HISTORY OF THE INTRODUCTION OF EXOTIC ELEMENTS INTO TRADITIONAL CHINESE MEDICINE

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An investigation into the history of using products derived from introduced species of plants and animals in traditional Chinese medicine (TCM) clearly demonstrates East-West cultural interaction. The research was performed in a framework arbitrarily set with the time limited to before 1911 and the material included in three important references: *Zhong Yao Zhi* (*A New Chinese Materia Medica*; Anonymous, 1959–1961), *Zhong Yao Da Ci Dian* (*An Encyclopedia of Chinese Medicines*; Anonymous, 1977–1979), and *Zhong Cao Yao Xue* (*Chinese Pharmacology*; Anonymous, 1976–1980). The work contains a list of 94 commercial products arranged alphabetically by scientific name, together with the equivalent Chinese and English names; a chronological account of the first record of the species and imported products; an analysis of the reasons for using extra-Chinese elements in TCM; and an account of the principles and criteria for identifying exotic species.

When I began to study the medicinal plants of China in the early 1930's, the knowledge of Chinese materia medica was scattered in various ancient herbals (*ben-cao*). I prepared a list of Chinese plant esculents used for the conservation of health (*bupin*), and bought the products from groceries and Chinese drug stores in Guangzhou (Canton). I went to Luo-fou Shan in Guangdong repeatedly to learn about the sources of my collection of *bupin* from the monks and nuns residing in various Taoist temples and to collect voucher specimens with the help of the local herb collectors.

During the entire period of the Sino-Japanese War (1937–1945), I taught at West China Union University in Chengdu. Together with several senior students, I conducted a survey of the medicinal plants in the herb shops of the area (Hu, 1945). During summer vacations I went with colleagues and students to live in the villages of the Giarong tribe; we explored the vegetation and studied the lives of migrant collectors of crude drugs in the alpine meadows of Min Shan and Qiong-lai Shan in western Sichuan. Between September 1946 and March 1968 I was working on the Chinese collection in the herbarium of the Arnold Arboretum, and my interest in medicinal plants was overshadowed by taxonomic research and the duties of a professional botanist. In connection with field work for the preparation of a *Flora of Hong Kong,* I taught in the Biology Department of Chung Chi College, Chinese University of Hong Kong,

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between March 1968 and October 1975. At first only a few students in that university were interested in the study of local medicinal plants. We collected specimens from herbalists in the area, identified the species, and ascertained their uses. Later, my colleagues Y. C. Kong (Biochemistry Department), H. M. Chang, and J. Ma (both of the Chemistry Department) showed a growing interest in research on the chemical composition of various Chinese crude drugs. To check the efficacy of the medicines, they tested them on animals. They asked me to identify the specimens and to contribute some botanical descriptions. Gradually, under the leadership of Chang, the Chinese Medicinal Material Research Centre was organized in the Chinese University of Hong Kong. This institution grew fast. With a strong staff, advanced instrumentation, and the support of the University, local institutions, and individuals, it soon attracted the attention of scientists and scientific institutions from around the world. Its computerized information on traditional Chinese medicine (TCM) is linked with medical centers in London, Tokyo, and Washington. It is a worldwide bridge for disseminating knowledge of Chinese materia medica both past and present. In connection with this research center, my interest in Chinese medicinal plants was revitalized. This report is one of the results of subsequent studies.

The aim of this report is to provide a window through which historians of science can see the facts and the nature of material exchange and cultural diffusion between China and people in lands far and near. In addressing the questions, I began with the words what, when, where, why, and how about exotics used in TCM. A workable framework was arbitrarily formed by setting a time limit of 1911, the year when China was transformed from an empire to a republic, and by selecting three modern references: *Zhong Yao Zhi* (*A New Chinese Materia Medica*; Anonymous, 1959–1961), *Zhong Yao Da Ci Dian* (*An Encyclopedia of Chinese Medicines*; Anonymous, 1977–1979), and *Zhong Cao Yao Xue* (*Chinese Pharmacology*; Anonymous, 1976–1980). The comprehensive treatise of *An Encyclopedia of Chinese Medicines* contains 5767 entries of crude drugs from 4161 species of plants, 442 species of animals, and 58 kinds of minerals. For each plant entry, the accounts include the recognized Chinese name, its synonyms, the source material with scientific identification, a morphological description illustrated by a line drawing, notes on distribution and ecology, and information on cultivation (if the species is not wild), harvesting time, and procedure, identifying characteristics of the market product, chemical composition, pharmacology, special treatment needed before dispensing, properties, target organs and illnesses, selected recipes, and ancient references. The *Supplement* to this work (Anonymous, 1979) gives indexes to Chinese and scientific names and synonyms, Chinese and English equivalents of the chemical components, chemical formulas and properties, against pharmacological references, a classified list of diseases with cross references to remedies, a detailed bibliography for chemical composition, experimental and clinical reports for each entry, and three checklists for modern and ancient systems of measurements. Much of the information for this article is based on these references.

KINDS OF EXOTICS IN TCM

The exotics in a flora of a country are either cultivated plants or adventives fully established in the area. Volumes 1–4 of *Zhong Yao Zhi* (Anonymous, 1959–1961) and volumes 2 and 3 of *Zhong Cao Yao Xue* (Anonymous, 1976–1980) were carefully checked for extra-Chinese elements. Ninety-four commercial products prepared from 98 exotic species of plants and eight species of animals were selected. Several products are prepared from similar substances of different species. An alphabetic list of the botanical and zoological identifications of these crude drugs is given for quick reference, with the animal entries following those for plants (see TABLE 1). When a crude drug is prepared from two or more related species, the epithet of the primary source is listed first. Included in the enumeration are the Chinese and English names, the place of origin, and the date the item was first recorded in a Chinese herbal or pharmacopoeia.

In the list only five items (less than five percent) are of animal origin. These are ox bezoar, elephant hide and tusks, rhinoceros horns, and the ambergris of the sperm whale. Plant materials include 26 kinds of seeds, 18 leafy shoots, leaves, or whole herbaceous plants, 16 fruits, nine resins, six roots, six flowers, four fragrant woods, two extracts, one bark, and an exudate of a desert plant (alhagi). Botanically, these products are from plants belonging to 55 families of dicots and five of monocots. The largest contributing family is the Leguminosae, with 15 species in 11 genera. The Cruciferae and the Cucurbitaceae each contributes four species, while the Euphorbiaceae, Malvaceae, Umbelliferae, Styracaceae, Labiatae, Solanaceae and Palmae are each represented by three species. The Piperaceae, Burseraceae, Guttiferae, Flacourtiaceae, Combretaceae, Apocynaceae, Rubiaceae, and Compositae are each represented by two species, and the remaining 33 families have only one species each.

CHRONOLOGICAL ACCOUNT

It is an undeniable fact that man occupied the habitable continents and large islands long before his existence was recorded by ancient and/or modern explorers. Intentionally, man moved with his favorite animals and plants; unintentionally, weed seeds and parasitic animals traveled with him. Dogs and the paper mulberry (*Broussonetia papyrifera* (L.) L'Hér.) in Polynesia are good examples of the former; many garden weeds, of the latter. Several of the extra-Chinese elements used in TCM arrived in China in a similar fashion, some during prehistoric time. We have material evidence that hemp arrived in China during the Neolithic period. Broomcorn (*Panicum miliaceum* L.) and hemp (*Cannabis sativa* L.) were reported by Q. R. Wang and Guo (1980) from an archaeological site of a Neolithic community, carbon 14 dated at 4850 B.P. ± 180 years, on terraced land by Da-xia-he in Gansu. Archaeological evidence such as this is rare. For our purposes we have to use historical records to show the chronological sequence of the employment of exotic elements in TCM. Such records, however, should not be taken as the time of introduction, the exact date of which is unrecorded. Moreover, many ancient herbals and phar-

TABLE 1. **Exotics in Chinese Materia Medica.**

SCIENTIFIC NAME	CHINESE NAME[1]	ENGLISH NAME	PORTION USED	PLACE OF ORIGIN[2]	YEAR RECORDED (A.D.)
Abutilon theophrasti Medicus	Qing-ma (1)	Abutilon	Seeds	SW As	659
Acacia catechu (L.) Willd.	Er-cha (2)	Catechu	Extract	Tr As	1596
Alhagi pseudalhagi Desv.	Ci-mi (3)	Alhagi	Exudate	Mid E	739
Aloë barbadensis Miller	Lu-hui (4)	Aloe	Extract	Afr	973
Amomum krervanh Pierre & Gagnep.	Bai-dou-kou (5)	Siam Cardamon	Fruits	SE As	973
Andrographis paniculata (Burm. f.) Nees	Chuan-xin-lian (6)	Kiryat, creat	Whole plant	Tr As	?
Aquilaria agallocha Roxb.	Chen-xiang (7)	Aloeswood	Wood	SE As	540
Areca catechu L.	Bing-long (8)	Betel nut	Fruits	Tr As	1300
Benincasa hispida (Thunb.) Cogn.	Dong-gua-zi (9)	Winter gourd	Seeds	Tr As	100
Bombax ceiba L.	Mu-mian (10)	Tree cotton	Roots	SE As	1596
Boswellia carteri Birdw.	Ru-xiang (11)	Frankincense	Resin	Mid E	540
Brassica hirta Moench	Bai-jie-zi (12)	White mustard	Seeds	Eur	540
Brassica rapa L.	Yun-tai-zi (13)	Field mustard	Seeds	Eur	659
Bryophyllum pinnatum (L. f.) Oken	Lu-di-shen-gen (14)	Air plant	Whole plant	Afr	1848
Caesalpinia sappan L.	Su-mu (15)	Sappanwood	Heartwood	SE As	659
Canavalia gladiata (Jacq.) DC. &/or *C. ensiformis* (L.) DC.	Dao-dou (16)	Sword bean	Seeds, roots	Tr As	1596
		Jack bean	Seeds	WI	1596
Cannabis sativa L.	Hu-ma-ren (17)	Hemp seed	Fruits	SW As	100
Capsicum frutescens L.	La-jiao (18)	Red pepper	Fruits	Tr Am	1621
Carica papaya L.	Fan-mu-gua (19)	Papaya	Fruits	Tr Am	1848
Carthamus tinctorius L.	Hong-hua (20)	Safflower	Corollas	Med R	973
Cassia angustifolia Vahl &/or *C. acutifolia* Del.	Fan-xie-ye (21)	Senna	Leafy shoots	Tr As	1894
Cassia occidentalis L.	Wang-jiang-nan (22)	Coffee senna	Seeds	Tr As	1407
Catharanthus roseus (L.) G. Don	Chang-chun-han (23)	Madagascar periwinkle	Leafy shoots	Mad	1848
Cinchona ledgeriana Moens. &/or *C. succirubra* Pav.	Jin-ji-na-pi (24)	Quinine	Bark	S Am	1765
Citrullus lanatus (Thunb.) Matsum. & Nakai	Xi-gua-cui (25)	Watermelon	Young fruits	Afr	1596

TABLE 1. **Continued.**

SCIENTIFIC NAME	CHINESE NAME[1]	ENGLISH NAME	PORTION USED	PLACE OF ORIGIN[2]	YEAR RECORDED (A.D.)
Cleome gynandra L.	Bai-hua-cai (26)	Spider-wisp	Leafy shoots	Tr Am	1596
Commiphora myrrha Engler	Mo-yao (27)	Myrrh	Resin	Mid E	973
Coriandrum sativum L.	Yuan-sui-zi (28)	Coriander	Seeds	SW As	1061
Crocus sativus L.	Fang-hong-hua (29)	Saffron	Styles	Med R	1596
Cucumis melo L.	Tian-gua-zi (30)	Sweet melon	Seeds	C As	1061
Daemonorops draco Bl.	Xue-jie (31)	Dragon's blood	Resin	Indon	659
Dalbergia sissoo Roxb. &/or *D. parviflora* Roxb.	Jiang-chen-xiang (32)	Sissoo, fragrant rosewood	Heartwood	Tr As	756
Datura metel L.	Yang-jin-hua (33)	Datura	Flowers	Tr As	1596
Dryobalanops aromatica Gaertner	Bing-pian (Long-nao-xiang) (34)	Borneo camphor	Resin	Indon	659
Euphorbia antiquorum L.	Huo-yang-le (35)	Fleshy spurge	Stems	India	1848
Euphorbia lathyris L.	Qian-jin-zi (36)	Moleweed	Seeds	Mid E	973
Ferula assafoetida L.	A-wei (37)	Asafetida	Resin	C As	659
Ficus carica L.	Wu-hua-guo (38)	Fig	Fruits	Med R	1407
Foeniculum vulgare Miller	Xiao-hui-xiang (39)	Fennel	Fruits	Med R	659
Garcinia hanburyi Hooker f. &/or *G. morella* Desv.	Teng-huang (40)	Gamboge	Resin	SE As	756
Gomphrena globosa L.	Qian-ri-hong (41)	Globe amaranth	Flowers	Tr Am	1688
Gossypium herbaceum L. &/or *G. hirsutum* L.	Mian-hua-gen (42)	Upland cotton	Roots	Sw As	1596
Hordeum vulgare L.	Mai-ya (43)	Barley	Fruits	Sw As	540
Hydnocarpus kurzii Warb. &/or *H. anthelminthicus* Gagnep.	Da-feng-zi (44)	Chaulmoogra	Seeds	SE As	1536
Impatiens balsamina L.	Ji-xing-zi (45)	Garden balsam	Seeds	India	1407
Ipomoea nil (L.) Roth	Qian-niu-zi (46)	Morning glory	Seeds	Tr As	540
Isatis tinctoria L.	Da-qing-ye (47)	Woad	Leaves	Eur	1061
Kochia scoparia (L.) Schrader	Di-fu-zi (48)	Summer cypress	Seeds	Med R	100
Lablab purpureus (L.) Sweet	Bai-bian-dou (49)	Hyacinth bean	Seeds	Med R	540

TABLE 1. **Continued.**

SCIENTIFIC NAME	CHINESE NAME[1]	ENGLISH NAME	PORTION USED	PLACE OF ORIGIN[2]	YEAR RECORDED (A.D.)
Lantana camara L.	Ma-ying-dan (50)	Lantana	Flowers, roots	Tr Am	1848
Lawsonia inermis L.	Zhi-jia-hua (51)	Henna	Leaves	Med R	300
Liquidambar orientalis Miller	Su-he-xiang (52)	Storax	Resin	As M	547
Linum usitatissimum L.	Hu-ma-zi (53)	Flax	Seeds	Euras	100
Luffa aegyptica Miller	Si-gua-luo (54)	Sponge gourd	Fiber of fruit	Tr As	1596
Mimosa pudica L.	Han-xiu-cao (55)	Sensitive plant	Whole plant	Tr Am	1848
Mirabilis jalapa L.	Zi-mo-li (56)	Four-o'clock	Roots	Tr Am	1708
Myristica fragrans Houtt.	Rou-dou-kou (57)	Nutmeg	Seeds	Indon	973
Nerium oleander L.	Jia-zhu-tao (58)	Oleander	Leafy shoots	Med R	1688
Nicotiana tabacum L.	Yan-cao (59)	Tabacco	Leaves	Tr Am	1624
Ocimum basilicum L.	Luo-le (60)	Sweet basil	Leafy shoots	Tr As	1061
Opuntia dillenii Haw.	Xian-ren-zhang (61)	Prickly pear	Fleshy stems	Tr Am	1848
Panax quinquefolius L.	Xi-yang-shen (62)	American ginseng	Roots	EN Am	1757
Papaver somniferum L.	Ying-su-ke (63)	Opium poppy	Fruits	As M	973
Phoenix dactylifera L.	Hai-zao (64)	Date	Fruits	Med R	300
Piper longum L.	Bi-ba (65)	Long pepper	Young fruits	Tr As	973
Piper nigrum L.	Hu-jiao (66)	Black pepper	Fruits	Tr As	659
Pistacia vera L.	Wu-ming-zi (67)	Pistachio	Seeds, bark	SW As	739
Pogostemon cablin (Blanco) Bentham	Guang-huo-xiang (68)	Patchouli	Leafy shoots	Philip	1061
Populus diversifolia Schrenk &/or *P. euphratica* Oliver	Hu-tong-lei (69)	Amber	Resin	Mid E	890
Portulaca oleracea L.	Ma-chi-xian (70)	Purslane	Whole plant	Tr Am	934[3]
Prunus dulcis (Miller) D. A. Webb	Bian-he-tao (71)	Almond	Seeds	SW As	739
Psidium guajava L.	Fan-shi-liu (72)	Guava	Leafy shoots	C Am	1848
Psoralea corylifolia L.	Bu-gu-zhi (73)	Bauchee seed	Seeds	India	973
Punica granatum L.	Shi-liu (74)	Pomegranate	Fruits	As M	540
Quisqualis indica L.	Shi-jun-zi (75)	Rangoon creeper	Seeds	SE As	973
Raphanus sativus L.	Lai-fu (76)	Radish	Seeds, roots	Med R	659
Ricinus communis L.	Bi-ma-zi (77)	Castor bean	Seeds	Afr	659

TABLE 1. **Continued.**

SCIENTIFIC NAME	CHINESE NAME[1]	ENGLISH NAME	PORTION USED	PLACE OF ORIGIN[2]	YEAR RECORDED (A.D.)
Rosmarinus officinalis L.	Mi-die-xiang (78)	Rosemary	Leafy shoots	Med R	739
Ruta graveolens L.	Yun-xiang (79)	Rue	Leafy shoots	Med R	273
Santalum album L.	Tan-xiang (80)	White sandalwood	Wood	Indon	540
Saussurea lappa (Dcne.) C. B. Clarke	Guang-mu-xiang (81)	Puchok, costusroot	Roots	Kashmir	100
Scaphium scaphigerum (G. Don) Guib. & Planchon	Pang-da-hai (83)	Pungtalai	Seeds	Tr As	739
Sesamum orientale L.	Hei-zhi-ma (82)	Sesame	Seeds	Afr	100
Strychnos nux-vomica L.	Ma-quian-zi (84)	Nux vomica	Seeds	Tr As	1596
Styrax benzoin Dryand &/or *S. benzoides* Craib. or *S. tonkinensis* Craib.	An-xi-xiang (85)	Sumatran benzoin; Siam benzoin	Resin	SE As	659
Syzygium aromaticum (L.) Merr. & Perry	Ding-xiang (86)	Cloves	Flower buds	Indon	973
Tamarindus indicus L.	Suan-jiao (87)	Tamarind	Fruits	Afr	1370
Terminalia chebula Retz.	Ke-zi (88)	Myrobalan	Seeds	India	659
Trigonella foenum-graecum L.	Hu-lu-ba (89)	Fenugreek	Seeds	Med R	1061
Bos taurus Gmelin	Niu-huang (90)	Ox bezoar	Gallstones	India	1848
Elephas maximus L.	Xiang-pi (91); Xiang-	Elephant	Hide, tusks	Tr As	1596
Physeter catodon L.	Long-yang (93)	Sperm whale	Ambergris	Indon	1228
Rhinoceros unicornis L.	Xi-jiao (94)	Rhinoceros	Horns	Tr As	100
R. sondaicus Desmarest &/or *R. sumatrensis* Cuvier		Rhinoceros	Horns	Indon	100
R. bicornus L. &/or *R. simus* Cottoni		Rhinoceros	Horns	Afr	1840

[1] The numbers in parentheses in this column correspond to the numerical sequence of Chinese idiograms provided in APPENDIX I.

[2] The abbreviations used are: Afr = Africa, As M = Asia Minor, C As = Central Asia, EN Am = Eastern North America, Eur = Europe, Euras = Eurasia, Indon = Indonesia, Mad = Madagascar, Med R = Meditterranean Region, Mid E = Middle East, Philip = Philippines, S Am = South America, SE As = Southeast Asia, SW As = Southwest Asia, Tr Am = Tropical America, Tr As = Tropical Asia, WI = West Indies.

[3] A native of the New World, this species was evidently dispersed to the Old by natural means, most likely through the dispersal of its dustlike seeds in storms that transported them to the upper atmosphere. This would explain its presence in TCM before Columbus had discovered the New World.

macopoeias are not properly dated, with some of them indicating just the reign of a certain emperor. The information traced from such records can only be broken down into broad categories of particular Chinese dynasties: the Han Dynasty and before, the Three Kingdoms Epoch, the North-South Division Epoch, the Tang Dynasty, the Song Dynasty, the Yuan Dynasty, the Ming Dynasty, and the Qing Dynasty. The designation of dynasty and epoch follows the chart given in the revised American edition of *Mathews' Chinese-English Dictionary* (see Mathews, 1972).

In the following explanations of the introduction of extra-Chinese elements, the romanization of the authors and the references follows the *New China Dictionary* (*Xin-hua Zi-dan*), hyphenated for the convenience of readers who do not know Chinese. The phrase *ben-cao* appears in many of the herbals and pharmacopoeias. This term has been translated as "materia medica." From the Tang Dynasty onward, many *ben-cao* were prepared under imperial orders. Publications sponsored and supported by the central government, and those prepared by individuals approved by the emperor, are here translated as "pharmacopoeias." Ancient Chinese herbals were hand-copied. Many of them were lost, others were changed by later workers with the original authorship retained to lend authority, and still others were incorporated into later works, giving credit to the original writers. Li Shi Zhen (1597) was the finest author of the third type. In his *Ben-cao gan-mu,* he first incorporated all known ancient records for each item entry, giving the name of the authors, and then adding his own observations and discoveries. The following account on the dating of the earliest records of the extra-Chinese elements in TCM represents a digest from Li (1597), *Zhong Yao Zi* (Anonymous, 1959–1961), and *Zhong Yao Da Ci Dian* (Anonymous, 1977–1979). These herbals and their respective authors have been included in the literature cited for this paper. For each entry an English translation of the title is followed by a pin-yin romanization, and as much pertinent publication information has been added as possible. These historical documents are available in research libraries in North America such as the collections of the Library of Congress and the Yenching Library at Harvard University. To assist scholars familiar with Chinese, a numerical list of Chinese idiograms for these titles is presented in APPENDIX II. The number of each reference in APPENDIX II follows the reference in the LITERATURE CITED section of this paper.

HAN DYNASTY AND BEFORE (B.C. 206–A.D. 200)

The first record of Chinese medicinal material is the *Herbal Classics of the Divine Plowman* (Shen-nong ben-cao jing). This work represents a crystallization of the empirical knowledge of the prehistoric and early historical people of China about the healing efficacy of natural objects (plants, animals, water, earth, and minerals). The authorship is not known, but it is attributed to Shen-nong, a mythological figure who is said to have tried hundreds of kinds of plants, to have used himself as an experimental subject, to have been poisoned three times daily, to have been saved, and to have learned how to help the people in their healthcare through his experiences. In this account, the exotic elements recorded included *Benincasa hispida, Cannabis sativa, Kochia scoparia, Linum usitatissimum, Saussurea lappa, Sesamum orientale,* and *Rhinaceros unicornis.*

Three Kingdoms and Western Jin Epochs (A.D. 200–300)

During this period there were two persons who wrote about their experiences in South China, where they had encountered Arabian traders with unusual objects. In *Collections of a Man of Peace* (Zi-an ji) Sima Sui (A.D. 231–273) mentioned that *Ruta graveolens* was used for keeping silverfish from books. Ji Han (A.D. 263–306) in *A Description of Plants of the South* (Nan-fang cao-mu Zhuang) recorded *Phoenix dactylifera* and *Lawsonia inermis,* introduced by Arabian merchants, and *Areca catechu,* from tropical Asia.

North South Division Epoch (A.D. 425–590)

The first increase in recorded knowledge of Chinese materia medica occurred during this period. The outstanding recorder was Tao Hong-jing, a native of southern Jiangsu Province. He was a well-educated person who refused to serve the government, preferring to retreat into the mountains to learn from the people of their experiences in preserving life. He considered that by leading this type of life, he could achieve the manifestation of the heart of the sages in the service of the people. He prepared two treatises on materia medica, *Unrecorded Materials of Eminent Physicians* (Ming-yi bie-lu) and *A Commentary on Shen-nong's Herbal Classics* (Shen-nong ben-cao jing ji-zhu). In the second work, he incorporated his findings of *Unrecorded Materials of Eminent Physicians* into a copy of Shen-nong's Herbal, using red ink for the information taken from Shen-nong's Herbal and black ink for his additions. Tao's work was quoted repeatedly by Li Shi-zhen. *Aquilaria agallocha, Boswellia carteri, Brassica hirta, Lablab purpureus, Punica granatum,* and *Santalum album* were recorded by Tao.

Tang Dynasty (A.D. 618–905)

Emperor Gao-zong ascended the throne in A.D. 650. He was concerned with having a complete pharmacopoeia and appointed the Minister of Works, Li Chi, to revise Tao's *Commentary on Shen-nong's Herbal Classics.* The complete work consisted of seven volumes and is known as *Duke Ying's Tang Pharmacopoeia* (Ying-gong Tang ben-cao). A decade later, Su Gong pointed out the need for a revision of this pharmacopoeia. The Emperor appointed a team of 22 persons to cooperate with Su Jing. The complete work, the *New Tang Pharmacopoeia* (Tang ben-cao), consisted of 53 volumes with illustrations. The extra-Chinese elements in this work were *Abutilon theophrasti, Brassica rapa, Caesalpinia sappan, Daemonorops draco, Dryobalanops aromatica, Ferula assafoetida, Foeniculum vulgare, Piper nigrum, Raphanus sativus, Ricinus communis, Styrax benzoin,* and *Terminalia chebula.* In the Tang Dynasty, Japan and Korea had diplomatic relations with China. Soon after this work was completed, it was copied and carried by returning students and/or diplomatic or Buddhist missions to those countries.

Several individuals interested in the materia medica of China did independent research on the subject. Chen Cong-qi completed the *Unrecorded Materia Medica* (Ben-cao shi-yi) in A.D. 739. He was a critical worker and added approximately 400 items not mentioned in the *New Tang Pharmacopoeia.* These additions were quoted by Li Shi-zhen. The extra-Chinese material included in Chen's work were *Alhagi pseudalhagi, Pistacia vera, Rosmarinus officinalis,* and *Scaphium scaphigerum.*

By the middle of the eighth century, the first materia medica of subtropical and tropical China and adjacent areas of the Indo-Malayan Peninsula appeared. This was Li Xun's *A Register of the Medicine Imported via the Seas* (Hai-yao ben-cao), completed in A.D. 756. Li's grandfather was an Arab with a successful spice and medicine trade; he resided partially in Guangzhou, then known as Nan-hai. His riches brought him such fame and honor that he was elevated to share the surname of the imperial family, Li, during the Tang Dynasty. With this background, and knowing the family business, Li Xun was qualified to write on the imported medicines that came from the South Seas. In this work, a product prepared from *Garcinia hanburyi* or *G. morella,* Teng-huang, was first mentioned.

By the close of the Tang Dynasty, an officer of the imperial government wrote about the strange things he saw beyond the Nanling Range. Liu Xun, in his *Records of Strange Articles* (Ling-biao lu yi, A.D. 889, 890), recorded a resin called tears of the Arabian tong (Hu-tong lei) and an almond that he described as a peach with a compressed kernel, both of which were seen in the homes of the Arabian traders. He gave a vivid description of the almond, saying in Chinese that this kind of peach was cultivated not for the flesh, but for the compressed kernels with thin shell that tasted like the seed of the northern peach; one end of the compressed kernel is round, and the other is pointed. These articles are products of *Populus euphratica* and *Prunus dulcis,* respectively.

SONG DYNASTY (A.D. 960–1200)

In the history of Chinese materia medica, the Song Dynasty could be considered the Golden Era for the publication of pharmacopoeias. The first Emperor, Tai-zu, appointed the Imperial Pharmacist, Liu Han, and a Taoist monk, Ma Zhi, to lead a team of nine in revising the Tang pharmacopoeia. Using the works written during the Tang Dynasty as references, they organized the material, placed many former names into synonymy, and added 133 new items. It took them seven years to complete the revision, which filled 21 volumes, with the accounts from *Shen-nong ben-cao* written in white ink and all other references in black ink. This work is known as the *Pharmacopoeia of the Kai-bao Reign* (Kai-bao ben-cao, A.D. 973). Exotic elements recorded were *Aloë barbadensis, Amomum krervanh, Carthamus tinctorius, Commiphora myrrha, Euphorbia lathyris, Myristica fragrans, Papaver somniferum, Piper longum, Psoralea corylifolia, Quisqualis indica,* and *Syzygium aromaticum.*

In A.D. 1058 the fourth emperor, Ren-zong, had the imperial medical team, headed by Zhang Yu-xi and Lin Yi, revise the 100-year-old *Pharmacopoeia of the Kai-bao Reign.* The working team added 82 new items and revised 17 entries. Known as the *Revised Pharmacopoeia of Gia-you Reign* (Gia-you bu-zhu shen-nong ben-cao, A.D. 1061) the work consists of 20 volumes. The new exotics were *Coriandrum sativum, Cucumis melo, Isatis tinctoria, Ocimum basilicum, Pogostemon cablin,* and *Trigonella foenum-graecum.* Emperor Ren-zong also issued a decree ordering officers of all the states and counties to prepare illustrations of their native natural objects used for healing purposes. On gathering the drawings, the Emperor appointed Su Song to prepare descriptions and to be the editor of the new work, which consists of 21 volumes and is known as *An Illustrated Pharmacopoeia* (Tu jin ben-cao, A.D. 1062). This work has been quoted by all subsequent authors dealing with Chinese materia medica.

In A.D. 1108, the second year of the Da-guan Reign, Emperor Hui Zong received a manuscript on materia medica prepared by Tang Shen-wei, a practitioner from Sichuan Province. In this manuscript, Tang modified the text of the *Revised Pharmacopoeia of Giao-you Reign* and incorporated the illustrations from *An Illustrated Pharmacopoeia.* To this combined work he added prescriptions and notes for dietary applications to each entry. He titled the manuscript *Verified Identification of Materia Medica* (Zheng-lei ben-cao). The Emperor accepted the manuscript, which then became known as the *Pharmacopoeia of the Da-guan Reign* (Da-guan ben-cao). In this work the fragrant woods of *Dalbergia sissoo* and *D. parviflora* were first mentioned.

Sinologists have characterized the Tang (A.D. 618–905) and the Song dynasties as the grand period of growth of Chinese culture. Contacts with nations far and near were frequent. Members of religious expeditions and diplomatic missions to India and southeastern Asia learned to use things unfamiliar to them, and they frequently brought samples and/or propagules back to China. Soldiers in war and traders in peace brought exotic things from nations near. With regard to the extra-Chinese elements used in TCM, the nature of the items recorded during the Tang Dynasty is very different from those of the Song Dynasty. In the Tang period medicines, food, spices, and resins and dyes, each with 25 percent of the total, comprised the material record. In the Song Dynasty the number of fragrant woods increased very prominently, consisting of one-half of the newly recorded exotics. During the Song Dynasty the central government supported the preparation of pharmacopoeias and evidently also encouraged the importation of fragrant woods and spices; furthermore, it established a Bureau of Spices and Medicines to oversee their importation. The reason for such governmental efforts will be explained below.

Yuan Dynasty (A.D. 1206–1368)

Historians often characterize this period as China under the Mongols. Although there was much communication and exchange of materials and ideas between the West and the East, very few new exotics were added to the Chinese materia medica. Practitioners of the Yuan Dynasty simply followed tradition, used the phamacopoeias of the Sung Dynasty, prepared their prescriptions, and carried on with their business. Near the end of the Yuan Dynasty, Zhu Zhen-heng prepared *A Supplement to Herbal Commentaries* (Ben-cao yan-yi bu-yi, A.D. 1358). In this work chaulmoogra (Da-feng-zi—*Hydnocarpus kurzii* and/or *H. anthelminthicus*) was first recorded.

MING DYNASTY (A.D. 1368–1644)

Countries such as Japan and Korea shared the heritage and information on Chinese medicine from the herbals and pharmacopoeias prepared in the Han, Tang, and Song dynasties. The Western World learned about Chinese medicine through the materia medica completed in the Ming Dynasty, particularly from Li Shi-zhen's *Materia Medica with Commentaries* (Ben-cao gang-mu, 1596). Unlike the works completed during the Tang and Song dynasties, those done during the Ming Dynasty were realized through individual interests and efforts. Five treatises dealing with exotic elements used in TCM are discussed here.

The *Materia Medica of Southern Yunnan* (Dian-nan ben-cao, A.D. 1370), by Lan Mao, contained *Tamarindus indicus. Famine Herbal* (Jiu-huang ben-cao, A.D. 1407), by Zhu Xiao, included *Cassia occidentalis, Ficus carica,* and *Impatiens balsamina.* Ni Zhu-mo, in *Organized Collections of Materia Medica* (Ben-cao hui yan, A.D. 1624), first recorded tobacco (*Nicotiana tabacum*), introduced primarily for smoking, but in recent years rural people in Fujian have used it in the preparation of a poultice, which is mixed with rice gin to treat breast cancer.

Li Shi-zhen, after failing the qualifying examinations for governmental officers, entered the second-best profession of the time, becoming a practitioner in medicine. With his knowledge of the Chinese classics and his practical experience in diagnosing illnesses and prescribing remedies, he prepared a manual for practitioners of traditional Chinese medicine, Ben-cao gang-mu. When Li used *gang* and *mu,* he implied arrangement and classification. From the approximately 800 references, he selected 1518 items; he also provided 374 new entries. For each of the 1892 objects, he gave a recognized name, which he called *gang,* and cited all the synonyms with his commentaries, which he called *mu.* To such a framework, he added information on properites, tastes, and efficacy against illness, as well as recipes. In his treatment the new extra-Chinese elements were *Acacia catechu, Bombax ceiba, Canavalia ensiformis* or *C. gladiata, Citrullus lanatus, Cleome gynandra, Crocus sativus, Datura metel, Gossypium hirsutum, Luffa aegyptica, Strychnos nux-vomica,* and the hide and tusks of *Elephas maximus.*

During the Ming Dynasty, a famous treatise on plants and agriculture, *Monograph of Flowers* (Qun fang pu, A.D. 1621) was published by Wang Xiang-jin. In this work *Capsicum frutescens* was first recorded.

QING DYNASTY (A.D. 1644–1910)

Information on the exotic elements used in TCM before the Qing Dynasty was recorded largely in ancient herbals or pharmacopeias. During the Qing Dynasty both the elements employed and the source references changed. The major portion of the information was recorded in treatises on horticulture and agriculture. The first such work was the famous *Flower Mirror* (Mi-chuan hua jing, A.D. 1688), by Chen Hua-zi. *Gomphrena globosa* and *Nerium oleander* were recorded in this work. *Mirabilis jalapa* first appeared in *Enlarged Monograph on Flowers* (Guang qun fang fu, A.D. 1708), by Liu Hao. Wu Yi-lo, in his *Newer Version of Materia Medica* (Ben-cao cong xin, A.D. 1757), first mentioned *Panax quinquefolius.* Zhao Xue-min, in his *Supplement of Ben-cao Gang Mu* (Ben-cao gang mu shi-yi, A.D. 1765) included quinine (*Cinchona succirubra* or *C. ledgeriana*), and ambergris from *Physeter catodon.*

The most outstanding work containing comprehensive information on the botany of China, *An Illustrated Treatise on Plants* (Zhi-wu ming shi tu kao, A.D. 1848), was prepared by Wu Qi-zhung. The extra-Chinese elements included in this treatise were *Bryophyllum pinnatum, Carica papaya, Catharanthus roseus, Euphorbia antiquorum, Lantana camara, Mimosa pudica, Opuntia dillenii, Psidium guajava,* and the gallstones of *Bos taurus.*

Belated Records

Two extra-Chinese elements commonly used in TCM before they were recorded in herbals or botanical treatises are creat (*Andrographis paniculata*), and senna (*Cassia angustifolia* or *C. acutifolia*). Evidence of their introduction into China during the Qing Dynasty is convincing for creat and tangible for senna.

Andrographis paniculata, a common weed in hedgerows throughout the plains of India, Bangladesh, and Burma, has been used locally in those countries in ethnomedicine for hundreds (thousands) of years. Some authors recorded it as an annual because it flowers during the first years of its life cycle. In the tropics new shoots emerge from the old plant after the dry season, and eventually the plant appears shrubby. I have seen the species growing in similar habitats in Hong Kong, flowering and fruiting the first year as an herb and growing as a perennial shrub in undisturbed sites.

Andrographis paniculata has been reported from northern India southward to Sri Lanka and eastward to Java. George Watt (1889) reported over two dozen vernacular names for the species, including kiryat (Hindi), kalmegh (Gengali), kiriyatta (Malay), kirata (Sanskrit), and qasabhuva (Arabic), from that vast area and cited its ethnomedical properties as a febrifuge, stomachic, tonic, alterative, and anthelmintic. As a bitter tonic, stomachic, and febrifuge, the herb has been shared and spread by ethnic people throughout tropical Asia but has been unrecorded until recently. Its widespread use and cultivation in northern China is modern, but its actual introduction must have been prior to 1932, when it was mentioned in *Records of Gathering Medical Herbs in South China* (Ling-nan cai-yue lu, Xiao, 1932).

From both the ethnobotanical practices and the vernacular names, it seems that *Andrographis paniculata* was introduced by the ethnic people living in the mountains of northern India, Balgadesh, Burma, and southern China. In the Bengal region the expressed juice of the leafy shoots is mixed with cardamon, cloves, and cinnamon, dried in the sun into small pills called alui, and used to treat children for colic, loss of appetite, and irregular stools, and adults after a fever and for advanced stages of dysentery and general debility. Watt gave additional information that creat leaves mixed with the pulp of ripe tamarind were carried by wandering doctors as an antidote to the venom of poisonous snakes. The tribes in the mountains of Guangxi and Guangdong also used *A. paniculata* for fever, dysentery, and snake bite.

Senna is a popular purgative in southern Asia. Its laxative principles are two glycosides, sennoside A and sennoside B. The commercial product consists of the dried leafy shoots of *Cassia acutifolia,* indigenous to northern Africa, and *C. angustifolia,* native to Yemen and southern Arabia. Dealers called the product from *C. acutifolia* Alexandrian senna, and that from *C. angustifolia* Arabian senna. Both species are cultivated in India, the source area of the senna imported into China, and both are shrubs 1 m tall with lanceolate leaves.

Historically, senna was introduced by the Arabs to India, where the species has been extensively cultivated. We have no record of its introduction by the Arabs into China. This could have been because Chinese herbal medicine had a better and more effective purgative, rhubarb (da-huang, *Rheum officinale* Baillon and *R. palmatum* L.), which was widely accepted by the people before the arrival of the Arabian traders. Consequently, the Arabs were unable to create a market for senna in China. This situation continued until the industrialized European countries forced China to open her ports for international business. According to records in the list of Chinese medicines prepared under the instruction of the British Inspector General of Customs, Robert Hart, for the China Imperial Maritime Customs Department (see Anonymous, 1889), senna entered China by sea via India and Japan and overland through Yunnan-Sichuan.

Effect of Time on the Nature of Extra-Chinese Elements

The chronological account of the recorded exotics used in TCM reveals several unique characteristics. First, they were obviously introduced into China a very long time ago. The record made about the beginning of the Christian era (*Herbal Classics of the Divine Plowman*) shows that seven exotics were already in use in Chinese medicine. Two of these items, puchok (root of *Saussurea lappa*) and the rhinoceros horn, were imported overland from India. The remaining five substances were obtained from plants that were spread in association with adventurous prehistoric and/or ancient people who traveled extensively by the means of their time. Hemp arrived in China almost 5000 years ago in association with Neolithic man.

The second outstanding characteristic is the continuous growth in the number of exotics, with gradual changes in what was imported. When the data are plotted in a simple graph (see Figure 1), the growth in number of exotics used in TCM becomes very obvious. Each point in the graph represents the accumulated number of exotics used in TCM at that particular time. The model is meaningful only when an item is used continuously from the time of its introduction. This condition is true with all the recorded exotics listed here because they are still in common use.

The change in the nature of the exotics becomes obvious after an analysis

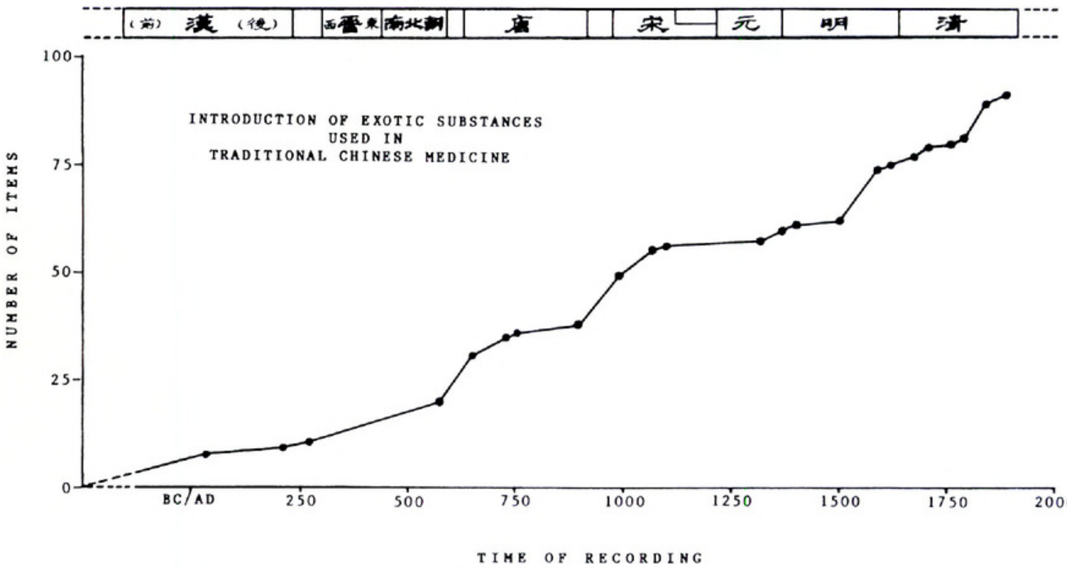


FIGURE 1. Increase in number of exotics used in TCM. Broken lines indicate time before and after period investigated in this study.

of their general function. Five of the earlier-mentioned seven items recorded from the Han Dynasty were from plants introduced primarily for daily necessities—that is, for food and fiber. There was only one substance among them, mu-xing (dried root of *Saussurea lappa*), that was imported as an aromatic medicine. At that early date, aromatic material comprised about 14 percent of the total imports. The increase in the proportion of aromatic products is very obvious. In the North-South Division Epoch, spices and aromatic materials were 37 percent of the total recorded items, in the Tang Dynasty 41 percent, and in the Song Dynasty 54 to 61 percent. The growth in exotic fragrant-wood species and aromatic substances reached a peak in the Song Dynasty due to the encouragement of the central government. During that period the State Department established a Bureau of Spices and Aromatic Medicine to deal with gifts and tributes of various diplomatic missions; the officers made requests and suggestions of articles to be brought into China in exchange for precious Chinese materials. In the Ming and Qing dynasties there was an obvious change of direction in importation. Substances for comfort and enjoyment of life other than spices and aromatic materials were brought in. Tobacco was recorded in the middle Ming, and cotton in the late Ming. Both these plants became extensively cultivated, one as a fumitory and the other for fiber. Their uses in medicine were secondary. During the Ming and Qing dynasties, introduction of plants for ornamental purposes increased very fast, from 27 percent of Ming importations to 50 percent of Qing records. New plants introduced for food comprised 18 percent of the species recorded in both the Ming and Qing dynasties.

The third prominent feature of the exotic elements used in TCM is the effort made toward self-sufficiency in the supply of these materials. Of all the plant products, 70 percent of the species have been cultivated as important field crops in China, two thirds of these for food, fiber, and ornamentals and one third for medicine. Six of the exotic elements are adventive species that have

TABLE 2. **Source areas and number of items.**

Place of origin	Number of species: Plants	Animals	Total
Tropical Asia	14	1 + 1*	14 + 1*
Mediterranean Region	14	0	14
Tropical America	13	0	13
Southeast Asia	8	0	8
Southwest Asia	5	0	5
Middle East	7	0	7
Africa	5	1	6
Indonesia	5	1 + 1*	6 + 1*
India	4	2	6
Europe	3	0	3
Central Asia	4	0	4
Asia Minor	2	0	2
Eurasia	1	0	1
Kashmir	1	0	1
Philippines	1	0	1
Madagascar	1	0	1
Eastern North America	1	0	1
Total	89	5 + 2*	94 + 2*

* Indicates similar products (e.g., rhinoceros horn) from two different species of these areas are both present in Chinese markets.

traveled with man unnoticed and have become weeds in China. Due to the climatic and ecological requirements of species from the humid tropics in southeastern Asia and the hot, dry arid lands of southwestern Asia, approximately 30 percent of the exotic plant elements and all of the animal products from those areas used in TCM are still imported.

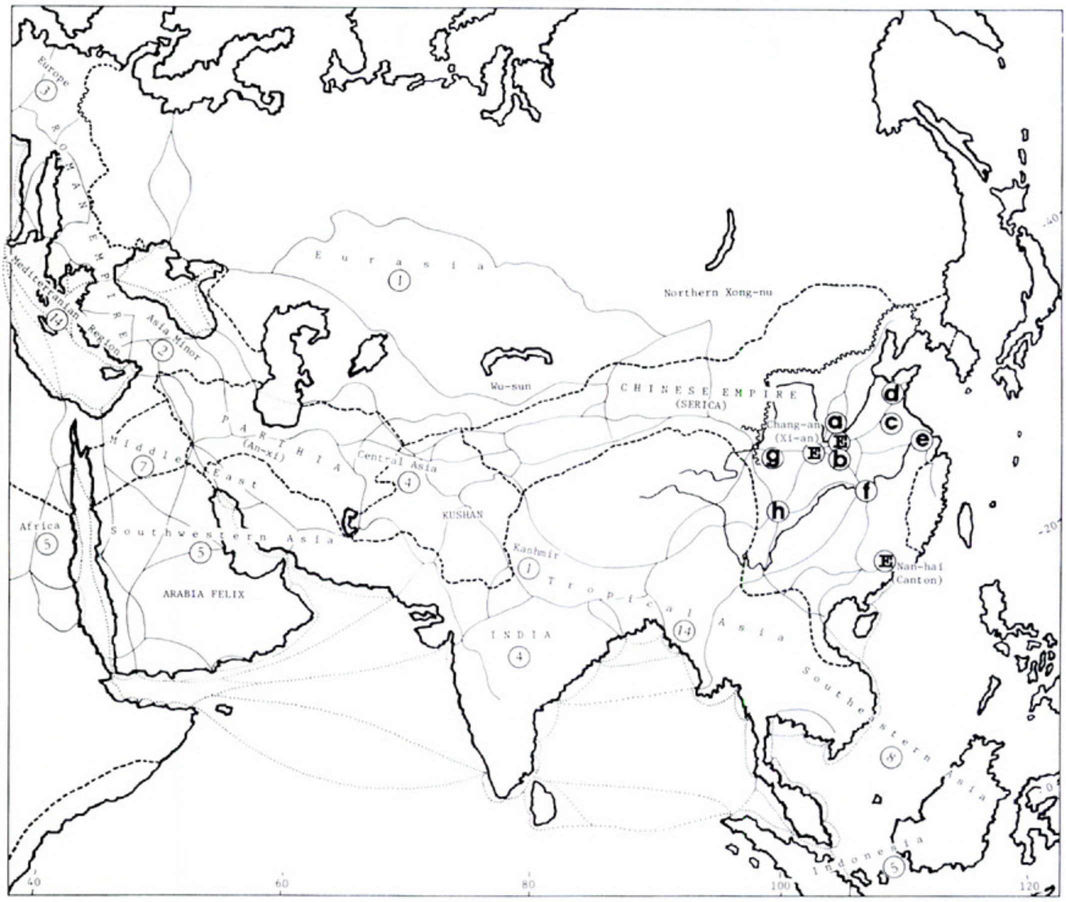
GEOGRAPHICAL ANALYSES

The geographic accounts provided here deal with the origins of the extra-Chinese elements used in TCM and the possible routes by which they were introduced. All the species are covered, whether they are cultivated, weedy, or foreign commercial products sold in Chinese markets.

SOURCE AREAS AND SPECIES

The names used for the source areas are loosely geographic, without any political significance. A summary of these areas and the number of species they have provided is given in TABLE 2.

The areas contributing most of the exotics used in TCM are tropical Asia, the Mediterranean region, and tropical America. Next in numbers of source species are southeastern Asia, the Middle East, southwestern Asia, Central Asia, Indonesia, and India. Europe has three species, Asia Minor has two, and the remaining areas have one each.



MAP 1. Asia ca. A.D. 100 showing routes of introduction of exotic elements used in TCM. Numerals denote number of species in each area. a, indicates royal residence of Emperor Yu. b–h, collecting centers of 9 tributary principalities of Emperor Yu: b, Yu-zhou; c, Xu-zhou; d, Qing-zhou; e, Yang-zhou; f, Jing-zhou; g, Yung-zhou; h, Liang-zhou. E represents three exchange centers in Chang-an (Xi-an), Guang-zhou (Canton), and Luo-yang.

ROUTES OF INTRODUCTION

The possible routes by which exotic species were introduced for cultivation or naturalization and over which exotic market products were transmitted are shown on a map of the major national and international paths of communication before and after the discovery of America at the end of the fifteenth century. In the foregoing discussion of the time of introduction of exotic elements into China, the first recorded time was in the Han Dynasty. MAP 1 shows the routes of communication within China and between nations of the East and the West. It represents a synthesis of information from Chinese and western sources.

The explanation of possible routes for the introduction of exotic elements used in TCM follows several principles. The first is that plants follow man, and ancient man traveled extensively over the earth. There are many records concerning the travels of ancient peoples. In China, during the reign of Emperor

Yu (2205–2198 B.C.), the supplies of the royal family were transported from the collecting centers of the nine tributary principalities (see MAP 1, a–h). These supply routes had become so effective that by the Tang Dynasty (A.D. 618–905) the most perishable tropical fruit, the litchi, was transported fresh from Guangzhou to Xian (Changan).

Ancient people did travel! When Confucius (B.C. 511–479) traveled with his disciples among the rulers of the feudal states, attempting to convince political leaders to accept his Doctrine of the Mean and to try his method of achieving national prosperity by starting with the well-being of the Chinese people, his contemporary, Herodotus, traveled in western Asia in Persia and many countries in the Mediterranean region, Europe, and northern Africa. Historical records from this time give no indication of direct communication between East and West. Nevertheless, the intermediaries had been successful in spreading African species such as *Sesamum orientale* and Central Asian taxa like *Cannabis sativa* to China.

The first recorded direct East-West contact that exerted obvious effects on the introduction of Chinese exotics was the famous Zhang Qian Mission to the West. However, before this Mission was possible, Emperor Wu had to make preparations by waging war to conquer rebelling chieftains and by sending gifts or negotiating marriages to appease less-resistant leaders of the ethnic peoples of the Central Asian steppes. In some of the military or diplomatic missions, thousands or even tens of thousands of people were involved. Even in Zhang's Diplomatic Mission to the Middle East, sixty-thousand people went with gifts, tributes, and weapons, as well as provisions and food for his men and animals. Plants followed man in war and peace in both directions. In Chinese history, after Zhang's mission, one of the captains responsible for safeguarding the communication route escaped with his men and settled in Armenia. He became an adviser to the Armenian king, helped him to achieve prosperity, and received high honors there. Consequently, together with the Chinese people and their lifestyle, plants were introduced to Armenia, the apricot (*Prunus armeniaca* L.) being the best-known example.

By this time in Chinese history, a great agricultural civilization had developed. Although kingdoms emerged and disappeared, palaces were built and destroyed, and wars occurred within and without, Chinese farmers continued working the land, discovering the secrets of nature, and trying to make the best use of all aspects of the environment to enable them to survive and to live better. One of the most outstanding features of Chinese agriculture was sericulture — domesticating a worm that produced silk, which could provide clothing and comfort at home. This aspect of Chinese agriculture gradually became very successful, providing splendor in courts, a medium for exchange, and a commodity for international trade.

Silk has played an important role in China's foreign relations. It has been used as a medium of exchange, as gifts for all the foreign ambassadors that came to pay homage to the emperors, and as a commodity of trade with the West. Actually, China was first known to the West as Serica, the land of silk. The routes for silk export were many, and they radiated in all directions; over them, in turn, exotics were introduced into China.

Once a route of communication was opened, the traffic continued unless stopped by some natural or manmade calamity. From the earliest record of exotics, we know that in or before the Han Dynasty at least four routes of communication were opened: land routes to the Mediterranean region and Africa, to Central Asia, and to Eurasia, Kashmir, and tropical Asia; and a sea route by which rue, dates, and henna were imported to South China by Arabs. Three centuries later, in addition to the products introduced over the ancient Central Asian trade routes, aromatic products from southeastern Asia entered China. During the Tang and Song dynasties, the volume of imports and the number of items continued to increase by both the land and sea routes. It is worthy of note that in the early days, few items were introduced from India. It was only in the Tang Dynasty that myrobalan was imported, and in the Song Dynasty that bauchee seed was recorded for the first time. During the Ming Dynasty tamarind, a species widely cultivated in India, was introduced into Yunnan. Exotics continued to be imported via many of the ancient trade routes after the discovery of the New World and the emergence of ports for international trade in the maritime provinces.

The fifteenth century was an era of maritime exploration and colonization by European countries. Soon after Christopher Columbus discovered the New World and Spain colonized tropical America, Vasco da Gama of Portugal sailed from Lisbon for Asia and returned with pepper (*Piper longum* and *P. nigrum*) from Malabar. Twelve years later Portugal captured Malacca, and three years after this the Portuguese reached China. In all the main ports of southeastern Asia the Portuguese found that important businesses were managed by Chinese residents. For over one hundred years before the arrival of Europeans, the Chinese Empire of the Ming Dynasty had a vigorous maritime enterprise in the western Pacific and Indian oceans. In 1405 the King of the Straits of Malacca submitted to China and became a protectorate of the Ming Empire. Five years later a Chinese naval force conquered King Wijayababu VI of Sri Lanka and brought him as a captive to China. When Ferdinand Magellan arrived in the Philippines in 1519, he found Chinese vessels in all the important trading ports. From the middle of the sixteenth century onward, the Philippine Islands were Spanish, annexed to Mexico. The overseas Chinese are well known for their loyalty to China; in their return trips they brought back to Fujian and Guangdong seeds and other propagules of plants they had learned to like. The red pepper and guava are good examples. At present, red pepper is cultivated in gardens throughout China, and the hot dishes of Sichuan and Hunan have won praises in metropolises worldwide. Guava is naturalized in Guangdong and Hong Kong, where people assume it is a native species.

After 1842, China was forced to open her ports for international trade. British citizens were hired by the Qing emperors and the Empress Dowager to manage the Imperial Maritime Customs. British residents in Chinese ports lived in beautiful homes decorated with exotic ornamental plants. Some of these species were first brought from the Americas into hothouses in London and were later distributed to British citizens throughout the world. Some of them—for example, *Lantana, Mimosa, Mirabilis,* and *Cleome*—arrived in China. After they were grown by the Chinese people or escaped from cultivation, they were used for medicinal purposes in China. Meanwhile, British businessmen brought medicinal products such as senna from India and ivory from Africa into Chinese markets for profit. The United States shared the economic interests of the western powers in China. American clippers sailed between Boston and Guangzhou carrying American ginseng and other commodities—including opium—for China, and tea, cotton, silk, and porcelain were acquired in return.

PRACTICAL ASPECTS

In a span of four millennia and from places extending over all habitable continents of the earth, plant and animal products have been introduced into China, where they have been used for medicinal purposes. Why are these substances used in healthcare? Is it merely psychological and cultural, or are there certain physical and chemical bases for such practices? This is a complicated subject to be discussed in a limited space. However, a few examples can be given to illustrate the nature of the issue.

Plants Introduced for Daily Necessities

An analysis of the nature of the extra-Chinese plants and their role in Chinese culture shows that a majority of the species were introduced by people as daily necessities (for example, food and fibers) or for pleasure (e.g., fumitories, masticatories, or ornamentals). These species are still cultivated primarily for the same purpose for which they were introduced, with medicinal uses secondary. The best examples are the radish (*Raphanus sativus*), the hyacinth bean (*Lablab purpureus*), and sesame (*Sesamum orientale*).

Radish. The radish probably came with Neolithic people from the Mediterranean region as a fast-growing vegetable (the small fleshy root or just the greens). Through selection and cultivation by ingenious Chinese farmers, hundreds of varieties were selected to fit the climatic and ecological conditions of a country extending from the seashore in the east to the arid plateau in the west, so that people might have fresh or pickled radish throughout the country and at all times of the year. Radish seeds are used in Chinese medicine as a tonic for internal organs and for improving strength. In villages, after the seeds are harvested, the old dried roots are saved for making a tea to improve digestion and to cure gas pains. Phytochemists have isolated many organic acids from the radish, including coumaric, caffeic, ferulic, and gentisic acids. Radishes are very rich in calcium.

Hyacinth beans. The hyacinth bean is a common vegetable in the frozen-food section of groceries in America, where it is sold as "Italian beans." In China it is cultivated for the young fruit, which is used as a vegetable. However, the mature seed is prescribed for diabetes mellitus. It is rich in protein, calcium, phosphatide, pantothenic acid, phytin, and tyrosinase.

Sesame. Sesame is cultivated for its seeds, which are an important source of edible oil. It is prescribed for the treatment of both external and internal ailments. Sesame is rich in protein and calcium and contains arachic, linoleic, and palimitic acids, sterols, sesamin, sesamolin, sesamol, and vitamin E.

EXOTICS INTRODUCED AS MEDICINE

Approximately one-third of the exotics were imported into China for use as medicine. A few examples of the imported extracts, resins, aromatics, and animal products (aloë from Africa via Arabia, asafetida from Central Asia, gambier from India, gamboge from Thailand, and rhinoceros horn from southeastern Asia) are selected to show the reasons for their importation.

ALOË. Aloë was first introduced into South China in the form of a reddish brown extract by Arabian traders. Most of its Chinese names were direct translations from the Arabic. In the *Pharmacopoeia of Kai-bao Reign* (A.D. 973), it was recorded as a resinlike powder from Persia. When ancient Chinese consumers asked the trader the *nature* of the material, they were told "elephant bile," due to its bitter taste. For this reason it was also recorded as *xiong dan* in Chinese literature. The material is an extract obtained from the leaves of *Aloë barbadensis,* a spiny succulent perennial attaining a height of 1 m (see FIGURE 2). "Chinese aloë" entered China from the south and has become naturalized in many parts of Fujian. Although there is no record of the introduction of the plant to South China, we know that it has been grown, segregated and developed into special forms there. In 1817 a living aloë plant was taken from South China to London. Adrian Haworth, a specialist in succulent plants, recognized a distinctive leaf feature (spots on both surfaces) and provided the name *A. barbadensis* var. *chinensis* (Haworth, 1819). Individuals were cultivated in British gardens under this name until J. G. Baker, on the basis of a flowering plant, renamed the taxon *A. chinensis* and determined it to be closely related to *A. abyssinica* (Baker, 1877).

In Chinese medical practice aloë has been used in combination with *Pinellia* tubers (Araceae), *Atractylodes* rootstock (Compositae), and licorice for the treatment of convulsions and epilepsy in children and adults. It contains aloenin, aloin, alomicin, aloesin, barbaloin, p-coumaric acid, protein, and calcium-oxalate crystals. Recently an Aloë Association was organized in South China to promote the cultivation of aloë and the production of medicines and cosmetics from them. Among my houseplants there is an old aloë (see FIGURE 2a) with unspotted, grayish, lanceolate leaves, spiny along the margin. Two years ago I put it out in the yard. By the end of the summer, many suckers had arisen from beneath the surface of the soil. I transplanted the suckers and repotted the mother plant. The immature plants appeared very different from the old one in that their leaves were erect, terete, and spotted throughout. Two years have passed; these young plants all have spotted leaves, the character used by Haworth in the description of *Aloë barbadensis* var. *chinensis.* China really has no native aloë, and the feature used in identifying the Chinese aloë is unstable, changing with the age of the plants.

ASAFETIDA. With respect to animal and plant resources for medicinal use, Central Asia is a land of poverty. In spite of geographic proximity, the only plant product imported from there into China for medicinal purposes is asafetida (*Ferula assafoetida*), known in TCM as a-wei. The crude drug is an irregular tearlike oleoresin with a powerful, foul odor and an acrid taste. The source species is a perennial herb that requires five to 18 years of vegetative

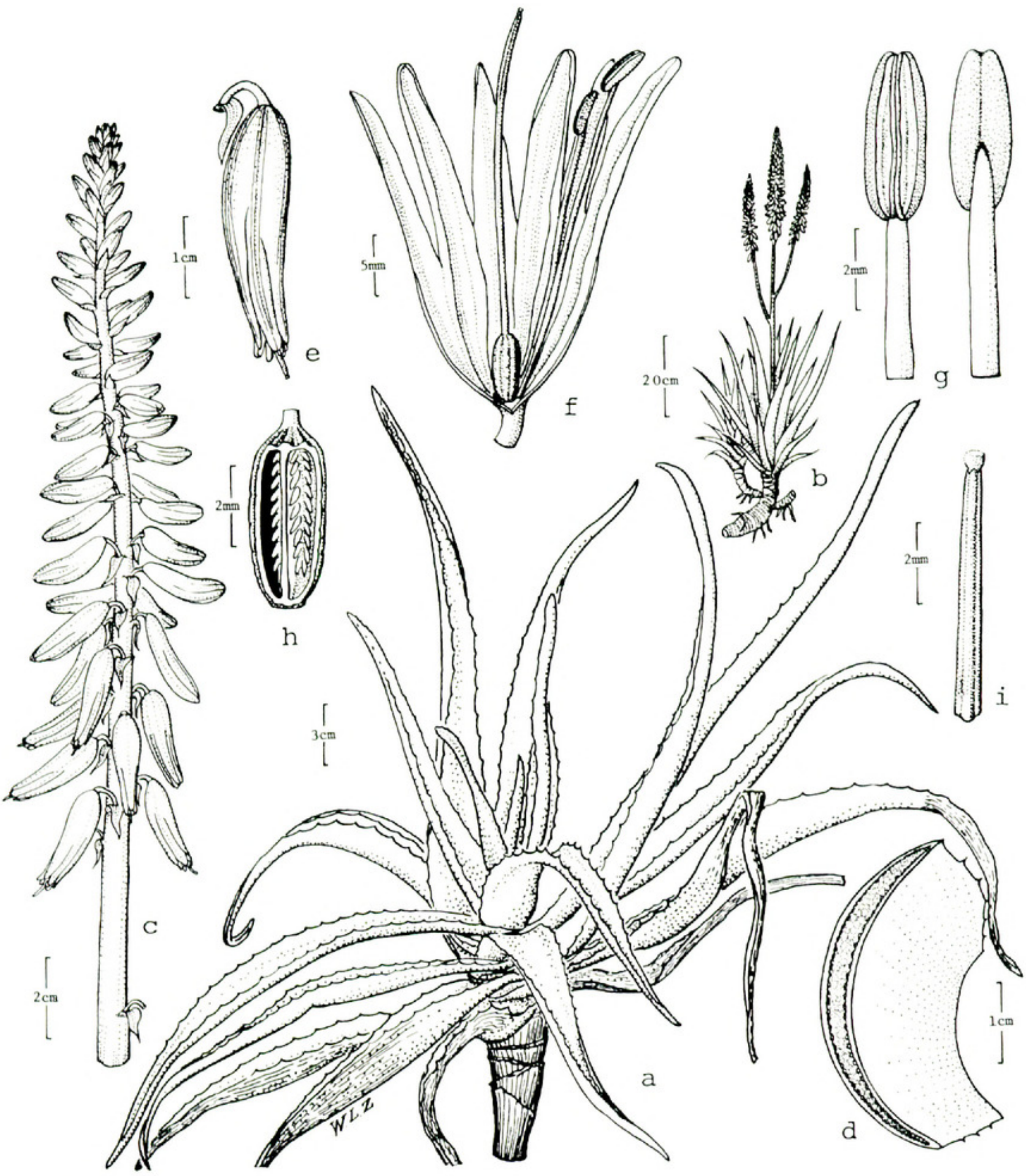


FIGURE 2. *Aloë barbadensis,* source species of commercial aloë: a, habit; b, flowering plant, showing branched scape; c, portion of flowering branch, showing position of fully open flowers; d, section of leaf, showing mucilaginous central portion; e, flower, showing outer perianth segments connate for basal half; f, flower, perianth split open and 4 stamens removed, showing ovary and free margin of inner segments; g, portions of 2 stamens, showing abaxial and adaxial views of anthers; h, vertical section of ovary; i, apical portion of trigonous style and stigma.

growth before it sends up an erect flowering stem. The people of Central Asia use the fresh leaves in food as Europeans use parsley. The straight, stout, canelike flowering stem (see FIGURE 3) can attain a height of two meters. The compound cauline leaves gradually become smaller upward, with the middle and upper ones subtending the flowering branches. The lower umbels bear staminate flowers only, while the upper ones include some perfect flowers as well. Each plant may produce hundreds of small, flat fruits; these split vertically

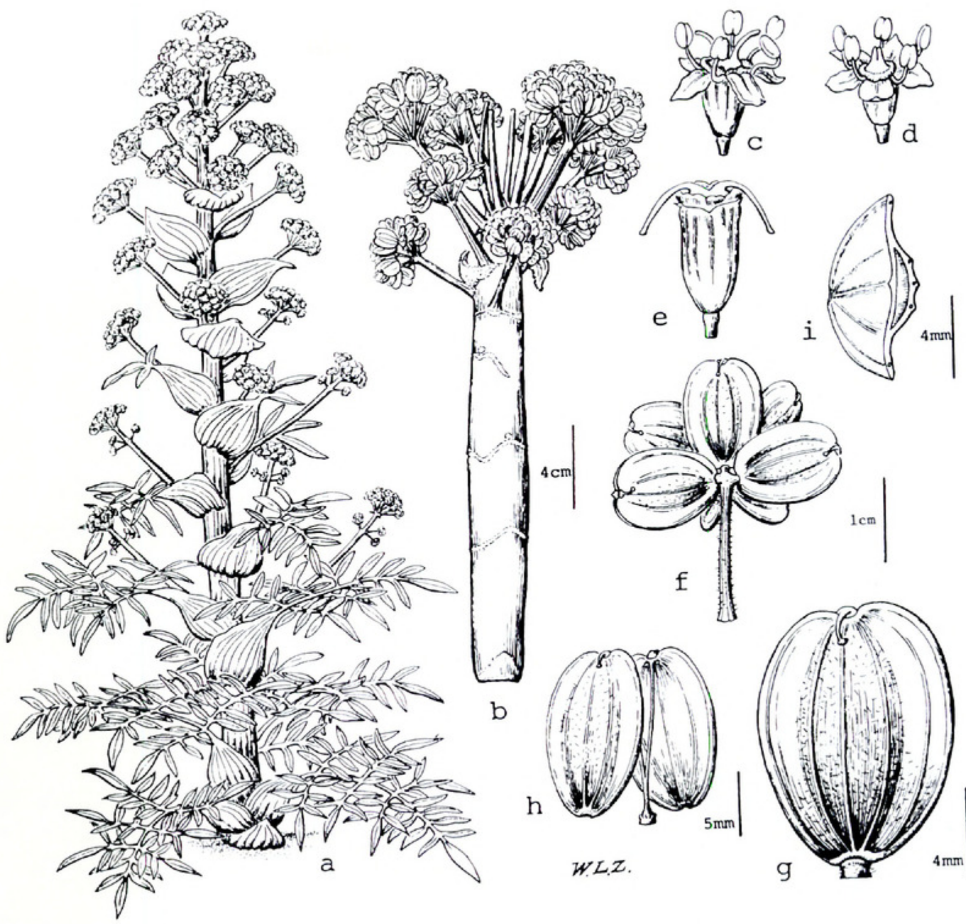


FIGURE 3. *Ferula assafoetida*: a, single erect stem bearing bipinnately compound lower leaves, laminas progressively smaller toward apex and finally constituting bracts subtending flowering branches; b, fruiting branch consisting of many compound umbels; c, perfect flower, showing elongate styles; d, staminate flower; e, young fruit; f, fruiting umbel; g, fully grown fruit; h, mature fruit after separation of mericarps, and attached at the top to the carpophore; i, a transverse section of a fruit showing the broad wings and the longitudinal canals (vittae).

into two winged mericarps, each containing one tiny seed. The mother plant dies after the seeds mature.

Asafetida is collected by removing the soil around the crown before the plant flowers, then cutting off a portion of the crown and protecting the plant from the sun. A thick, milky juice exudes from the cortex of the fleshy rootstock, collects on the surface, and hardens. After ten days the hardened mass is gathered, and another portion of the stem is cut off to let fresh juice ooze out. This process is repeated every ten days until the plant is exhausted, which usually takes about three months. The rootstock eventually dies.

Asafetida was introduced into China by Arabian traders over the sea route and first appeared in the pharmacopoeia of the Tang Dynasty (A.D. 659). A-wei was a Cantonese translation of the Arabian trade name. It is used for indigestion, lack of appetite, and gas pain. It contains volatile oils (10–71 percent), resin (40–64 percent), gum (25 percent), and ash (1.5–10 percent). Approximately

45 percent of the volatile oils is sec-butyl propenyl disulfide, which imparts the characterstic foul odor to the product. Ferulic acid and farnesiferol have also been identified. A-wei pills are available for pains of the chest and sides and lack of appetite. These are made from 7.5 g asafetida softened in vinegar into a paste, 15 g costusroot, 15 g betel nut, and 7.5 g black pepper. The powered costusroot, betel nut, and black pepper are mixed with the softened asafetida and cemented with cooked millet to make pea-sized pills. Taken with ginger tea, these are said to open up the internal physiological channels. The recipe is adapted from the well-known collection *Life Saving Recipes.* Recently, two species growing in Xin-jiang, *Ferula caspica* and *F. conocaula,* have been identified as alternative source species for a-wei.

GAMBIER. Gambier is prepared by decoction and evaporation from the heartwood of a tropical tree, *Acacia catechu* (see FIGURE 4). The plant, which may attain a height of 6–12 m, has bipinnately compound leaves, very tiny leaflets ciliate along the margin, small, yellowish flowers crowded in an elongate spike, and flat pods.

In tropical Asia gambier is chewed with betel nut. It is exported for tanning and dyeing. In China it is combined with an equal amount of the dried tuber of *Bletilla striata* (Thunb.) Reichb. f. (bai-ji), pulverized, and applied to sores in the mouth and boils. Gambier is an astringent containing catechutannic acid, catechin, epicatechin, phlobatannin, fisetin, quercetin, quercetagetin, protocatechuic tannins, and pyrogallic tannins. The tree has been introduced into Yunnan Province for commercial production.

GAMBOGE. Gamboge is a resin prepared from *Garcinia morella,* a tropical tree 18 m tall with opposite leaves, small, yellow, unisexual flowers, and juicy, round fruits (see FIGURE 5). The material is prepared by making incisions in the bark. A viscid yellow juice oozes out and dries on exposure to air.

The resin is collected in hollow bamboo sections, where it hardens into cylinders. It is soluble in water, alcohol, and oil and is much used by artists. It is fatally poisonous if taken internally. At present, it is only produced on a few small islands in southeastern Thailand and is taken to Singapore for distribution. In China it is an important external medication for cutaneous diseases, especially carbuncles, abscesses, ulcers, scabby head, and cancerous tumors. From the material, phytochemists have isolated a-guttiferin, b-guttiferin, morellic acid, isomorellic acid, morellin, isomorellin, dihydroisomorellin, ethoxydihydroisomorellin, morelloflavone, and neomorellin.

RHINOCEROS HORN. Whole horns have been brought into China from Thailand, Java, Sumatra, India, and adjacent tropical areas for medical use since prehistoric times. More recently, horns have also been imported from Africa for the same purpose. Rhinoceros horn was recorded in the first Chinese herbal, *Herbal Classics of the Divine Plowman,* and it is still in common usage. In TCM rhinoceros horn is used in the form of slices or powder and serves as a cooling and detoxifying agent, or as an ingredient in the preparation of emergency remedies for quick relief of heatstroke, high fever with delirium, or convulsions in children; there are many ancient formulas for it. After World War II medical scientists began to investigate its chemical composition and to study its pharmacological effects with animal assays. It has been found that

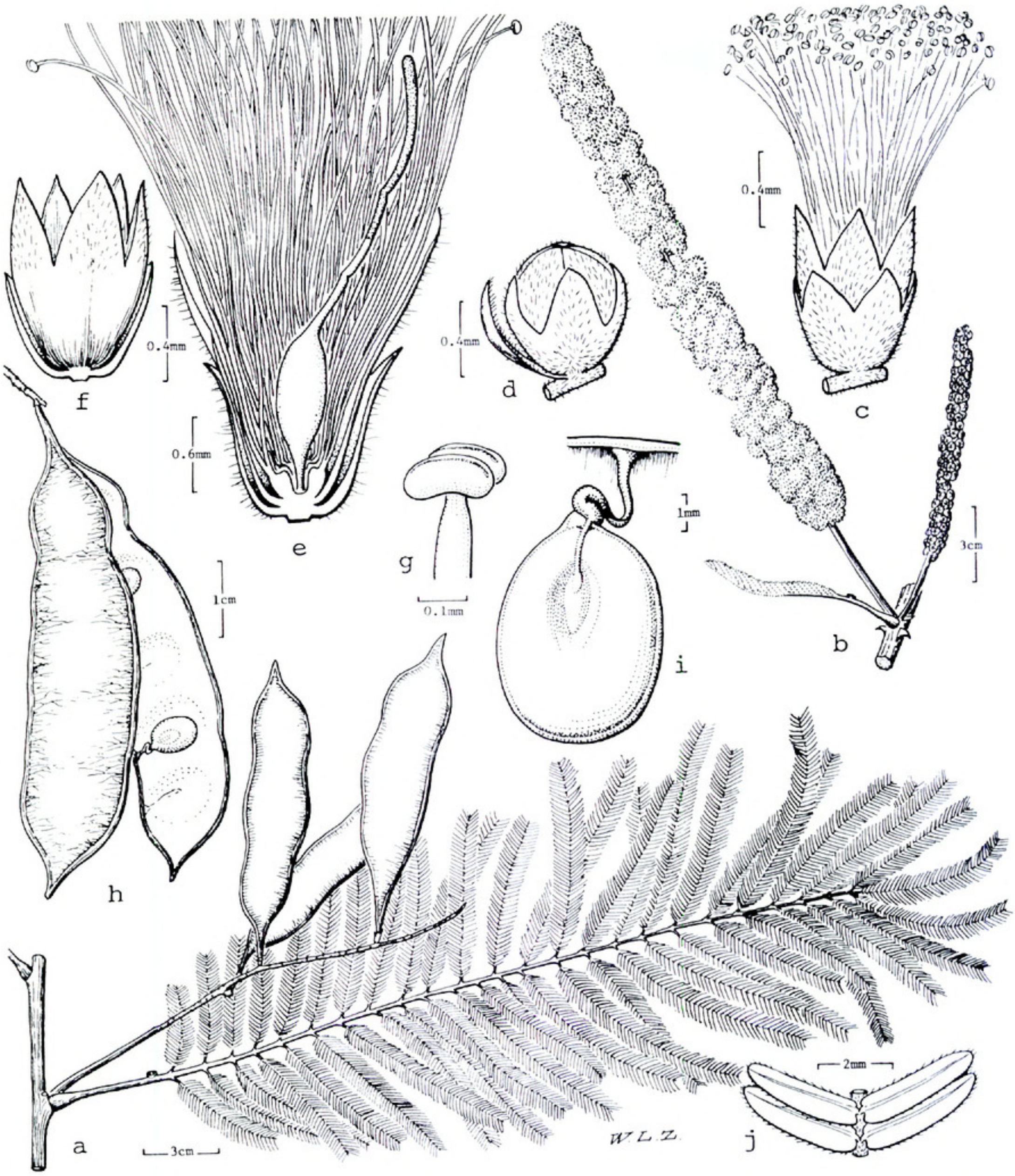


FIGURE 4. *Acacia catechu*: a, a fruiting branch showing 3 fruits and 1 even-bipinnately compound leaf with gland on adaxial side at apex of petiole; b, portion of growing young shoot, showing unfolding leaf with petiolar gland and 2 axillary spikes, 1 with flowers and 1 with buds; c, a sessile flower, showing small calyx and corolla and numerous stamens; d, flower bud subtended by linear bract; e, vertical section of flower, showing calyx tube, corolla, very short and stout staminal tube, threadlike filaments, and pistil consisting of ovary and clavate style; f, flower with portion of calyx, stamens, and pistil removed to show campanulate corolla; g, apical portion of stamen, showing attachment of anther; h, mature dehiscent fruit, showing 2 seeds; i, portion of fruit, showing seed with sigmoid funiculus attached to adaxial suture of pericarp; j, pair of leaflets, showing ciliate margin.

rhinoceros horn is very rich in protein (keratin), particularly in cystine, histidine, lysine, and arginine. It also contains peptides, guanidine derivatives, cholesterol, and asparagic acid. Water extracts of rhinoceros horn excite the muscles of isolated toad hearts and of *in situ* rabbit hearts. It strengthens

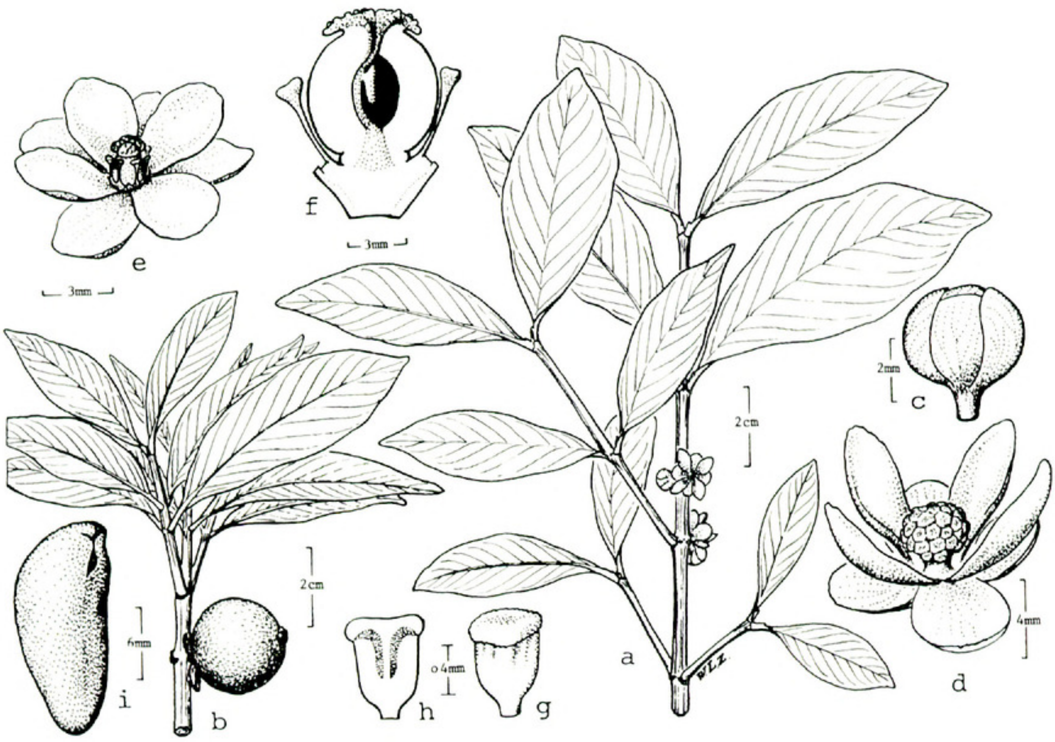


FIGURE 5. *Garcinia morella*: a, flowering branch, showing opposite leaves and staminate flowers; b, a fruiting branch, showing a fruit with persistent calyx; c, mature flower bud; d, staminate flower, showing 4 sepals, 4 petals, numerous stamens crowded at end of stout androphore; e, pistillate flower, showing staminodes and ovary; f, longitudinal section of very young fruit, showing position of ovule; g, stamen showing very short filament and orbicular apex of connective; h, vertical section of stamen, showing thecae and the thin position for dehiscing; i, lateral view of dried immature seed with elevated raphe and germination.

heartbeats and increases blood flow. Intravenous injections reduce experimentally induced fever. In the hind legs of toads it causes temporary short contractions followed by relaxation; it also relaxes the smooth muscles isolated from the intestine and uterus of rabbits.

EMERGENCY REMEDIES

Hospitals and ambulance services were unknown in China before 1910 and are rarely available to the general public today. In emergencies, such as heatstroke, convulsions in children, delerium and high fever, or loss of consciousness, the Chinese people rely primarily on rescue remedies. These preparations are composite formulas designed through the accumulation of knowledge and experience. These remedies are circulated in several forms—for example, pills (wan), powders (san), and red-coated elixir (dan)—that are available without a prescription. A random selection of ten of these emergency remedies from *A Handbook of Chinese Pharmaceuticals in Traditional Medicine* (Shong Yao Zhi Ji Shou Ce; Anonymous, 1974), reveals that each contains some imported material in amounts varying between 0.5 and 78 percent by weight. The number of ingredients in these rescue remedies varies from six in a cardiovascular pill (guan-xin su-he wan) to 50 in a blood-flow activator (shen-xue huo-luo wan). The amount of herbal material taken is very small, with 90 percent of the dosages being less than 1 g. Translations of two samples are presented below to show the nature of the remedies and the importance of exotic elements in their preparation. In the recipes, only the ingredients now imported from abroad are marked with asterisks. Products from the cultivated extra-Chinese elements, such as fennel seed from *Foeniculum vulgare* and menthol from *Mentha haplocalyx,* are not marked.

People's elixir (ren-dan): *Alpinia katsumadai* Hayata,* Katsumada's galanga, 31 g; *Amomum villosum* Lour., grain-of-paradise, 31 g; *Areca catechu* L.,* betel nut, 31 g; *Canarium album* (Lour.) Raeusch., Chinese olive, 31 g; *Carthamus tinctorius* L., safflower, 15.5 g; *Cinnamomum loureiroi* Nees, Saigon cinnamon, 31 g; *Citrus reticulata* Blanco, Mandarin orange peel, 31 g; *Dryobalanops aromatica* Gaertner,* Borneo camphor 7 g; *Foeniculum vulgare* Miller, fennel seed, 31 g; *Glycyrrhiza uralensis* Fischer, licorice, 248 g; *Mentha haplocalyx* Briq. (or *M. arvensis* L.), menthol, 28 g; *Poria cocos* (Schw.) Wolf, Chinaroot, 31 g; *Saussurea lappa* (Dcne.) C. B. Clarke,* costusroot, 46.5 g; *Syzygium aromaticum* (L.) Merr. & Perry,* cloves, 15.5 g; *Moschus moschiferus* L., musk, 3.1 g. The finished product is packed in tiny glass bottles as small red pills coated with cinnabar, each weighing 0.03 g. The dosage varies from between three and 20 pills, depending on the situation. In this formula, 20.5 percent of the ingredients by weight are imported.

Royal storax pill (su-he-xiang): *Aquilaria agallocha* Roxb.,* aloeswood, 31 g; *Boswellia carteri* Birdw.,* frankincense, 31 g; *Cyperus rotundus* L., nut grass, 31 g; *Dryobalanops aromatica* Gaertner,* Borneo camphor, 15 g; *Liquidambar orientalis* Miller,* storax, 15 g; *Piper longum* L.,* long pepper, 31 g; *Santalum album* L.,* sandalwood, 31 g; *Saussurea lappa* (Dcne.) C. B. Clarke,* costusroot, 31 g; *Styrax benzoin* Dryand. (or *S. tonkinensis* (Pierre) Craib),* benzoin, 31 g; *Syzygium aromaticum* (L.) Merr. & Perry,* cloves, 31 g; *Terminalia chebula* Retz,* myrobalan, 31 g; *Rhinoceros bicornis* L. (or *R. sumatrensis* Cuvier),* rhinoceros horn, 31 g; *Moschus moschiferus* L., musk, 23 g; and cinnabar, 31 g. This formula was first designed in the royal palace during the Song Dynasty and is still used. It calls for 14 ingredients, of which 11 (78 percent by weight) are exotics. The finished product consists of pills weighing ca. 3 g including the cementing material. Each dose contains ca. 0.16 g of herbal material.

CRITERIA FOR DETERMINING EXOTICS

In the foregoing list of exotics in Chinese materia medica (Table 1), items (e.g., *Abutilon theophrasti* and *Cannabis sativa*) are included that were formerly recorded, on the basis of assumption, as native to China (Spencer, 1984; Wang & Guo, 1980). Various other native Chinese plants (e.g., *Juglans regia*) that used to be regarded as introduced on the basis of hearsay are absent. After extensive field observations of the ecological conditions in China, investigations of ethnobotanical practices within the country, and intensive phytogeographical, systematic, and cytotaxonomic studies made in the herbarium and the library of the Harvard University Herbaria and the Chinese Library of the Harvard Yenching Institute, I used five criteria for determining which elements used in TCM are exotics. 1) Ecologically, the species is not adapted to grow in the natural flora or fauna of China and is thus dependent on man for survival. 2) Morphologically, it is a distinct taxon without closely related species in China. 3) Biogeographically, the center of species concentration is in a region far from China. 4) Cytologically, its chromosome complement is of high ploidy. The diploid progenitors are in distant phytogeographical areas. 5) Historically, plants and animals have moved with people and are changed by them; the routes of such movement are often traceable.

Application of these criteria proves positively that *Abutilon theophrasti* and *Cannabis sativa* are exotic elements in the flora of China and establishes that *Jasminum sambac* is not Arabic and *Juglans regia* is not Persian. The latter two species are indigenous to China, selected and developed by the ancient ethnic groups dwelling in areas where the wild species grew.

ABUTILON

In northern China *Abutilon* constitutes a minor fiber crop or—particularly in neglected disturbed areas of large cities such as Beijing, Nanjing, and Wuhan—is a weed. It was repeatedly introduced from China into the United States as a potential source of fiber for cordage. It has been called Indian mallow, stampweed, buttonweed, and Chinese velvetleaf and has become a troublesome weed in fields of corn, cotton, and soybeans. Spencer (1984) has estimated that the annual economic loss due to velvetleaf is approximately $343 million. In response to the request of American weed scientists, in 1984 I searched for the natural enemies of *Abutilon* in China, hoping to find some special animal or plant pathogens that I could bring back for the biological control of velvetleaf in the United States. From Hong Kong, I entered China and traveled all the way to Guangzhou, Lanzhou, Qinghai, Inner Mongolia, Datong in Shanxi, Beijing, Wuhan, Nanjing, and many areas in Jiangsu (including where *Abutilon* was formerly cultivated on my grandmother's farm) but failed to find any specific natural enemy. I studied the ecological conditions of the plants, took photographs, and collected voucher specimens. Subsequently, I concluded that *Abutilon* is not native to China. Occuring only in association with man, it is an isolated tetraploid with the related diploid progenitors growing in southwestern Asia. Apparently, what is known as the Chinese velvetleaf (*A. theophrasti*) was unintentionally introduced into China, having attached itself to man or his animals; it later became naturalized and was gradually domesticated and improved by Chinese farmers to furnish the bast fibers used in cordage and for making sandals. The medicinal use of the seed was first recorded in a seventh-century herbal. It is worthy of note that in the vicinity of Hong Kong and Guangzhou, the tetraploid perennial *A. indica* (L.) Sw. grows as a weed. Apparently the species of *Abutilon* in China are all adventives.

Cannabis or Hemp

The worldwide distribution of *Cannabis sativa* is mostly man related. Humans have captured and capitalized on the genetic variability and ecological plasticity of the species and have used it to meet their special needs. In India and now in Latin America, it has become a cash crop. Young fruits and leaves are harvested and used as a narcotic drug. Large quantities of the drug are sold in the United States as marijuana, the use of which has caused serious social problems. In China it is extensively cultivated as a minor crop for the useful bast fiber, which is stronger but less plentifully yielded than that of *Abutilon.* The medicinal use of its by-products (seeds, roots, bark, leaves, and young fruits) has not been important to Chinese farmers, at least not before the 1930's when I lived among them during the harvest season.

The origin and the systematics of the species of *Cannabis* have puzzled botanists throughout the history of botanical science. In China hemp appears in the earliest plant records as *ma,* which has become a generic term for different types of bast fibers and the names of their source species—for example, *huang-ma* for jute (*Corchorus capsularis* L.), *qing-ma* for velvetleaf (*Abutilon theophrasti*), and *zhou-ma* for ramie or China grass (*Boehmeria nivea* (L.) Gaud.). Archaeological evidence shows that *Cannabis* was associated with Neolithic dwellers in Gansu, the cradle of Chinese civilization (Wang & Guo, 1980). In this case, antiquity does not prove that *Cannabis* is indigenous to China, for the seeds were kept in an earthenware jar. *Cannabis* is an exotic element in the flora of China because its existence in the country is completely dependent on man. It is noteworthy that the young fruit, the most potent organ of the plant used in marijuana, was recorded in ancient Chinese classics, *Er-ya,* as *ma-fen* (ma grave) or *ma-lan* (blue ma or ma cradle). As a medicine, 0.6 g of *ma-fen* is given to patients with the warning that the material is poisonous, and when taken in excess it ruins a person, making him violent and crazy. The active principle is a resinous substance containing tetrahydrocannabinol (THC), which gradually disappears as the fruit matures. The Chinese people use ripe seeds as feed for pigeons fattened to be served in special restaurants.

Jasmine

The origin of the source species of *mo-li-hua,* used in the Chinese tea industry to produce the delicate flavor of jasmine tea, has been both erroneously recorded in botanical literature and misinterpreted in Chinese references. In classic botanical works, Linnaeus (1753) and Aiton (1789) cited two records based on plants introduced from Arabia and cultivated in European gardens under the common name "sambac." In 1753 Linnaeus proposed *Nyctanthes sambac* L., which Aiton transferred to *Jasminum* L. in 1789 to validate the currently used scientific name, *J. sambac* (L.) Aiton. Aiton also added the English name Arabian jasmine. In ancient Chinese writings, *mo-li-hua* first appeared in *Nan-fang cao mu zhong* (*A Description of Plants from the South,* A.D. 306), by Ji Han. Ji was from a famous educated family of the time. Through family connections he was appointed Awestricken General and Prefect of Xiang-yang. Xiang-yang (long. 122°8′ E, lat. 32° N) was an important communications post where diplomatic missions and merchants from southern China stopped to change means of transportation from boats to horses to continue along their journeys to the capital. At that time valuable tropical natural products such as ivory, rhinoceros horn, spices, and perfumes were sent as tributes to the emperor, kings, dukes, and local officers, or as material for exchange gifts. In Ji Han's office, a record of these products was made under the title *Nan-fang cao mu zhong.* When Li was assassinated in 306, the list contained about 80 items, each with a name and with the information supplied by the bearer. The second item on the list covers two species of *Jasminum.* The information given provided several facts. At the beginning of the fourth century, two kinds of white-flowered jasmine were transplanted from the tropics to the warm-temperate city of Xiang-yang in northern Hubei Province. Both types produced very fragrant flowers, for which the species had been domesticated in southern China (where Guangzhou was the major city). The species were native to the land west of Guangzhou—an area occupied by the Hu people, who had not adopted the Chinese culture. One species was called *mo-li-hua*; the other, *ye-xi-ming,* apparently a translation of the Persian-Arabic word "yasmin" ("jasmine" in English). The latter species has been identified as *J. officinale* L., which has compound leaves and is rarely cultivated in China.

Based on the above Latin and English names and the ancient Chinese records, early Chinese botanists began to draw the conclusion that *mo-li-hua* was native to the area between India and Arabia. Chen (1937, p. 1031) further explained, "It seems to have been introduced from southern Asia to China, first planted in South China, and now cultivated throughout the country for ornamental purposes. In Fuzhou, it is planted extensively, for there it is used to scent tea. The annual production reaches 2,000,000 catties." Actually, the areas in the vicinities of Guangzhou and Kunming both have large acreages planted with the crop.

Like other botanists of my generation, I used to believe that the *mo-li-hua* in Chinese gardens was introduced from Arabia. Then I saw the wild type of *Jasminum sambac* in Yunnan and studied the species in the natural flora of China. On 30 October, 1980, I was stranded in Si-mao after a lecture tour to the Tropical Botanical Garden, Academia Sinica, in Xi-shuong-ban-na, situated in the area of the Chinese Tai minority on the Yunnan-Thailand border. Since the small plane could not take off, I spent the extra time studying the plants in the gardens and in a nursery. Among the numerous pots of *mo-li-hua,* I saw some plants sending out one or two elongate vinelike shoots, which the nurseryman had trimmed off to produce a shrublike appearance. Suddenly I realized that I was looking at the prototype of the *mo-li-hua* that I had seen throughout China as shrubs in pots and in gardens. Actually, I was standing on the land where early cultivators began to domesticate *J. sambac,* transforming it from its natural clambering habit to a shrubby one.

To check the validity of this insight, I examined herbarium specimens of species of the genus *Jasminum* on a worldwide basis and studied the morphological characters and distributional patterns of the Chinese species in particular. Species of *Jasminum* have a pantropic distribution. The Chinese species can be divided into two major groups: the temperate deciduous ones, such as *yin-chun* (*J. nudiflorum* Lindley) and *tan-chun* (*J. floridum* Bunge), with shrub-like habits and yellow flowers that open early in the spring before the leaves, and the tropical evergreen ones, such as *su-xin* (*J. sinense* Hemsley), *gia-su-xin* (*J. amplexicaule* Buch.-Ham.), and *su-xin-hua* (*J. officinale* L. var. *grandiflorum* (L.) Kobuski), with vinelike habits and white fragrant flowers. Some of the species have simple leaves, while others have compound ones. *Mo-li-hua* is an evergreen plant with simple leaves and fragrant white flowers that often turn purplish pink with age. On plotting the distributions of the wild simple-leaved Chinese species of *Jasminum,* I was indeed surprised to find that six of them all closely related to *J. sambac* grow in an area within a 100 km radius of Si-mao (101°02′ E, 22°24′ N). These little-known species (*J. anastomasans* Wall., *J. coarctulum* Roxb., *J. coffeinum* Hand.-Mazz., *J. dunicolum* W. W. Sm., *J. nintooides* Rehder, and *J. sequinii* Léveillé) are not yet known in cultivation. This area where the morphological diversity and species concentration of *Jasminum* occurs, called Hu in the time of Ji Han, has been termed a "favored area for evolution" by one modern biogeographer and Cathaysia by Takhtajan (Hu, 1971, p. 222). It is the homeland of *mo-li-hua.*

Nine species of *Jasminum,* including *J. sambac,* are used in traditional Chinese medicine in the form of roots, stems, and leafy shoots. Apparently *J. sambac* was domesticated in Cathaysia and gradually spread by man to Arabia, from where it was introduced to Europe. All former records that ascribed its origin to Arabia were made on assumptions, and they are botanically unrealistic: *J. sambac* and closely related species grow in the humid tropics; the arid Arabian climate does not support such plants except in gardens.

Walnut

The origin of *Juglans regia* L. has puzzled early researchers interested in Chinese economic botany and the cultural exchange between East and West. Unfortunately, at the time when Laufer (1919) conducted his research into the ancient literature dealing with walnuts, the biology of *Juglans* and the ethnobotany of the ancient people who first cultivated, selected, and improved the wild progenitor into a form like *J. regia* (which has thin-shelled nuts with edible kernels) were yet unknown. Consequently, his conclusion that the English walnut has a Persian origin contradicts modern scientific findings. Moreover, under the influence of ancient Chinese and more recent foreign scholars, early botanists in China also considered *J. regia* to have been introduced. For example, a widely circulated reference (Chen, 1937, p. 136) stated, "According to tradition, the species is a native of Arabia, was introduced into China in the Han Dynasty, and is extensively cultivated in central and northern China today." The concept that the edible walnut is not Chinese should be rectified.

Current botanical data indicate that the walnut family (Juglandaceae) is old, having originated in the Northern Hemisphere. The present-day center of diversity is eastern Asia (Manchester, 1988), particularly China, where living species of *Platycarya* Sieb. & Zucc., *Engelhardtia* Leschen. ex Bl., *Pterocarya* Kunth, *Cyclocarya* Iljinskaja, *Carya* Nutt., and *Juglans* L. coexist. In Europe there are no native species of these genera, and in America only species of *Carya* and *Juglans* are indigenous. (Actually, these two genera have wider geographic distribution and more ecological amplitude in America than in China.) The natural species of *Juglans* are all monoecious, with small, green, unisexual flowers; the staminate ones are in pendulous catkins on second year growth, the carpellate ones in upright spikes terminating current year's growth. Additionally, all have lamellate pith in the young branchlets; alternate, pinnately compound, estipulate leaves; drupelike fruits, each developed from an inferior ovary, and nuts with thick shells that are very hard to break. The species with large, thin-shelled, relatively easy-to-crack nuts and tasty kernels, like *J. regia,* are of anthropogenic origin, having been selected through cultivation and/or hybridization. Botanical literature of the last two centuries has recorded many such species and horticultural forms (see Rehder, 1940, 1949). *Juglans* × *intermedia* Carr. was developed through hybridization between an American species (*J. nigra* L.) and an Asian one (*J. regia*); the thin-shelled horticultural forms *Juglans* 'Paradox' and *Juglans* 'Royal' were selected in the U. S. A. from hybrids of *Juglans hindsii* (Jepson) Jepson and *J. regia*; and *Juglans* 'James River Hybrid' from *Juglans nigra* × *J. regia*.

Ancient Chinese literature and recent ethnobotanical findings together confirm the fact that *Juglans regia* was cultivated from native wild species in China at the beginning of the Christian era. The earliest Chinese records concern the cultivation of walnuts in the capital (now called Nanjing) of the Kingdom of Wu (A.D. 222–277) and the quality of the kernel in the Eastern Jin Dynasty (ca. A.D. 326). In the royal garden called Hua-lin-yuan 84 walnut trees were in cultivation. Eastern Jin (A.D. 317–419) conquered Western Jin and used Nanjing as the capital. Fifty years later, Su Jun tried to overthrow the Jin government. The women of some rich families escaped the rebellion by going from Nanjing to Lin An Shan for safety. It was recorded that a messenger was sent to bring supplies from the capital to Lady Liu with a letter explaining the special fruits included. Regarding the walnut, the letter stated that it was originally grown in the farther land of Xi-qiang, that the outer shell was hard but the inner kernel sweet, and that it was sent as a special tribute because it was easy to carry (Laufer, 1919). The ethnobotanical significance of the above references has never been grasped by subsequent scholars (Chinese or foreign) who wrote about the edible walnut in China because they were uninformed concerning the land where the cultivated and wild species of walnut grow, or about the life, language, and culture of the people there, until China became involved in World War II.

The Sino-Japanese War began in 1937 and ended in 1945. During this period I taught in the Department of Biology, West China Union University, Chengdu. During summer vacations I hired some native hunters or medicine gatherers to help me with field work and with the study of vegetation and ethnobotany. We collected specimens of different species of *Juglans,* which they called *he-tao* (the cultivated trees in the villages) or *shan-he-tao* (the wild trees on the hillsides). In the summer of 1941, C. C. Liu (China's leading herpetologist), his associates, my assistant, and I followed a tributary of the Min River from Li-fan up the Mong-dong Valley. Opposite this valley in the mountains south of Li-fan lived the Qiang ethnic group. These people cultivated barley and corn, depended on wild onions and fern fiddleheads for vegetables, and kept dried, wild persimmons and walnuts in their houses. I was given some walnuts and shown how to crack them by placing two nuts in one hand and giving a quick squeeze. I was very surprised to know that walnuts could have such thin shells. Those that I had seen elsewhere in China had hard, thick shells and were rather rare; they were broken by a stone or a hammer. The ethnic people living in the mountain valleys of the Qiong-lai Range (Chung-lai on Map in Hu, 1956) had early selected and developed walnuts, and they continued to improve the quality to the state I had seen.

I ascended the Qiong-lai Range from different directions and reached several peaks covered by snow in August. At the level where broad-leaved deciduous forests fluorished, there were wild Chinese walnuts (*Juglans cathayensis* Sarg.) growing on the hillsides and cultivated trees of *J. regia* in the villages. In the Mong-dong Valley, the people were very proud of their special thin-shelled nuts.

The Qiong-lai Range and the adjacent land mass to the north and west were occupied by the ancestors of the Xi-qiang and by the Rong or Gia-rong. In the history of China, the name of this area has been changed many times. During the Three Kingdoms Epoch and the Eastern Jin Dynasty (A.D. 222–419) when *Juglans regia* was first mentioned in Chinese literature, the region was called "The Further-Land of the Western Qiang" by scholars. When the famous European explorers A. David and E. H. Wilson collected animal and botanical specimens there, they used "Eastern Tibet" on their labels and in their publications. When I collected in the area between 1938 and 1942, the western portion was administered by the Sikang provincial government, and the eastern portion was Sichuan (Szechuan), as printed on my field labels. On today's map of China, the entire region is in Sichuan. Early historians and sinologists misinterpreted the ancient records about Xi-qiang because they used a map of the twentieth century with the western Chinese boundary on the Pamir Mountains and took the phrase "farther land of Xi-qiang" to mean Persia. They thus shifted the origin of the walnut from western China to Persia. A botanist from Iraq, I. A. Al-Shehbaz, told me that all the walnuts in Iraq and Iran are cultivated. There is no wild species of *Juglans* in the Middle East.

The dispersal of *Juglans regia* was also through man's activities. Before 1950 the agriculture of the Qiang and Yong ethnic minorities in western Sichuan was for self-sustenance, as it was for 95 percent of all Chinese farmers. One or a few walnut trees may have been planted near the family house to provide nuts for family use, not for sale. They were for festivities, or to be used as a rich source of energy, especially for the men on their hunting trips or during religious pilgrimages. On such trips away from home, the rations were *zhan-ba* (roasted barley meal) and walnuts. In a wayside rest station the traveler just mixed the *zhan-ba* with hot tea and butter provided by the host, supplemented by a few nuts to make a meal. Often the walnut was given in exchange for favor or for gifts.

In ancient times the Qiang people were politically and militarily involved with the people using the Chinese language and writings to their east, and the Rong minorities were religiously associated with the people on the Tibetan plateau to the west. It was evidently through such activities that walnuts were carried eastward to the people in the plains of the Yellow and Yangtze rivers, and westward into Tibet, thence to northwestern India and Persia. The common Sanskrit terms for walnut, *akhota, aksota,* and *aksosa,* seem to confirm the movement of the Chinese *he-tao* to India via Tibet.

Generally, when a cultural trait passes between two peoples living in adjacent areas, it goes unrecorded, and the people receiving it take it as a matter of fact. This was exactly the case with walnuts in the lower Yangtze provinces. Apparently, ancient scholars like Ji Han of the fourth century were familiar with walnuts. In his *A Description of Plants from the South,* when he described nuts brought to Xiang-yang by special envoy, he compared them with the taste of walnuts. For example, in recording coconut from southern China, he stated that the white meat tastes like walnut, but it has a richer flavor.

CONCLUSIONS AND DISCUSSION

Having worked with plants for over sixty years, I am habitually inclined to treat a historical problem as I do a living organism: I investigate its development, structure, interaction within a community, and reaction to time, space, and human activities. I believe that scientific methods are applicable to the study of history as well as to work with biological objects. Guided by this, I started researching the introduction of exotic elements used in TCM.

Some extra-Chinese elements were introduced into China a very long time ago. Hemp, for example, entered China with Neolithic man, according to recent archaeological evidence. There has been a continuous growth in the number of plant and animal products introduced. Meanwhile, there has been a gradual change in the nature of the importations: daily necessities such as food and fiber gave way to aromatics and spices used in the preparation of emergency remedies in the Song Dynasty, and then to substances for comfort and enjoyment of life in the Ming and Qing dynasties. The importation of 99 percent of the items can be traced in ancient records. However, when a species is used only in folk medicine, shared by people living in adjacent areas, and spread through intermediaries, the time of its introduction into China may never be known. The creat of India (*Andrographis paniculata*) in South China is a good example.

The geographic analysis shows that tropical Asia, the Mediterranean region, tropical America, and southeastern Asia have been the primary contributors of the exotic elements used in TCM. Over 56 percent of the 94 items listed came from these four areas. Most of the species were introduced intentionally, although a few plants—including the velvetleaf (*Abutilon theophrasti*)—arrived in China as adventives following the movement of man.

Since China is rich in natural resources, why are animal and plant products imported into the country for healthcare purposes? First, it should be understood that adventure is in the nature of mankind, and plants and animals move with man. A majority of the extra-Chinese plant species was first introduced into China as daily necessities such as food and fiber for the ancient travelers. Today these species are still cultivated for the same purposes. Ingenious and inventive people who tried to use the agricultural by-products effectively discovered their medicinal uses long after their introduction into China. Radish, hyacinth bean, black sesame, and cannabis seed are good examples.

Second, the geographic position and the general climatic conditions of China limit the production of certain source species that require humid tropical or warm xerophytic conditions. Certain products from the tropics are needed for soothing the unbearable pain of abscesses, ulcers, and carbuncles, and for curing tenacious cutaneous diseases such as scabby head. Gambier from India and gamboge from Thailand are imported via Singapore for these purposes. Other products are needed in the preparation of rescue remedies used in such emergencies as heatstroke, epilepsy, convulsions in children, loss of consciousness, and delirium. Frankincense, borneol, cloves, and rhinoceros horns are imported primarily for such preparations. In the popular and nationally available people's elixir, 20.5 percent of the weight of the 15 ingredients is of extra-Chinese origin. In the more expensive royal storax pill, 78 percent of the total weight of the 14 ingredients consists of imported material. Recently, Chinese pharmaceutical manufacturers have tried to use synthetic materials and/or local products to substitute for imported elements obtained from endangered species—for example, using horns of the buffalo to replace those of the rhinoceros in prescriptions. However, these efforts have not stopped the flow of exotic natural products into the country for use in TCM.

In researching the origin of extra-Chinese elements used in TCM, I have encountered numerous incorrect and untrue statements both in the botanical literature and in ancient Chinese documents. Reports of *Abutilon* and *Cannabis* as indigenous to China, of *Jasminum sambac* as a native to Arabia, and of *Juglans regia* having a Persian origin are incorrect. After months of research, I have been able to rectify these erroneous concepts; for example, *Abutilon* and *Cannabis* have been added to the list of introduced species, and jasmine and walnut have been removed from my original list of exotics used in TCM.

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LITERATURE CITED

AITON, W. 1789. Hortus Kewensis. Vol. 1. London.

ANONYMOUS. 1889. List of Chinese medicines. China Imperial Maritime Customs, Miscellaneous Series No. 17. Shanghai.

———. 1959–1961. Zhong yao zhi (A new Chinese materia medica). (In Chinese.) 4 vols. Health Press, Beijing. [1.]

———. 1974. Zhong yao zhi ji shou ce (A handbook of Chinese pharmaceuticals in traditional medicine). (In Chinese.) People's Health Press, Beijing. [2.]

———. 1976–1980. Zhong cao yao xue (Chinese pharmacology). (In Chinese.) Vols. 2, 3. Jiangsu People's Press, Beijing. [3.]

———. 1977–1979. Zhong yao da ci dian (An encyclopedia of Chinese medicines). (In Chinese.) 2 vols. Shanghai People's Press. Shanghai. Supplement. Shanghai Science Technology Press, Shanghai. [4.]

———. 1980. Xinhua zidian (New China dictionary). revised ed. Commercial Press, Beijing. (In Chinese, with pin-yin.) [5.]

BAKER, J. G. 1877. *Aloë chinensis.* Bot. Mag. **103:** *t. 6301.*

CHEN, C. Q. 739. Unrecorded materia medica (Ben-cao shi-yi). (In Chinese, incorporated in S. Z. Li.) [6.]

CHEN, H. Z. 1688. Flower mirror (Mi-chuan hua jing). 6 Fascicles. Honzhou. (In Chinese.)

CHEN, Y. 1937. Illustrated manual of Chinese trees and shrubs. (In Chinese.) Nanking.

HAWORTH, A. H. 1819. Supplementum plantarum succulentarum. xi + 158 pp. I. J. Harding, London.

HU, S. Y. 1945. Medicinal plants of Chengtu herb shops. W. China Border Res. Soc. **15B:** 95–178.

———. 1956. Climbing the trails of the giant panda. Appalachia. **1956:** 164–172.

———. 1971. The Orchidaceae of China (II). The composition and distribution of orchids in China. Quart. Taiwan Mus. **24:** 181–223.

JI, H. A.D. 306. Nan-fang cai mu zhong (A description of plants from the south). (In Chinese). [7.]

LAN, M. 1370. Materia medica of southern Yunnan (Dian-nan ben-cao). 3 Fascicles. (In Chinese. Reprint, 1914, Kunming; Revision, 1975–1978.) [8.]

LAUFER, B. 1919. Sino–Iranica, Chinese contribution to the history of civilization in ancient Iran with special reference to the history of cultivated plants and products. Field Mus. Nat. Hist., Anthropol. Ser. **15:** i–iv, 185–630.

LI, C. 650? Duke Ying's Tang pharmacopoeia. (Ying-gong Tang ben-cao). 7 Fascicles. (In Chinese, incorporated in J. Su's work, the original lost.) [9.]

LI, CHANG-FU. 1966. Zhong-guo zhi min shi (History of Chinese emigration). 352 pp. Commercial Press, Taiwan. [10.]

LI, S. Z. 1596. Materia medica with commentaries (Ben-cao gang-mu). 52 Fascicles. (In Chinese. 1930 reprint, Shanghai Commercial Press; 1967 reprint in 2 vols., Hong Kong Commercial Press.) [11.]

Li, X. 756. A register of the medicine imported via the sea (Hai-yoa ben-cao). 6 Fascicles. (In Chinese. Incorporated in S. Z. Li, the original lost.) [12.]

Linnaeus, C. 1753. Species Plantarum. 2 vols. Holminae.

Liu, H. 1708. Enlarged monograph on flowers (Guang chun fang pu). 32 Fascicles. Beijing. (In Chinese.) [13.]

Liu, H., Z. Ma, *et al.* 973. Pharmacopoeia of the Kai-bao Reign (Kai-bao ben-cao). 21 Fascicles. (In Chinese. Incorporated in S. Z. Li's work, the original lost; available in many forms.) [14.]

Liu, X. 889–890. Records of strange articles (Ling biao lu yi). (In Chinese.) [15.]

Manchester, S. R. 1988. The fossil history of the Juglandaceae. Monogr. Syst. Bot. Missouri Bot. Gard. **21:** 1–137.

Mathews, R. H. 1972. Mathews' Chinese-English dictionary. Revised American edition. Harvard University Press, Cambridge, Massachusetts.

Ni, Z. M. 1624. Organized collection of materia medica (Ben-cao hui yan). 20 Fascicles. (In Chinese.) [16.]

Rehder, A. 1940. Manual of cultivated trees and shrubs hardy in North America. Macmillan, New York.

———. 1949. Bibliography of cultivated trees and shrubs hardy in the cooler temperate region of the Northern Hemisphere. Arnold Arboretum, Jamaica Plain, Massachusetts.

Sima, S. 231–273. Collections of a man of peace (Zi-an ji). (In Chinese.) [17.]

Spencer, N. R. 1984. Velvetleaf, *Abutilon theophrasti* (Malvaceae), history and economic impact in the United States. Econ. Bot. **38:** 407–416.

Su, J. 659. New Tang pharmacopoeia (Tang xin ben-cao). 53 Fascicles. (In Chinese. Original lost in China, 10 fascicles copied and taken to Japan by visiting Japanese scholars. Now available in Japan.) [18.]

Su, S. 1062. An illustrated pharmacopoeia (Tu jin ben-cao). 21 Fascicles. (Original lost, text incorporated in S. Z. Li). [19.]

Tang, S. W. 1108. Verified identification of materia medica (Zheng-lei ben-cao). 31 Fascicles. 30 Fascicles. (In Chinese. A commonly used name for Jing-shi zheng-lei bi-ji ben-cao; also known as Pharmacopoeia of the Da-guan Reign, Da-guan ben-cao; several later editions with changed names for the reigns of different emperors, the 1116 edition called Zheng-he Jing-shi zheng-lei bei-yong ben-cao. Reprinted in Nanjing in 1579.) [20.]

Tao, H. J. 500? Unrecorded materials of eminent physicians (Ming yi bie-lu). (In Chinese. Hand-copied manuscript lost, text incorporated in next entry.) [21.]

———. 500? A commentary on Shen-nong's herbal classics (Shen-nong ben-cao jing ji-zhu). 7 Fascicles. (In Chinese. Incorporated in S. W. Tang, also in S. Z. Li.)

Wang, Q. R., & D. Y. Guo. 1980. Studies on the hemp seeds and millet unearthed at Linjia remains in Dong-xiang county, Gansu province. (In Chinese.) Gansu Teachers University, Lanzhou.

Wang, X. G. 1621. Monograph of flowers (Chun fang pu). 30 Fascicles. (In Chinese.) [22.]

Watt, G. 1889–1893. A dictionary of the economic products of India. 6 vols. Calcutta. (*Andrographis,* **1:** 239–241. 1889.)

Wu, C. Z. 1848. An illustrated treatise on plants (Zhi-wu ming shi tu kao). 38 Fascicles. Tai-yuan, Shanxi. (In Chinese. Every species illustrated. See also, Zhi-wu ming shi tu kao chang bian. 22 Fascicles. In Chinese.) [23.]

Wu, P. 220–260. Herbal classics of the divine plowman (Shen-nong ben-cao jing). 3 Fascicles. (In Chinese. 799 edition by Sun et Sun.) [24.]

Wu, Y. L. 1757. Newer version of materia medica (Ben-cao cong xin). 6 Fascicles. Beijing. (In Chinese.) [25.]

Xiao, B. D. 1932. Records of gathering medicinal herbs in South China. 2 Vols. (In Chinese. Revised ed., 1936, incorporated in Zhuang, 1954–1963). [26.]

XU, G. J., *et al.* 1960. Yao Cai Xue. (Chinese Pharmacognosy). 1416 pp. People's Health Press, Beijing. [27.]

YAN, Y. H. 1253. Life saving recipes (Ji sheng fang). 10 Fascicles. (In Chinese.) [28.]

ZHANG, C. S. 1985. Han Dai Shi Chou Zhi Lu Kai Tuo Yu Fa Zhan. (The opening and development of the silk route in Han Dynasty.) Shi-hua Monthly **15**(1–2): 1–14.

ZHANG, Y. X. 1061. Revised pharmacopoeia of Gia-you Reign (Gia-you bu-zhu shen-nong ben-cao). 20 Fascicles. (In Chinese. Original lost, incorporated in S. Z. Li.) [30.]

ZHAO, X. M. 1765. Supplement to Ben-cao gang mu (Ben-cao gang mu shi yi). 10 Fascicles. (In Chinese.) [31.]

ZHU, X. 1407. Famine herbal (Jiu-huang ben-cao). 4 Fascicles. (In Chinese. Every species illustrated.) [32.]

ZHU, Z. H. 1358. A supplement to herbal commentaries (Ben-cao yan-yi bu yi). (In Chinese. Incorporated in S. Z. Li, 1597.) [33.]

ZHUANG, X. B. 1954–1963. Revision of Xiao's records of gathering medicinal herbs in South China. 2 Vols. 1963. [34.]

APPENDIX I. **Chinese ideograms of names of exotics used in TCM.***

1 苘麻	2 兒茶	3 刺蜜	4 芦荟	5 白豆蔻	6 穿心莲	7 沉香	8 槟榔	9 冬瓜子
10 木棉	11 乳香	12 白介子	13 芸苔子	14 落地生根	15 苏木	16 刀豆	17 火麻仁	18 辣椒
19 番木瓜	20 红花	21 番泻叶	22 望江南	23 長春花	24 金鸡纳皮	25 西瓜翠	26 白花菜	27 没药
28 芫荽子	29 番红花	30 甜瓜子	31 血竭	32 降真香	33 洋金花	34 冰片	35 火秧竻	36 千金子
37 阿魏	38 無花果	39 小茴香	40 藤黄	41 千日红	42 棉花根	43 麦芽	44 大風子	45 急性子
46 牵牛子	47 大青叶	48 地肤子	49 白扁豆	50 馬櫻丹	51 指甲花	52 苏合香	53 胡麻子	54 丝瓜络
55 含羞草	56 紫茉莉	57 肉豆冠	58 夹竹桃	59 烟草	60 罗勒	61 仙人掌	62 西洋参	63 罂粟殼
64 海棗	65 荜茇	66 胡椒	67 無名子	68 廣藿香	69 胡桐泪	70 马齿苋	71 偏核桃	72 番石榴
73 補骨脂	74 石榴	75 使君子	76 萊菔子	77 蓖麻子	78 迷迭香	79 芸香	80 檀香	81 广木香
82 黑芝麻	83 胖大海	84 馬錢子	85 安息香	86 丁香	37 酸角	88 柯子	89 胡芦巴	90 牛黄
91 象皮	92 象牙	93 龙涎香	94 犀角					

*The numbers correspond to those given in column two in TABLE 1.

APPENDIX II. Chinese ideograms of names of ancient herbals and pharmacopoeias.*

1 中药誌
2 中药制剂手册
3 中草药學
4 中药大辞典
5 新華字典
6 陳藏器 本草拾遺
7 嵇含 南方草木狀
8 蘭茂 滇南本草
9 李勣 英公唐本草
10 李長傅 中國殖民史
11 李時珍 本草綱目
12 李珣 海药本草
13 劉灝 廣群芳譜
14 劉翰 等 開宝本草
15 劉恂 嶺表錄異
16 倪朱謨 本草彙言
17 司馬嬰 子安集
18 蘇敬 唐本草 （新修本草）
19 蘇頌 图経本草
20 唐慎微 証類本草 （經史証類備本草, 大觀本草, 政和經史証類備用本草）
21 陶弘景 名医別錄
22 王象晉 群芳譜
23 吳其濬 植物名实图考 植物名实圖考長编
24 吳普（等述）, 孫星衍, 孫馮翼（校） 神農本草经
25 吳儀洛 本草從新
26 蕭步丹 嶺南採藥錄
27 徐國鈞 药材學
29 張春樹 漢代絲綢之路的開拓與發展
28 嚴用和 濟生方
30 掌禹錫 嘉祐補註 神農本草經
31 趙學敏 本草綱拾遺
32 朱橚 救荒本草
33 朱震亨 本草衍義補遺
34 莊學本 增訂嶺南採药錄

*The numbers correspond to those given in LITERATURE CITED. The names of authors are underlined.