark is considered astringent and demulcent.

A. senegal Willd. A small thorny tree, reaching a height of 3-5 m. with a girth of 30-60 cm.; it has a pale and smooth bark and white fragrant flowers. It is found on the dry rocky hills of Sind (Pakistan) and Rajasthan (India) and is abundant in the Sudan, Central Africa and Senegal. The trees are cultivated over very large areas in Kordofan, Sudan. It is a hardy species, surviving under most adverse conditions.

The tree yields the true gum arabic, which is an important commercial product. In Africa, it is regularly tapped from trees which are about six years old by making narrow transverse incisions in the bark in February and March. In about a month, tears of gum are formed on the surface and are gathered. The gum is almost odourless and has a bland taste. It is almost completely soluble in an equal weight of water, and gives a translucent, viscous and slightly acid solution. A 10 per cent solution is slightly laevorotatory. Gum of pharmacopoeial quality should give no reaction with ferric chloride. It is mostly used in medicine as a demulcent and as an emulsifying agent.

The *Acacia* thrive in the forests of northern Africa, occupying a zone stretching across the continent from Abyssinia in the east to Senegal in the west. The commercial Somali gum which is of fair quality is obtained from *A. glaucophylla* Steud and *A. abyssinica* Hochst. shrubs growing in the Somali country and Abyssinia. The following species yield a gum of brownish or reddish colour and are therefore less valuable: African *A. arabica* Willd., *A. stenocarpa* Hochst. ex A. Rich., *A. seyal* Del. and *A. ehrenbergiana* Hayne.

According to Nayar and Chopra [1] gum from *A. arabica* produced in India could serve as a substitute for that of *A. senegal*. Gums obtained from other species mentioned below are inferior in quality. Cape gum from *A. horrida* Willd. is very brittle and yields a gum of less adhesive mucilage. Talca or Sennar gum derived from *A. seyal* and *A. stenocarpa* has a greenish tinge and yields a ropy mucilage. Amritsar gum is obtained from *A. modesta* Wall.; it occurs in large brown tears and like *A. arabica* is used in calico printing. Magodore gum, from *A. gummifera* Willd. occurs in dark-brown little fissured tears. Wattle gum or Australian gum obtained from *A. pycnautha* Benth.,

a shrub growing in southern Australia, is reddish in colour owing to the presence of tannin.

1. NAYAR ; CHOPRA. *Distribution of British Pharmacopoeial drug plants and their substitutes growing in India*, New Delhi, Council of Scientific and Industrial Research, 1951, 56 p.
2. RANGASWAMY. *Indian J. Pharm.*, 1942, 4, 130.
3. WEHMER, C. *Die Pflanzenstoffe*, Jena, Verlag von Gustav Fischer, 1929-31, I, 488.

Agave (Amaryllidaceae)

The genus *Agave* was originally confined to North and Central America, including Mexico and the West Indies but many species are now extensively cultivated as ornamental and fibre plants throughout the warmer latitudes of the world. The greatest diversity of *Agave* is in the arid and semi-arid transition zone in the highlands of central Mexico where a large number of species and varieties occur, many of which are endemic and extremely local in distribution. The Puebla Desert covering parts of the states of Puebla, Hidalgo and Oaxaca, is a typical region where there is a large number of endemic species. This region is also one of extensive cultivation of the *Agave*.

The swollen meristems and enlarged parenchyma of the *Agave* together with its large succulent leaves protected by a cutinized epidermis, permit some well-adapted species to survive for several years without moisture in such regions as the Sonoran Desert of Baja California. Extensive explorations by Corell and others [1] show that a number of *Agave* species had a rather high sapogenin content, usually confined to the leaves. Among these are *A. promontori* Trel., *A. vilmoriniana* Weber, *A. roseana* Trel., *A. nelsonii* Trel., *A. cerulata* Trel., *A. sobria* Budge., *A. sullivanii* Trel., *A. toumeyana*, *A. atrovirens*, *A. mirabilis* Trel., *A. mapisaga* Trel. and *A. aurea* Budge. One of these, *A. roseana*, has yielded 2.5 per cent hecogenin, the highest yet found in the *Agave*. Hecogenin is a steroidal sapogenin and is a suitable plant precursor of cortisone and other steroidal hormones.

1. CORELL *et al.* *Econ. Bot.*, 1955, 9, 307.

Aloe (Liliaceae)

This is a genus of about 180 species of xerophytic plants indigenous to East and South Africa. Aloes flourish in a variety of climates and on the poorest soil. The fleshy and strongly cuticularized leaves are usually prickly at the margin and are arranged in dense rosettes.

When a leaf is transversely cut and held with its cut end downwards, a yellowish juice often forming vascular lumps flows out from the pericycle. The juice is collected and concentrated; on cooling it solidifies and constitutes the commercial drug aloes.

The official aloe species are: (a) Curaçao or Barbados aloes from *A. vera* Tourn. ex L. var. *officinalis* (Forst.) Baker; (b) Socotrine aloes (yellowish or blackish brown) from *A. perryi* Baker; (c) Zanzibar aloes (livery brown) also from *A. perryi*; and (d) Cape aloes from *A. ferox* Mill. and its hybrids. In addition to these, Natal aloes derived probably from *A. candelabrum* Berger resembling Cape aloes, Moka or Mocha aloes derived from *A. succotrina* Lam., Arabia and Jaffarabad aloes produced from *A. vera* at Jaffarabad, India, are also in use.

A. Barbadosensis Mill. (*A. vera* L.). It has a very short woody stem and lanceolate

embracing leaves, irregularly mottled with white spots. The flowers are bright yellow. It is a native of south-eastern Europe, North Africa and Madagascar. It is cultivated in Italy, Sicily, Malta and the West Indies.

A. perryi Baker. A perennial herb growing abundantly in Socotra and also found in eastern Africa and in Arabia. The trunk is about 30 cm. high bearing at the summit a dense rosette of pale green or reddish somewhat striated leaves. Flowers are tubular, reddish, later turning yellow. The fruit is a membranous capsule. The plant is used as a stomachic, tonic and purgative. It is useful in dyspepsia, jaundice and amenorrhoea. It contains barbaloin [2].

A. ferox Mill. A tree-like species—one of the tallest of the genus. It has a forked stem 3-5 m. long, 10-15 cm. in diameter furnished at the top with a dense rosette of lanceolate leaves with copious bristles on back and face. The flowers are striped white, tubular and in panicles.

Aloes contain a mixture of glucosides collectively called “aloin” which is the active constituent of the drug. Curaçao aloes contain 30 per cent of aloin, Socotra and Zanzibar aloes a little less, and Cape aloes only 10 per cent. The principal constituent of aloin is barbaloin—a pale yellow crystalline glucoside soluble in water. Other constituents are isobarbaloin, β -barbaloin, aloes-emodin and resins. The odour is due to traces of an essential oil [1].

Aloes has a bitter, disagreeable taste, and is largely used as a cathartic. Considerable griping pain is often associated with its action. It is more irritant than cascara sagrada, senna or rhubarb. Its action is largely limited to the colon and does not clean the whole alimentary canal. In chronic constipation it is, however, very useful. It produces pronounced pelvic congestion and is used for treatment of uterine disorders, generally in combination with iron and carminatives. Aloes is one of the constituents of several proprietary laxative preparations.

1. ASCHAN. *Arch. Pharm.*, 1903, 241, 340.

2. TSCHIRCH. *Arch. Pharm.*, 1898, 236, 200.

Ammi (Umbelliferae)

A. majus L. An annual umbelliferous herb native to the Mediterranean countries, this plant is found abundantly in the Nile Delta region of Egypt. It has brownish cremocarp fruits of cylindrical shape which are used in Egypt, in powdered form, for the treatment of leucoderma. From the fruits have been isolated the principles ammoidin, ammidin, and majudin; these have been shown to be identical with xanthotoxin, imperatorin and bergapten respectively [6]. Ammoidin given orally in doses of 50 mg. three times daily or applied externally in the form of a 1 per cent liniment, and followed in either case by exposure of the affected areas to sunlight or ultraviolet light, induces normal pigmentation in patients with leucodermic areas. Ammidin and majudin are comparatively less effective [4].

A. visnaga Lam. This is another *Ammi* species found growing in the waste lands of the Eastern Mediterranean and particularly in the region of the Nile Delta. It is a hardy plant growing to a height of 1.5 m. with fruits somewhat resembling those of the caraway. Decoctions of the fruits have long been used in Egypt as an antispasmodic in the treatment of ureteral spasm and kidney stones.

Three distinct crystalline substances have been isolated from the fruits in pure form, namely, khellin, visnagin and khellol glucoside. In general the fruits contain about 1 per cent of khellin, 0.1 per cent of visnagin and 0.3 per cent of khellol glucoside [1]. Khellin is the therapeutically important constituent. It has been both claimed and denied that khellol glucoside has a coronary vasodilating effect. Visnagin, if it is physiologically active, is present in such small quantities as to be relatively unimportant.

According to Anrep and others [3], khellin is a potent coronary vasodilator, being several times more active than aminophylline; it remains in the circulation for several hours and its action is thus prolonged. They treated 250 patients suffering from angina pectoris with khellin and found distinct improvement in 140 with moderate improvement in 85 and no effect in the others. They also used the drug successfully in many cases of bronchial asthma, especially in severe cases resistant to aminophylline and epinephrine. Snider and his co-workers [7] were unable to demonstrate any consistent or appreciable bronchodilator effect of khellin in two groups of 8 and 6 asthmatic patients. Side reactions such as nausea, constipation, light-headedness, diarrhoea, somnolence, insomnia, urticaria and dermatitis are reported to be frequent, particularly with larger doses [5].¹

Successful cultivation of *A. visnaga* was attempted by Abrol and others [2] in the semi-tropical climate of Jammu and Kashmir (India). Mid-October was found to be the optimum time for sowing the seed which is best sown in rows 60 cm. apart. When the seedlings are about 15 cm. high, the plants are thinned out so as to leave a minimum distance of 15 cm. between them. The yield of the fruit was nearly 260 lb. per acre. It was also observed that there was a profuse growth of the plant from the self-sown seed. It appears likely that the allied species, *A. majus*, might also be successfully cultivated under similar conditions.

1. Anonymous. *United States Dispensatory*, Philadelphia, J. B. Lippincott, 1955, p. 1545.
2. ABROL *et al.* *Indian J. Pharm.*, 1958, 20, 7.
3. ANREP *et al.* *J. Pharm. (Lond.)*, 1949, 1, 164; *Amer. Heart J.*, 1949, 37, 531.
4. FAHMY; ABU-SHADY. *Quart. J. Pharm.*, 1948, 21, 498.
5. ROSENMAN *et al.* *J. Amer. med. Ass.*, 1950, 143, 160.
6. SCHONBERG; SINA. *J. Amer. chem. Soc.*, 1950, 72, 4826.
7. SNIDER *et al.* *J. Amer. med. Ass.*, 1952, 150, 1400.

Anabasis aphylla L. (Chenopodiaceae)

This is a perennial herb which grows on the Russian steppes from the Caspian Sea to Turkestan, and is reputed to be a poisonous plant. It is reported [2] to contain about 2.3 per cent of alkaloids of which the most important is anabasine. Other alkaloids present are aphyllidine and aphylline. Anabasine is also a constituent of tobacco, *Nicotiana glauca*.

According to Haag [1] the physiological activity of anabasine is qualitatively the same as that of nicotine, but it is about three times as toxic for rabbits and guinea-pigs, and has a less exciting and more depressing action.

The interest evinced in its alkaloids is due to the insecticidal properties of the principal alkaloid anabasine. Commercial anabasine sulphate is a mixture of the total alkaloids of the plant and it has insecticidal properties similar to those of nicotine.

1. HAAG. *J. Pharmacol.*, 1933, 48, 95.
2. ORECHOFF. *Compt. rend. Acad. Sci.*, 1929, 189, 945.

1. For further information concerning the physical and chemical properties of these substances and their physiological action see: Hutterer and Dale, *Chem. Rev.*, 1951, 48, 543; Bailey *et al.*, *J. Amer. pharm. Ass.*, 1951, 40, 289; Ellenbogen *et al.*, *ibid.*, 1951, 40, 287.

Argemone mexicana L. — Mexican Poppy (Papaveraceae)

An annual with prickly leaves, bright yellow flowers, and bristly capsules containing seeds and resembling black mustard seeds. A native of America, it has run wild into many other countries including India. The seeds yield from 22 to 36 per cent of nauseous, bitter, non-edible oil, which is considered a remedy for skin diseases. In small amounts (1-2 ml.) it is a cathartic and in larger doses it causes violent purging and vomiting.

The seeds are sometimes found mixed with black mustard. Adulteration of edible mustard oil with argemone oil is probably responsible for outbreaks of epidermic dropsy [1, 2]. Its presence in concentrations of 0.2 per cent or less is detected by the rich orange-red colour which appears when concentrated nitric acid is added to the oil or its mixtures, or by the ferric chloride test [3, 4]. The plant contains barberine and protopine [5]. The seeds also are considered to have a medicinal value, as a laxative, emetic, expectorant and demulcent; taken in large quantities, they are said to be poisonous. The yellow juice which exudes when the plant is damaged is used externally in scabies, dropsy, jaundice, cutaneous affections and ophthalmia. The oil is considered to be a purgative and is also used for cutaneous affections.

1. CHOPRA *et al.* *Indian med. Gaz.*, 1939, 74, 193.
2. LAIL *et al.* *Indian J. med. Res.*, 1939, 27, 207.
3. MUKHERJI. *Curr. Sci.*, 1942, no. 279.
4. ONDERSTEEPOORT. *J. vet. Sci.*, 1937, no. 573.
5. SANTOS ; ADKILEU. *J. Amer. chem. Soc.*, 1932, 54, 2923.

Artemisia (Compositae)

A large genus of small herbs, comprising some 280 species found in the Northern Hemisphere. They are abundant in arid regions notably in the western United States, the Asiatic steppes and the arid parts of the north-western Himalayan region. They are also found in South Africa and South America. Artemisias, as an anthelmintic and a stomachic, were long in use amongst the Greeks and the Romans. The Persian and Arab physicians also employed them for the same purpose. Some artemisias are of medicinal interest and a few are prized for their volatile oils.

The chief source of santonin, in the U.S.S.R., is *A. cina* Berg. growing in abundance in Russian Turkestan and Persia. Other species which have been found to contain santonin include *A. mexicana* Willd., *A. neo-mexicana* Woot, and *A. wrightii* A. Grey, found in America, and *A. gallica* Willd. in East Germany, France, England and Scotland, and *A. maritima* L., a fairly widely distributed species spread from England to as far east as Chinese Mongolia. The content of santonin in the American and English species is too low to warrant commercial extraction [1]. *A. fragrans* Willd. and *A. parviflora* Roxb. occurring in Afghanistan have also been reported to contain santonin [9]. *A. maritima* growing in certain areas of Kashmir (India) and Kurram (Pakistan) has been found to contain substantial amounts of santonin (1-2 per cent), which is commercially extracted.

A. absinthium L. (Wormwood). This is an aromatic and bitter herb distributed over regions of northern Asia, Afghanistan and extending westward to the Atlantic. It is naturalized in eastern Canada and is cultivated in the United States. The commercial oil is produced in America. The herb contains about 0.3 per cent of volatile oil the chief constituent of which is thujone. It produces marked excitation of the autonomic system followed promptly by unconsciousness and general epileptic-type convulsions,

first clonic then tonic. Wormwood oil has a tonic and stimulating effect on the digestive organs and is sometimes also used externally. The plant also contains a bitter glucoside, absinthin and a crystalline compound. The essential oil of *A. absinthium* used to be a constituent of absinthe (a liquor containing oils of wormwood, angelica, anise and marjoram), but its addition is now prohibited [10, 13].

A. annua L. A strongly scented annual occurring in Pakistan, Waziristan, Afghanistan and north-eastern Asia. The plant is reported to yield about 0.3 per cent of essential oil composed principally of artemisia ketones, pinene, cineole, *l*-camphor, etc [11].

A. dracunculus L. A perennial herb found in western Tibet (14,000-16,000 ft.) and in Lahul and also in various parts of Afghanistan, western Asia, south and central Russia. The herb contains about 0.3 per cent of essential oil which is used for flavouring vinegar, and as a spice. The plant is cultivated in France for its essential oil "Oil of Targoon", the chief constituent of which is methyl chavicol. It also contains *p*-methoxycinnamic aldehyde [7]. In some countries it is cultivated as a spice.

A. herba alba L. This is a herbaceous plant, common in dry places of North Africa, Arabia, Syria and Persia. It yields 0.3 per cent of volatile oil, but the Egyptian variety *A. laxiflora* from Sinai gives as much as 1.6 per cent of the oil.

A. cina Berg. A small semi-shrub perennial; the leaves are bi- to multi-pinnatifid, those of the flowering stems being very minute; the flower heads are small (2.5 mm. long) and numerous. The plant varies greatly and several species have been made out of its varieties.

The plant grows in Persia and Turkestan and the flower buds are collected in July and August. At this stage the santonin content reaches its maximum and averages from 2.5 to 3.5 per cent. After blooming the flowers rapidly lose this principle. The manufacture of santonin in the U.S.S.R. is carried out at Tschimvent, Turkestan, which is conveniently situated near to the principal source of the plant on the Kirghiz steppes. The plant has been successfully cultivated in the Netherlands and at Washington in the U.S.A.

A. maritima L. This is a shrubby aromatic species, about 1 m. high with a woody root-stock; the stems are erect or ascending and much branched from the base. It is an exceedingly variable plant, with erect or drooping flower heads.

This is the only santonin-bearing species occurring in India and is common in several areas in the north-west of the Indian sub-continent, such as Kashmir, Kurram, Kagan, Bushabar, and Waziristan. However, only the plants growing in certain parts of Kashmir and Kurram have been found to contain santonin. In these areas santonin-free plants are also found. Badhwar [3] observed that in the earlier stages of growth, santonin-bearing plants in Kurram have red stems, while santonin-free plants have green stems and both turn brown as they grow older. The former he calls *A. maritima* forma *rubricaula*.

For profitable utilization the herb should contain not less than 1.2 per cent of santonin. The santonin content of artemisia from Kashmir has been reported by several workers to vary from 1 to 2 per cent and that of artemisia from the Kurram Valley from 1 to 1.6 per cent [3]. The quantity of the drug available in Kashmir has been estimated at over 180 tons per annum [5] and at about 25 tons per annum in the Kurram Valley [3].

Artemisias are xerophytic plants. In central Asia they grow in semi-desert areas where extremes of temperature both high and low prevail. The plants prefer a saline sandy soil. In Kurram, santonin-containing artemisia grows in soils rich in silt and fine

sand, with a high available potash content. A semi-arid climate and a saline sandy soil appear to be best suited to its cultivation. Plants raised from seeds or root cuttings appeared to flourish well, especially those grown in ridges. Cultivation studies on *A. maritima* were also carried out by Abrol and others [2]. It has been reported that matured soft stem cuttings root better than others.

Seasonal variation of the santonin content in the Kurram artemisia has been studied by Badhwar [3]. The maximum content of active principle is attained in the buds when they are fully developed, just before they open. With the opening of the buds there is a rapid fall of santonin. These results are similar to those reported in the case of *A. cina*.

Russia holds the major share in santonin production and trade and only limited quantities are being produced from Kashmir or Kurram artemisia. Santonin is also extracted in Great Britain and Germany from cultivated strains of *A. maritima*.

In addition to santonin, *A. maritima* contains β -santonin which has a much weaker anthelmintic action and pseudo-santonin devoid of any such action [6]. Artemisin is another bitter principle contained in *A. maritima* [7].

Santonin is very efficient in its action on round worms, less effective on thread worms and has no action on taenia. In ascaris, 5 grains of santonin with 1 c.c. of chenopodium oil are more effective than either of these separately [8]. Santonin is usually administered in very small quantities, 1-3 grains in the evening, followed by castor oil or a saline purge in the morning. It causes yellow vision (xanthopsia) and sometimes violet vision. In larger doses it induces headache, nausea, vomiting and convulsions. Cases of fatal poisoning have been reported and death takes place from cardiac and respiratory failure.

All the varieties of *A. maritima* contain essential oil which varies both in quantity and composition. The commercial oil, a by-product of santonin manufacture, is a thick yellow oil. The essential oil from Turkestan artemisia contains cineole and thujone. *A. maritima* var. *Karakewicz* yields an oil (0.6 per cent) containing 36 per cent camphor.

A. sacrorum Ledeb. This plant is found in western Tibet, the Tibetan regions of Kumaon, central and southern Russia, and Siberia. It is said to be given to horses for affections of the head. The plant yields 1 per cent of essential oil containing cineole, camphor, etc. [4].

1. Anonymous. *Bull. imp. Inst.*, (Lond.), 1934, 32, 33.
2. ABROL et al. *Indian J. Pharm.*, 1956, 18, 87.
3. BADHWAR. *Report on Kurram artemisias from the santonin standpoint*, 1934.
4. CHISTOVA. *J. Gen. Chem. (U.S.S.R.)*, 1935, 5, 1801.
5. CHOPRA ; GHOSH. *Indian J. med. Res.*, 1926, 13, 533.
6. DENSTON. *A text book of pharmacognosy*, London, Sir Isaac Pitman & Sons, 1945, 134 p.
7. FINNEMORE. *The essential oils*, London, Ernest Benn, 1926, 848 p.
8. MAPLESTONE ; MUKERJEE. *Indian med. Gaz.*, 1931, 66, 627.
9. QAZILBASH. *Bull. Sci. pharm.*, 1935, 42, 129.
10. SOLMAN, T. *A manual of pharmacology*, 7th ed., London, W. B. Saunders Co., 1948, p. 211.
11. WEHMER, C. *Die Pflanzenstoffe*, 1929-31, vol. 2, p. 1243, p. 1248.
12. ———. *ibid.*, Supplement, 1935, p. 22.
13. ———. *ibid.*, 2nd ed., 1950, vol. 2, p. 1245.

Balanites aegyptiaca Del. = *B. Roxburghii* Planch. (Simarubaceae)

A small spiny tree, about 6 m. high, with bifoliate ashy-green leaves. The fruit is an ovoid drupe with a sweet pulp possessing an unpleasant odour. The stone encloses a single oily seed. The tree is characteristic of drier parts of Arabia, Egypt, Eritrea,

tropical Africa, Burma and India. It is found chiefly on black cotton soil and does not thrive in rocky areas.

The pulp of the fruit is edible and is reported to be used for cleaning silk and cotton. It contains some saponin and is not astringent [1]. The kernel of seeds yield 43 per cent of a bland yellow tasteless oil [2]. The seeds, fruits, bark and leaves are reported to be anthelmintic and purgative. In Indian indigenous medicine the fruit is also considered useful for boils, leucoderma and other skin diseases. The African Arabs use the pulp as a fish poison. In Uganda the oil is used as a remedy for sleeping sickness and in Spain as a purgative. The seed kernels have long been known to contain a water-soluble saponin which is toxic to cold-blooded animals [4]. Kon and Wella [3] have isolated a new sapogenin which appears to belong to the group of steroid sapogenins and according to them is very closely related to tigogenin. The saponin is reported to be an active haemolytic agent and its toxicity for tadpoles is similar to that of digitonin.

1. HOOPER. *Agric. Ledger*, 1902, 9, 20.
2. ——. *ibid.*, 1911-12, 17, 130.
3. KON; WELLA. *J. chem. Soc.* 1939, 800.
4. WEIL. *Arch. Pharm.*, 1901, 239, 363.

Butea monosperma (Lam.) Kuntze. Syn. *B. frondosa* Koen. Ex Roxb. (Leguminosae)

A medium-sized deciduous tree 3-5 m. high and 1.6-2 m. in girth. The bark is bluish-grey or light-brown. The bright red flowers are 4-5 cm. long, they bloom in great profusion at the beginning of the hot season before the appearance of the new leaves. The pod contains a single seed at the apex. It is common throughout India, Burma and Ceylon. It is frost-hardy and drought-resistant and is a valuable species for reclaiming saline soils. Plantations can be cultivated on both irrigated and dry lands. The pods should be collected and sown before the commencement of the rains in lines 25-30 cm. apart for ordinary afforestation and 50 cm. apart for local cultivation.

It yields Butea gum (or Bengal kino) which contains a large proportion of tannin and mucilaginous material. On dry distillation it yields pyrocatechin. It is a powerful astringent and is given in many forms of chronic diarrhoea [4]. Birdwood [1] prescribes it for treatment of round worms. New, freshly powdered seeds give good results against ascaris [3]. Pounded with lemon juice and applied locally the seeds act as a powerful rubifacient [4].

The seeds contain 18 per cent of a tasteless yellow oil [6]. The fresh seeds contain a proteolytic enzyme which behaves like yeast trypsin [2]. The flowers contain: the glucosides butrin, butain and butin; an unidentified glucoside; a heteroside [5, 7, 8].

1. BIRDWOOD, G. T. *Practical bazar medicines*, Calcutta, Thacker Spink & Co., 1936, 41 p.
2. CHATTERJEE *et al.* *J. Indian Chem. Soc.*, 1938, 15, 101.
3. CHOPRA *et al.* *Indigenous drugs of India*, Calcutta, U. N. Dhur & Sons, 1958, p. 301.
4. DYMOCK, W.; WARDEN, C. J.; HOOPER, D. *Pharmacographia Indica*, London, Trubner & Co., 1890-99, vol. 1, p. 454.
5. HUMMEL; PERKIN. *J. Chem. Soc.*, 1904, 85, 1463.
6. KATTI; MANJUNATH. *J. Ind. Chem. Soc.*, 1929, 6, 639.
7. LAL; DUTT. *J. Indian Chem. Soc.*, 1935, 12, 262.
8. MURTI; SESHADRI. *Proc. Indian Acad. Sci.*, 1940, 12A, 477.

Calotropis (Asclepiadaceae)

C. procera (Ait) R. Br. A shrub 2-2.5 m. high, bearing purple-spotted, pink, scented flowers. The petals of this species unlike those of *C. gigantea* are more or less erect. It is distributed in western and central India, Persia and tropical Africa. The latex of *C. procera* contains caoutchouc; the coagulum contains resins and caoutchouc [3]. The latex contains trypsin, an active labenzyme, and a cardiac poison. From the latex of the African plant α -lactuceryl isovalerate and α -lactuceryl acetate have been isolated, which can be converted into iso-lactuceryl [6]. From the combined latex of *C. procera* and *C. gigantea*, uscharin, calotoxin and calactin have been isolated. On hydrolysis, uscharin gives uscharidin; calotoxin yields pseudo-calotropagenin on treatment with sodium hydroxide. The leaves and stalks of this species contain calotropin and calotropagenin [7].

The latex of *C. procera* is similar to that of *C. gigantea* in properties and is used similarly.

The potency of the cardiac principles, calotropin, uscharin and calotoxin, present in the latex are 83, 58 and 76 respectively, taking the potency of ouabain as 100 [4]. A process for the preparation of uscharin and uscharidin from calotropis juice (*C. procera* and *C. gigantea*) has been patented [13].

C. gigantea (L.) R. Br. ex Ait. A shrub or a small tree about 3 m. high, bearing unscented, pale purple or white flowers with spreading corolla lobes; it is distributed throughout India, the Malayan islands and south China.

The latex which is present in all parts of the plant contains caoutchouc. It contains two isomeric resinols α -calotropeol, and β -calotropeol and β -amyrin. It also yields a cardiac and fish poison, gigantol, similar to but not identical with uscharin [1, 8]. Pitchandi has described gigantol as one of the most virulent poisons known, probably being 15-20 times as toxic as strychnine, the fatal dose, for a dog, given intraperitoneally, being 0.5 mg. per kg. [11]. The latex also contains traces of glutathions and an enzyme similar to papain [5, 2]. The stem bark contains α - and β -calotropeols, β -amyrin, and volatile and fatty acids [9]. The seeds yield an olive green oil and a bitter toxic substance. The root bark contains β -amyrin, isomeric crystalline alcohols, giganteol and iso-giganteol [10].

The latex is a strong irritant to the skin and mucous membrane. An extract injected into the lymph sac of a frog caused slowing of the heart and acute gastroenteritis [12]. The latex is used in Indian indigenous medicine in combination with *Euphorbia neriiifolia* as a drastic purgative. It is also used as a local irritant. A tincture of the leaves is used in the treatment of intermittent fevers. Powdered flowers, in small doses, are useful in the treatment of colds, cough, asthma and indigestion. Powdered root bark gives relief in dysentery, the root bark is said to be similar to ipecacuanha in its action. In small doses it is diaphoretic and expectorant, and in large doses it is an emetic. The paste of the root bark is applied in elephantiasis.

1. BALKRISHNA *et al.* *Proc. Indian Acad. Sci.*, 1945, 22A, 143.
2. BASU; NATH. *J. Indian chem. Soc.*, 1936, 13, 34.
3. BUDHIRAJA. *Indian For. Leaflet*. 1944, no. 70, 8.
4. CHEN *et al.* *J. Pharmacol.*, 1942, 24, 223.
5. GANPPATE; SASTRI. *Proc. Indian Acad. Sci.*, 1938, 86, 399.
6. GERHARD; FRANZ. *Annalen der Chemie* 1936, 526, 252.
7. —; —. *ibid.*, 1941, 546, 233.
8. MURTI; SESHADRI. *Proc. Indian Acad. Sci.*, 1943, 18A, 145.
9. —; —. *ibid.* 1944, 21A, 8; 1945, 22A, 304.
10. —; —. *ibid.*, 1944, 21A, 147; 1945, 22A, 138.
11. PITCHANDI. *J. Inst. Chem. India*, 1948, 20, 34.
12. SHARMA. *Indian J. vet. Sci.*, 1934, 4, 63.
13. SOHN. *Fr. patent no. 848,922*, 9 Nov. 1939. (See *Chem. Abstr.*, 1941, 35, no. 6,393.)

Capparis (Capparidaceae)

C. decidua Edgew. (= *C. aphylla* Roth.). A densely branching shrub or small tree with scanty, small, caducous leaves found only on young shoots. It is found chiefly in the driest parts of the Deccan Peninsula, Rajasthan and Punjab and in Sind (Pakistan). It also occurs in Arabia, Egypt, North and tropical Africa.

The small round, fleshy, pink fruits and the flower buds are commonly pickled. The fruit is astringent and useful in cardiac troubles and biliousness. The tender leaves and branches are used as plaster for boils and swellings. When chewed they relieve toothache. The bark is acrid, laxative, diaphoretic, alexeteric, anthelmintic and useful against coughs, asthma and inflammations. The root and root bark are pungent and bitter, and are given in cases of intermittent fever and rheumatism [1].

C. grandis L. A small tree occurring in Rajasthan, the Deccan Peninsula, Burma and Ceylon. It yields an oil mainly used as an illuminant. An infusion of the bark and leaves is given internally for swellings and eruptions.

C. spinosa L. This is a small, prostrate shrub found in rocky and hilly localities in the Deccan Peninsula, Rajasthan, Ladakh and north-western India, and is also distributed in Afghanistan, western Asia, Europe, North Africa, Australia and the Sandwich Islands.

Commercial European capers are the pickled flower buds of *C. spinosa*. They have an acrid taste, and are considered useful in scurvy. In India, the buds and also the fruits are similarly used. Flower buds contain a glucoside, rutin, and 0.4 per cent pentosans [4]. They also contain rutic acid, pectic acid and a substance with a garlic odour, a volatile emetic constituent and saponin [3]. Caper seeds yield from 34 to 36 per cent of a pale yellow oil [2]. The root bark contains rutic acid and a volatile substance with a garlic odour.

The bark is bitter, aperient, diuretic, expectorant, emmenagogue and tonic. It is used in rheumatism, paralysis, toothache, affections of the liver, spleen and tubercular glands. The bruised leaves are used as a poultice in gout.

1. DALZIEL. *The useful plants of west tropical Africa*, London, The Crown Agents for the Colonies, 1948.
2. HILDITCH, T. P. *The chemical composition of natural fats*, London, Chapman and Hall, 1947, p. 158.
3. WEHMER, C. *Die Pflanzenstoffe*, Jena, Verlag von Gustav Fischer, 1929, I, vol. 1, p. 391.
4. WINTON, A. L.; WINTON, K. B. *The structure and composition of foods*, New York, John Wiley & Sons, 1935, vol. IV.

Cassia (Leguminosae)

The dried leaflets of *C. angustifolia* Vahl., known commercially as Tinnevely senna (or Indian senna), or of *C. acutifolia* Del., known commercially as Alexandria senna, constitute the senna of various pharmacopoeias.

C. acutifolia Del. It is a shrub indigenous to the Sudan but found growing wild in the Hejaz and in other parts of Africa. It possesses a straight, branched, whitish stem, 0.60-3 m. high. The leaves are alternate and pinnate with a pair of small narrow pointed stipules. The leaflets are sessile ovate-lanceolate, 1.25-2.5 cm. long and of a greyish-green colour. The flowers are yellow, in axillary racemes. The fruit is a flat, elliptical, obtuse, membranous, greyish-brown pod, 2.5×1.25 cm., and divided into 6 or 7 cells, each containing a cordate seed.

Alexandria senna is gathered from wild plants growing in Hejaz, from wild and cultivated plants growing in the Sudan and to a small extent from plants cultivated in India.

C. angustifolia Vahl. A low shrub having a habitat somewhat similar to *C. acutifolia*. It has an erect, smooth stem, and pinnate leaves, with from 4 to 8 pairs of leaflets. These are nearly sessile, lanceolate, slightly mucronate, oblique at the base, somewhat downy beneath. The most striking character of the leaflet is its length, varying from 2 cm. to 5 cm.; the stipules are minute, spreading and semi-hastate. The flowers are bright yellow in axillary and terminal racemes, rather longer than the leaves. The legume is long, membranous, tapering abruptly at the base, rounded at the top and 4.5×1.5 cm. in size. The pods are larger and narrower than those of the Alexandria variety and the brown area of the pericarp surrounding the seeds is larger. The remains of the style are distinct in the Tinnevely but not in the Alexandria type.

The finest grade of Indian senna is that grown in the district of Tinnevely and commercially known as Tinnevely senna. *C. angustifolia* is usually cultivated on dry land. It may be given light irrigation and grown as a semi-irrigated crop. Heavy irrigation is injurious. Sowing is done either by broadcasting or by dribbling, the seed rate being about 15 lb. per acre. The seeds have a tough coat and a certain amount of abrading of the surface is necessary to induce even and quick germination; this is secured by pounding the seeds lightly with coarse sand in a mortar. The plants require bright sunshine and occasional drizzle. Continuous rain during growth spoils the quality of the leaves. The plants are usually allowed to grow for 3-5 months only and the first flush of flower stalks is cut off to induce lateral branching. When the leaves are fully grown and are thick and bluish in colour, they are stripped off by hand. A second stripping is made after about a month and the plant is then allowed to bear flowers and set seed.

The leaves are spread out to dry in the shade on a hard floor, without overlapping. After 7-10 days, when the leaves have dried sufficiently and assumed a yellowish green colour, they are graded and packed under hydraulic compression. The pods also are dried and beaten out to separate the seed. A dry-land crop of senna yields 300 lb. of cured leaves and 75-150 lb. of pods. Yields from a wet-land crop of 750-1,250 lb. of cured leaf and 165 lb. of pods have also been reported [1, 7].

Senna is valued in medicine for its cathartic properties, and is especially useful in habitual constipation. It increases the peristaltic movements of the colon. The tendency to gripe caused by senna may be obviated by combining it with aromatics or saline laxatives. The pods have the same therapeutic effect as the leaves, but cause less griping. Senna is contra-indicated in spastic constipation and in cases of colitis. Henderson [3] reported that senna speeded passage through the caecum and ascending colon, by diminishing the normal anti-peristaltic waves in this area and reducing the absorption of water, thereby causing a bulkier and softer faecal mass.¹

Tutin [6] reported that the only anthraquinone derivatives present, either free or in glucosidal combination in senna were rhein and aloe-emodin. Straub [5] found 1 per cent of an easily hydrolysable glucoside which yielded emodin and was actively cathartic, and also a second glucoside which was more difficult to hydrolyse and slower in its laxative effect. Stoll [4] and his co-workers reported isolation of two glucosides—sennoside A and sennoside B, which are believed to be the laxative principles of senna. Fairbairn and Saleh [2] isolated a water soluble non-rhein glucoside which is as active as sennosides A and B and which exerts a synergistic effect on these glucosides.

1. ABROL *et al.* *J. Sci. Industr. Res.*, 1955, 14A, 432.
2. FAIRBAIRN; SALEH. *J. Pharm. Pharm.*, 1951, 3, 819.

1. For further information on the physiology see: Lens, *Schweiz. med. Wschr.*, 1923, 53, 887; Straub and Trinedl, *Arch. exp. Path. Pharm.*, 1937, 185, 1.

3. HENDERSON. *Canad. Med. Assoc. J.*, 1935, 32, 538.
4. STOLL *et al.* *Schweiz. natur. Forsch. Gesell.*, 1941, p. 235.
5. STRAUB. *Arch. exp. Path. Pharm.*, 1936, 181, 399; 1937, 185, 1.
6. TUTIN. *Trans. Chem. Soc.*, 1913, 103, 2006.
7. YEGNA NARAYAN IYER, A. K. *Field crops of India*, Bangalore, Bangalore Printing and Publishing Co., 1950.

Citrus colocynthis Schrad. (Cucurbitaceae)

An annual or a perennial herb with a prostrate or climbing stem, bearing smooth spherical fruits which are of a mottled green when young and somewhat yellow when ripe. The fruit contains a soft spongy pulp and seeds. *Colocynthis* is a native of the warmer parts of Asia and Africa. It is found in Arabia, Syria, and Egypt. In India it grows in the arid and sandy tracts of north-western, central and southern India. It is cultivated to some extent in Spain and Cyprus.

The dried pulp of the unripe but full-grown fruit, freed from the rind, constitutes the commercial drug *colocynthis* and is officially recognized in pharmacopoeias. It is a drastic hydragogue cathartic producing large watery evacuations. In large doses it causes violent griping, prostration, and sometimes bloody discharges. Even in moderate doses it is seldom prescribed except as an adjuvant to other cathartics. In the form of solid extract, it enters into many of the purgative pills of modern pharmacy.

Colocynthis contains an alkaloidal principle with a violent purgative action. It also contains α -elaterin, but none of the active β -elaterin. *Colocynthin* or *citrulin*, believed to be a glucoside, is a mixture of alkaloid and a crystallizable alcohol, *citrullol* [3]. The roots contain α -elaterin [1]. The seeds contain a brownish-yellow oil which contains an alkaloid, a glucoside, saponin, etc. [2].

1. AGARWAL; DUTT. *Curr. Sci.*, 1934, 3, 250.
2. ALIMCHANDANI *et al.* *J. Indian chem. Soc.*, 1949, 26, 515, 519.
3. POWER; MOORE. *Trans. chem. Soc.*, 1910, 17, 99.

Commiphora mukul (Hook. ex Stocks) Engl. (Burseraceae)

A small tree or shrub with spinescent branches occurring in the arid rocky tracts of Rajasthan, Sind, Baluchistan and Arabia. It is the source of Indian bdellium, a gum resin obtained by incision of the bark. Each plant yields about 1½-2 lb. of the product which is collected in the cold season. It is a substitute for African bdellium and a common adulterant of myrrh.

In Indian indigenous medicine, this gum is used as an astringent and an antiseptic; internally it acts as a bitter, stomachic and carminative, stimulating the appetite and improving digestion. Like other oleoresins it causes an increase of leucocytes in the blood and stimulates phagocytosis. It acts as a diaphoretic, expectorant and diuretic, and is said to be a uterine stimulant and emmenagogue. The resin is used in the form of a lotion for indolent ulcers and as a gargle in pyorrhoea alveolaris, chronic tonsillitis and pharyngitis. Inhalation of the fumes from burnt "guggul" is recommended in hay fever, acute and chronic nasal catarrh, laryngitis, bronchitis and phthisis.

The commercial product contains 1.45 per cent essential oil besides gum and resin [1]. The resin can be separated from the gum either by hot expression at 120°-130° C or by solvent extraction. The purified resin is transparent in thin films, but translucent or opaque in bulk.

1. DUTT *et al.* *Indian. J. med. Res.*, 1942, 30, 331.

Convolvulus (Convolvulaceae)

C. arvensis L. A pretty trailing or twining, glabrous or slightly pubescent herb with long cylindrical slender rhizomes and solitary peduncles 2-7 cm. long bearing from 1 to 3 funnel-shaped pink or white flowers. It is a common weed throughout the temperate regions.

The root possesses cathartic properties, and some European authorities regard it as poisonous because of the marked gastro-intestinal irritation it produces. The root is sometimes used in Sind as a substitute for jalap. Root contains convolvulin [2]. Dried rhizome contains about 4.9 per cent of a potent purgative resin [4].

C. scammonia L. A perennial twining vine native to Syria, Iraq, Asia Minor and Greece and known commercially as scammony. It is also cultivated to some extent in various parts of India.

Scammonium or scammony gum resin is obtained from the living root of the plant by cutting off its crown and collecting the exudation in mussel shells. The secretion is dried immediately and consists of resin. The drug, which is very expensive, was officially recognized in various pharmacopoeias. The resin appears to be in no way superior to other convolvulaceous resins and has now been replaced by these in pharmacopoeias. Scammony resin occurs in small brownish cakes having a somewhat cheesy odour. The dried roots of *C. scammonia*, known commercially as scammony roots, are 2.5 cm. in diameter and 20 cm. in length.

The roots contain from 3 to 13 per cent of resin which is almost entirely soluble in ether. The resin consists chiefly of the glucosides and methylpentosides of jalapinic acid and its methyl ester, besides ipuranol, tiglic acid, delta-alpha-methylbutric acid, scopoletin, 3:4-dihydroxy cinnamic acid, etc. [3].

Resins from rhizomes are hydrogogue and cathartic and are administered in dropsy and anasarca [1].

C. glomeratus Chois. ex DC. and *C. spinosus* Burm. f. Both species grow wild in Rajputana, Sind and Baluchistan and are reported to have a purgative effect.

1. CHOPRA, R. N. *Indigenous drugs of India*, Calcutta, Art Press, 1933, p. 577.
2. DYMCK, W.; WARDEN, C. J.; HOOPER, D. *Pharmacographia Indica*, London, Trubner & Co, 1890-99.
3. POWER; ROGERSON. *J. Chem. Soc.*, 1912, 101, 398.
4. WEHMER, C. *Die Pflanzenstoffe*, Supplement, 1929-31 Jena, Verlag von Gustav Fischer, 1935.

Datura (Solanaceae)

D. innoxia Mill. A coarse, bushy annual attaining a height of 90-120 cm. The leaves are dark-green, ovate, often somewhat cordate, 12.5×7.5 cm.; flowers are white and fragrant, about 7 cm. long; fruits are ovate-conical, nodding, about 5 cm. long and 4 cm. in diameter, opening at the apex into four valve-like forms, exposing a long central column bearing numerous light brown seeds. Like most other species of *Datura*, *D. innoxia* emits a rank, heavy, narcotic odour. It is used in India for the same purpose as *D. stramonium*. It is of interest as a possible source of the alkaloid scopolamine used as a pre-anaesthetic in surgery and obstetrics.

Scopolamine appears to be the major alkaloid present in all parts of the plant though from 10 to 20 per cent of hyoscyamine is also present [12]. Scopolamine (*l*-hyoscine) is a syrupy liquid soluble in most organic solvents, the hydrobromide is readily soluble in water and is used in medicine as a sedative. It is a cerebral depressant useful in

agitated or maniacal conditions. It is also used to produce amnesia and partial analgesia in labour. It is the best among all the drugs tested for preventing motion sickness either on rough seas or in air travel. A 0.3 per cent solution or ointment is used topically in ophthalmology [2, 3, 9].

The plant prefers rich clay loams and sunny situations. It can be grown directly from seed or by transplanting seedlings. Germination is slow and irregular and may be hastened by alternate exposure to freezing and thawing to weaken the seed coat. Seeds are sown in drills, 10 cm. apart, during spring. About 5 kg. of seeds is required for planting 1 acre; only about 50 per cent of the seeds germinate. Liberal quantities of rotted cow dung manure are applied to ensure healthy growth. Entire plants are harvested at the time of flowering when the alkaloid content is at its maximum.

D. stramonium L. A glabrous or farinose annual, usually 1 m. high. The stem is erect with spreading branches; the leaves are pale-green, ovate or triangular-ovate, 12-15 cm. long, irregularly toothed; the flowers are large, 8-20 cm. long, white or violet; erect, ovoid, thickly covered capsule with sharp spines, dehiscing into four valves; the seeds are numerous and reniform. The plant is native to Asia but has become naturalized in North and South America and southern Russia, and in most of the European countries, except northern Scandinavia. Though common as a weed in many parts of the world, *D. stramonium* is cultivated in the U.S.A. and Europe, with the object of obtaining a drug of uniform potency.

D. stramonium prefers a rich calcareous soil. It can be grown from seeds sown in spring, in drills 10 cm. apart; the plants are later thinned to stand 30 cm. apart in rows. The plant is sensitive to frost and sheltered situations are, therefore, to be preferred for cultivation. Entire plants are cut down when the fruits are mature but green, and then partially dried in the sun or in the shade. The leaves are stripped and dried separately. The seeds are shaken off from the capsules when the fruits begin to burst. Yields of 1,000-1,500 lb. of leaf and 700 lb. of seed per acre may be expected [6]. The use of nitrogenous manures, which favours the growth of the plant, also favours alkaloid formation [10].

Stramonium contains from 0.25 to 0.5 per cent of alkaloid, which consists chiefly of *l*-hyoscyamine, associated with atropine (*dl*-hyoscyamine) and *l*-hyoscyne (*l*-scopolamine) [1]. In addition to the above alkaloids, Chou [4] isolated two neutral principles which he called datugen and datugenin. Gerard [7] studied daturic acid obtained from the fixed oil from the seeds, and reported that it is the only naturally occurring acid with an uneven number of carbon atoms. More recent investigators [5, 11] claim it to be a mixture of acids with an even number of carbon atoms.

Stramonium is so similar to belladonna in its general physiological and therapeutic actions, and in its toxic manifestations, that the two drugs are practically identical. Historically, it acquired special repute as a treatment of asthma by way of smoking. The beneficial effect is doubtless due to the presence of atropine which paralyses the endings of the pulmonary branch of the vagus, thus relieving the bronchial spasm. Gunther [8] found that the smoke from a stramonium cigarette containing 1.25 gm. of the leaves contains as much as 0.5 mg. of atropine.

Stramonium may be used as a source of atropine. On a commercial scale atropine is prepared by the racemization of *l*-hyoscyamine which is contained in stramonium in appreciable quantities. Atropine is a stimulant for the central nervous system, acting specially on the motor area affecting co-ordinate movements and, in large doses, causing restlessness, talkativeness, and delirium. It prevents also the effects of acetylcholine at the terminations of the parasympathetic nerves which supply the glands, the plain muscles and the heart. When given orally or parenterally it diminishes certain body secretions. It is of considerable value for relaxing spasmodic contractions of involuntary muscles and is used for this purpose in renal and biliary

colic and asthma. In ophthalmology, atropine is extensively used for dilating the pupil and increasing intra-ocular pressure [2, 9].

Hyoscyamine is intermediate in its central action between atropine and hyoscyne. It causes less stimulation of the central nervous system than atropine and is a weaker sedative and hypnotic than hyoscyne, but it is more powerful than atropine in its peripheral action. It is used to relieve tremor, rigidity and excessive salivation in paralysis agitans. It is less reliable as a rapid sedative than hyoscyne hydrobromide [2].

1. Anonymous, *The British Pharmaceutical Codex*, London, Pharmaceutical Press, 1949, p. 419, 421, 422.
2. ———, *ibid.*, 1954, p. 724.
3. ———, *The United States Dispensatory*, 24th ed., Philadelphia, J. B. Lippincott, 1947, p. 1017.
4. CHOU, *Chin. J. Phys.*, 1935, 9, 77.
5. CLARK, *J. Amer. pharm. Ass.*, 1935, 24, 843.
6. DUTT, N. B. *Commercial drugs of India*, Calcutta, Thacker Spink & Co., 1928, p. 117.
7. GERARD, *J. Pharm. Chim. (Paris)*, 1892, p. 8.
8. GUNTHER, *Wien. Klin. Wschr.*, 1911, p. 748.
9. HENRY, T. A. *The plant alkaloids*, London, J. & A. Churchill, Ltd., 1949, p. 841-70.
10. JAMES, *Econ. Bot.*, 1947, 1, 230.
11. MANJUNATH, *J. Indian Chem. Soc.*, 1935, 12, 400.
12. TEJ SINGH *et al.* *Indian J. Pharm.*, 1957, 19, 187.

Delphinium zaili Ait. and Hemsl. (Ranunculaceae)

This is a perennial herb with bright yellow flowers found in Persia and Afghanistan. Its flowers mixed with the fragments of the flowering axes and stalks are imported and sold in Indian bazaars as "asbarg". The drug is considered to be a diuretic, detergent and an anodyne; it is useful in cases of jaundice, dropsy and disorders of the spleen. It is also employed as a poultice for swellings. The flowers and the flowering stems contain isorhamnetin, quercetin and probably kaempferol [1, 2, 3].

1. DYMCK, W.; WARDEN, C. J.; HOOPER, D. *Pharmacographia Indica*, London, Trubner & Co., 1890-99.
2. MAYER; COOK, *The chemistry of natural colouring matter*, New York, Reinhold Publishing Corporation, 1947, p. 189.
3. WEHMER, C. *Die Pflanzenstoffe*, Jena, Verlag von Gustav Fischer, 1929-31, vol. 1, p. 321.

Descurainia sophia (L.) Webb. ex Prantles = *Sisymbrium sophia* L. (Cruciferae)

This is an annual herb 30-60 cm. high, with small pale yellow flowers and ellipsoid, compressed, light brown seeds. It is found in Europe, North America and the temperate regions of Asia. In Asia it grows from Kashmir to Kumaon and extends to Baluchistan. The pungent odour of the plant when rubbed and its acrid taste are considered to be due to the presence of a volatile alkaloid [5]. The plant has been used externally to treat indolent ulcers.

The seeds are slightly bitter, expectorant, restorative and tonic and are reported to be useful in cases of fever, bronchitis and dysentery. They are also given internally for worms and urinary complaints and are used as a substitute for or adulterant of the seeds of *Sisymbrium irio* [1, 2, 4]. Heyl [3] has separated a toxic, and apparently uncrystallizable alkaloid.

1. Anonymous, *The United States Dispensatory*, 24th ed., Philadelphia, J. B. Lippincott, 1947.
2. CHOPRA, R. N. *Indigenous drugs of India*, Calcutta, Art Press, 1933, p. 528.

3. HEYL. *Ap. Ztg.*, May 1900, 30.
4. KIRTIKAR, K. R.; BASU B. D. *Indian medicinal plants*, Allahabad, Lalit Mohan Basu, 1935, vol. I, p. 156.
5. TOPF. *Zeit. f. Nat. Pharm. Central*, 1894, 494.

Duboisia hopwoodii F. Meull. (Solanaceae)

This is a small shrub, seldom exceeding 3 metres in height, possessing narrow lanceolate leaves. It is endemic in Australia and grows scattered throughout the drier regions of the country, mostly within the 250 mm. rainfall zone but extending in certain parts into the zone where annual rainfall is nearly 380 mm. It occurs in south-western Queensland along the Mulligan and Georgia Rivers in South Australia, and is perhaps most abundant in Western Australia. It generally inhabits sandy open country and is found as scattered individual plants or in small groups. The preparation made from leaves and twigs of *D. hopwoodii* is the "pituri" drug used by the aborigines as a narcotic and for chewing [1]. The leaves of this plant are reported to contain two alkaloids: nicotine and nor-nicotine [3]. According to Botomley and others [2] the nicotine content in *D. hopwoodii* varies from 0.4 to 5.3 per cent and the distribution of nor-nicotine is very sparse: from over 50 samples examined they could find nor-nicotine in only one.

1. BARNARD, C., "The duboisias of Australia", *Econ. Bot.*, 1952, 6, 3-17.
2. BOTOMLEY, W. *et al. Aust. J. Sci.*, 1945, 8, 18-19.
3. HATT, H. H. "A survey of Australian phytochemistry", *Proceedings of the Symposium on Phytochemistry, Government of the Federation of Malaya & Unesco, Kuala Lumpur*, Dec. 1957, p. 1-19.

Ephedra (Gnetaceae)

Ephedra is a genus of low, much branched, erect, procumbent or occasionally climbing shrubs, distributed chiefly in the arid regions of the temperate zones. Few drugs in recent years have attracted the attention of the medical profession as much as the alkaloid ephedrine from *E. sinica*—the Chinese plant "Ma-huang". The drug has been in use in China for the last five thousand years. The habitat of *Ephedra*, however, is not confined to China alone but has a much wider geographical distribution.

Ephedra of the *British Pharmaceutical Codex* consists of the dried young branches of *E. sinica* Stapf. and *E. equisetina* Bunge, indigenous to China, and *E. gerardiana* (including *E. major*) indigenous to India. It contains not less than 1.25 per cent total alkaloids calculated as ephedrine.

E. equisetina Bunge. A native of China. It is a dioecious shrub attaining the height of 1-2 m. The stem is woody below and bears green, herbaceous, smooth branchlets above. The leaves consist of two opposite, brown, membranous to coriaceous sheaths about 2 mm. long, connate through half or more of their length.

E. sinica Stapf. Also a native of China. It is a shrub attaining a height of 30 cm. with greyish-green, rough branchlets, 1-1.5 mm. thick. The leaves are reduced to membranous sheaths, 4 mm. long. Inflorescence is short spikes, terminal or at the upper axils, generally dioecious, occasionally monoecious. The fruiting cones are ellipsoidal-globose, 6-8 mm. long.

E. gerardiana Wall. = *E. vulgaris* Hook. f., non. A. Rich. This plant is endemic to

India and is found scattered in the drier regions of the temperate and alpine Himalayas, from Kashmir to Sikkim, at altitudes of 7,000 ft. to 16,000 ft. and is frequently found at Chamba, Lahul, Spiti, Bashahr (north of Simla), Kashmir and Ladakh. It is a small, almost erect shrub, variable in size, but typically not exceeding a few inches in height. It bears dark-green, cylindrical, striated, often curved branches arising in whorls, with internodes of branchlets 1-4 cm. long and 1.2 mm. in diameter. The fruits are ovoid, red and edible. The plants found at Dattamula in Kashmir are rich in alkaloids. Var. *saxatilis* Stapf. is taller and ascending, it occurs in Garhwal and Kumaon; var. *sikkimensis* is erect and robust but soft, and occurs in Sikkim.

E. major Host syn. *E. nebrodensis* Tineo. An upright rarely ascending, densely branched shrub, up to 2 m. high. It is reported from Lahul. The twigs of this species closely resemble those of *E. gerardiana*.

Medicinal species of *Ephedra* have been successfully cultivated in the U.S.A., England, Kenya and Australia. The plants are propagated by seeds, layers, or divisions of the rootstock. Seeds are sown during early spring, 5 cm. apart and 1.25 cm. deep, in drills, the distance between rows being 75 cm. Watering and weeding are necessary for about a year. The plants are hardy and grow satisfactorily even in extreme xerophytic conditions [4, 9].

The alkaloid content increases with the age of the plant, and the best time to collect the green twigs, which constitute the commercial ephedra, is when the plants are four years old and are in blossom. Rainfall has a marked adverse effect; the alkaloid content decreases from May to August and thereafter gradually increases till it attains its maximum value in October-November. The alkaloid content of the green twigs is considerably greater than that of the woody stems; berries and roots contain hardly any alkaloid. The twigs should be dried in the sun. Artificial drying at high temperatures must be avoided. It has been observed that drying at 120°F for three hours decreases the alkaloid content from 1.22 to 0.17 per cent. The dried twigs when stored in dry, closed containers protected from light retain their activity without loss over a long period [11].

Among the Indian species, *E. major* is the richest source of ephedrine. The plants collected from Lahul contain over 2.5 per cent total alkaloids of which nearly three-fourths is ephedrine. The total alkaloid content of the green stems of *E. intermedia* ranges from 0.7 to 2.33 per cent of which only about one-tenth is ephedrine, the rest being pseudo-ephedrine. Other species, namely, *E. equisetina*, *E. sinica*, *E. distachya*, *E. gerardiana*, yield chiefly ephedrine.

A decoction of the stems and roots is reported to be used in Russia to treat rheumatism and syphilis and the juice of the berries is given in affections of the respiratory passages. The therapeutical activity of ephedra is due to the presence in the drug of the alkaloids, ephedrine and pseudo-ephedrine. The conversion of pseudo-ephedrine to the commercially useful *l*-ephedrine is not easily accomplished. On reduction ephedrine yields the therapeutically useful deoxyephedrine and methamphetamine. Ephedrine has been synthesized and the synthetic product (*dl*-ephedrine, melting point 76°) is marketed under the name racephedrine.

The pharmacological action of ephedrine is similar to adrenalin. Its pressor and vaso-constrictor activity is slower and less than that of adrenalin but is more persistent. It is more stable under metabolic conditions and, unlike adrenalin, can be given orally. It stimulates the respiratory centre increasing the depth of respiration, reinforces heart action and dilates the bronchi, especially when they are in spasm, hence its use in bronchial asthma; it contracts the uterus and dilates the pupils. It also stimulates the central nervous system, this analeptic action being the basis for its use in the treatment of depression and for the relief of narcolepsy, although for this purpose its derivative, deoxyephedrine (amphetamine) seems to have some

advantages. Topical application reduces hyperaemia without after-dilatation. It is used in vasomotor rhinitis, coryza, congestion of the mucous membrane, acute sinusitis and hay fever. Ephedrine has a slight local anaesthetic action and this property seems to be greatly developed in the *l*-*d*- and *dl*-forms of cinnamylephedrine [6].

Qualitatively, *d*-pseudo-ephedrine resembles ephedrine, but its effect, particularly on the blood pressure, bronchi and higher centres, is weaker. The effect of both the alkaloids on the kidney is to produce a dilatation of the blood vessels and an increase in kidney volume, but the initial momentary constriction produced by ephedrine is absent in the case of pseudo-ephedrine and the diuretic effect is more marked. It is cheaper and less toxic than ephedrine and has been used in the treatment of asthma with good results. It has no effect on the uterus [2, 3].

In excessive doses, ephedrine causes nervousness, insomnia, headache, vertigo, palpitation, sweating, nausea and vomiting, occasionally praecordial pain, and sometimes dermatitis.

Ephedrine and its salts are used for therapeutic effect both locally and systematically. In allergic syndromes, the salts relieve nasal congestion in hay fever, relax bronchiolar muscle spasm in bronchial asthma and are especially useful in preventing asthmatic attacks in chronic cases [8]. Because of its stimulant effect on the central nervous system, ephedrine is beneficial in the treatment of narcolepsy [5]. Systematically, it is used in the prevention of hypotension during spinal anaesthesia [10]. Ephedrine has been used to prevent nitritoid crises by giving orally 50 mg. of a salt prior to the injection of substances which may cause such crises [1]. Excellent results have been reported from its use in treatment of nocturnal enuresis or dribbling due to poor sphincter tone [7]. The drug also has a mydriatic effect.

1. ALEXANDER. *Proc. Mayo*, 1935, 10, 377.
2. BRAY; WITTS. *Indian med. Gaz.*, 1934, 59, 401.
3. CHOPRA *et al.* *Indian J. med. R.*, 1929, 17, 375.
4. CHRISTENSEN; HINER. *J. Amer. Pharm. Ass.*, 1939, 28, 199.
5. COLLINS. *Ann. intern. Med.*, 1932, 5, 1289.
6. HENRY, T. A. *The plant alkaloids*, London, J. A. Churchill, 1949, p. 642, 643.
7. KITTREDGE; BROWN. *New Orleans Medical and Surgical Journal*, 1944, 96, 562.
8. RUBITSKY *et al.* *J. Allergy*, 1950, 21, 559.
9. SIEVERS. *J. Amer. pharm. Ass.*, 1938, 27, 1221.
10. WEINSTEIN; BARRON. *Amer. J. Surg.*, 1936, 31, 154.
11. TANG; WANG. *J. pharm. Soc. (China)*, 1943, 27.

Euphorbia (Euphorbiaceae)

E. antiquorum L. A fleshy shrub or a small tree with cylindrical or fluted trunk and from 3 to 5 angled, upwardly curving jointed, thorny branches. It is distributed throughout the hotter parts of India and Ceylon up to altitudes of 2,000 ft. on the hills. It is often grown for hedges.

The plant is considered to be purgative and digestive. It has a pungent odour and a bitter taste. A decoction of the stem is given for gout. The juice of the plant is used as an irritant in rheumatism. It is applied to warts and other cutaneous affections. It is also used in the treatment of nerve disorders and dropsy. The latex is used for killing maggots in wounds; it is also reported to be used as fish poison. A saline extract of the stem shows antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* [4, 11].

E. hirta L. = *E. pilulifera* auct. non L. An erect or ascending annual with hairy stems. The leaves are 15-50 cm. high, opposite, elliptic-oblong or oblong-lanceolate. It is

common in waste ground throughout the hotter parts of India and is also naturalized in other tropical countries.

Levison [14] found in it several glucosides, resins, wax and volatile matter. Power [16] found a monohydric alcohol, euphosterol, among other constituents, none of which seems of therapeutic value. Ueda and Hsu isolated from the herb an alkaloid which was identified by them as xanthorhamin [19]. Later, Hallett and Parks isolated *l*-inositol [10].

According to Dikshit and Rao [6] the drug appeared to have a fairly marked action on the respiratory system, depressing the respiration and producing a well-marked dilatation of the bronchioles of cats and dogs. Given by the mouth in large doses it produced local irritation of the stomach, nausea and vomiting. Injected intravenously it has a depressant action on the movements of the intestines; the peristalsis stops immediately and there is relaxation of muscle tone. The cardiovascular system is also depressed and the blood pressure falls, chiefly on account of its depressant action on the heart; this action was confirmed by perfusion experiments.

The fluid extract of the plant is relatively non-toxic; it appears to contain two active principles, one of which causes a spike phase in the ileum of the guinea-pig and the other a relaxing action of smooth muscles [15].

E. hypericifolia L. A small, slender, sparsely pubescent, erect, ascending or decumbent annual, with opposite, short-stalked oblong leaves, common throughout the hotter parts of India. It is also found in tropical areas in both hemispheres, except in Australia and the Pacific Islands.

An infusion of the dried leaves is considered astringent and feebly narcotic; it is used in dysentery, diarrhoea, menorrhagia and leucorrhoea. It is sometimes given with milk to children in cases of colic. It is reported to contain a phenolic substance, an essential oil, a glucoside and an alkaloid [20].

E. nerifolia L. A large succulent shrub or a small tree, up to 6 m. high, with jointed, cylindrical or possibly pentagonal branches bearing short, stipular thorns more or less confluent in vertical or slightly spiral lines; the leaves are fleshy, 15-30 cm. long, terminal on the branches. The plant closely resembles *E. nivulia* but can be distinguished from it by the position of the thorns, which in this species grow on warty knobs, while in the latter, they are based on flat corky patches. The plant is common in rocky ground throughout the Deccan Peninsula and is also found in Baluchistan and the Malayan islands. It is often cultivated for hedges in villages throughout India.

The latex is acrid, rubefacient, purgative and expectorant and is liable to cause dermatitis. It is used to remove warts and cutaneous eruptions. The juice is employed in earache; mixed with soot it is applied in ophthalmia. A succus compounded of equal parts of the juice and simple syrup gives relief in asthma [1, 5, 13]. The latex contains caoutchouc [2].

E. nivulia Buch-Ham. A shrub or a small tree, up to 9 m. high, with green cylindrical, jointed, often whorled branches armed with spines; the leaves are fleshy, up to 22 cm. long. The plant is found in the dry rocky regions in almost all parts of India, and in the dry forests of Peru and Burma. The juice of the leaves is given as a purgative and diuretic. It is said to be used for relieving earache. Mixed with margosa oil it is applied externally in rheumatism. The root bark is used in dropsy [12].

E. resinifera Berg. The most important product of the genus *Euphorbia* is the dried latex, known as euphorbium, obtained from incisions in the stems of *E. resinifera*. This is a fleshy cactus-like plant found in Morocco. Euphorbium occurs in the shape of tears, or in oblong or roundish masses about the size of a pea or larger, often forked

and perforated with one or two small conical apertures produced by the prickles of the plant around which the juice has concreted and which sometimes remain in the mass. It is so acrid that people collecting or powdering it are compelled to protect their nostrils, eyes and mouth.

Euphorbium taken internally is a very irritant emetic and cathartic and in large doses acts as a violent gastro-intestinal poison. Because of the severity of its action, it is no longer used internally in some countries. Applied to the mucous membrane of the nostrils it excites violent irritation, attended by incessant sneezing and sometimes bloody discharges. Externally applied it inflames the skin, often producing vesication. It enters into some epispastic preparations and is especially employed in veterinary practice as a vesicant.

Fluckiger [7] isolated a substance analogous to lactucon, which he named euphorbon. Tschirch and Paul found euphorbic acid, euphorbin malic acid and bitter and acrid principles. The plant also contains α - and β -euphorbol [18].

E. royleana Boiss. A shrub or a small tree, up to 5 m. high, with whorled spiny branches with five to seven sides and alternate, spatulate, thick and deciduous fleshy leaves. It is common on the outer dry slopes of the western Himalayas, chiefly at altitudes of 3,000-5,000 ft. It is commonly grown in hedges in sub-Himalayan tracts and adjacent plains.

The fresh latex has a rich sweet odour. It is acrid and possesses cathartic and anthelmintic properties. It is liable to cause dermatitis and is reported to be injurious to the eyes. The latex contains water, water-solubles and caoutchouc [1, 2].

E. tirucalli L. An unarmed shrub or small tree, with erect branches and smooth, cylindrical, polished, whorled branchlets bearing small linear-oblong, caducous leaves. The trunk is covered with rough, greenish-brown bark with a cracked appearance. It is a native of Africa and naturalized in India, especially in the drier parts of Bengal and South India, and largely grown in hedges.

The latex of *E. tirucalli* is vesicant and rubefacient and is used as an application for warts, rheumatism, neuralgia and toothache. It acts as a purgative in small doses, but in large doses it is an acrid irritant and emetic. It is also used for coughs, asthma and earache. The latex is toxic to fish and rats. Decoctions of the tender branches and of the roots are administered in colic and gastralgia. The ash is applied as a caustic to open abscesses [17]. The latex contains caoutchouc. From the fresh latex a terpenic alcohol, isoeuphorol, identical with euphol (from *E. resinifera*), has been isolated. However, dried latex which has been stored for some months does not contain isoeuphorol, but a ketone, euphorone, which on reduction yields isoeuphorol and euphorol, the latter being the principal reduction product. Taraxasterol and tirucallol isomeric with euphorol have been isolated [2, 8, 9].

E. trigona Haw. An erect, glabrous, fleshy shrub or a small tree with spiny ascending branches and small oblanceolate-spatulate leaves. It occurs in the dry rocky hills of the Deccan and in the deciduous forests of Andaman Islands and Moluccas.

The latex is acrid and vesicant. It is a drastic purgative even in small doses. The juice from heated leaves is used for earache. Powdered leaves, alone or with turmeric, are used as a poultice for boils. Vegetative parts of the plants are reported to contain hydrocyanic acid. The latex contains 1.5 per cent caoutchouc [3].

E. trigona, as described here, also embraces *E. cattimandoo*, *E. ellioti* = *E. trigona* (*Flora of British India*, vol. V, p. 256). The latter is distinguished from *E. trigona* chiefly by its 5-winged, instead of 3-winged branches.

E. atoto Forst. f. Another species of Euphorbia of minor medicinal value. It is a fleshy

shrub occurring on the Malabar Coast and in the Andaman Islands. Its milky juice is used as an abortifacient and an emmenagogue.

1. BADHWAR *et al.* *Indian J. Agric. Sci.*, 1945, 15, 162.
2. BUDHIRAJA ; BERI. *Indian For. Leaflet.*, 1944, no. 70.
3. CAIUS ; BURKILL. *J. Bombay nat. Hist. Soc.*, 1938, 40, 264.
4. CHOPRA *et al.* *J. Bombay nat. Hist. Soc.*, 1941, 42, 878.
5. DEY, K. L. *The indigenous drugs of India*, Calcutta, Thacker Spink & Co., 1896, 2nd. ed., p. 124.
6. DIKSHIT ; RAO. *Proc. Indian Sci. Congr.*, 1931, 349.
7. FLUCKIGER. *Amer. J. Pharm.*, 1868.
8. GOPALACHARI ; SIDDIQUI. *J. sci. industr. Res.*, 1949, 8B, 234.
9. HAINES ; WARREN. *J. chem. Soc.*, 1919, 2554 ; 1950, 1562.
10. HALLET ; PARKS. *J. Amer. pharm. Ass.*, 1951, 40, 474.
11. JOSHI ; MAGAR. *J. sci. industr. Res.*, 1952, 11B, 261.
12. KIRTIKAR ; BASU. *Indian medicinal plants*, Allahabad, Lalit Mohan Basu, 1935, vol. 2, 2204 p.
13. KOMAN, M. C. *Report on the investigation of indigenous drugs*, Madras Govt. Press, 1920, I, II, (Rep. no. 5).
14. LEVISON. *Amer. J. Pharm.*, 1885, 147.
15. LLOYD ; HELLEMAN. *J. Amer. pharm. Ass.*, 1948, 37, 491.
16. POWER. *Chem. & Drugg.*, 1913, 544.
17. RAO. *Flowering plants of Travancore*, Trivandrum, Government Press, 1914, 352.
18. TSCHIRCH ; PAUL. *Arch. Pharm. Berl.*, 1905, 249.
19. UEDA ; HSU. *J. Taiwan pharm. Ass.*, 1949, 1, 40.
20. WEHMER. C. *Die Pflanzenstoffe*, Jena, Verlag von Gustav Fischer, 1929-31, vol. II, p. 609.

Ferula (Umbelliferae)

Asafoetida is an oleo-gum-resin obtained by incision from the living rhizome and root of *F. asafoetida* L., *F. foetida* Regal, *F. narthex* Boiss. and other species of *Ferula* such as *F. rubricaulis* and *F. alliacea* Boiss.

F. alliacea Boiss. Is a coarse perennial herb 1.5-2 m. tall with thick fleshy roots. The aerial shoots appear after the rains and bear bipinnate leaves and numerous umbels at the top.

F. asafoetida L. Is a tall perennial herb which grows 1.5-2 m. high and has thick fleshy roots. The leaves are bipinnate and the numerous umbels bear a large number of fruits.

F. foetida Regal. Grows in Persia, Kandhar and Afghanistan. It is a coarse umbelliferous plant growing 1.5-2 m. high, with large fleshy roots covered by bristly fibres. It has large bipinnate radical leaves, and a nearly naked stem ending at the top in very numerous umbels.

F. narthex Boiss. Grows abundantly in the villages of Kashmir, in Baltistan, Astore, in western Tibet and Afghanistan. It is 1.5-2.5 m. high, bearing leaves 30-60 cm. long with secondary and tertiary pinnae decurrent; the ovary is glabrous, the fruits are 50×80 mm.; broad vittae are clearly seen, and there is one in the dorsal furrows.

Commercial supplies of asafoetida reach Europe and America, via the Persian Gulf ports and Bombay, in an almost semi-liquid state, or as irregular, more or less pliable masses composed of agglutinated tears imbedded in a weak matrix, or as loose tears. The odour and therapeutic virtues of asafoetida are due chiefly to its volatile oil. Freshly distilled, it is a colourless liquid but becomes yellowish on ageing; it has an

offensive odour and a taste which is at first flat but becomes acrid. The main constituent of this oil is a mercaptan ($C_{17}H_{14}S_2$)[2]. Baumann [1] found in a sample of asafoetida 69 per cent acetone-soluble resin consisting of an ethereal oil, resinol, asaresinol, ferulic acid ester and free ferulic acid. The resin on distillation *in vacuo* produced umbelliferone.

Although rarely used in the West, in the East asafoetida has been extensively used from the earliest times, particularly as a carminative in the treatment of flatulent colic. As an emulsion enema, it is commonly used for abdominal distension in pneumonia and post-operative cases. The volatile oil of asafoetida is eliminated through the lungs, and for this reason the drug has been used as a stimulating expectorant in the treatment of bronchitis, whooping cough and asthma.

There are other species of *Ferula* growing in dry regions which are used medicinally by the country folk, principally *F. galbaniflua* and *F. sumbul*.

F. galbaniflora Boiss. and *F. sumbul* Hook f. These species growing in Persia and south-east of Samarkand, respectively, yield commercial galbanum (Levant). This is an oleo-gum resin, obtained in part from a natural exudation from the stem but chiefly by incising the root.

Galbanum occurs in brownish tears which are usually small and softer than those of asafoetida. The odour is rather pleasant and the taste is characteristic and disagreeable. Galbanum contains about 9.5 per cent of volatile oil, 63.5 per cent of alcohol-soluble resin and 27 per cent of gum and impurities; 44 per cent of the resin contained in galbanum is soluble in a sodium carbonate solution and contains a crystalline unsaturated acid (galbarsenic acid) having a lactone grouping and which on heating yields umbelliferone. The remainder of the resin consists largely of neutral crystalline substances which also yield umbelliferone; free umbelliferone is also present [3].

1. BAUMANN. *Quart. J. Pharm.*, 1929, 2, 621.

2. MUNNICH; FRESERIUS. *Arch. Pharm. Berl.*, 1936, 274, 461.

3. TREASE, G. E. *A text book of pharmacognosy*. London, Bailliere, Tindall & Cox, 1946, 444 p.

Foeniculum vulgare Mill. = *F. capillaceum* Gilib.; *F. officinale* All. — Fennel (Umbelliferae).

Fennel is a stout, glabrous, aromatic herb, 1.5-2 m. high, with pinnately decompound leaves and small yellow flowers in compound terminal umbels; the fruit is oblong, ellipsoid or cylindrical, 6-7 mm. in length, straight or slightly curved, greenish or yellowish brown; the mericarp is 5-ridged with prominent vittae.

The plant is native to southern Europe and Asia. Among wild and cultivated fennels, there are a large number of varieties and races, the fruits differing in size, odour and taste. They are hardly distinguishable from one another and are regarded as races, varieties or sub-species of *F. vulgare*. The varieties which yield commercially important volatile oils are referred generally to the sub-species *capillaceum* and classified as two distinct varieties: var. *vulgare* (Mill.) Thellung—cultivated or wild, yielding Bitter Fennel Oil; and var. *dulce* (Mill.) Thellung—cultivated, yielding Sweet, or Roman, or Florence Fennel Oil. Var. *vulgare* is cultivated chiefly in the U.S.S.R., Rumania, Hungary, Germany, France, Italy, India, Japan, Argentina and the U.S.A. The cultivation of var. *dulce* is confined to France, Italy and Macedonia in southern Europe.

It thrives best in rich, well-drained loam, or black, sandy and sandy-clay soils which contain sufficient lime. It is propagated easily by seeds, but can also be grown by root or crown division. Seeds are sown broadcast by hand or by shallow drills, 45 cm. apart, at the rate of 10 kg. per hectare. The time of sowing is October-November in

the plains of India and March-April in the hills. When 7-10 cm. high, the plants are thinned out to about 30 cm. apart. Cultivation includes occasional weeding and irrigation, once a week during dry weather. The crop is harvested before the fruits are fully ripe. The stems are cut with a sickle and spread out in loose sheaves to dry in the sun. When dry, the fruits are threshed out and cleaned by winnowing. An average yield of fennel seed at 700-1,000 kg. per hectare has been reported. Under suitable conditions, a yield of up to 1,750 kg. of seed per hectare is also possible [2, 4].

Fennel fruits contain a volatile oil, the yield ranging from 1 to 6 per cent, the average being 3.51 per cent. The yield of oil is highest in the seeds of German and Rumanian origin and lowest in the East Indian seed.

The main constituent of the oil from the fruits of cultivated *F. vulgare* is anethole. Oils of good quality contain from 50 to 60 per cent anethole. Other constituents are *d*- α -pinene, camphene, *d*- α -phellandrene, dipentene, *d*-fenchone, etc. The residue left after the distillation of the essential oil is used as a feed for cattle [3].

The fruits are aromatic, stimulant and carminative. They are recognized officially in the pharmacopoeias of all countries and are used in the treatment of diseases of the chest, spleen and kidney. They are employed also as a corrective for less pleasant drugs, particularly senna and rhubarb. Fennel is a constituent of liquorice powder and of preparations for allaying griping. Fennel is also largely used as a spice in cooking and in the preparation of pickles, candies and liquors [1].

1. CHOPRA, R. N. ; CHOPRA, I. C. ; HANDA, K. L. ; KAPOOR L. D. *Chopras indigenous drugs of India*, 2nd ed., Calcutta, U. N. Dhur and Sons Ltd., 1958, 816 p.
2. CROOKS ; SIEVERS. *Condiment plants*, United States Dept. Agr., Bur. Plant Ind., July 1941, 19 p.
3. GUENTHER, E. *The essential oils*, New York, D. Van Nostrand Co., 1953, vol. IV.
4. WILKIE ; KOLCHOV. *The domestic production of essential oils from aromatic plants*, Columbus, Ohio, 1940, 28 p. (*Natl. Farm. Chemurgic Council Bull.*)

Glycyrrhiza — Liquorice (Leguminosae)

G. glabra L. A perennial herb, of which there are several varieties. The underground portion consists of a slender branching rhizome bearing a number of rootlets. The stems are herbaceous, erect, and 1-1.3 m. high. The leaves are alternate, consisting of several pairs of ovate, blunt, petiolate leaflets. The flowers are arranged in axillary spikes having long peduncles. The plant grows best on sandy or clay soil in valleys which are subject to occasional inundation from nearby rivers.

G. glabra var. *B-violacea* Boiss. yields the Persian liquorice which is collected in Iran and Iraq and, as its name implies, it bears violet flowers. *G. glabra* var. *typica* Reg. and Herd. is grown in Spain, Italy, England, France, Germany and the U.S.A. *G. glabra* var. *glandulifera* Reg. and Herd. is abundant in the wild state in Galicia and central and southern Russia. Asiatic liquorice is obtained from *G. uralensis* Fisch. which is found in Siberia, Turkestan and Mongolia, and is grown also in China.

The plants usually grow well in deep, sandy but fertile soil, near streams. The usual method of propagation is by replanting young pieces of stolon, but it can be grown from seed. The underground organs are sufficiently developed by the end of the third or fourth year at which stage they are dug up and washed. Enough always remains in the ground to renew itself during the ensuing three years. A great deal of it is peeled and cut up into short lengths before drying, but it is also used unpeeled [4].

Liquorice root contains from 5 to 10 per cent of a characteristic principle, glycyrrhizin, also known as glycyrrhizic acid ; it also contains 5 to 10 per cent of sugars and some bitter substances, in addition to resins, cellulose, lignin, etc. Glycyrrhizic acid is said to be 50 times as sweet as sucrose. On hydrolysis it yields glucuronic acid and

glycyrrhetic acid. *Glycyrrhiza* appears also to contain spasmolytic and esterogetic principles [1].

Powdered liquorice is used for various pharmaceutical purposes, in the preparation of pills and as a flavouring agent. In the form of extract, glycyrrhiza is frequently incorporated in cough medicines by virtue of its demulcent and expectorant properties. It has been observed to be effective in the treatment of duodenal and gastric ulcer. Card *et al.* [2] found that glycyrrhetic acid, when given to a patient with Addison's disease, had effects on weight and electrolytes similar to those found after administration of desoxycorticosterone and cortisone; the acid did not, however, prolong the survival of rats whose adrenal had been removed. Investigations by Costello and Lynn [3] led to the finding that significant, though small, amounts of estrogenic material are present in glycyrrhiza. The extract is used in the tobacco trade as a moisture-conditioning, flavouring and sweetening agent. It is also used in confectionery and brewing to give aroma. After the extraction of the water-soluble matter, the spent pulp is subjected to a second extraction with dilute caustic soda solution. This secondary extract is utilized as a foam stabilizer in the manufacture of farm fire-extinguishers. The residual material is used as a fertilizer in mushroom culture.

1. Anonymous. *The United States Dispensatory*, Philadelphia, J. B. Lippincott, 1955, p. 618.
2. CARD *et al.* *Lancet*, 1953, I, 663.
3. COSTELLO; LYNN. *J. Amer. pharm. Ass.*, 1950, 39, 177.
4. TREASE. *A text book of pharmacognosy*, London, Bailliere, Tindall & Cox, 1946

Hyoscyamus (Solanaceae)

H. muticus L. Egyptian henbane consists of the dried leaves, flowering tops and smaller stems of *H. muticus*. The plant is a desert herbaceous perennial 1-3 ft. high, the cauline leaves are petiolate, ovate or oblong, entire or toothed, pubescent or somewhat woolly. Lower flowers are pedicellar; calyx teeth in fruit are short, triangular, not acute; the corolla is bright yellow or nearly white and the capsule about 6 mm. in diameter. The plant is indigenous to Egypt and is also found east of Kabul, and is reported to grow in the Punjab and Sind in West Pakistan. The drug is collected chiefly from plants growing wild in Egypt and exported to various countries for alkaloid extraction. The drug from this source is easily recognized by the presence of the characteristic branching and non-glandular hairs which are found on both the stems and the leaves. It yields a larger proportion of total alkaloids than the official species, *H. niger* L. (henbane). According to the *British Pharmaceutical Codex* [1], Egyptian henbane contains about 0.6 to 1 per cent of total alkaloids, of which 90 per cent is hyoscyamine. The *Indian Pharmacopoeia* [2] requires that it contain not less than 0.5 per cent of hyoscyamine. The therapeutic effects and general physiological action of *Hyoscyamus* are very similar to those of belladonna and stramonium, since the principal active ingredient of all these is hyoscyamine. The most important use of *hyoscyamus* is to provide relief from painful spasmodic conditions of the non-striated muscles, characteristic of lead colic and irritation of the bladder. It is also employed to allay nervous irritation which is symptomatic of various forms of hysteria and irritable cough; it is considered inferior to scopolamine for these purposes. Externally, cataplasms or fomentations of fresh *hyoscyamus* leaves have been used to allay pain, although it is not certain how effective this treatment is [3].

H. albus L. So named because of the whiteness of its flowers, is a perennial plant growing in the Mediterranean countries. It has leaves 5-10 cm. long, with a slender petiole 2-6 cm. long and a coarsely toothed margin, and simple and glandular trichomes,

each with a unicellular head. *H. albus* is used in France in the same way as *H. niger* and *H. muticus*, as it appears to have identical medicinal properties. *H. albus* is thus a possible substitute for the official drug; the leaves contain 0.2 to 0.56 per cent and the root 0.1 to 0.14 per cent total alkaloids consisting of hyoscyamine and hyoscyne.

1. Anonymous. *The British Pharmaceutical Codex*, London, The Pharmaceutical Press, 1949, p. 425.
2. ——. *The Indian Pharmacopoeia*, 1955, p. 269.
3. ——. *The United States Dispensatory*, Philadelphia, J. B. Lippincott Co., 1955, p. 675.

Lavandula officinalis Chaix, syn. *L. vera* D.C. — Lavender (Labiatae)

Lavender is an evergreen shrub which, under cultivation, attains a height of about 1 m. The leaves are oblanceolate-linear with revolute margins. The upper branches bear terminal spikes of six to ten flowers; the posterior tooth of the calyx, much larger than the others, is bluish-violet and very hairy; the corolla is a purplish-grey, and tubular; the four stamens are inserted on the hairy throat of the corolla.

L. officinalis is a native of Mediterranean regions, growing wild on the dry, barren, sunny mountain slopes of southern France and Italy.

Lavandin (*L. officinalis* Chaix, *L. latifolia* Vill.) is a hybrid between true lavender and spike lavender (*L. latifolia*) growing wild at medium altitudes and yielding lower priced oil of lavandin.

Spike lavender, *L. latifolia*, grows wild at low altitudes. It is not planted, since it grows naturally and abundantly in Spain, the present main producing region of spike oil. Spike oil is of an even lower quality than lavandin. The higher altitudes produce plants yielding the best oil.

A silico-calcareous, loose, easily drained soil is best suited for the growing of lavender. Since lavender seed has a very hard pericarp, it must be kept in humid sand for some time in order to bring about germination. When the young shoots emerge they are transplanted into nurseries and watered frequently and only after several months are the plants transplanted into the open fields. Propagation by cuttings requires considerable care and is not always very successful. Some growers give preference to young plants taken from elevated altitudes, where only the best lavender is found. These plants are less expensive than those from seedlings and are also hardier. However, these wild plants should be carefully selected and collected when very young. This is usually done during May; they are then raised in a nursery for half a year, frequently watered and, during the autumn, transplanted into the open fields. The seedlings may be transplanted at a distance of 50-60 cm., in rows 1.7-2 m. apart, giving approximately 10,000 plants per hectare. During the first two years, an annual ploughing in autumn or winter should be undertaken, followed by one or two superficial tillings with a cultivator, and finally by at least one hoeing. After the second year the hoeing may be omitted. Although the yield is insignificant in the first year, and small in the second year, the young plants must be pruned carefully. The third year produces the first sizeable crop, which increases in the fourth and fifth years. Wild or cultivated, lavender is always cut by hand with sickles. From the third year on, a yield of 2,000 kg. of stalks and flowers per hectare is considered normal and a yield of 3,000 kg. satisfactory. Nitrogen, in the form of sodium nitrate, and ammonium sulphate produce prolific growth but potassium salts are harmful. For a high yield of oil, phosphates have been recommended.

The fresh flowering spikes yield about 0.5 per cent of volatile oil. The amount varies according to the variety, season, and method of distillation. Modern steam stills give a rather higher yield. The oil contains esters (chiefly linalyl acetate), linalol,

geraniol, cineole along with numerous other compounds [1]. Genuine continental lavender oil normally contains over 35 per cent of esters. Oil of spike, which is used extensively in the making of cheap perfumery, contains a very small amount of esters but a high proportion of free alcohols calculated as borneol (23-41 per cent). Lavandin oil contains from 6 to 9 per cent of esters and about 35 per cent of alcohols.

Lavender oil is used chiefly as a perfume although it has carminative and stimulant properties.

1. GUENTHER, E. *The essential oils*, New York, D. Van Nostrand Co., 1949, vol. II.

Lophophora williamsii Coulter (Cactaceae)

This plant, commonly known as peyote or mescal buttons, is a small, fleshy, spineless, perennial cactus with a subterranean main axis. From this arise a number of aerial shoots which have the appearance of peltate fungi, and bear tufts of yellowish-white hairs among which spring pinkish flowers. This constitutes the mescal button. The plant is indigenous to northern Mexico and now grows in Zacatecas, Chihuahua and on both sides of the Rio Grande near Laredo, Texas.

The species was first placed in the genus *Echinocactus* by Lemaire and was described as *E. williamsii*. It was later transferred to the genus *Anhalonium*, and subsequently made the type of a new genus, *Lophophora*, by Coulter. The *L. lewinii* seems to be a variety rather than a distinct species. Buttons of *L. lewinii* and *L. williamsii* are easily distinguished by the fact that the surface of the former is traversed by 13 narrow shallow furrows giving the appearance of as many irregular or broken ribs or obtuse ridges, while in the latter case the furrows are 8 in number and regular.

Mescal contains the following alkaloids: anhalamine, anhalomine, anhalodine, lophophorine and pellotine, which are all closely related. It also contains mescaline (mezcaline) which is 3,4,5-trimethoxyphenylthylamine, and anhaline which is identical with hordenine found in barley.¹

From time immemorial the Indians of the Rio Grande have used mescal buttons to induce intoxication during their religious rites.

The physiological action of the mescal alkaloids has been studied chiefly by Heffter, Raymond-Hamet and Grace [1, 2, 4]. The most active of the alkaloids is lophophorine, which in doses of about 12 mg. per kg. of body weight causes violent tetanic convulsions in the rabbit, similar to those caused by strychnine. Pellotine also causes tetanic convulsions in the lower animals but in man its most characteristic effect is to induce the feeling of drowsiness, which has led to its experimental use as a hypnotic [3] with some, but uncertain, effect. Anhalodine is also somewhat stimulant to the central nervous system but much less powerful. The characteristic effects of the mescal button seems to be due chiefly to its mescaline content. According to Grace [1] this alkaloid produces a progressive depression of the central nervous system involving the respiration, the motor reflexes, and the circulatory apparatus. In experiments on human subjects it caused nausea, dizziness, dilatation of the pupil, some blurring of vision and, somewhat later, characteristic hallucinations, as well as disturbance of the olfactory and gustatory senses.

The therapeutic value of the mescal button is doubtful; it has, however been employed to a limited extent in the treatment of various forms of neurasthenia and hysteria, and it is of value in cases of asthma. It has also been alleged to be useful in the treatment of neuralgic and rheumatic affections.

1). For information concerning the chemistry of these alkaloids refer to: T. A. Heury, *Plant alkaloids*, London, J. & A. Churchill Ltd., 1949, p. 154.

1. GRACE. *J. Pharmacol.*, 1934, 50, 359.
2. HEFFTER. *Arch. exp. Path. Pharmac.*, 1898, 40, 385.
3. PILCZ. *Wien. klin. Wschr.*, 1896, 9.
4. RAYMOND-HAMET. *ibid.* 1933, 169, 97.

Papaver somniferum L. (Papaveraceae)

The air-dried milky latex obtained by incising the unripe but fully grown capsules of *P. somniferum* or its variety *album* De Candolle (white poppy) constitutes opium. It is generally believed to be derived exclusively from *P. somniferum* and its variety *album*.

P. somniferum is an annual, glabrous or glaucous herb up to 120 cm. high, indigenous to Asia, but cultivated in many tropical, sub-tropical and temperate countries. It has large oblong, serrate to dentate-serrate leaves, clasping at the base, and long peduncles with nodding buds that expand into erect flowers which, while usually purplish, are in its varieties sometimes white, pink, violet, or red. The fruits are globose capsules each with an 8-12 rayed sessile stigma and containing numerous small oily seeds. There are several varieties of this species, of which the two best known are the white and the black poppy, so named after the colour of their seeds. In white poppy the flowers are white or silver-grey; the capsule is somewhat flattened both at the top and the bottom; the seeds are white. The black poppy usually has violet flowers; the capsule is somewhat smaller and more globular, and the seeds are of a slate colour.

Although it is generally believed to be a native of the arid regions of Asia minor, *P. somniferum* grows wild in southern Europe and even in England. It is at present cultivated extensively in India, Persia, Turkey, Yugoslavia, Macedonia, Bulgaria, China, Manchuria and Asia Minor for opium, and in other parts of Europe for the seeds.

Opium is generally obtained from plants that have been cultivated in rich, well-manured soil, in warm and temperate climates. The poppy seed, often mixed with sand, is sown broadcast over the tilled field in early autumn. In Asia Minor, about 13 ounces of seed is used to the acre. The fields are weeded in the spring when the poppy has grown to a height of about 15 cm., and the plants are then thinned out so as to stand about 60 cm. apart. They flower in April and May and the capsules mature from June to July. While nearly all parts of the poppy contain a white milky juice (latex), the unripe capsules contain this juice in especial abundance. The capsular wall is traversed by a network of branching and anastomosing latiferous vessels which contain the latex. In the green, unripe capsule this latex is richest in morphine content but, as they turn yellow and ripen, the morphine content diminishes while that of codeine and narcotine increases. Shortly after the petals and stamens fall, usually in the late afternoon or early morning while the temperature is low, transverse oblique or vertical incisions are made in the unripe capsules with a single-bladed knife having one saw edge (*dgeezguee*) or a several-bladed knife (*nushtar*), care being taken not to cut through the inner wall of the capsule lest valuable juice be lost and the seeds injured. The white juice exudes and soon hardens on the outside of the capsule into brownish masses which are scraped off the following day on to a wooden tray. The scrapings are later transferred to earthen vessels or larger trays or dumped on the ground, where the opium is kneaded by hand to a uniform consistency. It is then shaped into balls, cakes or, more rarely, sticks [6].

Commercial opiums may be classified into the following varieties: Turkish, Macedonian, Bulgarian, Persian, Indian, Chinese and Egyptian opium.

Opium varies considerably in appearance, composition and quality according to place of origin and mode of manufacture. In addition to some 25 alkaloids (mentioned below) present in opium, it contains acetic, lactic, sulphuric, and meconic acids,

gummy and pectinous substances, albumin, wax, fat, caoutchouc resin, and several other substances such as meconin, meconoisin, etc. [3]. The alkaloids, and the average opium content of some of them, are as follows :

Morphine 3-20 per cent (Serturmer, 1806)
Codeine 0.3 per cent (Robiquet, 1832)
Neopine
Thebaine 0.4 per cent (Pelletier, 1835)
Porphyroxine
Medonodine
Papaverine 0.8 per cent (Merck, 1848)
Pseudopapaverine
Codamine 0.002 per cent
Laudamine 0.01 per cent
Laudanosine 0.0008 per cent
Lathopine 0.006 per cent
Cryptopine 0.08 per cent

Papavermine
Narcotine 5 per cent (Derosne, 1803)
Canoscopine 0.2 per cent
Pseudomorphine 0.2 per cent
Tritopine 0.0015 per cent
Hydrocotarnine
Narceine (Pelletier, 1832)
Rhocadine
Protopapaverine
Laudanidine
Oxynarcotine
Protopine

The opium alkaloids are divided into two groups : (a) The phenanthrene-pyridine group comprising morphine, codeine, pseudomorphine, neopine and thebaine ; (b) the benzyl-isoquinoline group, consisting of papaverine, narcotine and most of the remaining alkaloids. The members of the first group are very strong bases and very poisonous, while the second group as a whole has less marked physiological action. Opium is evaluated according to the amount of morphine contained in the sample—this being the most abundant, and physiologically the most active, of the alkaloids [2].

The narcotic and analgesic action of opium is primarily due to its morphine content, the other alkaloids present being responsible for its secondary effect. The important alkaloids have, in all cases, a narcotic action, decreasing in the following order: morphine, papaverine, codeine, narcotine, thebaine. On the other hand, the effect on the reflexes is a gradually increasing characteristic of the last-named members of the group until, in thebaine, the stimulating action on the spinal cord entirely counteracts the depressant action on the cerebral hemispheres. The action of opium is exerted less rapidly than that of morphine, as absorption appears to take place less easily. Narcotine and papaverine relax the intestinal muscle, in strong contrast to morphine and codeine which increase its tone ; this action is a contributing factor to the greater constipating effect of opium as compared with that of morphine. Preparations of opium are therefore preferred in the treatment of diarrhoea and intestinal disorders [1].

According to Macht [5] narcotine differs essentially from morphine in its action upon the respiratory centre, acting as a stimulant rather than a depressant. Dikshit [4] reported that narcotine, like papaverine, inhibited the intestinal peristalsis, but was not sufficiently active to be clinically useful for this purpose.

1. Anonymous. *The British Pharmaceutical Codex*, London, The Pharmaceutical Press, 1954, p. 518.
2. ——. *The United States Dispensatory*, Philadelphia, J. B. Lippincott Co., 1955, p. 929.
3. CHOPRA *et al.* *Indigenous drugs of India*, Calcutta, U. N. Dhur & Sons, 2nd ed., 1958, p. 208.
4. DIKSHIT. *Indian J. med. Res.*, 1932, 19, 765.
5. MACHT. *J. Pharmacol.*, 1915, 7, 339.
6. YOUNGKEN. *A text book of pharmacognosy*, Philadelphia, P. Blackinton's Son & Co., 1936, p. 338.

Peganum harmala L. — Wild Rue (Zygophyllaceae)

A bushy herb 30-90 cm. high with a thick perennial root stock. The leaves are irregularly divided, the flowers are white with sepals persistent, exceeding the corolla ;

the fruit is a capsule, depressed at the apex. The plant is found in the dry Mediterranean regions of Europe and Africa and also in Tibet.

The seeds and roots contain four alkaloids: harmaline, harmine, harmalol, and peganine, which appears to be identical with vasicine (from *Adhatoda vasica*). The first three of these are closely related chemically, harmaline being a methoxy-harmalol and dihydroharmine [3].

The seeds have been used medicinally since the time of Dioscorides. In India they are employed as an anthelmintic and a narcotic. The physiological effects of the seeds have been studied by Gunn and his co-workers [2], the most important being a primary stimulation of the motor tracts of the cerebrum and probably also of the spinal cord, causing coarse tremors and clonic convulsions. There is perhaps at this stage also some excitation of the intellectual functions. Later, poisonous doses lead to a depression of the central nervous system, accompanied by motor weakness, failing respiration, low blood pressure, due largely to weakness of the heart muscle, and fall of temperature. They appear also to have a depressant action on the contractility of the non-striated muscles. The convulsive effects are apparently due to harmine and harmaline. Harmalol causes a progressive paralysis without primary stimulation. The alkaloids are toxic to several lower forms of animal life, notably helminths and protozoa [1]. The drug has also been of medical interest because of its effect in encephalitis lethargica as a stimulant to the central nervous system [4, 5]. Harmaline, in a concentration of 1 in 25,000, applied to the heart of a frog reduced the cardiac activity and caused bradycardia; harmine has practically the same action as harmaline [6].

1. GOULTHARD. *Biochem. J.*, 1934, 28, 264.
2. GUNN. *Arch. int. Pharmacodyn.*, 1935, 50, 279.
3. HENRY, T. A. *The plant alkaloids*, London, J. A. Churchill Ltd., 1949.
4. MARINESCO. *Arch. exp. Path. Pharmac.*, 1930, 154, 301.
5. MULLER. *Med. Klinik*, 1931, no. 17.
6. OVEJER. *Farmacoter. act. (Madrid)*, 1946, 3, 842.

Pergularia extensa N.E. Br. = *Daemia extensa* R. Br. (Asclepiadaceae)

This is a perennial twining shrub found throughout the hotter parts of India and also in Afghanistan. In Indian medical practice it is given internally in asthma, amenorrhoea [1] and applied locally to rheumatic swellings.

Dymock [3] mentioned the presence of an alkaloid which he designated as duemine. Dutta and Ghosh [2] isolated from the whole plant three sterols in pure state, and the fourth in a fairly pure state. They could not find any alkaloid reported previously, but they obtained 24 per cent of inorganic salts consisting mainly of potassium nitrate and potassium chloride. In addition a bitter resin is present and three bitter substances, one glucosidic in nature. The bitter principle A has been found to be inactive, principle B somewhat active, and principle C most active.

P. extensa compares favourably with pituitrin in its action on the uterus and produces the same intensity of contraction. Pituitrin acts with equal intensity on the upper and lower segments of the uterus, while *Pergularia* produces earlier and well-marked contraction in the upper uterine segment only, quite similar to the contractile processes of normal labour. Its use in the first stage of labour is rational [1]. Unlike pituitary extract progesterone does not appear to inhibit the action of *Pergularia* on the uterus. Clinical trials with *Pergularia* have not been reported so far. *Pergularia* exerts a stimulating effect on the smooth muscle of the intestines. The gastric secretions are stimulated and these increase the total acidity of the gastric juice.

Pergularia appears to have a generalized stimulating effect on the involuntary

muscles, both plain and striated, and produces a pronounced effect on the circulatory system, raising the arterial blood pressure. The tone and movements of the urinary bladder are increased. The stimulant action of *Pergularia* appears to be due partly to direct stimulation of the involuntary muscles and partly to the stimulation of post-ganglionic cholinergic nerves.

1. CHOPRA *et al.* *Indigenous drugs of India*, 2nd ed., 1958, Calcutta, U. N. Dhur & Sons.
2. DUTTA ; GHOSH. *J. Amer. pharm. Ass.*, 1947, 250.
3. DYMCK, W. ; WARDEN C. J. ; HOOPER, D. *Pharmacographia Indica*, London, Trubner & Co. 1891, vol. II, p. 442.

Psysochlaina praealta (Don.) Miers (Solanaceae)

This is a perennial glabrous herb, 0.6-1.3 m. in height, with corymbose erect. The leaves are 10-15 × 8 cm., petioled; the flowers are pedicelled; the calyx lobes lanceolate; the corolla is tubular-funnel-shaped and the capsule 1.25 cm. in diameter. The plant grows in the inner dry district of Ladakh at altitudes of 10,000-16,000 ft. It is also reported to be found in Sinkiang (China).

In their search for alkaloids, workers of the Drug Research (now the Regional Research) Laboratory, Jammu, first isolated 1.02 per cent of alkaloids, 80 per cent of which is hyoscyamine from the leaves of the plant [3]. The roots were later found to contain 0.64 per cent alkaloids calculated as hyoscyamine [2]. On further investigation, leaves were found to contain 0.01 per cent of hyoscyamine and fairly large amounts of chloride, nitrate and sulphate of potassium [4]. Hyoscyamine is a good source for the manufacture of atropine and other related alkaloids. The presence of these alkaloids has also been confirmed by biological experiments [1].

The annual output of the dry leaf from the whole of Ladakh district is estimated to be 50,000 lb. Since the area is rather inaccessible it is possible to assure a supply of only half this quantity. The plant is reported to be easily cultivated at suitable places in Ladakh, and the annual output could be considerably increased according to the demand. The plant is considered to be poisonous to horses but not to livestock, and it is sometimes harvested and dried as winter fodder. Some plants bear black sclerotia which are much more poisonous. The seeds are used by the local people as a vermifuge to eradicate round-worms, and as an emetic in cases of bilious attack. The leaves are applied to boils.

Attempts were made to cultivate the plant in more accessible regions, at a lower altitude of 5,000 ft. Although the alkaloidal percentage is lower in plants cultivated at a lower altitude than in those of the original habitat (above 10,000 ft.), the content of the active principle tends to rise with the maturity of the plant.

1. CHOPRA *et al.* *Bulletin Nat. Inst. Sci. (India)*, 1955, no. 4, 25.
2. HANDA. *J. sci. industr. Res.*, 1952, 11B, 505.
3. — *et al.* *ibid.*, 1951, 10B, 182.
4. — *et al.* *ibid.*, 1952, 11B, 505.

Pimpinella anisum L. — Anise (Umbelliferae)

Anise is an annual plant, about 30 cm. high, with an erect, smooth, branching stem. The lower leaves are rounded-cordate, lobed, incised-serrate; the middle are pinnate-lobed with cuneate or lanceolate lobes; the upper are trifid, or undivided linear. The

flowers are small, white, and in terminal compound umbels, without involucre. The fruit is a mouse-shaped cremocarp.

The anise plant is a native of Egypt and of the Levant, but it has been introduced into southern Europe and is cultivated in all warm climates, especially in the U.S.S.R., Germany, Italy, Spain, France, Bulgaria, Turkey, India, Tunisia, Syria, Chile and Mexico.

A light, well drained, fertile or moderately rich sandy loam is the most suitable soil for the growth of anise. It is grown from seed usually sown in spring directly in the field since transplanting has a harmful effect. The seeds, which should not be more than two years old, are sown two to the inch (2.5 cm.) at a depth of half an inch (1.25 cm.). When 5-8 cm. high, the seedlings are thinned to stand 15 cm. apart in the row. Rows may be 0.5-1 m. apart. About 2 kg. of seed will plant an acre, with rows 1 m. apart. The plants must be cultivated frequently and thoroughly throughout the growing season [3].

According to Crooks and Sievers [1] the plants are pulled out and stacked in the field to dry; in some cases the tops are cut off by hand, tied in bundles, and then stacked in conical piles with the fruiting heads towards the centre so that the seed continues to mature. The harvesting of anise presents a difficult problem owing to the progressive ripening of the umbels and to the uneven ripening of seed within each umbel. As a rule the plant is either pulled or cut when all the seeds of the umbel are still green. Under favourable conditions, a yield of 200-300 kg. of seed per acre may be expected.

The ripe fruit of anise gives a volatile oil called anise oil. The yield of oil varies from 2 to 3 per cent. The chief constituent of the oil is anethole (80-90 per cent). Other constituents are methyl chavicol and anisketone [2].

Anise oil is a mild aromatic carminative and is occasionally employed to stimulate peristalsis in cases of flatulent colic. The oil is, however, widely used in the flavouring of culinary preparations, pharmaceuticals, tooth-pastes and mouth-washes.

1. CROOKS; SIEVERS. *Condiment plants*, United States Department Agr., Bur. Plant Ind., July 1941.
2. GUENTHER, E. *The essential oils*, New York, D. Van Nostrand Co., 1953, vol. IV.
3. STOCKBERGER. *Drug plants under cultivation*, 1935. (*United States Dept. Agr. Farmers Bull.* no. 663.)

Plantago (Plantaginaceae)

Plantago seed is the dried, ripe, cleaned seed of *Plantago psyllium* L. or of *P. indica* L., known commercially as Spanish or French psyllium seed, or of *P. ovata* Forsk., known commercially as blond psyllium or Indian plantago seed.

P. psyllium L. An annual, erect, glandular, hairy, caulescent herb native to Mediterranean countries, such as Greece and Egypt. It bears flattened, linear to linear-lanceolate leaves with peduncles rising from the upper axils and terminating in ovate capitate spikes.

P. psyllium L. is extensively cultivated in France, where the planting takes place early in March, the plants maturing about the end of August. When the entire field is about three-quarters mature the plants are mowed between dawn and 8 a.m. when the dew is heaviest, so as to prevent many of the seeds from falling during the mowing operation. The plants are allowed to partially dry in the sun, and are then transported to the threshing floor. After threshing the seeds are cleaned by means of blowers [3].

The seeds contain the glucoside, acubin; the enzymes, invertin and emulsin; and a mucilaginous substance called xylin. They also contain oxalic acid and mucic acid [1]. Hepburn and Laughlin [4] report the presence of crude fat, fibre, protein, gums, etc. The gums contain pentosans and galactans.

P. indica L. = *P. arenaria* Waldstein and Kitaibel, *P. ramosa* Gilib. An annual, much branched, glandular, hairy herb whose distribution is similar to that of *P. psyllium*.

P. ovata Forsk. is an annual, acaulescent herb native to the Indian sub-continent and extensively cultivated in the north-western provinces and to a lesser extent in Persia and various Mediterranean countries. The plant bears sessile, linear-lanceolate to lanceolate leaves. The flowers are small and crowded on short cylindrical-ovate to oblong spikes terminating in long woolly peduncles. The seed is collected by nomadic tribes in the Punjab and the north-western frontier provinces of Pakistan.

Plantago seed is used in medicine almost exclusively in the treatment of chronic constipation and dysenteric disorders. The efficiency of the drug would appear to be entirely due to the large quantities of mucilage it contains. The seeds of *P. ovata* have been exhaustively examined by Chopra [2]. The glucoside, acubin, is physiologically inactive. The tannins which are present in appreciable quantities have little action on the entamoebae and bacteria. The digestive enzymes act on the mucilage to a very limited extent, especially when it is on the seed. It thus passes through the small intestine unchanged and during its passage lines the mucous membrane, acting as a demulcent and lubricant. During its passage it coats the inflamed and ulcerated mucosa and protects it from being irritated by fluids and gases thus enabling lesions to heal quickly. The mucilage exerts an inhibitory action on such bacteria as *B. shiga*, *B. flexner*, *B. coli*, and other faecal organisms. Further, being of colloidal nature, it has a remarkable power of absorbing bacterial and other toxins.

Clinical trials by Chopra [2] show that plantago seed is very beneficial in cases of chronic dysentery of amoebic and bacillary origin and in chronic diarrhoea due to irritative conditions of the gastro-intestinal tract.

As the seeds are indigestible their retention in the intestines may form a nucleus for mechanical obstruction and at least two such cases have been recorded. To minimize the possibility of harmful effects, the seed should be soaked in water for several hours before ingestion. The seeds should not be ground or masticated it has been demonstrated in experimental animals that when comminuted and then ingested they released a pigment which deposited in the renal tubules, although no effect was observed on the urea clearance, the phenol-sulfonphthalein excretion or the microscopic appearance of the urine [5].

1. Anonymous. *The United States Dispensatory*, Philadelphia, J. B. Lippincott Co., 1955, p. 1071.
2. CHOPRA, R. N. *Indian med. Gaz.*, 1930, 65, 628.
3. GATHERCOAL, E. N.; WIRTH, E. H., *Pharmacognosy*, Philadelphia, Lea & Febiger, 1936, 671.
4. HEPBURN; LAUGHLIN. *Amer. J. Pharm.*, 1930, 102, 565.
5. THIENES; HALL. *Amer. J. dig. Dis.*, 1941, 8, 307.

Rosmarinus officinalis L. — Rosemary (Labiatae)

Rosemary is an evergreen shrub with erect stems divided into numerous long, slender branches bearing many sessile, opposite leaves, about 2.5 cm. long. These are rigid and green on the upper surface, woolly, whitish and glandular beneath. The margins are revolute, and the midrib is very prominent on the lower surface. Rosemary bears

verticillasters of mauve flower. The upper tip of the corolla is 2-lobed and the lower 3-lobed; only the anterior pair of stamens develop.

The plant is indigenous to Southern Europe, it grows wild and abundantly in lime soil on arid and sunny mountain slopes, especially in Spain, Dalmatia, Tunisia, Morocco, and southern France. Since the price of the oil has always been low, rosemary is not cultivated except for ornamental purposes.

Rosemary yields about 1 to 2 per cent of volatile oil which contains 0.8 to 6 per cent of esters calculated as bornyl acetate, and 8 to 20 per cent of total alcohols calculated as borneol [1].

Because of their aromatic taste, the leaves are employed as a condiment in seasoning European dishes and sauces. They are also considered to be emmenagogue and gently stimulant. Oil of rosemary has been used chiefly in combination with other drugs as a carminative. It is also employed as an ingredient in rubefacient liniments and as a perfuming agent.

1. GUENTHER, E. *The essential oils*, New York, D. Van Nostrand Co., 1949, vol. III.

Salvia officinalis L. — Sage (Labiatae).

Sage is a hardy perennial, a low shrub or sub-shrub; the leaves are oblong-lanceolate or ovate, 2-10 cm. $\times$ 1.25 cm., with the upper surface greyish-green and the under surface light greyish-green. The flowers are blue; the fruits consist of black nutlets, borne in open cups.

Salvia officinalis grows spontaneously in the form of low bushes and tufts on bold, rocky, barren and sunny hillsides of the Dalmatian Islands and on the adjacent Adriatic coast. It is cultivated in the state of Washington and in the neighbourhood of Tarzana, California, where the soil and climatic conditions are similar to those of Dalmatia. It grows in a wide range of fertile, well drained soils provided they are supplied with sufficient nitrogen. The best soil, however, is a rich clayey loam, light sandy soil being unsuitable. According to Stockberger [2] the seeds should be sown in early spring in rows from 60-90 cm. apart; the seedlings should be thinned later to stand about 30 cm. apart. Seedling plants have a tendency to produce narrow leaves which give a lower yield. The proper way to grow sage in order to achieve a uniform and good quality is to take cuttings from a desirable type; this is the method usually employed. The cuttings set as early in the spring as weather conditions permit, and yield a large crop. Only one picking should be made the first year, after which two or three pickings may be made in one season for the following five or six years.

Harvesting is a rather tedious and delicate task since not all the leaves are desirable. When not cut properly the plant is likely to perish; hence harvesting machines are not employed and the leaves are hand-picked like tea. Young plants that have not yet reached the flowering stage contain the largest amount of oil and have the finest aroma. The leaves are placed on large canvas sheets, thoroughly dried, and carefully stored in bags. The harvesting starts early in June, and continues throughout the dry season up to the beginning of September.

Sage contains a volatile oil. At the beginning of the harvest the yield of oil runs as high as 2 per cent, but it decreases towards the end of the harvest to about 0.7 per cent, the average yield being 1.4 per cent. Dalmatian sage oil contains salvene, *d*- α -pinene, cineole, *d*- β -thujone, *l*- α -thujone borneol, *d*- α -camphor [1].

The highly aromatic leaves, after drying, are widely used for seasoning dishes and canned foods. Sage is a stimulant and a carminative; it also possesses astringent and mild antiseptic properties and is therefore used as a gargle. The volatile oil is employed

as a convulsant, resembling in its action the oil of wormwood, but less powerful. Sage oil, however, is mostly used for flavouring foods.

1. GUENTHER, E. *The essential oils*, New York, D. Van Nostrand Co., 1949, vol. III.
2. STOCKBERGER. *Drug plants under cultivation*, 1935, 31 p. (*United States Dept. Agr. Farmers' Bull.* no. 663.)

Selenicereus grandiflorus Brit. and Rose — Night-blooming cereus (Cactaceae)

This is a large fleshy, perennial, creeping and climbing vine, with terete, usually 7-9 sided stems, bearing occasional adventitious roots and terminal and lateral flowers 20-30 cm. in diameter, exhaling a vanilla-like odour. It is a native of Jamaica and is frequently grown in hot-houses.

Sultan [3] claimed to have isolated from this plant an alkaloid cactine, but subsequent investigators have not confirmed his findings.

The drug has long been used in tropical America in the treatment of dropsy and it has been recommended as a cardiac remedy. Hatcher and Bailey [2], however, reached the conclusion that it is physiologically inert. Gordon Sharp [1], on the basis of a review of the literature and his own extensive clinical trials, reached the conclusion that the drug was therapeutically useless. It has nevertheless had some use in various neurogenic disturbances of cardiac rhythm such as accompany Graves' disease, nicotinism, neurasthenia and allied affections.

1. GORDON SHARP. *Practitioner*, 1894, 53.
2. HATCHER; BAILEY. *J. Amer. med. Ass.*, 1911, 56, 26.
3. SULTAN. *Amer. J. Pharm.*, 1891, 424.

Solanum (Solanaceae)

From most of these species one or another of several steroid alkaloids, usually also glucosidal in character, have been isolated. The chemistry of these was, until recently, obscure.

S. carolinense L. A common perennial herb, popularly called horse nettle, which propagates extensively by rhizomes and grows in dry fields throughout the central and eastern United States. The stem is erect, branched, rough-pubescent, and covered with stout, yellowish prickles. The leaves are oblong-ovate, sinuate-lobed, hairy and prickly like the stem. The flowers are regular and arranged in unilateral racemes. The corolla is violet and the stamens are exserted and yellow. The fruit is an orange yellow berry 7-20 mm. in diameter.

The berries are actively poisonous, and the toxic principle appears to be solanine [6]. An organic acid called solanic acid is also present. The plant contains an alkaloid solanine which has an acrid and bitter taste and leaves a persistent tingling sensation on the tongue [2]. According to Thornton [5] it causes stupor and spinal convulsions. It has long been used, especially in the southern United States, in the treatment of epilepsy [6]. It is claimed that the plant has antispasmodic and sedative properties.

S. xanthocarpum Schrad. and Wendl. An annual, low, diffuse herb, with more or less scattered rough hairs; the stems are prickly, procumbent and branching. The leaves are ultimately glabrous, oblong, pinnatifid, with nerves on both surfaces armed with

numerous long, straight prickles. The flowers are blue, solitary or in small cymes. The berries are glabrous, 12 mm. in diameter, yellow often blotched with green. It is found throughout India and also in Sindh, Rajputana and other arid regions.

The roots of the plant are considered to have expectorant properties and are used in the treatment of cough, asthma, catarrhal fever, and chest pain. The juice of the berries is considered to be useful in the treatment of sore throat and a decoction of the plant is given in cases of gonorrhoea. Leaves are applied locally to relieve pain and the juice of the leaves with black pepper is used in the treatment of rheumatism. Fruits yield carpesterol and 1.3 per cent of gluco-alkaloid solanacarpine and alkaloid solanocarpidine [5]. Brigg [2] obtained gluco-alkaloid solanacarpine from the seed and believed it to be identical with solasonine.

The alkaloids which are called solanines possess the toxic properties characteristic of the saponins. When introduced into the blood stream they produce destruction of the red corpuscles, vomiting, diarrhoea, eventual paralysis and coma, sometimes preceded by violent convulsions [1]. According to Hano [4] who compared the physiological effects of solanine and solasonine, the haemolytic properties are about equal. Both are stimulating to non-striated muscle, and in large doses cause tonic spasm of the muscles. Solanine stimulates the heart while solasonine depresses it.

1. Anonymous. *The United States Dispensatory*, 1955, 1866.
2. BRIGGS. *J. Amer. chem. Soc.*, 1937, 59, 1404.
3. GATHERCOAL, E. N. ; WIRTH, E. H. *Pharmacognosy*, Philadelphia, Lea & Febiger, 1936, 561.
4. HANO. *Bull. Ges. Physiol. exp. Pharm.*, 1937, 99, 674.
5. SAIYED ; KANGA. *Proc. Indian Acad. Sci.*, 1936, 4A, part II, 255.
6. THORNTON. *Ther. Gaz.*, 1896, 12.

Thymus vulgaris L. — Thyme (Labiatae)

This pubescent sub-shrub has more or less curved stems, the leaves are lanceolate or ovate-oblong, 1-10 mm. $\times$ 0.5-5 mm., with revolute margins and both surfaces greyish-green and glandular hairy. The flowers are in axillary clusters or in terminal glomerules; the lower calyx lobe is 2-cleft, the lobes having awl-shaped, linear divisions; the four stamens are exserted.

Thyme is indigenous to the Mediterranean countries, growing profusely on arid mountain slopes in the south of France, Spain, Algeria and in Morocco. It is also grown in gardens in Europe and the United States for culinary purposes. The largest production of thyme oil comes from wild plants growing in Spain, in the provinces of Almeria and Murcia. The harvest takes place during the blooming period of the plant, i.e., from July to August. The harvesting of thyme is even more tedious than that of lavender or rosemary. The leaves and flowering tops are used for distillation. Thyme yields from 1 to 2.6 per cent of yellowish-red volatile oil [1]. The yield of oil from Spanish field-stills is only about 0.73 per cent, owing to the primitive distillation method used. The chief constituent of the oil is thymol—usually 20 to 30 per cent, and sometimes about 50 per cent. Other constituents of the oil are carvacarol, isomeric with thymol, linalool, *l*-borneol, pinene, etc. [2].

Thyme is a stimulant, a carminative and a condiment. Oil of thyme is a powerful germicide which has a pleasant odour and is used in many pharmaceuticals, gargles and mouth-washes. The oil causes mental excitement and serves as a diffusible stimulant in cases of collapse. Thymol is an antiseptic, a parasiticide and a deodorant. It is anthelmintic, and is especially useful in the treatment of hook-worm [1].

1. GATHERCOAL, E. N. ; WIRTH, E. H. *Pharmacognosy*, Philadelphia, Lea & Febiger, 1936, 852.
2. GUENTHER, E. *The essential oils*. New York, D. Van Nostrand Co., 1949, vol. III.

Urginea maritima Baker and *U. indica* Kunth — Squills (Liliaceae)

Squills are the fleshy inner scales of the bulb, cut and dried, of the white variety of *U. maritima* (L.) Baker, or of *U. indica* Kunth, known in commerce respectively as white or Mediterranean squill, and Indian squill. *The Indian Pharmacopoeia* recognizes the same substance as squill bulb.

U. maritima = *U. scilla* Steinh. A perennial herb, with fibrous roots proceeding from the base of a large bulb, which sends forth several long, lanceolate, pointed, somewhat undulated, shining, deep-green leaves. From the midst of the leaves a round, smooth, succulent flower-stem rises, 30-90 cm. high, terminating in a long, close spike of whitish flowers. The fruit is an oblong 3-lobed capsule. This species of squill grows in sandy soil along the sea coast of Spain, France, Italy, Greece, and other countries bordering on the Mediterranean. The bulbs are collected in August; the roots and dry membranous outer scales are removed, and the bulbs are cut transversely into slices which are dried in the sun or by heating before they are packed in casks. The fresh bulb of *U. maritima* is pear-shaped, weighing as much as 5 or 6 lb. The bulb contains a viscid, very acrid juice, which inflames and even excoriates the skin. Drying attenuates this effect while only little medicinal power is lost.

A variety of squill growing in Algeria and which produces red bulbs has been extensively employed as a poison for the extermination of rats. In this red squill the outer scales are dry, brittle and deep reddish-brown, the inner scales vary from a light creamy-pink to deep purple and the central scales are usually white. It contains the same cardiac glucosides as does the white squill but in addition a substance highly toxic to rats. The chief toxic action of red squill is on the central nervous system [15]. Madaus and Koch [4] found that mice and guinea pigs are also susceptible to this poisonous effect and red squill should therefore not be used as a source of therapeutic preparations. Stoll and Renz [9] isolated from red squill scilliroside, which they claim is the toxic principle.

U. indica. A plant resembling *U. maritima* but which produces a tunicated bulb about the size of an onion. It grows in sandy soil near the sea coast throughout India and extends to the Himalaya mountains. According to Chopra and Mukerjee [2] the medicinal properties of Indian squill are similar to those of Greek squill.

Although the chemical investigation of European squill was started by Merck [5] and pursued by several others, the genuine cardiac glucosides of *U. maritima* were first isolated by Stoll and his co-workers [11]. They isolated two fractions: water insoluble containing scillaren A, and water soluble containing scillaren B. The chemistry of scillaren A has been fully analysed by Stoll *et al.* [11]. On hydrolysis it yields scillabiose (glucorhamnose) and scillaridin A. A new crystalline cardiac glucoside, scilliroside, was obtained by Stoll and Renz [10] from the red variety which is a rat poison. Indian squill has been analysed by Seshadri *et al.* [7] and found to contain scillaren A and scillaren B. In more recent studies Stoll and Kreis [8] separated from the scillaren B fraction the following cardioactive glucosides: glucoscillaren A; scillipheoside, glucoscillipheoside, scillicryptoside, scilliglaucoside, scillicyanoside, scillicoeloside and scillazaurosides. Roques [6] reported isolation of the two heterosides, urginonin and urginoside; it is not apparent whether these are identical with any of the aforementioned glucosides.

In the past century squill was a popular diuretic and nauseant; its effects were attributed to local irritation of the kidney and stomach respectively. At present, however, it is classed with the digitalis group and it is generally believed that its diuretic and emetic effects are secondary to its cardiac action. It exerts upon the heart the

characteristic effect of the digitalis glucosides. Squill is more rapid and less persistent in its effects and therefore comparatively free from danger of cumulative action [13]. White *et al.* [14] reported that there was rarely any evidence of diuresis, but Kahlen and Stoll [3, 12] found that it was more actively diuretic than digitalis. Violent vomiting and purging have been reported from overdoses of squill, but Madaus and Koch [4] claimed that local irritation caused by squill is due to the presence of raphides and is therefore not a property of the active principles of solutions of this drug.

The glucosides scillaren A and scillaren B have the following clinical effects: rapid action of short duration due to rapid excretion, and hence slight tendency to cumulative action. In terms of "cat units" these glucosides are much more active on an equal weight basis than digitoxin and other cardioactive glucosides, except ouabain and strophanthin. Unlike the crude extracts, scillaren A and scillaren B are well absorbed by the gastro-intestinal tract [1].

1. Anonymous. *The United States Dispensatory*, Philadelphia, J. B. Lippincott Co., 1955, p. 1306.
2. CHOPRA ; MUKERJEE. *Indian. med. Gaz.*, 12, 666.
3. KAHLEN. *Dtsche med. Wschr.*, 1939, 65, 1667.
4. MADAUS ; KOCH. *Z. ges. exp. Med.*, 1939, 107, 199.
5. MERCK. *Pharm. Ztg, Berl.*, 24, 286.
6. ROQUES. *Compt. rend. Soc. Biol.*, 1948, 142, 1532.
7. SESHADARI *et al.* *J. sci. industr. Res.*, 1950, 9B, 114.
8. STOLL ; KREIS. *Helv. chim. acta.*, 1951, 34, 1431.
9. — ; RENZ. *Compt. rend. Acad. Sci.*, 1940, 210, 508.
10. — ; —. *Helv. chim. acta*, 1942, 25, 43, 377.
11. — *et al.* *ibid.*, 1933, 16, 703.
12. —. *ibid.*, 1934, 17, 592, 641 ; 1935, 18, 82, 120.
13. WEBER. *Med. Welt.*, 1940, 14, 118.
14. WHITE *et al.* *J. Amer. med. Ass.*, 1920, 75, 971.
15. WINTEN. *J. Pharmacol.*, 1927, 31, 137.

PART TWO

With particular reference to the pharmacological aspects

by

R. PARIS, and G. DILLEMANN

Materia Medica Laboratory, Faculty of Pharmacology, Paris

GENERAL REMARKS

The object of arid zone research is to provide the data for planning the development of such zones and in particular to determine first what use can be made of their natural vegetation and second how far it may be possible to introduce crops useful to man.

In the domain of medicinal plants, we are concerned with species whose interest does not lie in the possibilities offered by the basic substances of which they are formed (wood, fibres) or by their food reserves such as polyholosides or lipids, the formation of which may be slowed down by arid climatic conditions owing to the nearly constant ratio, for each species, between the dry weight of the substance formed and the amount of water passing through the plant.

The active principles which usually give medicinal plants their properties belong to the category of substances generally classified today as "secondary"—alkaloids, heterosides, essences containing terpenes or phenyl-propane derivatives (cinnamics, etc.), lignans, resins, gums, etc.

The manufacture of these principles by the plant may or may not vary with the climatic conditions; aridity may be conducive to it or the contrary. We shall have to consider these questions in general terms.

The relative aridity ratings adopted are those suggested by P. Meigs [116]¹ in his Unesco-sponsored maps of the distribution of arid climatic zones in the two hemispheres.

On examining these maps, one is struck by the rarity of ultra-arid zones, true deserts, and conversely by the magnitude of the areas classed merely as arid or semi-arid. Some of the latter may indeed be called deserts by the geographer—e.g., the Kalahari and Karroo deserts in South Africa and the deserts of Central Australia—but climatologically they fail to qualify as such.

Obviously these regions of less than maximum aridity are the ones for which surveys of the native vegetation and investigations of what exotic plants could be introduced would be most valuable. It is there that a reasonably varied flora is to be found and that the possibilities of acclimatization are probably the best. As Leroy [102] remarks: "it is perhaps over-ambitious to try to grow plants useful to man in areas where the rainfall is below 200 millimetres per year" and indeed the

1. The figures in brackets refer to the bibliography at the end of the chapter.

development of the great area of less arid land alone is a task which may take generations.

INFLUENCE OF ARIDITY ON THE CONTENT OF ACTIVE PRINCIPLES IN PLANTS

A plant's disposition to manufacture certain secondary principles is governed by two sets of factors: intrinsic, i.e., the qualities hereditary in a particular species or breed; and extrinsic or environmental, i.e., soil and particularly climate.

Intrinsic factors. A plant manufactures a particular principle only if it inherits the disposition to do so. However, this power may be latent only, i.e., the principle will be manufactured only in very specific climatic conditions. Henrici [78] gives a typical instance of the effects of drought on plants—though not, in this case, medicinal plants—from South Africa: when wilting under the dry conditions after the rainy season, certain Gramineae develop the power to manufacture cyanogenetic substances which (so far, at least, as is determinable by reaction tests of considerable sensitivity) they lack most of the time. Again, this property may not be shared by all the individuals of a species but be found only in certain strains: within certain species chemically variant strains are distinguishable, identified by the presence of a principle not found in other strains of that species. Examples of this phenomenon—for alkaloid, essence and heteroside forming plants—were given during a symposium held at Wageningen in September 1957 [1]. Lastly, marked differences in the power to secrete a particular principle are observable between individuals of the same species or strain.

It was originally assumed that the extrinsic factors were the more important, but modern research on the cultivation of medicinal plants, on phanerogamia, on bacteria, and on actinomycetes and penicillium, which produce antibiotics, has demonstrated the primacy of the intrinsic factors, i.e., of the culture or strain.

Extrinsic factors. Much work has been done on various medicinal plants to determine the most favourable conditions for maximum yields of the active principle. For these questions the reader is referred to the reports of the 1957 Wageningen symposium [1], at which one of the subjects was the influence of external factors, and to reviews by Fluck on the influence of soil [61] and climate [62] on the active principles in medicinal plants.

In the case of arid zone plants, the question has to be asked whether or not the edaphic and ecological conditions in a particular area are conducive or not to the formation of principles usable in medicine; the method of attack and the "status" of the conclusions will both differ accordingly as the object in view is to find local plants with possibilities or to introduce exotics from other regions.

Whether or not a given arid or semi-arid zone favours plants with specific chemical features can only be established by methodical surveys like those carried out by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia or by the Office de la Recherche Scientifique et Technique d'Outre-Mer (ORSTOM) in French Africa. Thus, it is only after the chemically interesting plants have been identified that statistics can be compiled or rules formulated about their behaviour and the results, while they will of course represent a contribution to phytogeography, will not be much help towards the discovery of similarly useful plants in other regions.

On the other hand, appreciation of the optimum climate or edaphic conditions for high concentrations of the principle which constitute a plant's sole interest will be an essential preliminary to the introduction of that plant into other regions, or even to widening its natural radius.

General data on the influence of arid climates on the amount of medically useful principles in plants are scarce. Most of the information available has already been reviewed by Fluck [62]; it covers plants containing alkaloids, essential oils and mucilaginous materials. This information is outlined briefly below.

Plants containing alkaloids. McNair [115] has calculated the percentages of families with species secreting alkaloids for four types of climate, ranging from the tropical to the temperate. The results reflected the influence not of relative rainfall but of temperature on the distribution of these families and therefore have nothing to contribute to the arid zone question.

Webb's [189] statistics of the flora of Australia, based on the findings of the survey referred to earlier, give figures of "alkaloid" species in the different ecological formations, which indicate that the proportion of such species to other vegetation is lowest in the arid regions; but the phenomenon is interpreted as being the result not of climatic but of edaphic factors and in direct relation to the low estimated nitrogen content of these soils (maximum 0.053 per cent) attributable to the paucity of cover vegetation.

However, Webb's interpretation is challenged by the investigations in the true deserts of Africa by Killian and Feher [94], who concluded from their study of the nitrogen content of the soil that the high total content of N and the constant occurrence of nitrates prove that desert soils not only contain nitrogen-fixing and nitrifying organisms but that those organisms are in the active state. We can also cite Emberger's [49] judgement that their research had shown that "... the potential fertility of even the most arid soils is considerable".

In reality, Webb's figures [189] should be compared with those of the mean nitrogen contents of the soils which, according to Scheffer [166], range from 0.1 to 0.3 per cent, but with a large proportion—up to 98 per cent of the total content—in the form of non-assimilable organic nitrogen. Killian and Feher [94] were "surprised to find the various bacteria involved in the nitrogen cycle, more particularly the nitrifying and denitrifying nitrogen-fixing species, invariably present, as also in the majority of other desert soils". This may improve the ratio of assimilable to total nitrogen which would explain the difference between their conclusions and Webb's. It would be interesting to ascertain accurately the exact value of this ratio in desert soils.

Furthermore, while "alkaloid" species are relatively few in number in arid zones some are found (e.g., *Ephedra*, *Echinocactus*, *Duboisia*, *Hyoscyamus*, *Peganum*, *Anabasis*) with alkaloid contents which are on occasion very high. It would thus appear legitimate to infer that the nitrogen level of arid soils is no bar to the secretion of alkaloids by plants genetically equipped to do so. When we come to consider *Hyoscyamus muticus*, we shall see that climate seems to have a much greater influence on the alkaloid content, though its exact degree can only be determined by studying a single clone or a single pure strain to discount the idiosyncracies of individual plants.

Plants secreting essences. The secretion of essential oils by certain plants appears to play a part in protecting them against drought. This suggests that the property is a xerophytic characteristic and in fact plants secreting essential oils appear to be more numerous in arid than in humid habitats. For the whole of this question the reader is referred to the digest and commentary by Fluck [62] already mentioned, which recalls Rovesti's interpretation in terms of osmotic pressure and Theodoresco's argument that the essential oils form a film which lowers the vapour pressure. Independently of these questions of the distribution of oil-bearing plants and of their possible protective mechanisms against aridity, Rovesti has also investigated the influence of aridity on the composition of the essences. In the article cited the relationship

between levels of aridity and of essence content does not appear to have been examined.

Mucilaginous plants. Species with mucilaginous vegetative organs are likewise more abundant in the arid regions and the mucilage probably also plays a part in water retention. Killian and Lemée [95] remind us that, contrary to the original assumptions on the point, the osmotic pressure of the cell sap of many arid zone plants is low and a much more important factor in water retention is represented by the hydrophile cellular colloids. This can be related to the formation of gums in certain xerophile species, the more so as it is a well established fact, as we shall see with the *Acacias*, that the production of the gum is contingent on low atmospheric and soil humidity [140].

ITEMIZED STUDY OF MEDICINAL PLANTS OF THE ARID ZONES¹

Gnetaceae

Ephedra. Originally a very ancient drug "Ma-huang" was prepared from several Chinese species of the *Ephedra* genus. Nowadays some of these and other species are used for the extraction of ephedrine, a sympathomimetic alkaloid. Being of fairly simple structure, ephedrine can in practice be synthesized on a commercial scale, and a number of methods are known. However, while synthesization of racemic ephedrine is fairly simple—and it is in fact manufactured in this way in a number of countries—the further processes needed to obtain laevorotatory ephedrine presents certain complications (especially as it is impossible to racemize the dextrorotatory isomer). Hence extraction of the natural alkaloid is at present cheaper than synthesis.

The alkaloid contents of the different species of *Ephedra* vary widely, being nil in some and as high as 2 per cent in others. Further *l*-ephedrine is not the only alkaloid found in these species in which *d*-pseudo-ephedrine and the normal and methyl derivatives of both have also been identified. As all pharmacopoeias insist, only those alkaloid-rich species in which *l*-ephedrine predominates (up to 80 per cent of total alkaloid content) can be used for extraction.

Of the thirty-odd species of the genus, the first to be used were two natives of northern China, *Ephedra sinica* Stapf and *E. equisetina* Bunge. The course of international affairs later led to the use of three Indian species—*E. gerardiana* Wall. (= *E. vulgaris* Hook f.), *E. nebrodensis* Tineo (= *E. major* Host.) and *E. intermedia* Schrenk and Meyer with its *Tibetica* variety (Chopra *et al.* [33] and Garland [64]). In general, these species are richer in ephedrine than the Chinese, *E. nebrodensis* having the highest and *E. intermedia* the lowest yield. *E. nebrodensis*, incidentally, is also found in Spain. In consequence of a succession of political crises which made supplies of these species difficult to obtain, research was begun on the *Ephedra* of Europe, Africa and the Americas. Of the seven known American species (*E. nevadensis* Wats, *E. californica* Wats, *E. trifurca* Torrey, etc.), none, according to Nielsen and his colleagues [123], contains alkaloids. As regards the African species, Laffargue [100] says that *E. vulgaris* is widely distributed in Egypt but details of its alkaloid content do not appear to have been published; the remainder have been cited, notably by Narbonne [121]. Fahmy and El Deeb [57] state that *E. alte* (*E. alata*?) of the Egyptian desert contains no ephedrine but in *E. alata* Decne var. *alenda*, from the Sahara *d*-pseudo-ephedrine has been found (see Chevalier [31]). (Unpublished report of the Laboratoire de Matière Médicale de la Faculté de Pharmacie de Paris.)

1. This study covers the phanerogamae only, Engler and Rendle's classification is followed.

The *Ephedra* are creeping or climbing shrubs similar in form to the Horsetails. They are highly ramified with very small scaly leaves growing at the nodes.

Lucienne George [69] has made an exhaustive anatomical study of the *Ephedra* and claims that they are "distinguished by a strongly xerophytic structure". The xeromorph characteristics of these species are sinking of the stomata below the general level of the epidermis, thickened and often resin- or wax-covered cuticle, squamous leaves, occasionally linear but usually of very small size.

The habitats of the species are perfectly congruous with their morphological characters. The species of the *Alatea* sub-genus include highly xerophyte Saharan species, and the American species are found mainly in arid or alkaline areas, in deserts and on mountain slopes. Precise information on habitat has not been given for all species.

Ghosh and Krishna [70] also suggest that dry conditions favour a high alkaloid content: they have found that Indian species growing in humid areas are poor in alkaloid and that the content is always low during the rainy season, rising later.

For a species to be of interest for ephedrine extraction it is therefore necessary first and foremost that it has inherited the tendency to secrete it; thus in India itself, *E. foliata* Boissier produces no ephedrine. Another necessity is a dry climate promoting ephedrine secretion and the harvest must follow immediately after the driest period of the year.

There would therefore seem to be little prospect of being able to use species other than the four or five now known as ephedrine sources. Attempts at acclimatization are of course possible and examples from Australia have been reported by Barnard and Finnemore [10]. The results appear to have been encouraging but these writers give no information as to the climate of the regions of cultivation. Similar experiments might be tried in semi-arid regions but present no obvious interest.

After a period in the forefront of medical fashion, particularly for affections of the ears, nose and throat, it is now less used and a number of other synthetic vasoconstrictors are preferred.

Liliaceae

Liliaceae secreting alkaloids; species yielding colchicine. Colchicine, an alkaloid of the tropolone group, has had a reputation for some twenty years past for its antimitotic properties. Much research has been done on the structure of colchicine and neighbouring substances of which a digest will be found in a review of research by Bellet [13]. Colchicine is extracted mainly from the *Colchicum autumnale* L., a fairly humid grassland plant but it is also found in a number of other species of this and adjacent genera (Santavy and others [165]). Of these other species one is of interest, the "lofout" or *Androcymbium gramineum* MacBridge, a colchicum of the pre-desert oases of the southern Sahara; according to Perrot [143] the colchicine in its organs approaches the average secured from the autumn crocus itself. Albareda [2] states that this species occurs in a small and very limited area in Spain in the south-east of the province of Almeria on stony, sandy and dry ground. Attempts have been made to spread it over a wider area by seeding and transplanting.

Drar [41] reports that *C. ritchii* (= *C. montanum* L.?) grows in Egypt but shows only negligible traces of colchicine whereas elsewhere the colchicine content in this species is appreciable.

World demand for *Colchicum* corn probably runs to several tons per year; it might therefore be worth while to harvest the "lofout" in the desert areas of the Sahara or Spain. For purposes of expanding its present areas of cultivation or its introduction

into other dry countries, "lofout" is preferable to the *Colchicum* species as its colchicine content remains high in dry climates.

Liliaceae yielding cardiotonic heterosides. In addition to the lily of the valley (*Convallaria maialis* L.), a flower of the cooler European woodlands, in which the active principles are cardenolides akin to those of the digitalis group, this category includes Squill (*Scilla maritima* L. = *Urginea scilla* Steinh. = *U. maritima* Baker) whose properties come from different though comparable heterosides, the bufadienolides, which Stoll [172] one of the experts on them, has recently discussed.

Squill grows in the sandy coastal areas of the Mediterranean. It is rare on the European coasts of the Mediterranean except in Greece and Malta, but much more plentiful on the southern shore in North Africa and Asia Minor. It is fairly common in Algeria and also, according to Drar [42], abundant in Libya near Benghazi and Derna. Boyko [21] reports that it is plentiful in Israel where a study has been made of it by Hareubeni [73]. The heterosides of squill are used as cardiac stimulants and diuretics. The drug itself consists of the scales of the bulb and there are two types of it, white and red, the latter being abundant in Algeria and mainly employed as a rat poison owing to its high specific toxicity.

Wild squill at present appears to be fairly plentiful and its cultivation would seem to have been considered only in India [47]. Incidentally, there is another species in India, *U. indica* Kunth, which is included in the *Indian Pharmacopoeia* and in the *Fourth Addendum to the British Pharmacopoeia* of 1932. It was imported in large quantities into Great Britain during the war. According to Chopra and Mukherjee (remarks on the note by Forsdike and Meek [63]) this species has the same properties as the common squill, which confirms the chemical investigation by Seshadri and Subramanian [167].

We learn from Hutchinson [86] that there are other *Urgineas* native to South Africa but little work appears to have been done on their chemistry.

Two other species of *Liliaceae* are reported to have the same specific toxicity for rats, namely *Bowiea volubilis* Hawey [89] and *Dipcadi cowanii* H. Perrier [7]. *Bowiea* which grows in the Kalahari area of South Africa contains bufadienolides which are being studied by Tschache [180] and Katz [92]. *Dipcadi* which is native to Central Madagascar, does not appear to have been subjected to any study on similar lines.

Liliaceae yielding anthracenic heterosides. The thickened juice from the leaves of various species of *Aloe* is used in medicine as a laxative and purgative, properties due to the presence in these plants of a variety of principles of the aloes-emodin and anthraquinone type, particularly the latter's reduction products (anthrone or anthranol), usually in the form of heterosides. Paris and Durand [135] have recently issued a study of the chemical tests for checking these saps in which they also examine the various species from which they are derived and the active principles they contain.

The main component, a heteroside which has been isolated in the crystalline state, is aloin or barbaloin. It is not yet known whether the genin is an anthrone or an anthranol, or whether the sugar is a pentose or a hexose or how these elements are combined in the molecule. As Durand has shown, we know still less about the nature of the isobarbaloins (except that they are definitely not isomers of barbaloin) and β -barbaloin, adjacent substances which have never yet been isolated in the pure state. Aloe emodin, a true anthraquinone of fully known structure, is found only in small quantities. The resin which accounts for 10 to 15 per cent of the drug, has recently been studied by Auterhoff [6] and appears to include a para-coumaric ester and a resin-tannol.

Aloes are typical xerophytes, foliaceous succulents, with fleshy indeciduous leaves. They are perennials, subsisting in the form of a woody stalk which may be very short or fairly long, in the latter case single or ramified; the leaves, often growing in rosettes,

are elongated and sharply pointed with entire prickly margins. From this rosette arises the terminal inflorescence of red or yellow flowers with joined petals. Anatomical features are the thick cuticle covering the epidermis, the substantial mucilaginous parenchyma accounting for more than half the thickness of the stem and the "aloin bearing" tissue contained in an endoderm in each vascular bundle and forming a kind of pericycle.

According to Killian and Lemée [95] we still know very little about the hydric economy of these plants.

The indications are that the sole original habitat of the aloes was Africa and that they were taken from there to India and America. They are mainly located in East and South Africa where the principal medicinal species are found. The commonest form of the drug, the "Cape aloes", is made from the juices of *A. ferox* Miller, *A. africana* Miller and *A. spicata* Baker, and hybrids bred from *A. ferox* and the other two species. The French Pharmacopoeia describes the source of Cape Aloes as the above species and "others found in the same region". However, according to Dyer [48], the aloes collected in the Cape Province is mainly *A. ferox*, which grows wild on the rocky slopes in sufficient abundance for artificial cultivation never to have been considered. "Socotra aloes" are also prepared from an African species, *A. perryi* Baker found in East Africa and Arabia but the quantities marketed today are much reduced. Lastly we have "Curaçao aloes" extracted from *A. vera* L. (= *A. vulgaris* Lam.), a plant of African origin but "naturalized" in America. Unlike the other African species mentioned, *A. vera* is a cultivated plant grown in the Dominican Republic, on the Venezuelan coast and in the Island of Aruba for the commercial production of the aloes drug which has expanded considerably over the last few years.

The output from these growing centres and the yield of the wild plants in the Cape is normally enough for current therapeutical needs. While *A. ferox* is a worthwhile asset of the South African desert, it would not appear that the extension of its area or its introduction into other arid zones would serve much purpose although it has recently been reported that new uses for the drug have been found as a bacteriostatic cicatrizant.

Liliaceae yielding steroid saponosides. These are sapogenin precursors of cortisone and the steroid hormones; at present this group comprises the species of *Yucca* only and their value consists in their secretion of a steroid genin which can be used for the manufacture of cortisone.

The steady increase in the use of the natural substance, a steroid hormone of the adrenal cortex, had confronted the pharmaceutical industries of the principal countries with the problem of finding a source of supply in quantity. The smallness of the quantities in the adrenals ruled out direct extraction and total synthesis would have involved a long series of operations. Hence the manufacturers' thoughts quickly turned to the possibility of partial synthesis from natural steroids. Numerous compounds of this type were available: biliary acids, certain sterols specially abundant in a variety of plant species, a heteroside of cardenolide type (sarmenocymarin extracted from a *Strophanthus*) and lastly a number of steroid sapogenins; Sannié [164] has produced a comprehensive digest of the whole question. The great abundance of the sapogenins in certain species, more particularly monocotyledons, seems to make them one of the more satisfactory raw materials for the semi-synthesis of cortisone and, over the last few years, a great deal of research has been done on where they can be obtained, on their structure (see more particularly R. E. Marker *et al.* [108]) and on their conversion into cortisone [39, 40]. Consideration has also been given to using them for the semi-synthetic preparation of sex hormones.

The *Yucca* is one of the genera with the greatest abundance of steroid saponosides.

Duisberg [43] produced a study of the chemistry of the genus for the Symposium on Desert Research in 1952, while studies of the chemistry of the sapogenins obtained by hydrolysis of *Yucca* saponosides—yuccagenine, hecogenine—have been made by Marker and his collaborators [107] and in France by Heitz, Sannié and their collaborators [77]. An interesting point is that in certain species of *Yucca* the French researchers did not find the same sapogenins as Marker and have accordingly suggested the possibility of “certain structural isomerisms” caused by the conditions in which the plant has lived. This possibility should be given careful consideration when experimenting on the introduction of these species outside their natural areas.

The *Yucca* is a perennial with a woody stem bearing a bunch of long ribbon-like fleshy indeciduous leaves from which a floral axis continues forming a panicle of fairly large flowers usually white in colour. It is a plant of the desert and semi-desert regions of Mexico (more particularly lower California) and the United States of America; in certain arid zones, according to Cabrera [26], the dominant species is the *Y. valida* while McGinnies [114] reports that at high altitudes in the south of the United States of America it is *Y. brevifolia*. In all these areas *Y. glauca* and *Y. elata* are found in great quantities and on occasion are exploited commercially, though these species are very slow growing and their re-occupation of “harvested” areas is a long drawn out business. While the fruits of certain species are consumed, the main usefulness of the plants consists in the long textile fibres yielded by their leaves, and the residue after extraction of the fibres is an important source of saponosides both in tonnage available and percentage yield of the principles.

The *Yucca*, then, offers a worth-while supply of raw material for the new industry of steroid hormones and probably that most easily obtainable in quantity. Of course other Liliaceae—though not xerophile—are also known to be rich in steroid saponosides, e.g., ruscogenin *Smilax* and *Ruscus aculeatus*, but whereas they must be specially gathered for the sole purpose of extracting the active principle, with the *Yucca*, as with the *Agave* (see below), the raw material is available ready gathered as waste product from another manufacturing operation.

Amaryllidaceae

The *Agave* is a genus of Amaryllidaceae, a family known to be very closely classified to Liliaceae; the principal difference is the position of the ovary, which is free in the Liliaceae and adherent in the Amaryllidaceae.

Indeed the posture and large succulent leaves of the *Agave* are strongly reminiscent of some *Aloe*, though the latter is of African origin and the former is a native of America.

They are xerophyte plants and plentiful in the same parts of western America as the *Yucca*. According to McGinnies [114] the *Agave* is a constituent of one of the typical plant associations of the southern Californian deserts but other species, such as *A. Goldmaniana* or *A. Dudleya* are commoner along the coast of Baja California [26]. Various species of *Agave*, e.g., *A. siselana* and *A. rigida*, have long been used as a source of textile fibres and are cultivated elsewhere in Mexico, for instance Yucatan. Attempts of varying success have also been made to cultivate the *Agave* in Asia, in West Africa and in East Africa. It is in the last of these areas that the results have been best. *A. lecheguilla*, less common in Mexico than the other species [26], appears to offer good prospects as a source of fibre [144], but as yet does not seem to have been put to use on a commercial scale.

Hydrolysis of the *Agave* saponosides produces several genins. The most interesting appears to be hecogenin, and both Spensley [27, 169, 170] and Hassall and Smith [75] point to *A. siselana* as offering an important source of hecogenin from the waste remaining after the extraction of the fibres. Various American *Agave* species have

been studied by Wagner and his collaborators [186] and two Indian species by Gedeon and Kinel [66]. The same genins found by Marker [111] in species growing in America have been identified by Heitz, Lapin, Sannié and Barchewitz [77] in cultivated species on the French Côte d'Azur. Thus the *Agave*, even more than the *Yucca*, offers abundant raw material for the semi-synthesis of cortisone.

Certain species, more particularly *A. atrovirens* and *A. tequilana* in Mexico, are used for the making of pulque, an alcoholic drink, in which Massieu and his colleagues [112] have reported finding traces of vitamin B₁₂. As the Mexican diet includes no foodstuffs of animal origin, pulque, of which vast quantities are consumed, is thus a significant item as a source of the vitamin despite the minute percentage of it present.

Dioscoreaceae

Many representatives of this family are also rich in saponosides from which steroid sapogenins can be hydrolysed. The most important of these genins are diosgenin, of which Marker and Tsukamoto [105] have made a study, and botogenin, the structure of which has been determined by Marker [110]. These genins have proved usable for the semi-synthesis of sex hormones such as progesterone and testosterone, while diosgenin has also been used for the partial synthesis of cortisone (Lemin and Djerassi [101]).

The source of both genins is almost exclusively the numerous Mexican species of *Dioscorea*. According to Dyer [48], however, encouraging results in the production of diosgenin have been obtained in South Africa from certain *Dioscorea* and from the locally endemic *Testudineria*—plants with odd root stocks resembling a turtle's carapace. As Dyer's comment occurs in a study of the arid zones of South Africa, the inference would seem to be that these species are found in arid habitats and in fact both the *Testudineria* and some *Dioscorea* have been reported in the Kalahari. In contrast, other *Dioscoreaceae* in Madagascar and French West Africa, of which a systematic study has been made by Sannié [164] only contain diosgenin in quantities too small to warrant their use for commercial production.

Gramineae

A number of aromatic Gramineae of the hot regions, today usually ascribed to the *Cymbopogon* genus, are of great commercial importance as a source of essences for use primarily in perfume manufacture but also in antiseptics and insect repellents.

The most important species are Lemongrass or Indian Verbena (*C. citratus* and *C. flexuosus*), the Citronellas (*C. nardus* and variant), Palmarosa (*C. martini*) etc. [23]. Their essential oils are rich in aliphatic terpen alcohols and aldehydes (geraniol, citral, etc.).

Some species of the genus are desert plants and there are two to which it is worth drawing attention: *C. proximus*, which Drar [41, 42] says could be supplied in very large quantities by the southern parts of the eastern Egyptian desert and which yields a volatile oil. At the present time commercial dealings in this plant are only on a very small scale in local markets for use solely in traditional remedies. Drar considers, however, that it would be worth carrying out further research on the plant.

In the south Sahara [31], *C. schoenanthus* is extremely common. Its floral panicles are used for making febrifuge infusions while the roots are fragrant and used in perfume manufacture. The species is also found in appreciable quantities in the north-west of the Sahara in the Beni-Abbès region and it has been included by the Centre de Recherches Sahariennes in its list of plants worth investigating.

Chenopodiaceae

This family includes a proportion of genera consisting of more or less halophytic xerophytes. Delbès [36] reports that in the Syrian desert, between the Gulf of Akaba and the Persian Gulf, " various species of Chenopodiaceae cover considerable surfaces made up of ' pans ' where soil salinity (sodium and magnesium sulphates and carbonates) has risen through the imbalance between evaporation and rainfall . . . which is extremely low and sometimes nil in certain years ". It follows that the species in question are halophytes tolerant of an ultra-dry climate and essentially desert plants. *Anabasis* and *Salsola* are two genera of special importance, and there are two others worthy of mention—*Chenopodium* and *Haloxylon*.

Anabasis. This genus comprises from 15 to 20 species, shrubs with articulate and highly ramified limbs bearing leaves of very reduced size. A detailed study of the anatomy of four species has been made by Rosengart-Famel [158]. Evenari and Richter [51] have also studied *A. articulata*'s mechanism for the reduction of transpiration surfaces.

The most important species is *A. aphylla* L. which is abundant in the steppes of the Caspian region, in Turkestan and Transcaucasia and also found in the Syrian deserts. It is a highly poisonous plant which cattle will not touch. In 1929, Orechhoff [125] discovered a volatile liquid base, anabasine, a pyridyl-piperidine and hence an isomer of nicotine. Subsequently the same alkaloid was identified as the principal alkaloid in three species of *Nicotiana*, notably in *N. glauca*. In *A. aphylla* anabasine is found with two other bases, lupinin and aphyllidine [163]. According to tests on plants from Turkestan, the proportion of all alkaloids is between 3.56 and 4.48 per cent. Klyshev [96] reports however that the content varies with the stage of growth; he obtained values ranging from 4.65 per cent of total alkaloids in May to 1.88 per cent in August, three-quarters of this total consisting of anabasine. Finally he draws attention to the fact that soils with the lowest mineral content tend to produce plants with the highest total alkaloid yields. Thus while the species adapts readily to soils of high salinity, its yield of alkaloids is adversely affected by them.

Anabasine, like nicotine, is a powerful insecticide. *A. aphylla* is therefore of obvious commercial interest and suggests the desirability of investigating the production and chemistry of other species. Although there is really very little documentation available, Y. Rosengart-Famel [158] has verified that the aerial parts of *A. prostrata* Pomel and *A. aretioides* Moq. and Coss. have constituents giving the common alkaloid reactions but he has gone no further. There seems to have been no investigation of the chemistry of *A. reticulata* Moq., found both in the Sahara (Ozenda [127]) and forming populations in the deserts of Israel (Boyko [21]), but there is *prima facie* proof of its poverty in alkaloids in the fact that it is becoming rare if not extinct in North West Africa as a result of overgrazing; Emberger [49] says that it is even difficult to gather in any quantity as the young shoots are avidly devoured by goats, sheep and camels (Y. Rosengart-Famel [158]).

Hence it cannot be asserted that apart from *A. aphylla* there is any other species of this genus which is both abundant and rich in alkaloids and can be developed for anabasine extraction. This reduces the problem to one of where else in the arid zone could *A. aphylla* be introduced; a problem which does not seem to have been considered as yet.

Haloxylon. These are large bushes or small trees with cylindrical and often articulate branches, without sharply differentiated leaves and showing botanical characters fairly close to *Anabasis*. They are strongly xeromorphic in structure with deep root systems and various other features which reduce transpiration—absence of leaves, thick cuticle and sunken stomata. Migahid [118] classes them as succulent xerophytes.

Some fifteen species are known and the anatomy of one of them, *Haloxylon tamarixifolium* Pau., found in North Africa, Egypt, Syria and Spain, has been investigated by Y. Rosengart-Famel [158].

The various species are distributed over the steppes of Turkestan, the Syrian desert, the Sahara, etc. Their ecological requirements are fairly close to those of *Anabasis* and like that genus they are halophytic xerophytes.

At present nothing is being done with them commercially and there seems to have been no serious study of their chemistry, though Y. Rosengart-Famel [158] did show that *H. tamarixifolium* is as rich in alkaloids as *A. aphylla*. He managed to isolate two basic principles, one liquid and laevorotatory (anabasine is dextrorotatory) and the other crystallizable and showing a *prima facie* approximation to salsolin. These researches would certainly be worth carrying further.

Salsola. The forty-odd species of this genus are primarily halophyte but a proportion of them are also found only in arid or semi-arid zones. Thus in certain desert areas of north-west Africa, they form a characteristic association and they are also found in the saline sub-desert areas of East Africa, as components of the halophyte populations, on the central Karroo plateau in South Africa, in the Syrian desert, and in the Karakoum sand desert (Turkmenistan), where they are among the typical desert plants.

In the Karakoum desert, *S. richleri* (= *S. arbuscula*) and *S. subaphylla* have been identified as rich in alkaloids. An exhaustive chemical study of the first species was made by Orechoff [126] and three alkaloids were isolated: salsoline, of known and fairly simple isoquinolinic structure; salsolidine, closely adjacent to it as an O-methyl-salsoline; and salsamine, found in traces only and still of unknown structure. From the chemical point of view, a notable feature of these alkaloids is that they are closely adjacent in composition to the alkaloids in the Cactaceae, one of which carnegin, is N-dimethylsalsoline. From the pharmacodynamic angle, salsoline is of interest for its hypotensive properties, its action being similar to that of papaverin. These properties have resulted in its adoption in recent years into the pharmacopoeia of the U.S.S.R.

These encouraging results seem to be arguments for trying the other arid zone species for alkaloids.

Caryophyllaceae

The Caryophyllaceae are a family with few medicinal or xerophyte representatives. However they include one species of the *Spergularia* genus and a few *Gypsophila*, which are worth a mention.

Spergularia marginata Kittel. A remedy which has long been used in medicine is Snakeroot, consisting of the stem and roots of the North American *Polygala senega*, a "saponin drug" containing approximately 5 per cent of triterpene saponins and possessing marked expectorant properties. While the official drug in many countries (Germany, France, Switzerland, etc.) is the genuine *Polygala*, a so-called "Syrian Snakeroot", which looks something like it, has sometimes been substituted over the past few years.

R. Paris and P. Lys [136] were able to establish that Syrian Snakeroot is prepared from *Spergularia marginata* Kittel, a plant mainly of the coastal dunes and saline soils of North Africa and the Middle East, but with no exclusive predilection for such arid areas as it is also found in the damp parts of oases. Paris and Lys also sought to discover whether the substitution was due to the similarity in the external appearance of the two plants or there was a certain justification for it in that they possessed comparable properties which had been discovered empirically. The latter was found to

be the case: Syrian Snakeroot does in fact contain saponins though in amounts no more than one-tenth of those in *P. senega*; on the other hand it has the advantage of lower toxicity.

Gypsophila. In addition to the accepted and typical saponin drug *Saponaria officinalis* L., use is also made—under the names of Egyptian, Oriental or Spanish *Saponaria*—of several species of *Gypsophila* with fairly voluminous root systems extremely rich in saponosides. No recent research seems to have been done on these roots though there have been earlier tentative identifications of the parent plants (Planchon and Collin [146, II, p. 766]) as *G. struthium* and other species found in Spain (*G. fastigiata*, Italy (*G. arrostii*) or Iran (*G. paniculata*). With the exception of the last named, no study seems to have been made of the Oriental species cited by Boissier [19] or Post [149]; the desert growing Djebel-Druze species listed by Mousterde [120] are too small in size to come into the picture.

In addition to these species of *Gypsophila*, several species of *Ankyropetalum* from the Syrian, Lebanese and Mesopotamian deserts (*A. gypsophiloides*, *A. caelesyriacum*), which have extensive root systems, would seem worth investigating and this is now being done in our laboratory.

Capparidaceae

This small family is represented in the arid zones by two species only; neither species is medicinal in the strict sense though both are of definite significance for the health of animals or men.

The first is *Courbonia virgata*, a toxic plant which, according to Drar [42], is fairly widespread in the Egyptian and Sudanese deserts. The active principle, found in the roots, twigs and leaves, was isolated by Henry [79, 80] and has been identified as a derivative of tetramethylammonium.

The other is the Caper *Capparis spinosa* L., whose floral buds or capers are used as a condiment and are much sought after for the special flavour given to them by a sulphuretted essential oil.

The Caper is a low shrub with recumbent twigs bearing oval leaves and spiny stipules. Apart from certain areas in the South of France where it is grown commercially on an extensive scale, it is a Saharo-Sindi arid zone species, found in abundance in the rocky areas of the Sahara [127] but also widely distributed in Morocco, Tunisia and Algeria and as far as East Africa; it is also grown as a crop in many countries (Iran, etc.).

Capers for local consumption are also obtained from other species of *Capparis*.

Euphorbiaceae

Various species of *Euphorbia* are distributed fairly widely in more or less arid regions. The most distinctive types, typically xeromorphic, are the fleshy stemmed cactoid *Euphorbias* found in Africa which have much the look of *Cereus* in America. While these species are commonest in the Cape district, where *E. grandidens* Haw. may grow as tall as 16 m. in the Karroo desert, they are also found in north-west Africa [88]. The only species of any medical interest is *E. resinifera* Berg. and Schmidt which is abundant in Morocco, in the upper Oum-er-Rebia basin and on the slopes of the whole Entifa Massif [65]. An acrid and highly vesicant resin, which is used as a rubefacient mainly in veterinary practice, is yielded by tapping. Thus the market for the resin is very limited and can be more than met from the abundant supply of wild plants.

Ricinus. Although the castor-oil plant cannot be classed as a plant specially resistant

to drought and its water requirements are even on the high side [150], Pichi-Sermolli [145] reports that it is quite common in several parts of the arid and semi-arid belts of tropical East Africa, mainly towards the north.

These two observations are not necessarily contradictory: the content of the first is the viability of *Ricinus* as a crop, while with the second the reference is to plants in what is probably their original range of habitat. It is generally conceded that this species originated in tropical Africa though some authorities think it came from India. Its established popularity as an ornamental and medicinal plant led to the domesticated plant being spread all over the world and today it is for the most part sub-spontaneous. *Ricinus* is highly polymorphous and large numbers of ecotypes of it are known which may well go hand in hand with the wide variations in water requirements.

The pharmaceutical uses of the plant (the oil has purgative properties) are insignificant compared to the industrial: the oil from the seeds has long been used as a lubricant and is now the raw material for the manufacture of a synthetic textile, rilsan (a polyamide analogous to nylon).

Thus there is already large-scale cultivation of *Ricinus* in many countries though not in arid or semi-arid zones, and its introduction is under study in others such as the United States of America and Southern France. (For all these economic aspects see Rautou [150].)

As a perennial between 40° North and South latitude *Ricinus* was utilized by the Moroccan Forestry Services after the first world war for anchoring sand dunes on the Atlantic coast, which Perrot and Gentil [144] have described as "an admirable use for a soil which not only is itself valueless but whose mobility is a continuing danger for neighbouring areas".

According to Palumbo [129] *Ricinus* was abundant and sub-spontaneous in Libya and the question of its cultivation in that region was investigated in 1932.

In view of the growing demand for castor oil, there is a possibility that it may be of interest as a crop in the coastal areas of North Africa even if yields are lower than in those countries which, like Brazil and India, are at present the largest producers.

Zygophyllaceae

For many years the only one of the few species in this family known to medical science was *Guaiacum officinale*, the wood or resin of which was used as a sudorific, diuretic and a treatment for gout.

It is now known that the agent from which these properties mainly derive is guaiaretic acid of the recently identified lignan group. The name was coined by Howarth for compounds which, being the result of dimerization of polyoxycinnamic acids and alcohols, fall within the group of phenylpropane derivatives, and have some kinship with the lignans. There have been several recent surveys of these substances and their chemical and biological properties (Hearon and MacGregor [76], Herrmann [82]).

Several of the lignans are of some value in the treatment of carcinoma, as anti-oxigens, and as activators in "botanical" insecticides.

One of the most important lignans was discovered in a typical xerophyte genus, the *Larrea*. The genus belongs to the New World arid zone flora and two species are particularly widespread: (a) *L. tridentata*, in the desert of the southern United States and the northern part of Mexico where, over immense areas *L. tridentata* with *Fraseria dumosa* or *L. tridentata* with *Flourensia cernua* associations are the sole vegetation [26]; (b) *L. divaricata* which marks a recognized zone in the Great Basin desert in the United States [114] and is plentiful in the Gran Chaco desert in northern Argentina where it forms associations with *L. nitida* and *L. cuneifolia*.

L. divaricata ("creosote bush") is a spreading thorny deep-rooted bush with divided glutinous leaves; partial foliation takes place at the beginning of the wet

season, and a second crop having a lower moisture content appears at the beginning of the dry season.

With *L. tridentata*, it is one of the most widely distributed shrubs of the desert regions of America, particularly on calcareous soils, extending even into the most arid sectors.

It is a typical xerophyte and has attracted the interest of numerous research workers. Runyon [161] has investigated the leaf sequence and Ashby [4] the large numbers and the apparent lack of special adaptation of the stomata; while Mallery [103] discovered a marked seasonal variation in the osmotic concentration of the juices in the leaves.

L. divaricata has long been an Indian remedy against rheumatism and certain skin affections and it has now been found to contain nor-dihydroguaiaretic acid (N.D.G.) in proportions sometimes as high as 12 per cent [43, 44, 128, 130]. Duisberg [44] incidentally, showed that the amount of the principle present rose with any rise in the amount of water available to the plant, proving that drought conditions are not a prerequisite for the secretion of the N.D.G. acid and resin.

N.D.G. acid has been identified again in *L. nitida* [99] and is probably also present in *L. cuneifolia* [153], which is rich in acid resin. Seemingly, no attempt has been made to look for it in *L. tridentata* despite the commonness of this species in America.

With test-tube cultures at least, N.D.G. acid acts as an antibiotic against staphylococci and paratyphoid and certain diphtheroid bacilli [181]; it is also in great demand for its good antiseptic, and in particular its strong anti-oxygenic, properties which have given it world importance. As an additive in proportions ranging from 0.005 to 0.01 per cent it prevents oils and greases going rancid and its very low toxicity permits its use in edible fats (butter, milk, lard, etc.).

The *Larrea* species are thus outstandingly useful and marketable desert plants but their abundance on the American continent makes their introduction into other continents of doubtful economic value.

Zygophyllum is another exclusively xerophyte genus but confined solely to the steppe and arid zone flora of the Old World—North Africa, South Africa, Arabia, Asia, etc.

So far few chemical and physiological studies have been issued on these species, but R. Paris and C. Perez, who have recently produced a digest of them [138], have themselves begun an investigation of an endemic Algero-Tunisian species, *Z. Cornutum* Coss., which, according to Ozenda [127] is a traditional "empirical remedy for sugar diabetes". It is an extremely ramose shrub with whitish twigs and nearly cylindrical, fleshy, stipulate leaves. In a preliminary study the investigators have been able to confirm "the hypoglycaemic action on rabbits of *Z. cornutum* tips administered *per os*" and to make a start on the task of isolating the active principle.

In view therefore of its newly demonstrated hypoglycaemic properties the plant has possibilities: one of the known concerns of contemporary pharmacology being to discover substances—whether among the synthetic chemical principles (sulfamides) or the botanical (hypoglycaemic plants)—which will control diabetes and end the sufferer's slavery to insulin injections.

In another genus of zygophyllaceous xerophytes, *Tribulus*, one of the most important species, *T. terrester* L., widely distributed in the arid zones of both hemispheres, contains a photosensitizing principle, observed by Brockmann [22], which has caused poisoning among sheep. Efforts to isolate the hepatic toxin have so far been fruitless; it causes the blood to accumulate phylloerythrin, a photodynamic agent produced by the microbic breakdown of chlorophyll in the stomach of the sheep. De Kock and Enslin [97] have managed to isolate a number of steriod sapogenins (diosgenin, ruscogenin, etc.) from this species of *Tribulus*.

Peganum harmala L. is a low growing herbaceous perennial with extremely ramose

stems and divided, narrow segmented leaves, abundant mainly in the arid zones of the Old World—in Eastern Morocco and around Marrakesh [67], in parts of the Sahara [127], in the steppes of Cyrenaica [41], in the Egyptian deserts [41], in Asia, in the Iranian and Turkestan steppe, and even in Europe in the south Russian and Hungarian steppes with halophile vegetation, and in Spain.

As a result of its disagreeable rue-like scent its seeds were formerly used as an emmenagogue, like *Ruta graveolens*. Harmaline was extracted by Göbel as long ago as 1843, followed shortly after by Fritsch's extraction of harmine. Both alkaloids are easy to obtain by crystallization from the seeds and roots and are found in the seeds in proportions ranging from 2 to 3 per cent and even 4 per cent. Their chemistry has been much studied and their indolic structure, a tryptophane derivative, definitely established [81]. Two further alkaloids have since been isolated, harmalol, which is indolic and of which harmaline is the methylic ester, and peganine or vasicine, a quina-zolinic alkaloid. Koretskaya [98] has recently reported the isolation of yet two other alkaloids.

The two main alkaloids have proved a trifle disappointing for therapeutic purposes: harmin has been shown to have anthelmintic properties (against *Ascaris lumbricoides* and *Taenia serrata*), to have some effect—though less than quinine—on the malaria parasite and to have an action on the extra-pyramidal motor system which can be used in the treatment of Parkinson's disease with variable but sometimes brilliant results. The properties of harmaline are similar but its toxicity is twice as great. These alkaloids are known as hallucinogens and it has recently been observed that they act antagonistically to serotonin or 5-hydroxytryptamine, to which much attention is at present being devoted. This may lead to new therapeutic uses for them (Perrault and Clavel [139]).

For the moment *P. harmala* is rarely used in medicine and its abundance in the wild state leaves no justification for its cultivation or introduction elsewhere.

Simarubaceae

Balanites aegyptiaca Del. After some hesitation about its systematic classification, the *Balanites* genus now ranks as one of the Simarubaceae [133].

The genus includes some species peculiar to the arid zones—*B. orbicularis*, *B. glabra*, *B. tomentosa* and *B. aegyptiaca*. The last-named is found in the arid areas of a belt running from Senegal through Mauretania to Arabia, especially in the Eritrean savannahs, on the Libyan plateaux and across the Sudan to the Egyptian deserts [41, 42] where it is particularly plentiful on the hills of the Red Sea and in the Gebel Elba district.

It is the characteristic tree of several of these regions either growing alone or with various species of *Zizyphus* and *Tamarix*. The thick protective cuticle on its twigs and leaves make it, according to Drar [42], a xerophyte "admirably adapted to habitats where resistance to drought is the limiting factor".

Long valued as a hardwood and for its oil-bearing seeds it has lately revealed two further desirable qualities: Tayeau and his colleagues [176] have found the edible fruit to contain proteins which are of special value in these regions where diet is deficient in nitrogenous substances; and further its bark is rich in saponosides [106, 109], from which a mixture of sapogenins, with diosgenin predominant, can be extracted by hydrolysis. Diosgenin has also been found in an Indian species, *B. roxburghi*. As we have already seen diosgenin can be used for the manufacture of cortisone and sex hormones, which entitles the tree to rank as a medicinal plant.

Burseraceae

Two genera of this family, *Boswellia* and *Commiphora*, yielding resinous gums of

some commercial interest, belong to the arid zone flora of tropical East Africa in the type vegetation called by Pichi-Sermolli [145] "sub-desert scrub with trees".

The *Boswellia* is a genus of about a dozen species of small trees or bushes distributed over the dry parts of north-east Africa and south-east Arabia with secretory ducts in the bark containing an odoriferous gum resin, which is commonly known as frankincense or olibanum. According to Howes [85], the principal species exploited commercially are *B. carterii* Birdw. and *B. freriana* Birdw. growing in inhospitable country, rough and mountainous, which makes collection difficult. Other species, which are of no commercial importance, also yield odoriferous gum resin: the West African *B. dalzielii* Hutch.; *B. serrata* Roxb., which gives so-called "Indian Incense", from the dry hills of northern India; and in north-east Africa *B. bhowdajiana* Birdw. and *B. papyrifera* Hochst.

According to Pichi-Sermolli [145], the trees are carefully protected and are only tapped when they have reached a good size. The local inhabitants do not attempt to increase the number of trees but much greater yields could be obtained from those they have.

Nowadays frankincense is rarely used in pharmacology although it is still included, for example, in the French Pharmacopoeia. However, further chemical research has been carried out fairly recently by Jones and Nunn [91] on the gum and by Trost [178] on the composition of the resin, from which he managed to extract certain Boswellic acids. Various investigations have been conducted on the composition of these acids which belong to the currently very interesting pentacyclic triterpenoid group [190]. On the strength of its properties, frankincense is used in powders, pastilles and fumigation papers, to some extent also in perfumery as a fixing agent for other perfumes [24] and, last but not least, liturgically, the surviving reminder of the precious rarity which made it a fitting gift of the Magi.

Another of the Three Kings' Gifts, Myrrh, is also a gum resin secreted by a number of thorn-bearing shrubs, of the genus *Commiphora* which comprises some fifty species mostly belonging to the arid zone flora of tropical East Africa [25].

According to Pichi-Sermolli [145, page 348] the male Myrrh (herabol) probably comes from *C. playfairii*, *C. myrrha* and perhaps *C. abyssinica*, and the female (bisabol) from *C. erythraea*.

The indications are that all *Commiphora* produce gum resins or oleo-resins that are commercially valuable. Thus bdellium comes from *C. africana* and Balm of Gilead from *C. opobalsamum*. *C. guidottii*, *C. socotrana* and *C. parvifolia* yield gum resins whose properties have not been fully explored and *C. cornii* and *C. setulifera* probably yield oleo-resins.

Myrrh is still used to some extent in pharmacology as an aromatic stimulant. It is included in the French Codex of 1949 and is an item in a number of standard preparations ("alcoolat de Fioravanti", "élixir de Garus", etc.).

Chemical research on it has pursued a parallel course to that on incense; Hough [84] and Jones [90] studied the composition of the gum and Trost and Doro [179], extracted some sesquiterpene derivatives.

"Absolute" or pure myrrh should also be an excellent fixative usable in the perfumery industry on the same lines as "absolute" incense.

Rhamnaceae

This family provides pharmacology with several drugs which have purgative properties due to the presence of anthra-glucosides, e.g., from the barks of frangula (*Rhamnus frangula* L.) and *Cascara sagrada* (*Rh. purshiana*), and from the drupes of the buckthorn (*Rh. cathartica*).

These plants tend to prefer well watered areas, the predilection being most marked

in *Rh. frangula* and in *Rh. lanceolata*, an American species also fairly rich in anthracene derivatives, which grows along river banks and on humid declivities.

However, a few species are included in the flora of arid and semi-arid regions, for example among the Palestinian *Rhamnus* [60]: *Rh. palaestina* Boiss. of the Palestinian desert [120], *Rh. libanotica* Boiss., *Rh. punctata* Boiss. and *Rh. alaternus* L. The two last species which are spineless, with persistent coriaceous leaves have been studied by Voutyrakis [185] who was able to establish that while *Rh. punctata* cannot be used as a substitute for frangula or cascara, *Rh. alaternus* can bring a good source of anthra-glucosides; this finding was confirmed by Russian research on specimens growing in Azerbaidjan. *Rh. alaternus* can thus be used as a substitute in those parts of Asia and the Mediterranean where it is abundant and where *Rh. frangula* and *C. sagrada* are not found.

Another Rhamnacea, *Paliurus*, a Mediterranean shrub formally classified as a *Rhamnus* (*Rh. paliurus* L.) but now a separate genus (*P. aculeatus* Lam.), has characteristically alate dry fruits, traditionally accepted as a diuretic, from which R. Paris [132] has managed to isolate a crystallized heteroside; this he has identified with rutoside, a principle used in medicine and normally extracted from Sarrasin or Sophora buds.

Zizyphus is a genus comprising a number of species originally sub-desert but now spread over vast areas as a result of their dietetic importance. Chevalier [32] who has produced a study of the most numerous species, remarks that "they have become so common and have adapted themselves so thoroughly to the most diverse climates that to all appearances they might be endemic plants".

They are trees or shrubs, usually thorny and often small leaved. The common jujube (*Z. sativa* Goetn. = *Z. jujuba* Lam.) probably from Mongolia and Turkestan originally but now widespread in Asia Minor and North Africa, is also cultivated in southern Europe and in America. Its fruit is edible and quite pleasant.

Z. lotus Lam. is found on the semi-desert steppes of North Africa and in Asia Minor and *Z. nummularia* Wight and Arn. throughout the Sahara and the Indian desert; there are also more or less xerophile varieties of both *Z. spina-christi* Willd. and *Z. mauritiana* Link.

All species have edible fruits and have figured or do figure in the diet of certain populations. The jujube also has definite emollient properties for which it was formerly classed as one of the four "pectoral" fruits and is still used for making pectoral cough drops. In China it is taken as a tonic under the name of "Hsuan Tsao Ren".

Little recent work has been done on the chemistry of *Zizyphus*, and the only significant result obtained is that from Kawaguti's demonstration [93] which showed that the seeds contain betulinic acid of the triterpene group.

Leguminosae

This family, one of the most extensive in the vegetable kingdom, supplies pharmacology with a very large number of drugs, which are sought after for a variety of principles. A number of these principles are found in species included in the flora of the arid or semi-arid zones.

Alkaloidal and toxic species. Although this family provides many food plants, for men (beans, peas, lentils, etc.) and animals (alfalfa, clover, sainfoin, etc.) it also includes a fairly large number of species containing alkaloids, heterosides or various little known substances which render them toxic. A proportion of these species are used in medicine, notably common broom and *Physostigma venenosum*. So far as we are aware no alkaloidal species of the arid zones has so far been used therapeutically

on any important scale, although research has already been done on some of them.

Among the *Retamas*—a kind of Papilionaceae fairly close to the *Genista*—alkaloids have been found in *R. sphaerocarpa* Boiss., a Mediterranean species which grows on sandy soils on the Spanish and North African tablelands. Retamine, which Battandier and Mallosse [11] separated as long ago as 1897, was detected again by Ribas and his colleagues [157] and identified as a hydroxysparteine. They have also [158] isolated *d*-sparteine (in contrast to *l*-sparteine, the alkaloid of the common broom) and, from the fruits, cytisin, an alkaloid of the same group, and sphaerocarpine, an acetyl derivative of a hydroanabasine [155]. The oxytocic action of retamine is nearly twice as strong as that of sparteine.

Some of these alkaloids, namely, retamine, anagyrine, cytisine, lupanine and sphaerocarpine, have been isolated by Vazquez and Ribas [182] from *R. monosperma* Boiss. (= *Genista monosperma* Lam.) also. This is another plant of North Africa and Spain and one of its varieties, *R. Webbii* Spach, is endemic in Morocco where Nauroy [122] reports that it is used as an abortive. He was able to verify that it had a high alkaloid content and this probably consists mainly of retamine.

R. negra (?), probably from Argentina originally, is understood to have been shown by E. Merck [117] to contain several alkaloids—sparteine, genisteine and sarothamine and a flavonoid, scoparine, all of them principles detected in the common broom. Hydroxytyramine is also said to have been detected which would account for the strong hypertensive action of *R. negra* on the blood pressure.

The Saharo-Indian species *R. retam* Webb does not so far appear to have been tested for alkaloids although the species has been reported by the Centre de Recherches Sahariennes. It is an extremely typical xerophyte and several writers have discussed its drought-resisting mechanism [95]. It is abundant in the desert regions of North Africa and is an element in a sub-association indicative of a potential soil for growing almonds [49].

Crotalaria is a tropical and sub-tropical genus of *Genistae* (Fabaceae) and includes some species forming part of the arid zone flora of North, north-east and East Africa. While some are grown as fodder, others have a toxic content of alkaloids such as monocrotaline and dicrotaline akin to the alkaloids of the *Senecios* and Boraginaceae [154]. No research appears to have been carried out into the chemistry of the arid zone species of this genus.

Alhagi is a kind of Papilionaceae found in North Africa and India and can be included as one of the alkaloidal Leguminosae since Soviet chemists in the course of a systematic research on plant alkaloids were able to demonstrate the principles in two species of the genus—*A. camelorum* Fish., native to Central Asia and *A. pseudoalhagi*.

However, the commonest species is the Saharo-Sindi *A. maurorum* D.C. (= *Hedysarum alhagi*) which secretes manna. It is a low ramose bush 35-40 cm. in height with the members bearing axillary spines and simple leaves, and spreads over the Egyptian and Libyan deserts as far as the Sahara. Shmueli [168] has made a study of its xerophytic comportment.

The *Alhagi* manna is considered in some quarters to have been the manna of the Bible. Other authorities, however, are more inclined to favour a lichen, e.g., *Leconora esculenta*, or the excretions of *Tamarix mannifera*. In a study of the mannas of Persia, Moghadam [119] rejected the claims made for *Alhagi*, one reason being its purgative properties which would make the manna almost uneatable.

In the hot season, the leaves and branches of the shrubs become covered with small droplets, initially of the consistency of honey and gradually thickening. To harvest the manna the aerial members of the plant are cut off and shaken over a cloth. By this means a quantity of rounded "tears" is obtained, viscous to begin with,

but becoming fairly hard later. The root stocks of this species display individual variations in secretory powers and do not all produce manna every year or in every region.

One component identified in this manna is saccharose, and melezitose was also found by Villiers [184] though not by all subsequent researchers.

Moghadam [119] tells us that the *Alhagi* manna "is one of the principal laxatives and purgatives in the compendium of traditional Persian remedies". It is not used in the Western countries where preference is given, for these purposes, to a "manna" from the ash tree in which the active principle is a mixture of mannitol and various oligoholositides.

A. camelorum can also exude a manna in which melezitose had likewise been identified.

Another genus of alkaloidal Leguminosae worth mention is *Piptadenia*, one of the sub-order Mimoseae. *Piptadenia* is smoked by some South American Indians and appears to have hallucinogenic properties, probably ascribable to the presence of bufotenin, an nitrogenous dimethyl derivative of 5-hydroxy-triptamine or serotonin, isolated by Stomberg [175] from the seeds of *P. peregrina* Benth. Other indolic bases have also been discovered in these seeds and also in *P. macrocarpa* Benth. and, in weaker concentrations, in *P. paniculata*. Several *Piptadenia* originating in Florida or South America (Brazil, Colombia), grow in semi-arid regions.

The properties of some of the toxic Leguminosae are due to the presence of cyanogenetic principles which have been definitely identified in certain species of this family. The best known of these is *Phaseolus lunatus* L. the seeds of which, known as Java, Burma, etc. beans have caused a number of fatal cases of poisoning among human beings.

A plant abundant in the sub-desert regions of the Nile Valley is *Lotus arabicus* L. which Fahmy and Saber [58] have recommended for the preparation of a spirit which could replace the distillate of cherry laurel. The toxic effects of this plant on horses, sheep and goats has long been known to the Arabs and the Anglo-Egyptian troops learnt it expensively from the losses among their baggage animals during the Sudan campaigns.

An equal danger to sheep and camels is another species extremely rich in cyanogenetic principles *L. jolyigi* Batt., which is abundant in the western and central Sahara [127].

The seeds of *Abrus precatorius*, or jequirity, probably owe their toxic properties to a phytotoxin, abrine (not to be confused with the amino-acid of the same name), but they may also contain alkaloids. They are put to infrequent and limited use in the treatment of certain chronic forms of conjunctivitis.

The scarlet seeds, with black streaks corresponding to the hilum, are unmistakable. The plant itself is a creeper with paripinnate composite leaves and its areas of growth are in India, the West Indies and East Africa, where, according to Pichi-Sermolli [145] it belongs to the arid zone flora.

Anthraceniferous species : *Cassia*. The various anthraceniferous drugs (rhubarb, aloes, frangula, cascara, buckthorn and senna) are still the most widely used purgatives, as they have been for centuries past. The purgative action was for a long time attributed to the anthraquinone derivatives which had been isolated from them. However, the work, successively, of Wasicky [187], Casparis and Goldin [28], Straub and Gebhardt [174], Stoll, Kussmaul and Becker [173] and Fairbairn [59], led to its being recognized that in fact these oxydation forms produce little effect and that the purging action was due to the presence of reduction derivatives (anthranols and anthrones) which are only stable in the plant in combination with sugars, i.e., in the heteroside state as anthra-glucosides such as the sennosides in the sennas [134]. These

findings have brought about some degree of revival in the use of these drugs, mainly of rhubarb and senna.

The sennas or cassias of the *Senna* section belong to the *Caesalpinia* sub-family. Of the 400-odd species of *Cassia* four are mainly used in medicine—the three sennas and cassia, *C. fistula* L. (of the *Cathartocarpus* section).

For many years the sennas on the market came from two species of cassia only: Tinnevely or Indian senna from *C. angustifolia* Vahl. and Khartoum or Alexandria senna from *C. acutifolia* Del. Later a third species was admitted to the French Codex, *Cassia obovata* Coll. as Sudan senna.

At the time of writing the bulk of the sennas used in Western Europe are from India and their source is *C. angustifolia*. *C. acutifolia*, formerly highly esteemed, is next in importance but comparatively little used, while *C. obovata*, although accepted by the French pharmacopoeia has never achieved commercial success. The predominance of *C. angustifolia* is not due solely to its intrinsic quality but also to its usually excellent presentation, free of foreign bodies with a minimum of stalk, etc.

All three species are low bushy shrubs growing to a height of 40-60 cm. with composite paripinnate leaves and yellow flowers ripening to flat pods. The medicament is contained in the folioles and pods. Perrot [140], who produced an exhaustive study of these species in 1920, considers them "endemic to the pre-desert zone of the African Sudan, certain areas of Arabia and probably Persia".

Wild *C. angustifolia* is apparently abundant in the arid areas of East Africa from the Somali coast down to Mozambique and in Arabia, but is not used as a source of supply of the drug, at any rate for export. It is this species which is cultivated on a large scale in southern India in the Tinnevely district.

C. acutifolia grows in the desert parts of Nubia where the drug was long gathered from the wild plant; later cultivation was started in the neighbourhood of Khartoum. For many years this senna was processed for the market with meticulous care and formerly had a commercial importance which it has now lost. According to Drar [41], the species has almost entirely vanished from the Egyptian desert as a result of excessive extraction, but apparently a certain amount is still grown in Egypt. It is common in the southern Sahara according to Ozenda [127], and Perrot [141] has also reported it in the French Sudan section of the Sahara.

C. obovata is distributed over the whole of the Egyptian Sudan and it is common in the south and central Sahara down to Upper Senegal, the Niger and the Chad areas. So far as is known the Sudan senna yielded by this species is obtained exclusively by collection from the wild plant.

The senna used in pharmacology should come from these three species only, but from time to time other less active cassias are fraudulently offered for sale as senna, notably *C. auriculata* which has been used in India for the afforestation of a number of semi-arid regions.

The sennas are still of considerable commercial importance and dealings in them run to hundreds of tons per year. Being completely adapted to a desert climate, these species could readily be introduced and cultivated in arid regions, e.g., the Sudan. However, while they are easy to grow and require little care, their yield is only marketable if the drug is pure and of good quality, i.e., gathered at the right time and collected solely from the officinal species, well dried—this is easy enough in regions where the atmosphere is never humid—and above all, carefully sorted, retaining the foliole and pods exclusively. Last and most important, from the commercial aspect, careful consideration must be given to price trends for these drugs, potential export markets and the willingness of importers to handle them.

Gummiferous Leguminosae. Two genera rich in gummiferous species are the *Acacia*

of the sub-order Mimoseae, which give gum arabic and the *Astragalus* of the Papilionaceae family, which give gum tragacanth.

The 600 species of *Acacia* are distributed over the tropical and sub-tropical regions throughout the world, with Australia accounting for half the number. The Australian acacias are diploid ($2n = 26$) as are those in North and South America, where they grow in Texas, Argentina and Chile. On the other hand, the many varieties in Africa, from Eritrea and Somaliland to the Congo and the Cape, are all tetraploid ($2n = 52$), except in north-east Africa, where, as in India [5], both types exist.

The species of *Acacia* yielding gum are fairly numerous and are to be found in Africa, Asia, the Americas and Australia. A few years ago, Perrot [140] attempted to compile a comprehensive list of them, and pointed out that, "it is in the 'Sudanese' belt running from east to west across Africa and in the arid near-desert region that the main gummiferous trees are found". The distribution of the gummiferous acacias has been dealt with by Bond [20] and a census made by Chevalier [30].

The best—i.e. least coloured, purest and most soluble—gum arabic is obtained from *A. senegal* Willd. (= *A. verec* Guill. and Perrot), a small many-branched tree with bipinnatisect leaves, intrastipular thorns and blossom arranged in long cylindrical spikes. The species is found throughout the Sudan belt from the Red Sea to Senegal and while most of the gum is collected in the Egyptian Sudan [3, 18] a certain amount is also harvested in French West Africa (Chevalier [29]) and in the Chad area (Venault [183]).

Two further species are also of some importance as gum producers—*A. segal* Del., *A. arabica* Willd. with its variety *A. nilotica*. According to Drar [42] neither is an arid or semi-arid zone species: the first is characteristic of the sub-humid zone and the second is always confined to river banks and irrigated areas; *A. nilotica* is invariably found around springs.

A. senegal, on the other hand, forms natural populations in dry regions where rainfall is rarely more than 300 to 400 millimetres. Indeed, according to Venault [183], this acacia only secretes gum in any quantity in zones where the average rainfall is below 500 millimetres. Perrot [140] also observes: "on land where soil moisture is conserved, the acacia exudes no gum or insignificant amounts only; this is an indisputable fact".

There would therefore seem to be a connexion between this acacia's living conditions in arid climates and the formation of the gum. While certain authorities have attributed the phenomenon to invasion of the plant by bacteria or fungi, as Madame Bezanger-Beauquesne [17] recalls, Perrot consistently maintained that it was difficult to explain it otherwise than by "biological imperatives of which the chief is the conservation of water in the actual structure of the plant". Today it is generally accepted that water retention by hydrophile colloids is one of the most effective xerophyte mechanisms [95].

The physical properties of gums have long been known and have been dealt with by Perrot [140] and Mantel [104] among others. However it is only in the last few years that chemists have turned their attention to the problem of their chemical composition. Gums are known to consist of chains of osuronic acids consisting of a resistant nucleus formed by an uronic acid and one or more strongly fixed oses plus various other more loosely bound oses. Thus the resistant nucleus of gum arabic is glycuronosido-6-galactose with more loosely bound molecules of arabinose and rhamnose. Madame Bezanger-Beauquesne [14] and Hirst [83] have both reviewed the recent work on the composition of gums.

Gum arabic has emollient and bechic properties and an emulsifying power of which much use is still made in pharmaceuticals. It continues to be employed extensively in the manufacture of confectionery, glues, finishes, etc., and it thus remains a valuable article of trade. It is one of the main "cash crops" of the desert regions, but its market

value depends above all on the care taken in its collection, cleaning and "packaging".

Gum tragacanth, of much less importance commercially, comes from a limited number of species of *Astragalus* distributed over the sub-desert regions of Asia Minor, Kurdistan and Iran. All are thorny often bushy suffrutices with deciduous leaves and yellow flowers.

According to Planchon and Collin [146] and Trease [177] the gum is obtainable from a fairly large number of species though the main ones are *A. gummifer* Labill. and *A. adstringens* Boiss. and Haussn.

The gum tragacanth forms in the centre of the stems and exerts sufficient pressure on the enclosing tissues to exude when a deep enough incision is made.

It is only fairly recently that its composition has been investigated. Apparently it is a mixture of a neutral polyholoside (arabo-galactane) and a uronide (galacturonic acid) bearing terminal molecules of fucose and xylose [15, 16].

The main pharmaceutical use of gum tragacanth is as an emulsifier; its other uses have been given by Beach [12].

Miscellaneous medicinal leguminosae. We classify under this head three species, originating in more or less arid regions, the market for which is currently supplied almost entirely from cultivated plants.

The liquorice (*Glycyrrhiza glabra* L.) and its numerous varieties is to all appearances a spontaneous growth in the Mediterranean area (Spain, Portugal, Sicily, Greece) and in Asia Minor (Iran, Crimea, Turkestan). Possibly its original home was the Asiatic part of the Mediterranean basin from where it spread to southern Europe [129].

The climate is dry in all these regions but the liquorice is not an unquestionable xerophyte and seems to do well in wadis with frequent dry periods on irrigated land, etc. The most xerophile variety appears to be *G. violacea* Boiss.

At the present time, liquorice is cultivated in many lands with fairly dry climates—such as Spain, the principal producer—but which are not classifiable as arid regions.

Drar [42] planted a plot of liquorice 20 years ago in the desert west of Alexandria and has found that it survives there, with a yearly growth of new leaves and shoots, despite the low rainfall. He considers that the behaviour of this plant under desert conditions would repay fuller study.

Liquorice root has been used in medicine from time immemorial and is an important article of trade. Fresh interest in this plant has been aroused by various investigations which were analysed in 1958 by Madame Pointet-Guillot [148]. The structure of glycyrrhizine is now known to include a triterpene glycyrrhetic acid, with flavone derivatives and a follicular-type oestrogen substance in addition. Over and above its traditional sweetening and expectorant properties, the effectiveness of liquorice in the treatment of gastric ulcers, its "cortisone-like" action in the mineral metabolism and its oestrogen properties make it a plant of continuing wide medical uses. In addition it has a variety of industrial uses, particularly in the preparation of certain types of tobacco.

The carob tree (*Ceratonia siliqua* L.), a largish tree with persistent coriaceous leaves, is described by Auguste Chevalier (Evreinoff [52]) as "a xerophyte only tolerant of the hot climates of the sub-tropical countries". It appears to have grown wild at one time in the Mediterranean region (Levant and Arabia) but it is only known now as a cultivated or sub-spontaneous plant. Its cultivation probably dates back to more than 2000 B.C. According to Evreinoff [52] the most likely climate for profitable cultivation should be the Mediterranean type with abundant autumn precipitations. In actual fact the main plantations are in Spain, Italy, Cyprus, Greece, and Syria but some carob is also grown in Turkey, Tunisia, Palestine, the southern U.S.S.R., Iran and even America (California and Arizona). Italy, Cyprus and Greece are the

principal sources of supply for the export trade to the United States, England and Germany.

The fruits, or carobs, are used primarily for fodder, with the production of human foodstuffs and alcohol distillation next in importance. While requirements for medicinal use are on a much smaller scale, they do absorb about ten tons of fruit or seeds a year. Both are powerful anti-diarrhoeics, the fruit contains pectine and tannin and the seeds mannans and galactans; the greatest demand is for the seeds which are widely used in infantile diarrhoea.

Fenugreek (*Trigonella foenum-graecum* L.), a Saharo-Sindi species, is probably a native of Asia Minor but has been cultivated in North Africa since the most distant ages. According to Auguste Chevalier [31] and Ozenda [127] it is cultivated in the Saharan oases as far as the Hoggar and the neighbourhood of Timbuctoo.

The plant itself, a herbaceous annual with trifoliolate leaves, is used as fodder while the seeds, which have an unpleasant smell and taste, are used as a tonic, restorative and appetizer. Sannié [164] has reported that the seed's significant diosgenin content could serve for the demi-synthesis of cortisone derivatives and sex hormones.

Rosaceae

The Rosaceae family is poor in medicinal plants and includes very few xerophile species.

Thus in the present context only the almond (*Amygdalus communis*) can be cited. It is native to Iran and its natural habitats are no more than semi-arid. In its cultivated form, however, it has been introduced over the whole Mediterranean basin and it can be grown as an orchard tree in dry zones: Emberger [49] designates the sub-association with *Retama raetam*, a typical xerophyte, as a good indicator, in Tunisia, of areas where cultivated almonds would do well.

Almonds, sweet or bitter, are mainly used for food and for oil production. In pharmacology they are used as emulsifiers and for their oil.

Cactaceae

The cacti are a plant family particularly well adapted to desert climates. They are typical xerophytes with succulent mucilage-rich stems. Almost all species are American but various genera have adapted so well to other continents that a number of species (*Opuntia* in particular) are firmly established in Africa, Asia and Mediterranean Europe. The deserts of Mexico and the south-western United States, of the Colombian coast and of Venezuela, and the Argentine Chaco are the principal habitats of the cacti which vary widely in shape and often attain gigantic sizes there.

Several species (*Cereus*, *Trichocereus*, *Anhalonium*, *Carnegiea*, *Echinocactus*, etc.), contain alkaloids of known composition, determined in most instances by Spath, for which the formulae can be found in any general work, such as Henry [81] on alkaloids.

Notwithstanding their possession of these active principles [35] and the great amount of research done on their physiological properties [87], the cacti are of little importance as medicinal plants.

The most remarkable species is the peyotl or *Echinocactus Williamsii* Lem. of Mexico—the cactus country *par excellence*. Much research—historical, chemical and pharmacological had been done on peyotl, on which Rouhier read [159] and subsequently published [160] a paper under the title of *La plante qui fait les yeux émerveillés* (The plant of visions).

Some Indians in Mexico and the United States regard it as a sacred plant and prepare “mescal buttons” from the aerial stems sliced and dried, the attraction being the coloured visual hallucinations induced. Though the toxicity of peyotl is low it is nevertheless

a narcotic and accordingly the sale of mescal buttons is restricted in the United States.

Peyotl contains a number of alkaloids in proportions which appear to vary with the stage in the plant's life cycle and perhaps with external conditions. Some of these alkaloids, like anhaline and mescaline, are phenyl-ethylamine derivatives while the rest, anhalanine, anhalonidine, peyotline, lophophorine, are produced by the cyclization of the first series and are thus derivatives of isoquinoline.

Attempts have been made to use the stimulating effects of this cactus and its alkaloids on the central nervous system in psychiatry. The galenical preparations appear the most suitable, but worthless imitations made from other inactive cacti are often substituted for the true medicinal plant. Mescaline is also used for the same purpose.

Of the other alkaloidal species, some kinds of *Cereus* have been shown to have various pharmacological properties [87] but no medicinal use appears to be made of them.

As regards the *Opuntia* and particularly the Barbary fig (*Opuntia vulgaris* Mill.) so widely established in the Mediterranean basin, they provide nourishing fruit and the flowers are used as an anti-diarrhoeic, a property which R. Paris [131] ascribes partly at least to the presence of a flavonoside. Various species of *Opuntia*, the nopals, are cultivated in Mexico, for the breeding of the cochineal beetle, which of course is the source of the colouring matter, carmine.

Myrtaceae

The myrtle, *Myrtus communis* L., is a non-deciduous shrub which originated in the coastal areas of the Mediterranean basin. It is a component of the vegetation of dry stations such as the *garrigues* and *maquis* of southern Europe and is also distributed fairly extensively in the oases of North Africa. The high tannin content of the leaves and the essence they contain give them some uses in pharmacology.

The *Eucalypti* are trees, often very tall, indigenous to Australia, where they are a very valuable natural resource, supplying timber, pulpwood and tannin. A large number of species (180 out of 600) have been shown to have leaves with high contents of essences which vary in composition but are always combinations of terpene derivatives. Of the essence-forming species, about ten yield an essential oil with not less than 70 per cent of cineol which can be used as medicinal oil. The one most used, and official in a number of countries, is *E. globulus*.

The ecological requirements of *Eucalypti* vary widely. Some are pure hygrophytes while others grow in the semi-desert areas of Australia where annual rainfall is below 250 mm. [151].

Many species have been introduced into other parts of the world, mainly Africa, America and to some extent even Europe, but the majority appear to have been mesophytes or hygrophytes. There remains the possibility that various essence-forming species of the dry regions, e.g., *E. dumosa* and *E. oleosa*, would be worth propagating in other arid areas.

Granataceae

The pomegranate tree, *Punica granatum* L., is probably a native of Persia but was already being cultivated before recorded history for the beauty of its flowers and for its edible fruit. Long naturalized in the Mediterranean coastal areas, the tree is grown in southern Europe, in the Algerian oases and in the arid parts of California, Arizona and northern Mexico. It is from these regions where the climate combines heat and dryness that the best fruits come but they only reach full size if the rainy season coincides with the period when they form.

The bark of the stem and root are used in pharmacology as taeniafuges, a property

conferred by the alkaloids they contain—pelletierine and methyl-pelletierine, both piperidine derivatives.

Umbelliferae

Of the various genera of Umbelliferae used for their essences, alkaloids or bitter principles, two at most can be regarded as belonging to the flora of semi-arid regions, *Ammi majus* L. and *A. visnaga* Lam. Both are found mainly on sandy soils in Mediterranean countries, but preferably near the rivers and canals of Egypt and Morocco, with the south of France as their extreme range. After a fairly long record of general usage, clinical and chemical research on both species, particularly the second, has recently led to uses being found for them in conventional medicine: *A. vulgaris* in dermatology and *A. visnaga* principally as a source of khellin, a vasodilator of the coronary circulation [137, 147].

There are, however, other Umbelliferae which are used as sources of gum resins or resins, all of which belong to the desert flora of Iran or North Africa, but the uses for these plants are limited, and would probably not warrant either their cultivation or their introduction into other regions.

Gum ammoniac is a gum resin produced by *Dorema ammoniacum* and *D. aucheri* Boiss., two large perennials of the desert areas of Iran where they grow mainly in the Kurdistan and Louristan mountains. They have extensive root systems and stout stems yielding a milky sap on tapping, which solidifies into tears of gum. Gum ammoniac is used as an anti-spasmodic and expectorant [50].

Asafoetida is another gum resin and comes mainly from *Ferula asafoetida* L., a tall plant with a thick perennial stock, also a native of Louristan and Turkestan. Some asafoetida are obtained [124] from *Scorodosma foetidum* Bunge which grows in the desert region between the Caspian and Aral Seas.

Tapping *Ferula asafoetida* at the bottom of the collar produces exudations of a sap which, on hardening, forms drops of gum with a strong smell of garlic. It is used in some countries as an anti-spasmodic and emmenagogue.

Galbanum, which is used for much the same purposes, comes from various species of *Ferula* of Persian origin *F. galbaniflua* Buhse, the main species, growing preferably in humid areas, with *F. rubricaulis* Boiss. and *F. schair* Borgez, from the deserts of Khorassan and Turkestan.

Thapsia garganica L. and *Th. villosa* L. with which it is sometimes confused are both extremely common in North Africa, Morocco and Libya. *Th. garganica* is not as xerophile as the *Ferula* species; according to Nauroy [122] it is plentiful mainly in rocky areas of Morocco.

Digestion of the root bark in alcohol produces a resin used mainly as a revulsive and less commonly as a drastic purge. According to Drar [42] the whole plant is in certain conditions poisonous to cattle and thus restricts range grazing possibilities in Cyrenaica.

Oleaceae

The manna ash, *Fraxinus ornus* L., probably originated in Asia Minor and south-east Europe where it appears to be a spontaneous growth. At the present time, however, the tree is found mainly in the form of large-scale plantations in Sicily and Calabria which have a monopoly as manna producers. Not only is the manna ash tolerant of these dry regions, but such conditions are even necessary for the formation of the manna as has been proved by attempts to introduce the tree into other insufficiently arid regions. The position is thus analogous to that of the gum-forming *Acacia*.

Harvesting is carried out by tapping the trunk whereupon sap exudes solidifying

into a manna consisting of 50 per cent of mannitol and about 20 per cent of galactoside-saccharoses. This manna, of which the best quality, flake manna, is official in a number of countries, is used as a mild laxative particularly suitable for children.

The olive tree (*Olea europaea* L.) is only incidentally medicinal. Originally native to Palestine and Asia Minor it is now grown in great numbers throughout the whole Mediterranean basin and is completely tolerant of very dry conditions. Indeed the wild variety *silvestris* is found in the spontaneous or sub-spontaneous state in the semi-arid regions of North Africa, more particularly in Libya.

Olive oil is mainly an article of food, but is also used in medicine as a cholagogue and as a medium for various medicaments. The leaves are used for their hypotensive and hypoglycemic properties.

Apocynaceae

This is the family to which *Strophanthus* belongs, certain species of which provide chemotherapy with cardiotonic heterosides used concurrently with those from the *Digitalis* genus, of which the most important is ouabain. This heteroside owes its name to the fact that it was originally identified in the bark of the tree *Acokanthera ouabaïo* Poix, which secretes it like the six or seven species of the same genus which grow on the dry denuded East African uplands from Ethiopia to the Cape. The *Acokanthera* species, like the *Strophanthus* in the less arid regions, are used by the natives for making poisoned arrows.

The *Acokanthera* are not at present used in medicine but a study of their chemistry was started some years ago by Reichstein and his collaborators (see, for instance, Bally, Mohr and Reichstein [8]). In addition to ouabain, the bark of these trees contains cardenolides such as the acovenosides and acolongiflorosides.

The leaves of the oleander, *Nerium oleander* L., also contain a cardiotonic heteroside, oleandioside, which is used in medicine to a very limited extent. This evergreen shrub is grown in the Mediterranean area for the beauty of its flowers.

According to Auguste Chevalier [31] it is fairly common in the steppic zone of North Africa and runs along the wadis into northern Sahara where it is again found in quantity in the Tassili and Hoggar mountains.

The number of wild plants and of ornamental plants is more than sufficient for all pharmaceutical needs.

Asclepiadaceae

Certain species of this family also contain heterosides of the cardenolide type. The first of them is *Calotropis procera* Ait., a small tree with large leaves of Saharo-Sindi origin, common in the central and southern Sahara, East Africa and Libya, where it is associated with *Balanites aegyptiaca*, and in Egypt. While not markedly xeromorphous it is a typical xerophyte but according to Cabrera [26] it is reputed—in those parts of South America where it has been introduced—to indicate the presence of water fairly near the soil surface. According to Ozenda [127] it is used to treat mange in camels and Pichi-Sermolli [145] tells us that it is used in native medicine as an emetic and an anti-dysenteric. However its best known product is the bark of the root known as Mudar bark which yields a latex used by some tribes as a poison for their arrows. Research on this bark has brought to light at least five principles from which an identical genin can be extracted by hydrolysis, namely, calotropagenin [67, 74].

Cardiotonic heterosides [152] particularly periplocin (or periplocoside), were isolated from *Periploca graeca* L., a hygrophytic vine of the Mediterranean region.

Analogous heterosides appear to have been found in other species—*P. aphylla*, *P. forsteri* and *P. nigrescens* Afzel [113].

As the arid zone flora includes a Saharo-Mediterranean representative of the genus *P. laevigata* Ait., fairly common, according to Ozenda [127], throughout the Sahara, this species would be well worth investigating.

Convolvulaceae

This family contributes little more to the pharmacopoeia than the glucosides in which the roots of fairly numerous species of the *Ipomoea*, *Convolvulus* and probably *Cascuta* genera are rich.

The Aleppo Scammony (*Convolvulus scammonia* L.) grows in the sub-desert areas of the Middle East—the Crimea, Turkey, Iraq, the Levant and Mesopotamia. The resin, obtained from the roots by incision, has purgative properties like all the other *Convolvulus* resins but, probably as a result of the scarcity of collectors, it has been almost ousted from the market by Mexican Scammony (*Ipomoea orizabensis*) which is now used instead.

Solanaceae

Among the various genera of Solanaceae known to be rich in alkaloids, two groups are distinguishable: one consisting of *Atropa*, *Datura*, *Hyoscyamus*, etc. and distinguished by the presence of alkaloids acting parasymphatholytically; the other comprises mainly the more nicotine-rich *Nicotiana* species.

Of the first group, various species of *Hyoscyamus* are specific to particular desert areas, the most typical being probably *H. muticus* L. and its sub-species *H. falezlez* Maire = *H. falezlez* Cosson.

H. muticus is indigenous to Egypt, the Middle East, Arabia, Iran and India and according to Drar [42], is the only wild plant in the Egyptian deserts of sufficient commercial value to justify its export. On the strength of this, Fahmy [53, 54] and Saber and Balbaa jointly [162] have made studies of it that could serve as models of this kind for desert plants and are extremely instructive on the whole range of problems posed by such plants.

Plants with alkaloids acting parasymphatholytically can be used either for making extracts or other galenical preparations or as the raw material for the extraction of the actual alkaloids—hyoscyamine and its racemic form, atropine and scopolamine. For the latter use, a high content of the alkaloids is naturally a consideration and there has been a change over from *Atropa belladonna*, used originally, to *H. muticus* roots in which the alkaloid content (from 0.50 to 1 per cent) is more satisfactory.

To begin with *H. muticus* was gathered in such quantities that, according to Drar [42], it was almost exterminated. Attempts were then made to cultivate it both in Europe and Egypt itself, but Saber and Balbaa [164] reported that little success was achieved in Europe while in Egypt plants under cultivation proved to be poorer in alkaloids than those growing wild. This they considered to be, most probably, the result of insufficiently detailed study of the edaphic and climatic conditions experienced by the plant in the wild state prior to starting cultivation. They accordingly started this investigation with special attention to habitat, associated plants, climatic and edaphic factors, etc. Fahmy [53, 54] had already found that, with this species, irrigation militated against a high alkaloid content, the percentages being greatest in those plants grown under the most arid conditions.

Meanwhile, however, a new consideration arose with the appearance on the market of a new genus, the Australian *Duboisias*, which are formidable competitors of the Egyptian Henbanes and according to Drar [41] already preferred to them.

As regards the other desert Henbanes, there appears to have been hardly any collection of *H. falezlez* on any scale. *H. boveanus* Ascher-Schw. seems to be merely an ecological variant of *H. muticus* Drar [162]; *H. albus* L. var. *desertorum* (= *H. desertorum* Tackh. and Drar) on analysis by Fahmy and El Deeb [56] proved much less rich in alkaloids than *H. muticus*, having about the same percentage as the European *H. niger*.

Withania somnifera Dunal, regarded in East Africa as a narcotic and anti-epileptic [145], was investigated by Fahmy [55] and by Haddad [71], with *W. obtusifolia* T. Tackh. as a control but they were unable to detect any of the solanaceous alkaloids.

The two *Duboisia* species mentioned earlier as supplanters of Egyptian Henbane are *D. myoporoides* and *D. leichhardtii*, rich in hyoscyamine and scopolamine, and both endemic to Australia. However, both grow on the east coast in areas where the monthly precipitations are over 50 mm.

A third species, *D. hopwoodii*, according to Barnard [9] and confirmed by McKee (in a private communication), is confined to the dry parts of Australia where annual rainfall does not usually exceed 250 mm., and is thus a semi-arid zone plant, but unlike the first two species secretes nicotine and nor-nicotine in place of tropanic alkaloids; the quantities vary widely according to the origin of the specimen.

Globulariaceae

Provence Senna (*Globularia alypum* L.), a suffrutex of Mediterranean origin with coriaceous leaves, does best in dry areas. It is found in southern Europe and North Africa from Morocco, where it grows in the dry forests of the lower mountain slopes up to 2,000 m., to the Fezzan north of the Tibesti, where it grows at high altitudes. It is also a high altitude plant in the Saharan Atlas and the Hoggar. *Globularia* has purgative properties on the strength of which it is used as a senna substitute [130].

Labiatae (Menthaceae)

Many essence-forming Labiatae exhibit fairly definitely xeromorph characteristics in the shape of narrow, coriaceous leaves, with curled margins and hairy surfaces. Particular examples are, *Hyssopus officinalis* L., *Lavandula* spp., *Romarinus officinalis* L. and *Thymus* spp., which are of Mediterranean or near-Mediterranean origin and grow on the dry stations and arid slopes of southern Europe, northern Africa and the Middle East. All yield essences used mainly in perfumery, sometimes as raw material for the extraction of certain principles, and to a small extent in pharmacy.

Hyssop is found in Europe in a belt running from France to the southern part of the U.S.S.R., and also in Iran. It is a vulnerary with bechic and carminative properties in addition.

The Lavenders are also vulneraries. *Lavandula vera* D.C. and *L. spica* Cav., wild and cultivated, are used mainly in perfumery and their hybrid "Lavandin" is now grown on a large scale in France and Italy. There are other more xerophile species, e.g., *L. staechas* L., abundant in the wild state in Spain but seemingly not harvested in any quantities, and *L. antineae* Maire, which is endemic in the Sahara. The latter has a very strong lavender scent but as yet no research appears to have been done on it.

Rosemary is another vulnerary, with a choleric action like officinal lavender and thyme. It ranges from Spain to Asia Minor and is raised on arid chalk soils in Provence, Spain and Dalmatia.

Thyme (*Thymus vulgaris* L.) a suffrutex of the Mediterranean garrigues, has the

same properties, and its essence which is rich in phenols (thymol and carvacrol) is also an antiseptic. Cultivated, it is a garden plant grown principally for flavouring.

In contrast to this, the Spanish thyme (*T. zygis* L.) from the arid regions of the Iberian peninsula, with up to 1 per cent of essence, is used in industry for the extraction of thymol which forms 50 per cent of the essence. In another Mediterranean species, *T. capitatus* Hoffm., abundant, for instance, in the Sinai peninsula and *T. broussonetii* Boiss., widely distributed in southern Morocco, the proportions of the phenols are reversed and the main component of the essence is carvacrol [144], which is of much less commercial value than thymol.

Certain species of the *Ocimum* genus yield a camphor-rich essence, for instance *O. canum* Sins which is raised in the Crimea and the Ukraine for that reason. Another species of Kenyan origin, *O. kilimandscharicum* Guerke, also has commercial possibilities and has been cultivated to some extent in Turkey [68] and in India [38].

Cucurbitaceae

One of the few species of this family used in medicine is a highly xerophile plant, *Citrullus colocynthis* Schrad. (= *Colocynthis vulgaris* Schrad.) with a fruit whose pulp is an extremely violent purgative chiefly used in the English-speaking countries.

The plant belongs to the Mediterranean and Saharo-Sindi floras and is common throughout the Sahara and the desert and sub-desert areas of Morocco, Egypt, Sudan, and Iran. Though it is a typical xerophyte, *Colocynthis* is not structurally xeromorph but has large, thin cuticled leaves; its drought-resistance mechanism has been investigated by Hamouda [72] and Del Rij [37]. According to Laffargue [100], in Egypt the plant is not cultivated but grows wild and the fruit yields only small quantities of a very yellow pulp. The export market demand for a white pulp is supplied by the *Colocynthis* of the Egyptian Sudan.

Compositae

The large family of the Compositae does not include many medicinal species and of these, few belong to the flora of the arid or semi-arid zone.

The most important of the latter are the *Artemisias*; there is also *Grindelia squarrosa*, a semi-succulent American plant with expectorant and antispasmodic properties. Some research has also been done on *Helichrysum* which is represented by certain arborescent species, not yet investigated, in the xerophile flora of South Africa.

Santonin-forming Artemisias. The unopened flower heads of an *Artemisia* are used as an anthelmintic, known as Santonica, and the exact species, long in doubt, is today agreed to be *A. cina* Berg., which probably belongs to the *A. maritima* collective species; it owes its properties principally to its santonin content. Its habitat is the steppes of the Arabo-Caspian region where it is collected in large quantities and exported to all countries.

As there have been several occasions when this plant has almost vanished from the market, various parties have sought to end their dependence on this single source of supply by growing the same species in other regions and by seeking other santonin-forming *Artemisias*. Attempts to grow *A. cina* elsewhere have proved extremely disappointing. The santonin content of the flower heads varies with the origin of the specimen from traces only to over 1 per cent [50]. So far no success appears to have been achieved in growing santonin-rich plants outside their country of origin, Russian or Iranian Turkestan.

Various other steppic species have also been tried: *A. herba-alba* Asso., marketed as Barbary santonica, is widespread in North Africa, Morocco and the Sahara and

Egyptian deserts and has vermifuge properties though it contains no santonin. It normally yields about 0.3 per cent of a volatile oil containing thujone; according to Drar [41], the amount rises as high as 1.6 per cent in the *laxiflora* variety of the Sinai peninsula. The African dry area *A. campestris* L. similarly contains no santonin nor does the Saharo-Sindi *A. judaica* L., found in the Egyptian desert, though some is said to have been detected in specimens from other regions [41]. The *A. monogyna*, from which Japanese researchers have extracted from 1 to 2 per cent of santonin, would appear to be identical with that found on the Hungarian steppes on which Stocker [171] has done research and to be merely another sub-species of *A. maritima*.

CONCLUSIONS

We have tried to produce an inventory of the medicinal plants native to the arid or semi-arid zones, with observations on their therapeutic and commercial possibilities.

The task presented certain difficulties in view of the almost complete lack of biological information on the floras consulted. A praiseworthy exception is P. Ozenda's recent Saharan Flora [127] which we managed to procure in the course of our work and which could serve as a model for all arid zone floras. Much valuable information was also derived from the lists supplied to us by the Centre de Recherches Sahariennes and from the Unesco publications on plant ecology. For certain species, however, it proved impossible to find any detailed ecological information and this must be the excuse for any possible omissions from, or mistaken inclusions in, the lists. One of the most urgent targets is felt to be the completion of individual lists of the plants of each desert or group of kindred arid zones by specialists in their respective floristics.

Dr. A. M. Sandoval, Director of the Centro de Documentación Científica y Técnica de México has indeed sent us a mass of documentation on the plants of the Mexican deserts. Unfortunately, the parcel only reached us when we were nearing the conclusion of our work and we were thus unable to take full advantage of the contents.

Apart from the classical medicinal plants, often officinal, which have been known and used for many years, much still remains to be done before we shall have a comprehensive inventory of all the species with therapeutic possibilities. A systematic study needs to be made of all the plants used in native medicine—for the Sahara alone Ozenda [127, p. 88] mentions several on which no chemical research has yet been done. It is common knowledge that so far such research has paid excellent dividends and that native use for the plants (ordeals by poison, fish poisons, poisonous arrows) have given the first clue to quantities of new therapeutic agents.

Another possibility is the methodical prospection of vegetation for new plants yielding alkaloids or miscellaneous principles (cardiotonic heterosides, steroid saponinins, essences) on the lines of Webb's work in Australia [188]. At a less ambitious level, it could pay to investigate all the other species of any genus containing one of known usefulness. This was how the Indian *Ephedras* were discovered and among non-xerophile plants, *Holarrhena africana* and *Rauwolfia vomitoria* from the clues, respectively, of *H. antidiysenterica* and *R. serpentina*. We have in several places suggested investigations which should be made of specified genera.

The most notable arid zone medicinal plants are those in which the useful principle is formed in greater abundance under drought conditions, as with *Acacia senegal* or *Hyoscyamus muticus*. The succulents, *Aloe* and *Agave*, *Cactus* and cactiform Euphorbes, are, on balance, of scant medical interest.

A plant of medical value and abundant in the wild state is not necessarily a source of wealth, its marketability being largely conditioned by economic factors. Thus it may be recalled that wild *Cassia acutifolia* and *C. obovata* have been practically

driven off the market by Indian Senna; the gum of *Acacia senegal* is not saleable everywhere; and *Hyoscyamus muticus* is meeting heavy competition from the more alkaloid-rich *Duboisia*.

A fairly wide range of originally xerophile plants are now raised in quantity in regions of much lower aridity, with markedly higher yields: examples are *Cassia angustifolia*, the carob tree, the olive tree, the castor-oil plant, West Indian aloes, fenugreek, etc. Tests could be made to indicate the likelihood of the same crops paying in arid zones, using suitably selected strains or ecotypes. Chouard [34] has already tried this type of "reacclimatization" (e.g. castor-oil plants) at the Beni-Abbès centre.

Conversely experiments could be made in acclimatizing plants native to regions of low aridity, subject to not trying to establish them in areas where the rainfall level was lower than 200 mm. per year.

To sum up, the xerophile medicinal plants can play a part in the economic reclamation of the arid zones.

The first stage should consist in exploiting the desert species, *Acacia*, *Cassia*, *Hyoscyamus*, *Larrea*, etc., to best advantage, with special attention to the improvement of yields and primary processing and with due provision for the preservation of the species (protection against over-grazing and destructive collecting methods).

Thereafter attention might be shifted to the species of xerophytic origin now normally grown in relatively well-watered regions and an attempt be made to extend their cultivation into regions of more arid climate.

BIBLIOGRAPHY

1. ANON. "Über Arznei- und Nutzpflanzenkultur. Einflüsse der Umwelt chemische Rassen", *Arbeitsstagung — Wageningen*, 9-11 Sept. 1957, Amsterdam, De Boer, 1958, 119 p.
2. ALBAREDA, J. M. "Influence des changements de la végétation dans les sols arides", *Écologie végétale, actes du colloque de Montpellier*, Paris, Unesco, 1955, 84-87. (Collection *Recherches sur la zone aride*, V.) [Summary in English.]
3. ALLAND, "Gomme du Soudan anglo-égyptien". *Bull. Sci. pharm.*, 1914, 21, 477-487.
4. ASHBY, E. "Transpiratory organs of *Larrea tridentata* and their ecological significance", *Ecology*, 1932, 13, 182-188.
5. ATCHISON, E. "Studies in the Leguminosae. II. Cytogeography of *Acacia* (Tourn.) L." *Amer. J. Bot.*, 1948, 35, 651-655.
6. AUTERHOFF, H.; BALL, B. "Khaltstoffe und Wertbestimmung von Aloe Drogen und ihren Zubereitungen", *Arzneim. Forsch.*, 1945, 4, 725-729.
7. BALANSARD, M. A. "Contribution à l'étude chimique du bulbe de *Dipcadi cowanii* (Ridl.) H. Pert.", *Ann. Mus. colon. Marseille*, 1944, 2, 20-23.
8. BALLY, R. R. O.; MOHR, K.; REICHSTEIN, T. "Die Glykoside der Wurzelrinde von *Acokanthera friesiorum* Mark", *Helv. chim. acta*, 1952, 35, 45-50.
9. BARNARD, C. "The Duboisias of Australia", *Econ. Bot.*, 1952, 6, 3-17.
10. —; FINNEMORE, H. "Drug plant investigations", *J. Coun. sci. industr. Res.* 1945, 18, 277-285.
11. BATTANDIER; MALOSSE, TH. "Sur un nouvel alcaloïde", *C. R. Acad. Sci.*, 1897, 125, 360-362.
12. BEACH, D. C. "History, production and uses of tragacanth", *Advanc. in Chem. Ser.*, 1954, 11, 38-44.
13. BELLET, P. "Les principes des extraits du Colchique et leurs dérivés", *Ann. pharm. franç.*, 12, 821-832.
14. BEZANGER-BEAUQUESNE, M^{me}. "Les substances polyuroniques", *Ann. pharm. franç.*, 1946, 4, 271-301.
15. —. "Progrès dans le domaine polyuronique", *Ann. pharm. franç.*, 1953, 11, 297-309.
16. —. "Les substances polyuroniques, troisième revue", *Ann. pharm. franç.*, 1956, 14, 795-812.
17. —. "Gommes et mucilages", *Bull. Soc. bot. Nord de la France*, 1958, 11, 1-10.
18. BLUNT, H. S. *Gum arabic, with special reference to its production in the Sudan*, London, Oxford University Press, 1926, 50 p., 21 pl., 2 fig.
19. BOISSIER, E. *Flora orientalis*, Genève, 1867-1888, 6 vol.

20. BOND, W. R. G. "Distribution of Sudan acacias", *Sudan — Notes and Records*, Khartoum, Macorquodale and Co., no. 2, 81-89.
21. BOYKO, H. "Iran, Israel and Turkey", *Plant ecology. Reviews of research*, Paris, Unesco, 1955, 40-76. (*Arid zone research*, VI.) [Résumé en français.]
22. BROCKMANN, H. "Photosensitivity caused by fluorescent plant pigments", *Forsch. Fortschr. Dtsch. Wiss.*, 1943, 19, 299-301; *Chem. abstr.*, 1945, 39, 1899.
23. BROWN, E.; MATTHEWS, W. S. A. "Notes on the aromatic grasses of commercial importance", *Colon. Pl. Anim. Prod.*, 1951, 2, 174-187.
24. BURGER, A. M. "Die absoluten Resinoide als neue ideale Fixateure und Parfümgrundstoffe", *Riechstoff-Industr.*, 1937, 12, 121-123, 135-136.
25. BURTT, B. D. "Observations on the genus *Commiphora* and its distribution in Tanganyika Territory", *Kew Bull.*, 1935, 101-117.
26. CABRERA, A. L. "Latin America", *Plant ecology. Reviews of research*, Paris, Unesco, 1955, 113. (*Arid zone research*, VI.) [Résumé en français.]
27. CALLOW, R. K.; CORNFORTH, J. W.; SPENSLEY, P. C. "Source of hecogenin", *Chem. & Ind. (Rev.)*, 1951, 699-700.
28. CASPARIS, P. C.; GÖLDIN VON TIEFENAU, H. "Studien über die Anthrachinon Drogen — I", *Schweiz. ApothZtg*, 1923, 61, 501-505.
29. CHEVALIER, Aug. "Sur la production de la gomme arabique en Afrique-Occidentale française", *Rev. Bot. appl.*, 1924, 4, 256-263.
30. —. "Revision des *Acacia* du Nord, de l'Ouest et du Centre africain", *Rev. Bot. appl.*, 1928, 8, 46-53, 123-131, 197-207, 263-271, 357-363, 432-434, 574-579, 643-650, 707-715.
31. —. "Les productions végétales du Sahara et de ses confins Nord et Sud", *Rev. Bot. appl.*, 1932, 12, 669-924.
32. —. "Les Jujubiers ou *Ziziphus* de l'Ancien Monde et l'utilisation de leurs fruits", *Rev. Bot. appl.*, 1947, 27, 470-483.
33. CHOPRA, R. N.; KRISHNA, S.; GHOSE T. P. "Indian Ephedras: their chemistry and pharmacology", *Indian J. med. Res.*, 1931, 19, 177-219.
34. CHOUARD, P. "Sur l'économie de l'eau dans les régions arides", Acad. d'agric. de France, extr. séance du 22 mai 1957.
35. CRUSE, Robert R. "Chemurgic survey of desert flora in the American south-west", *Econ. Bot.*, 1949, 3, 111-131.
- 35a. DATTA, N.B. [See/voir, no. 47.]
36. DELBES, P. "Irak, Jordanie hachémite, Liban, Arabie saoudite, Syrie et Yémen", *Écologie végétale, compte rendu de recherches*. Paris, Unesco, 1955, 135-150. (*Recherches sur la zone aride*, VI.) [Summary in English.]
37. DEL RIJ, V. "Studio monografico del *Citrullus colocynthis* Schrad; Relazione et comunicazione tenute all 3 Congresso di Studio Coloniale in Firenze", *R. Erbario coloniale*, 1937, 70-74.
38. DEOGUN, P. N. "Le Camphre. Ses possibilités d'extraction et de production dans l'Inde", *Indian For.*, 1950, 76, 139-143, after/d'après *Rev. Bot. appl.*, 1931, 51, 543-547.
39. DJERASSI, C.; RINGOLD, H. J.; ROSENKRANTZ, G. "Steroidal sapogenins: XV. Experiments in the hecogenin series (Part 3): Conversion to cortisone", *J. Amer. chem. Soc.*, 1951, 73, 5513-5514.
40. —; —; —. "Steroidal sapogenins: XXXVII. Experiments in the hecogenin series (Part 6): Conversion to cortisone", *J. Amer. chem. Soc.*, 1954, 76, 5533-5536.
41. DRAR, Mohammed. "Plants of raw material in the deserts of Egypt", *Proceedings, Symposium on Scientific Problems of Land Use in Arid Regions*, Heliopolis, 1954, 70-76.
42. —. "Egypt, Eritrea, Libya and the Sudan", *Plant ecology. Reviews of research*, Paris, Unesco, 1955, 151-194. (*Arid zone research*, VI.) [Résumé en français.]
43. DUISBERG, P. C. "Chemical components of useful or potentially useful desert plants of North America and the industries derived from them", *Proceedings, International Symposium on Desert Research, Jerusalem*. Sponsored by Research Council of Israel in co-operation with Unesco, Jerusalem, Research Council of Israel, 1952, 281-294. (*Special Publication*, no. 2.)
44. —. "Some relationships between xerophytism and the content of resin, nordihydroguaiaretic acid, and protein of *Larrea divaricata*", *Plant Physiol.*, 1952, 27, 769-777.
45. —; SHIRES, L. B.; BOTKIN, C. W. "Determination of nordihydroguaiaretic acid in the leaf *Larrea divaricata* (creosote bush)", *Analyt. Chem.*, 1949, 21, 1393-1396.
46. DURAND, M. *Contribution à l'étude des Aloès officinaux et en particulier de leur essai physico-chimique*, thèse doct. pharm. (État) Paris, Jouve, 1958, 149 p.
47. DATTA, N. B. "Drug culture in Bengal", *Indian med. Rec.*, 1936, 6, 261-264.
48. DYER, R. A. "Angola, South-West Africa, Bechuanaland and the Union of South Africa", *Plant ecology. Reviews of research*, Paris, Unesco, 1955, 195-218. (*Arid zone research*, VI.) [Résumé en français.]

49. EMBERGER, L. "Afrique du Nord-Ouest", *Écologie végétale, compte rendu de recherches* Paris, Unesco, 1955, 219-249. (*Recherches sur la zone aride*, VI.) [Summary in English.]
50. ETESSAMI, S. Contribution à l'étude de la matière médicale de l'Iran, th. doct. Univ. Paris (pharmacie), Paris, Jouve, 1949, 167 p.
51. EVENARI, M.; RICHTER, R. "Physiological-ecological investigations in the wilderness of Judea", *J. Linn. Soc. (Bot.)*, 1937, 51, 335-361.
52. EVREINOFF, V. A. "Le Caroubier ou *Ceratoria siliqua* L.", *Rev. Bot. appl.*, 1947, 27, 389-401.
53. FAHMY, I. R. "Egyptian *Hyoscyamus muticus* L.", *C. R. Congrès intern. méd. trop. et hyg.*, Le Caire, 1928-1932, 5, 501-538.
54. —. "The alkaloidal percentage of *Hyoscyamus muticus* L. growing in the various districts of Egypt", *Bull. pharm. Égypte*, 1936, 10, 25-27.
55. —. "*Withania somnifera* Dunal (Solanacées)", *Bull. pharm. Égypte*, 1944, 6, 48-52.
56. —; EL DEEB, S. R. "*Hyoscyamus albus* var. *desertorum*: a contribution to the study of some Egyptian medicinal plants and drugs", *Bull. Pharm. Égypte*, 1931, 3, 29-35.
57. —; —. "*Ephedra alie* (alata?), a contribution to the study of some Egyptian medicinal plants and drugs", *Bull. pharm. Égypte*, 1931, 3, 112-130.
58. —; SABER, A. A. Hefny. "*Lotus arabicus*: a contribution to the study of some Egyptian medicinal plants and drugs", *Bull. pharm. Égypte*, 1931, 3, 131-133.
59. FAIRBAIRN, J. W. "The active constituents of the vegetable purgatives containing anthracene derivatives", *J. Pharm. Lond.*, 1949, 1, 683-692.
60. FEINBRUN, N. "The genus *Rhamnus* in Palestine", *Palest. J. Bot.*, Jerusalem, 1945, 3, 165-169.
61. FLÜCK, H. "The influence of the soil on the content of active principles in medicinal plants", *J. Pharm. Lond.*, 1954, 6, 153-163.
62. —. "The influence of climate on the active principles in medicinal plants", *J. Pharm. Lond.*, 1955, 7, 361-383.
63. FORSDIKE, J. L.; MEEK, H. O. "Indian squill and its differentiation from European squill", *Pharm. J.*, 1946, 157, 104-105; *Quart. J. Pharm.*, 1946, 19, 340-350.
64. GARLAND, E. A. "Indian Ephedras", *Indian For.*, 1938, 64, no. 10.
65. GATTEFOSSE, J. "Les plantes dans la thérapeutique indigène au Maroc", in PERROT, E.; GENTIL, L., *Sur les productions végétales du Maroc*, 1921, 73-123. (*Mat. vég. Drog. Parf.*, notice, no. 10.)
66. GEDEON, J.; KINEL, F. A. "Steroid Sapogenine aus indischen Agavearten", *Arch. Pharm. Berl.*, 1953, 286, 317-319.
67. GEIGER, W.; HESSE, G.; LETTENBAUER, G.; SCHILDKNECHT, H. "Calotoxin aus Calotropin; zur Konstitution der Calotropagenins", *Naturwissenschaften*, 1957, 44, 328.
68. GENÇİZ, Y. "*Ocimum Kilimandscharicum*", *Agric. Rev.*, Ankara, 1947, 8, 52-56.
69. GEORGE, Lucienne. Contribution à l'étude des Gnêtales, thèse doct. sci. nat., Nancy, 1930, 175 p.
70. GHOSH, T. P.; KRISHNA, S. "Jahreszeitliche Veränderung de Alkaloidgehalts der indischen *Ephedra* Arten", *Arch. Pharm. Berl.*, 1930, 268, 636-643.
71. HADDAD, D. Y. "*Withania obtusifolia* T. Tackh.", *Bull. pharm. Égypte*, 1934, 6.
72. HAMOUDA, M. A. *Studies on the water relations and transpiration of the Egyptian desert plants*, Thesis Fac. Sci., Cairo Univ., 1954.
73. HAREUBENI, A.; HAREUBENI, H. *Thesaurus plantarum terrae erez Israël: De Urginea maritima L. et Asphodelo microcarpo*, Jerusalem, 1941.
74. HASSALL, C. H.; REYLE, K. "Constitution of calotropagenin", *Chem. & Ind. (Rev.)* 1956, 487.
75. SMITH, B. S. W. "Hecogenin from *Agave sisalana* by microbiological hydrolysis", *Chem. & Ind. (Rev.)*, 1957, 1570.
76. HEARON, W. M.; MACGREGOR, W. S. "The naturally occurring lignans", *Chem. Rev.*, 1955, 55, 957-1068.
77. HEITZ, S.; LAPIN, H.; SANNIE, Ch. BARCHIEWITZ, P. "Recherches sur les sapogénines à noyau stérolique: IV. Les génines d'Agaves et de Yuccas", *Bull. Soc. Chim. biol.*, 1954, 36, 227-236.
78. HENRICI, Marguerite. "Physiological plant studies in South Africa: II. Transpiration of grasses and other plants under arid conditions", *Union S. Africa Dept. Agric. Rept. Vet. Educ. and Res.*, 1926, no. 11/12, 671-702; *Biol. Abstr.*, 1928, 5030.
79. HENRY, A. J. "The toxic principle of *Courbonia virgata*: its isolation and identification as a tetramethyl-ammonium salt", *Brit. J. Pharmacol.* 1948, 8, 187-188.
80. —; GRINDLEY, D. N. "*Courbonia virgata*: its chemical composition and basic constituents", *J. Soc. chem. Ind. Lond.*, 1949, 68, 9-12.
81. HENRY, T. H. *The plant alkaloids*, Philadelphia, 1949, 804 p.
82. HERRMANN, K. "Über Lignane und ihre praktische Bedeutung", *Pharmazie*, 1957, 12, 147-155.
83. HIRST, E. L.; JONES, J. K. N. "The gums and mucilages of plants", in *Handbuch der Pflanzenphysiologie*, VI, Berlin, Springer, 1957, 500-517.

84. HOUGH, L. ; JONES, J. K. N. ; WADMAN, W. H. " Constitution of gum myrrh — I ", *J. Chem. Soc.*, 1952, 796-800.
85. HOWES, F. N. " Age-old resins of the Mediterranean region and their uses ", *Econ. Bot.*, 1950, 4, 307-316.
86. HUTCHINSON, J. *A botanist in Southern Africa*, London, 1946, 686 p.
87. JACQUET, M^{lle} R. *Recherches botaniques et chimiques sur quelques Cactacées*, thèse doct. Univ. Paris (pharmacie), Paris, 1934, 176 p.
88. JAHANDIEZ, E. " Les Euphorbes cactéifères du nord-ouest de l'Afrique ", *Rev. gén. Bot.*, 1921, 33, 177-182.
89. JARETZKY, R. ; REBHOLZ, S. " Untersuchungen über die Möglichkeit einer therapeutischen Verwendung der Zwiebel von *Bowiea volubilis* Harvey ", *Arch. Pharm. Berl.*, 1943, 281, 337-353.
90. JONES, J. K. N. ; NUNN, J. R. " Constitution of gum myrrh — II ", *J. chem. Soc.*, 1955, 3001-3004.
91. — ; —. " The structure of frankincense gum ", *J. Amer. chem. Soc.*, 1955, 77, 5745-5746.
92. KATZ, A. " Über die Glykoside von *Bowiea volubilis* Harvey ", *Helv. chim. Acta*, 1958, 41, 1399-1404.
93. KAWAGUTI, R. ; KIM, K. W. " Constituents of the seeds of *Zizyphus vulgaris* Lamk. var. *spinosa* Bunge ", *J. pharm. Soc. Japan*, 1940, 60, 343-352 ; *Chem. Abstr.*, 1941, 35, 1396 ; II. " Betulinic acid ", 11, 595-596. *Chem. Abstr.*, 1941, 35, 3997.
94. KILLIAN, Ch. ; FEHER, D. *Recherches sur la microbiologie des sols désertiques*, Paris, Lechevallier, 1939, 127 p.
95. — ; LEMEE, G. " Les xérophytes : leur économie d'eau ", in *Handbuch der Pflanzenphysiologie*, III, Berlin, Springer, 1956, 787-824.
96. KLYSHEV, L. K. " Biochemical study of *Anabasis aphylla* ", *Izvest. Akad. Nauk. Kazakh SSR, Ser. Fiziol. i Biokhim. Rastenii*, 1947, 60-87 ; *Chem. Abstr.*, 1952, 46, 6706.
97. KOCK, W. T. DE ; ENSLIN, P. R. " Chemical investigations of photo-sensitization diseases of domestic animals : I. Isolation and characterization of steroidal sapogenins from *Tribulus terrestris* ", *J. South African chem. Industr.*, 1958, 11, 33-36.
98. KORETSKAYA, N. I. " Alkaloids of *Peganum harmala* : I. Isolation of two new alkaloids ", *Zhur. Obshchei Khim. (J. gen. Chem. Moscow)*, 1957, 27, 3361-3364 ; *Chem. Abstr.*, 1958, 52, 9163.
99. LABAN, E. A. " Extraction and essay of nordihydroguaiaretic acid in *Larrea nitida* ", *Chem. Abstr.*, 1953, 47, 7126. (Tesis Quim. Univ. Chile, 1950, 2, 17-32.)
100. LAFFARGUE. " Les possibilités en plantes médicinales de l'Égypte ", IV^e Congrès international des plantes médicinales et des plantes à essence, 1931, 277-281.
101. LEMIN, A. J. ; DJERASSI, C. " The conversion of diosgenin to cortisone via 11-ketosteroids of the 5- β -series ", *J. Amer. chem. Soc.*, 1954, 76, 5672-5674.
102. LEROY, J. C. Intervention à la suite de la communication de Migahid A. M. (See/voir no. 118).
103. MALLERY, T. D. " Changes in the osmotic value of the expressed sap of leaves and small twigs of *Larrea tridentata* as influenced by environmental conditions ", *Ecol. Monogr.*, 1935, 5, 1-35.
104. MANTELL, C. L. " The water soluble gums ", *Econ. Bot.*, 1949, 3, 3-31.
105. MARKER, R. E. ; TSUKAMOTO, T. ; TURNER, D. L. " Sterols-100-Diosgenin ", *J. Amer. chem. Soc.*, 1940, 62, 2525-2532.
106. — ; WAGNER R. B. ; GOLDSMITH, D. P. J. ; ULSHAFFER, P. R. ; RUOF, C. H. " Sterols CLVI - Sapogenins 68. The steroidal sapogenin from *Balanites aegyptiaca* Wall. ", *J. Amer. chem. Soc.*, 1943, 65, 1248-1249.
107. — ; — ; ULSHAFFER, P. R. ; WITTBECKER, E. L. ; GOLDSMITH, D. P. J. ; RUOF, C. H. " Sterols CLVII - Sapogenins 69. Isolation and structures of thirteen new steroidal sapogenins. New sources for known sapogenins ", *J. Amer. chem. Soc.*, 1943, 65, 1199-1209.
108. — ; —. " Steroidal sapogenins ", *J. Amer. chem. Soc.*, 1947, 69, 2167-2230.
109. — ; — ; —. " New sources of sapogenins ", *J. Amer. chem. Soc.*, 1947, 69, 2242.
110. — ; LÓPEZ, J. " Steroidal sapogenins - no. 168. The structural relationship of botanin ", *J. Amer. chem. Soc.*, 1947, 69, 2397-2398.
111. — ; —. " Steroidal sapogenins - no. 170. Biogenesis of the steroidal sapogenins in Agaves, Manfreda and Hesperaloe ", *J. Amer. chem. Soc.*, 1947, 69, 2403-2404.
112. MASSIEU, G. ; AGUIRRE, O. ; CRAVIOTO, R. O. " Nota sobre la actividad de vitamina B₁₂ en el pulque ", *An. Esc. nac. Cienc. biol., Méx.*, 1953, 7, 45-48.
113. MAULI, R. ; TAMM, Ch. " Die Glykoside von *Periploca nigrescens* Afzel ", *Helv. chim. acta.*, 1957, 40, 299-305.
114. MCGINNIES, W. G. " The United States and Canada ", *Plant ecology. Reviews of research*, Paris, Unesco, 1955, p. 250-301. (*Arid zone research*, VI.) [Résumé en français.]

115. MCNAIR, J. B. "The taxonomic and climatic distribution of alkaloids", *Bull. Torrey bot. Cl.*, 1935, 62, 219-226.
116. MEIGS, P. "World distribution of arid and semi-arid homo-climates", *Reviews of research on arid zone hydrology*, Paris, Unesco, 1953, 203-210. (*Arid zone programme*, I.) [Existe également en français.]
117. MERCK, E. "*Retama negra* and its active constituents", *Anno. E. Merck*, 1937, 50, 365-383; *Chem. Abstr.*, 1938, 32, 7212.
118. MIGAUD, A. M. "Water economy of desert plants", *Proceedings, Symposium on Scientific Problems of Land Use in Arid Regions*, Heliopolis, 1954, 3-35.
119. MOCHADAM, S. *Les Mannes de Perse*, Paris, 1930, 145 p.
120. MOUTERDE, P. *La flore du Djebel Druze*, Beyrouth, 1953, 224 p.; Paris, Lechevallier.
121. NARBONNE, G. *Contribution à l'étude des Ephedra : Ephedra nord-africains et leurs alcaloïdes*, th. doct. Univ. Alger (pharmacie), Alger, V. Heintz, 1940, 120 p.
122. NAUROY, J. *Contribution à l'étude de la pharmacopée marocaine traditionnelle (drogues végétales)*, th. doct. Univ. Paris (pharmacie), Paris, Jouve, 1954, 152 p.
123. NIELSEN, C.; MACCAUSLAND, H.; SPRUTH, H. C. "The occurrence and alkaloidal content of various *Ephedra* species", Part I : *J. Amer. pharm. Ass.*, 1927, 16, 288-294; Part II : *J. Amer. pharm. Ass.*, 1928, 17, 427-430.
124. OLIVIERI, J. *Les espèces utiles du genre Ferula*, th. doct. Univ. Paris (pharmacie), Paris L. Declume, 1914, 117 p.
125. ORECHOFF, A. "Sur les alcaloïdes de l'*Anabasis aphylla*", *C. R. Acad. Sci.*, 1929, 189, 945.
126. —; PROSKURNINA, N. "Über die Alkaloide von *Salsola richteri*", *Ber. dtsh. chem. Ges.*, 1933, 66, 841-843.
127. OZENDA, P. *Flore du Sahara septentrional et central*, Paris, Centre national de la recherche scientifique, 1958, 486 p.
128. PAGE, J. O. "Determination of dehydronorguaiaretic in the creosote bush", *Analyt. Chem.*, 1955, 27, 1266-1268.
129. PALUMBO, F. *Notes sur les plantes médicinales et aromatiques des colonies italiennes*, thèse doct. Univ. Paris (pharmacie), Lons-le-Saunier, 1932, 132 p.
130. PARIS, R. "Sur le noircissement des feuilles de Globulaire Turbith (*Globularia alypum* L.)", *Bull. Soc. bot. Fr.*, 1946, 93, 159-162.
131. —. "Sur un flavonoside des fleurs d'*Opuntia vulgaris* Miller", *C. R. Acad. Sci.*, 1951, 233, 90.
132. —. "Sur le flavonoside des fruits du *Paliurus aculeatus* Lamk.", *C. R. Acad. Sci.*, 1951, 235, 1, 1329-1331.
133. —; AUBRAT, M^{lle} M.-Y. "Le genre *Balanites*, ses affinités et sa place en systématique", *Bull. Soc. bot. Fr.*, 1946, 93, 202.
134. —; DAVID-CUNY, M^{me} M.-F. "A propos du dosage des dérivés anthracéniques dans quelques drogues purgatives", *Ann. pharm. franç.*, 1955, 13, 488-494.
135. —; DURAND, M. "A propos de l'essai des Aloès-dosage photométrique de l'aloïne", *Ann. pharm. franç.*, 1956, 14, 755.
136. —; LYS, P. "Sur l'origine botanique et la composition chimique du "Polygala de Syrie (*Spergularia marginata* Kittel)", *Ann. pharm. franç.*, 1954, 12, 171-179.
137. —; POINTET, M. "L'*Ammi visnaga*", *Prod. pharm.*, 1957, 12, 255.
138. PEREZ, C.; PARIS R. "Sur une nouvelle drogue hypogly-cémiante, le *Zygophyllum cornutum* Cosson", *Ann. pharm. franç.*, 1958, 16, 86-90.
139. PERRAULT, M.; CLAVEL, B. "Sérotonine et anti-sérotonines", *Sem. Hôp. Paris*, 1957, 33, 810-812.
140. PERROT, Em. *La gomme arabique, le séné et quelques autres produits végétaux du Soudan anglo-égyptien*, Lons-le-Saunier, Office national des matières premières végétales, 1920, 72 p. (Notice no. 5.)
141. —. "Une plante nouvelle pour le Sahara soudanais (*Cassia acutifolia* Del.)", *Bull. Soc. bot. Fr.* 1928, 75, 102-103.
142. —. "Sur les productions végétales indigènes ou cultivées de l'Afrique-Occidentale française", Lons-le-Saunier, Office national des matières premières végétales, 1929, 195 p. (Notice no. 31.)
143. —. "Une plante nouvelle à colchicine, le 'lofout', Liliacée saharienne", *Bull. Sc. pharmacol.*, 1936, 38, 257-258.
144. —; GENTIL, L. *Sur les productions végétales du Maroc*, Lons-le-Saunier, Office national des matières premières végétales, 1921, 170 p. (Notice no. 10.)
145. PICHI-SERMOLLI, R. E. G. "Tropical East Africa", *Plant ecology. Reviews of research*, Paris, Unesco, 1955 p. 302-360. (*Arid zone research*, VI.) [Résumé en français.]
146. PLANCHON, G.; COLLIN, E. *Les drogues simples d'origine végétale*, Paris, 1896, 2 vol.
147. POINTET, M. *Contribution à l'étude de l'Ammi visnaga L.*, th. doct. Univ. Paris (pharmacie), Paris, Jouve, 1954, 150 p.

148. POINTET-GUILLOT, M^{me} M. *Contribution à l'étude chimique et pharmacologique de la Réglisse*, th. doct. Univ. Paris (pharmacie), Paris, Jouve, 1958, 146 p.
149. POST, G. E. *Flora of Syria, Palestine and Sinai*, 2nd ed. Beirut, 1932-1933, 2 vol.
150. RAUTOU, S. "Le Ricin en France méridionale", *Ann. Amélior. Plantes*, 1958, 75-112.
151. RENIER, H. J. *Les Eucalyptus en Australie et en Tasmanie*, Bruxelles, Direction de l'agriculture, 1953, 126 p.
152. RENZ, J. "Glucosides cardiotoniques de *Periploca graeca* L.", *Rev. Bot. appl.*, 1953, 32, 52-55.
153. REY, F. Pablo. " *Larrea cuneifolia* Cav. ", *Rev. Col. Farm. nac.*, 1946, 13, 55-62; *Chem. Abstr.*, 1947, 41, 566.
154. RIBAS, I. *Recientes progresos de la investigación en el campo de las alcaloides de las Papilionaceas. Discurso inaugural*, Compostela, 1957, 112 p.
155. —; VEGA, J. "Alcaloides de Leguminosae Papilionaceas XX. Alcaloides de los frutos de la *Retama sphaerocarpa* Boiss.", *Ion. Madr.*, 1953, 13, 148-156.
156. —; MARQUES; FRAGA, F.; GESTO, M. D. V. "Some alkaloids of *Retama sphaerocarpa*", *An. Soc. esp. Fis. Quim.*, 1949, 45B, 757-766; *Chem. Abstr.*, 1950, 44, 2539.
157. —; SÁNCHEZ, A.; PRIMO, E. "The alkaloids of *Retama sphaerocarpa* and the constitution of retamine", *An. es. Fis. Quim.*, 1946, 42, 516-538; *Chem. Abstr.*, 1947, 41, 4894.
158. ROSENGART-FAMEL, Y. *Étude botanique, chimique et pharmacodynamique de diverses espèces Anabasis et Haloxylon*, th. doct. Univ. (pharmacie), Paris, 1937, 135 p.
159. ROUHIER, A. *Monographie du Peyotl. Echinocactus williamsii Lem.*, th. doct. Univ. Paris (pharmacie), Lons-le-Saunier, Declume, 1927, 367 p.
160. —. " *La plante qui fait les yeux émerveillés: le Peyotl* ", Paris, 1927.
161. RUNYON, E. G. "The organization of the creosote bush with respect to drought", *Ecology*, 1934, 15, 128-138.
162. SABER, A. Hefny; BALBAA, Shafik I. " *Hyoscyamus muticus* L., in relation to its natural environmental conditions ", *Proceedings, Symposium on Scientific Problems of Land Use in Arid Regions*, Heliopolis, 1954, 77-110.
163. SADYKOV, A. S.; OSTROSECHENKO, O. S.; KASYMOV, T. K. "The alkaloids of *Anabasis aphylla*", *Dokl. Akad. Nauk Uzbek SSR*, 1954, 25-27 (in Russian, en russe); in *Chem. Abstr.*, 1956, 50, 5241.
164. SANNIE, Ch. "La synthèse des hormones génitales et cortico-surrénales à partir des plantes exotiques", *Rev. Bot. appl.*, 1955, 2, 28-39.
165. SANTAVY, F.; CERNOCHE, M.; MALINSKY, J.; LANG, B.; ZAJICKOVA, A. "Isolement des substances des bulbes des différentes espèces du genre Colchique", *Ann. pharm. franç.*, 1951, 9, 50-59.
166. SCHEFFER, F. "Der organisch gebundene Stickstoff des Bodens, seine Verwertbarkeit", *Handbuch der Pflanzenphysiologie*, VIII, Berlin, Springer, 1958, 179.
167. SESHADRI, T. R.; SUBRAMANIAN, S. S. "Chemical examination of Indian squill", *J. sci. industr. Res. India*, 1950, 9B, 114-118.
168. SHMUEL, E. "The water balance of some plants of the Dead Sea salines", *Palest. J. Bot., Jerusalem, Ser.*, 1948, 4, 117-143.
- 168a. SMITH, B. S. W. [See/voir, no. 75.]
169. SPENSLEY, P. C. "A source of hecogenin", *Chem. & Ind. (Rev.)*, 1952, 426-428.
170. —. "A source of hecogenin III. Extraction from Sisal juice", *Chem. & Ind. (Rev.)*, 1956, 229-231.
171. STOCKER, O. "Transpiration und Wasserhaushalt in verschiedenen Pflanzen in der ungarischen Alkalisteppe", *Jb. wiss. Bot.*, 1933, 78, 751-856.
172. STOLL, A. "Sur les substances cardiotoniques de la Scille maritime (*Scilla maritima* L.)", *Experientia*, 1954, 10, 282-297.
173. —; KUSSMAUL, W.; BECKER, B. "Die wirksamen stoffe der *Senna*", *Verh. Schweiz. Naturf. Ges.*, 1941, 142, 235-236.
174. STRAUB, W.; GEBHARDT, H. "Über die wirksamen Inhaltsstoffe der Folia Sennae", *Arch. exp. Path. Pharmac.*, 1936, 181, 399-407.
175. STROMBERG, V. L. "The isolation of butotenine from *Piptadenia peregrina*", *J. Amer. chem. Soc.*, 1954, 76, 1707.
176. TAYEAUT, F.; FAURE, M^{lle} F.; SECHET, M^{me} J. "Recherches sur la valeur alimentaire des protéines du *Balanites aegyptiaca* (Simarubacées)", *Bull. Soc. Chim. biol.*, 1955, 37, 629-633.
177. TREASE, G. E. *Textbook of pharmacognosy*, 64th ed., London, 1952, 821 p.
178. TROST, F. "Sugli ossiacidi triterpenici dell' incenso somalo", *Anr. Chim. appl., Roma*, 1937, 27, 178-188.
179. —; DORO B. Sui sesquiterpeni e sulle reazioni di riconoscimento della mirra maschio, *Ann. Chim. appl., Roma*, 1936, 26, 126-130.
180. TSCHESCHE, R.; DÖLBERG, U. "Zur Kenntniss der Bufadie nolid-glykoside aus *Bowiea volubilis* Harvey", *Chem. Ber.*, 1957, 90, 2378-2382.

181. TSUCHIYA, H. M.; DRAKE, C. H.; HALVORSON, H. O.; BIETER, R. N. "An antibacterial substance from a plant", *J. Bact.*, 1944, 47, 422.
182. VÁSQUEZ GESTO; RIBAS, I. "Alcaloides de Papilionaceas. XXVIII : Alcaloides de la *Genista monosperma* Lam. (*Retama monosperma*)", XXVIII Congreso intern. de Quim. ind., 1955.
183. VENAULT, G. "La gomme arabique dans la région du Tchad", *Agron. trop.*, Nogent, 1946, 1, 179-181.
184. VILLIERS. "Recherches sur le mélézitose", *Ann. Chim. (Phys.)*, (5), 1877, 12, 433-437.
185. VOUTYRAKIS, C. "Recherches sur les *Rhamnus alaternus* L. et *punetata* Boiss.", *Ann. Fac. Méd. Pharm.*, Beyrouth, 1937, 6, 257-324.
186. WAGNER, R. B.; FORKER, R. F.; SPITZER, P. F. "The Δ^9 12-ketosteroidal sapogenins", *J. Amer. chem. Soc.*, 1951, 73, 2494-2497.
187. WASICKY, R. "Zur Mikrochemie der Oxymethylantrachinone und über ein Anthraglykoside spaltendes Enzym im Rhabarber", *Ber. dtsh. bot. Ges.*, 1915, 33, 37-45.
188. WEBB, L. J. *Australian phytochemical survey*, Commonwealth Scientific and Industrial Research Organization, Part I : 1949, *Bulletin* 241, 56 p.; Part 2 : *Bulletin* 268, 1952, 99 p.
189. ———. "Alkaloid potentialities of the Australian flora", *J. Aust. Inst. agric., Sci.*, 1953, 19, 144-157.
190. WHITE, D. E. "The pentacyclic triterpenoids", *Rev. of pure and appl. Chem.*, 1956, 6, 191-248.

A LIST OF ARID ZONE MEDICINAL SPECIES¹

- Abrus precatorius* L. (Leguminosae), 73
Abutilon hirtum G. Don. (Malvaceae)
A. indicum Sweet.
A. theophrasti Medic.
Acacia abyssinica Hochst. (Leguminosae), 17
A. arabica Willd., 16, 17, 75
A. arabica Willd. var. *nilotica*, 75
A. ehrenbergiana Hayne, 17
A. glaucophylla Steud., 17
A. gummifera Willd., 17
A. horrida Willd., 17
A. leucophloea Willd.
A. modesta Wall., 17
A. pycnantha Benth., 17
A. senegal Willd., 17, 75, 84
A. seyal Del., 17, 75
A. stenocarpa Hochst., 17
A. vereke Guill. & Perrott., 75
Achillea santolina L. (Compositae)
Achyranthes aspera L. (Amarantaceae)
Acokanthera ouabaio Poix. (Apocynaceae), 80
Aerva tomentosa Forsk. (Amarantaceae)
Agave atrovirens Karw. (Amaryllidaceae), 18, 63
A. aurea Budge., 18
A. cerulata Trel., 18
A. dudleya, 62
A. goldmaniana Trel., 62
A. lecheguilla Torr., 62
A. mapisaga Trel., 18
A. mirabilis Trel., 18
A. nelsonii Trel., 18
A. promontori Trel., 18
A. rigida Mill., 62
A. roseana Trel., 18
A. siselana Perrine, 62
A. sobria Brandeg., 18
A. sullivanii Trel., 18
A. tequilana Weber, 63
A. toumeyana Trel., 18
A. vilmoriniana Weber, 18
Alhagi camelorum Fisch. (Leguminosae), 72, 73
A. maurorum D.C., 72
A. maurorum Medic.
A. pseudoalhagi Desv., 72
Aloe africana Mill. (Liliaceae), 61
A. barbadensis Mill., 18
A. candelabrum Berger, 18
A. ferox Mill., 18, 19, 61
A. perryi Baker, 18, 19, 61
A. spicata Baker, 61
A. succotrina Lam., 18
A. vera L., 61
A. vera L. (*A. barbadensis* Mill.), 18
A. vera Tourn. ex L. var. *officinalis*, 18
A. vulgaris Lam., 61
Ambrosia maritima L. (Compositae)
Ammi majus L. (Umbelliferae), 15, 16, 19, 20, 79
A. visnaga Lam., 15, 16, 19, 20, 79
Amygdalus communis L. (Rosaceae), 77
Anabasis aphylla L. (Chenopodiaceae), 20, 64, 65
A. aretioides Moq. & Coss., 64
A. articulata Moq., 64
A. prostrata Pomel, 64
A. reticulata Moq., 64
Androcymbium gramineum Macbride (Liliaceae), 59
Andrographis echioides Muell. Arg. (Acanthaceae)
Ankiropetalum caelesyriacum Boiss. (Caryophyllaceae), 66
A. gypsophiloides Fenzl., 66
Argemone mexicana L. (Papaveraceae), 21
Artemisia absinthium L. (Compositae), 21
A. annua L., 22

1. Page numbers are given when the species are mentioned in this volume.

- A. campestris* L., 84
A. cina Berg., 21, 22, 23, 83
A. dracunculus L., 22
A. fragrans Willd., 21
A. gallica Willd., 21
A. herba-alba L., 22
A. herba-alba Asso., 83
A. herba-alba Asso. var. *laxiflora*, 22, 84
A. judaica L., 84
A. maritima L., 21, 22, 23, 83, 84
A. maritima forma *rubricaula*, 22
A. mexicana Willd., 21
A. monogyna Waldst. & Kit., 84
A. neo-mexicana Woot., 21
A. parviflora Roxb., 21
A. persica Boiss.
A. sacrorum Ledeb., 23
A. scoparia Waldst. & Kit.
A. siversiana Ehrh.
A. wrightii A. Gray, 21
Astragalus adstringens Boiss. & Haussn. (Leguminosae), 76
A. gummifer Labill., 75, 76
A. hamosus L.
A. heratensis Bunge
Atropa belladonna L. (Solanaceae), 81

Balanites aegyptiaca Del. (Simarubaceae), 15, 23, 69, 80
B. glabra Mild. & Schlechter, 69
B. orbicularis Sprague, 69
B. roxburghii Planch., 23, 69
B. tomentosa Mild. & Schlechter, 69
Barleria prionitis L. (Acanthaceae)
Bergia odorata Edgew. (Elatinaceae)
Blepharis edulis Pers. (Acanthaceae)
B. linariaefolia Pers.
Boswellia bhowdajiana Birdw. (Burseraceae), 70
B. carterii Birdw., 70
B. dalzielii Hutch., 70
B. freriana Birdw., 70
B. papyrifera Hochst., 70
B. serrata Roxb., 70
Bowiea volubilis Hawey (Liliaceae), 60
Bryonia cretica L. (Cucurbitaceae)
Butea frondosa Roxb. (Leguminosae), 24
B. monosperma (Lam.) Kuntze, 16, 24

Cadaba farinosa Forsk. (Capparidaceae)
Calligonum polygonoides L. (Polygonaceae)
Calotropis gigantea Ait. (Asclepiadaceae), 16, 25
C. procera Ait., 16, 25, 80
Caltha polypetala Hochst. (Ranunculaceae)
Capparis aphylla Roth. (Capparidaceae), 26
C. decidua Edgew., 26
C. grandis L., 26
C. spinosa L., 26, 66

Carissa spinarum L. (Apocyanaceae)
Carthamus oxyacantha Bieb. (Compositae)
Cassia acutifolia Del. (Leguminosae), 15, 16, 26, 27, 74, 84
C. angustifolia Vahl., 15, 16, 26, 27, 74, 85
C. auriculata L., 74
C. fistula L., 74
C. obovata Coll., 74, 84
Ceratonía siliqua L. (Leguminosae), 76
Cistanche tubulosa Wight (Orobanchaceae)
Citrullus colocynthis Schrad. (Cucurbitaceae), 15, 16, 28, 83
Cleome brachycarpa Vahl. (Capparidaceae)
Clerodendrum phlomoides L. (Verbenaceae)
Colchicum autumnale L. (Liliaceae), 59
C. montanum L., 59
C. ritchii R. Br., 59
Colocynthis vulgaris Schrad. (Cucurbitaceae), 83
Colytea nepalensis Sims. (Leguminosae)
Commiphora abyssinica Engl. (Burseraceae), 70
C. africana Engl., 70
C. cornii, 70
C. erythraea Engl., 70
C. guidottii Chiov., 70
C. mukul Engl., 28
C. myrrha Engl., 70
C. opobalsamum Engl., 70
C. parviflora, 70
C. playfairii, 70
C. roxburghii Alston
C. setulifera Chiov., 70
C. socotrana Engl., 70
Convallaria maialis L. (Liliaceae), 60
Convolvulus arvensis L. (Convolvulaceae), 29
C. glomeratus Choisy, 29
C. scammonia L., 29, 81
C. spinosus Burm. f., 29
Corallocarpus epigaeus Benth. & Hook. f. (Cucurbitaceae)
Corchorus aestuans (Tiliaceae)
C. capsularis L.
C. depressus Christensen
C. fascicularis Lam.
C. trilocularis L.
Courbonia virgata Brongn. (Capparidaceae), 66
Crotalaria albida Heyne (Leguminosae)
C. burhia Buch. Ham.
C. prostrata Rottl.
Cucumis melo L. (Cucurbitaceae)
C. prophetarum L.
C. trigonus Roxb.
Cymbopogon citratus Stapf (Graminae), 63
C. flexuosus Stapf, 63
C. martini Stapf, 63
C. nardus Rendle, 63
C. proximus Stapf, 63

C. schoenanthus Spreng., 63
Cytisus scoparius Link. (Leguminosae)

Daemia extensa R. Br. (Asclepiadaceae), 45
Daphne oleoides Schreb. (Thymelacaceae)
Datura inoxia Mill. (Solanaceae), 15, 29
D. stramonium L., 15, 29, 30
Delphinium nudicaule Torr. & Grey (Ranunculaceae)
D. staphisagria L.
D. zalil Aitch. & Hemsl., 31
Descurainia sophia Webb (Cruciferae), 16, 31
Dioscorea spp., 63
Dipcadi cowanii H. Perrier (Liliaceae), 60
D. erythraeum Webb & Benth.
Dorema ammoniacum Don. (Umbelliferae), 79
D. aucheri Boiss., 79
Duboisia hopwoodii F. Muell. (Solanaceae), 32, 82
D. leichhardtii F. Muell., 82
D. myoporoides R. Br., 82

Echinocactus gibbosus D. C. (Cactaceae)
E. williamsii Lem., 77
Echinopsis eyriesii Zucc. (Cactaceae)
Ephedra alata Decne var. *alenda* (Gnetaceae), 58

E. californica Wats., 58
E. distachya L., 33
E. equisetina Bunge, 32, 33, 58
E. foliata Boiss., 59
E. gerardiana Wall., 32, 33, 58
E. gerardiana Wall. var. *saxatilis* Stapf, 33
E. gerardiana Wall. var. *sikkimensis*, 33
E. intermedia Schrenk & Meyer, 33, 58
E. intermedia Schrenk & Meyer var. *tibetica*, 58
E. major Host., 32, 33, 58
E. nebrodensis Tineo, 33, 58
E. nevadensis Wats., 58
E. sinica Stapf, 32, 33, 58
E. trifurca Torrey, 58
E. vulgaris Hook f., 32, 58
Eucalyptus dumosa A. Cunn. (Myrtaceae), 78
E. globulus Labill., 78
E. oleosa F. Muell., 78
Euphorbia antiquorum L. (Euphorbiaceae), 16, 34
E. atoto Forst., 36
E. cattimandoo W. Ell., 36
E. ellioti Léandri, 36
E. grandidens Haw., 66
E. hirta L., 16, 34
E. hypericifolia L., 16, 35
E. nerifolia L., 16, 25, 35
E. nivulia Buch. Ham., 16, 35
E. pilulifera auct. non L., 34
E. resinifera Berg., 16, 35, 66
E. royleana Boiss., 16, 36
E. sanguinea Hochst. & Steud.

E. tirucalli L., 16, 36
E. trigona Haw., 16, 36
E. turcomanica Boiss.

Fagonia cretica L. (Zygophyllaceae)
Farsetia hamiltonii Royle (Cruciferae)
F. jacquemontii Hook. f. & Thoms.
Ferula alliacea Boiss. (Umbelliferae), 16, 37
F. assa-foetida L., 16, 37, 79
F. foetida Regel, 16, 37
F. galbaniflua Boiss. & Buhse, 16, 38, 79
F. narthex Boiss., 16, 37
F. rubricaulis Boiss., 37, 79
F. schair Borszcz., 79
F. sumbul Hook. f., 16, 38
Ficus arnottiana Miq. (Moraceae)
F. carica L.
Flemingia strobilifera R. Br. (Leguminosae)
Flourensia cernua (Zygophyllaceae), 67
Fluggea leucopyrus (Koen.) Willd. (Euphorbiaceae)
Foeniculum capillaceum Gilib. (Umbelliferae), 38
F. officinale All., 38
F. vulgare Mill., 15, 16, 38
F. vulgare Mill. var. *vulgare* (Mill.) Thellung, 38
F. vulgare Mill. var. *dulce*, 38
Franseria dumosa A. Gray (Compositae), 67
Fraxinus ornus L. (Oleaceae), 79

Genista monosperma Lam. (Leguminosae), 72
Globularia alypum L. (Globulariaceae), 82
Glycyrrhiza glabra L. (Leguminosae), 15, 16, 35, 76
G. glabra var. *glandulifera* Reg. & Herd., 35
G. glabra var. *typica* Reg. & Herd., 35
G. glabra var. *uralensis* Fisch., 35
G. glabra var. *violacea* Boiss., 35, 76
Gossypium herbaceum L. (Malvaceae)
Grangea maderaspatana Poir. (Compositae)
Grewia populifolia Vahl. (Tiliaceae)
G. tenax Fiori
G. villosa Willd.
Grindelia squarrosa Dunal (Compositae), 83
Guaiacum officinale L. (Zygophyllaceae), 67
Gymnosporia spinosa Fiori (Celastraceae)
Gypsophila arrostii Guss. (Caryophyllaceae), 66
G. fastigiata L., 66
G. paniculata L., 66
G. struthium L., 66

Haloxylon recurvum Bunge ex Boiss. (Chenopodiaceae)
H. salicornicum Bunge
H. tamarixifolium Pau, 65
Hedysarum alhagi L. (Leguminosae), 72
Heliotropium eichwaldi Steud (Boraginaceae)
H. ophioglossum Stocks.

- H. strigosum* Willd.
H. tuberculosum Boiss.
Holarrhena africana D. C. (Apocynaceae), 84
H. antidysenterica Wall., 84
Hyoscyamus albus L. (Solanaceae), 15, 40
H. albus L. var. *desertorum*, 82
H. boveanus Ascher-Schw., 82
H. desertorum Täckholm, 82
H. falezlez Cosson, 81
H. muticus L., 15, 40, 81, 84
H. niger L., 40, 82
Hyssopus officinalis L. (Labiatae), 82
Indigofera linifolia Retz. (Leguminosae)
I. oblongifolia Forsk.
Inula grantioides Boiss. (Compositae)
Ipomea orizabensis Ledenois (Convolvulaceae)
 81
Kylinga triceps Rotth. (Cyperaceae)
Larrea cuneifolia Cav. (Zygophyllaceae), 67, 68
L. divaricata Cav., 67, 68
L. nitida Cav., 67
L. tridentata Coul., 67, 68
Lavandula antineae Maire (Labiatae), 82
L. latifolia Vill., 16, 40
L. officinalis Chaix, 16, 40
L. spica Cav., 82
L. staechas L., 82
L. vera D. C., 82
Lecanora esculenta (Lecanoraceae), 72
Leucas cephalotes Spreng. (Labiatae)
L. urticaefolia R. Br.
Lindenbergia indica O. Kuntz (Scrophu-
 lariaceae)
Lophophora lewinii C. H. Thompson (Cacta-
 ceae), 42
L. williamsii Coulter, 16, 42
Lotus arabicus L. (Leguminosae), 73
L. jolyigi Batt., 73
Lycium barbarum L. (Solanaceae)
L. ruthenicum Murr.
Mollugo cerviana Ser. (Ficoidaceae)
M. nudicaulis Lam.
Moringa aptera Gaertn. (Moringaceae)
M. concanensis Nimmo
Myrtus communis L. (Myrtaceae), 78
Nerium oleander L. (Apocynaceae), 80
Nicotiana glauca R. Grah. (Solanaceae), 20, 64
Ochradenus baccatus L. (Resedaceae)
Ocimum canum Sins. (Labiatae), 83
O. kilimandscharicum Guerke, 83
Olea europaea L. (Oleaceae), 80
O. europaea L. var. *silvestris*, 80
Opuntia coccinellifera Mill. (Cactaceae)
O. dillenii Haw.
O. ficus-indica Mill.
O. nigricans Haw.
O. stricta Haw.
O. vulgaris Mill., 77, 78
Paliurus aculeatus Lam. (Rhamnaceae), 71
Panicum miliaceum L. (Gramineae)
Papaver dubium L. (Papaveraceae)
P. rhoeas L.
P. somniferum L., 15, 43
P. somniferum L. var. *album* De Candolle, 43
Pavonia odorata Willd. (Malvaceae)
P. propinqua Garcke
Peganum harmala L. (Zygophyllaceae), 16,
 44, 68, 69
Pegoletia senegalensis Cass. (Compositae)
Pentatropis cynanchoides R. Br. (Asclepia-
 daceae)
Pergularia extensa N. E. Br. (Asclepiadaceae),
 16, 45
Periploca aphylla Decne. (Asclepiadaceae), 81
P. forsteri Decne., 81
P. graeca L., 80
P. laevigata Ait., 81
P. nigrescens Afzel, 81
Perooskia abrotanoides Karel. (Labiatae)
Phaseolus lunatus L. (Leguminosae), 73
Phoenix dactylifera L. (Palmae)
Phyllanthus maderaspatensis L. (Euphor-
 biaceae)
Physochlaina praelia Miers. (Solanaceae), 15,
 46
Physostigma venenosum Balf. (Leguminosae),
 71
Pimpinella anisum L. (Umbelliferae), 15, 16,
 46
Pinus gerardiana Wall. (Pinaceae)
Piptadenia macrocarpa Benth. (Leguminosae),
 73
P. paniculata Benth., 73
P. peregrina Benth., 73
Plantago amplexicaule Cav. (Plantaginaceae)
P. arenaria Waldst. & Kit., 48
P. ciliata Desf.
P. indica L., 47, 48
P. lagocephala Bunge
P. ovata Forsk., 47, 48
P. psyllium L., 47, 48
P. ramosa Gilib., 48
Pluchea pinnatifida Hook. F. (Compositae)
Polygala senega L. (Polygalaceae), 65
Populus euphratica Oliv. (Salicaceae)
P. nigra L.
Portulaca oleracea L. (Portulacaceae)
P. quadrifida L.
P. tuberosa Roxb.
Prosopis specigera L. (Leguminosae)
Pulicaria glaucescens Jaub. & Spoch.
 (Compositae)

Medicinal plants of the arid zones

Punicata granatum L. (Punicaceae), 78

Rauwolfia serpentina Benth. (Apocyniaceae), 84

R. vomitoria Afzel, 84

Retama monosperma Boiss. (Leguminosae), 72

R. negra, 72

R. raetam Webb, 72, 77

R. sphaerocarpa Boiss., 72

R. webbii Spach., 72

Rhamnus alaternus L. (Rhamnaceae), 71

Rh. cathartica L., 70

Rh. frangula L., 70

Rh. lanceolata Pursh., 71

Rh. libanotica Boiss., 71

Rh. palaestina Boiss., 71

Rh. paliurus L., 71

Rh. punctata Boiss., 71

Rh. purshiana D. C., 70

Ricinus communis L. (Euphorbiaceae), 66, 67

Rosmarinus officinalis L. (Labiatae), 16, 48, 82

Ruscus aculeatus L. (Liliaceae), 62

Ruta graveolens L. (Rutaceae), 69

Salsola arbuscula Pall. (Chenopodiaceae), 65

S. foetida Del.

S. kali L.

S. richleri Karel., 65

S. subaphylla C. A. Mey., 65

Salvadora oleoides Decne (Salvadoraceae).

S. persica L.

Salvia aegyptiaca L. (Labiatae).

S. cabulica Benth.

S. officinalis L., 15, 16, 49,

S. spinosa L.

Saponaria officinalis L. (Caryophyllaceae), 66

Sarcostemma acidum (Roxb.) Voigt (Asclepiadaceae)

Schweinfurthia sphaerocarpa A. Br. (Scrophylariaceae)

Scilla maritima L. (Liliaceae), 60

Scorodosma foetidum Bunge (Umbelliferae), 79

Selenicereus grandiflorus Brit. & Rose (Cactaceae), 16, 50

Sida grevioides Guill. & Perrott. (Malvaceae)

Sisymbrium orio (Cruciferae), 31.

S. sophia L. 31,

Solanum albicaule Kotschy (Solanaceae)

S. carolinense L., 15, 50

S. dulcamara L.

S. gracilipes Decne

S. incanum L.

S. xanthocarpum Schrad. & Wendl., 15, 50

Solenostemma argel Hayne (Asclepiadaceae)

Spergularia marginata Kittel (Caryophyllaceae), 65

Statice aegyptiaca Pers. (Plumbaginaceae)

S. cabulica Boiss.

Strophantus spp. (Apocynaceae), 80

Suaeda fruticosa Forsk. (Chenopodiaceae)

S. monoica Forsk.

Tamarix aphylla Karst. (Tamaricaceae)

T. dioica Roxb.

T. gallica L.

T. mannifera Ehrenb., 72

Tecomella undulata (G. Don.) Seem. (Bignoniaceae)

Testudinaria (Dioscoreaceae), 63

Thapsia garganica L. (Umbelliferae), 79

Th. villosa L., 79

Thymus broussonetii Boiss. (Labiatae), 83

T. capitatus Hoffm., 83

T. vulgaris L., 51, 82

T. zygis L., 83

Trianthema pentandra L. (Ficoidaceae)

Tribulus alatus Del. (Zygophyllaceae)

T. terrester L., 68

Trichodesma africanum R. Br. (Boraginaceae)

T. indicum R. Br.

Trigonella foenum-graecum L. (Leguminosae), 77

Urginea indica Kunth. (Liliaceae), 52, 60

U. maritima Baker, 52, 60

U. scilla Steinh. 52, 60.

Withania obtusifolia T. Tackh. (Solanaceae), 82

W. somnifera Dunal, 82

Yucca brevifolia Engelm. (Liliaceae), 62

Y. elata Engelm., 62

Y. glauca Nutt., 62

Y. valida Brandeg., 62

Zizyphus jujuba Lam. (Rhamnaceae), 71

Z. lotus Lam., 71

Z. mauritania Link., 71

Z. nummularia Wight & Arn., 71

Z. sativa Gaertn., 71

Z. spina christi Willd., 71

Zygophyllum coccineum L. (Zygophyllaceae)

Z. cornutum Cosson, 68

Z. simplex L.