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Dedication: Kim E. Hummer

Volume 39 of *Horticultural Reviews* is dedicated to Dr. Kim E. Hummer, who has brought tireless enthusiasm to the vital work of conserving plant genetic resources and the very important biological and historical information they represent. Kim is research leader for the USDA Agricultural Resource Service gene banks in Corvallis, Oregon, and Palmer, Alaska. She has been a steward for the world's cultivated and wild diversity of many temperate fruit, nut, and other specialty crops for nearly three decades. Her research on genetics and germplasm, international collaborations, plant expeditions and exchanges, and release of new cultivated varieties have expanded the world's access to rare plant materials and improved not only our food security but also our ability to

study and enjoy the unique diversity of these crops. Kim's strategic characterization of adaptive traits, such as disease resistance, and establishment of test plantings in geographic locations that push the traditional limits of production have encouraged the exciting expansion of horticultural industries and the cultivation of previously underutilized species.

Kim arrived at the Corvallis Repository in 1982, where she had a dual assignment to manage the gene bank's record-keeping system and to determine vitamin C and other fruit constituents using HPLC analysis. In 1987, she took the helm as curator for the temperate fruit and nut collections, which included the eight major genera: *Corylus, Fragaria, Humulus, Mentha, Pyrus, Ribes, Rubus, and Vaccinium*. Small collections of other minor crops added about 30 additional genera to the mix. This obscure USDA facility in the backwoods of Oregon was little known in the 1980s outside of a small community of specialty crop breeders and researchers. Under Kim's guidance, every one of these collections has grown to represent the largest and most genetically diverse ex situ living assemblage in the world for these genera. The world is literally beating a path to the door of the National Clonal Germplasm Repository in search of the plants, seeds, and information housed at the facility.

Kim was born on September 17, 1952, in Washington, DC, and raised in Bethesda, Maryland. She left Maryland to pursue higher education at St. Lawrence University in Canton, New York, where she graduated in 1974. She moved to Burlington, Vermont, to study cold hardiness of *Forsythia* with Dean Evert and Norm Pellett and completed her MS in 1978. While at the University of Vermont, she caught the plant-collecting bug when the universitysponsored her to collect *Rhododendron* species in the Great Smokey Mountains of North Carolina. This

was to be the first of many expeditions into the wild to capture plants and bring them into captivity, where they can be studied and cultivated. Kim left the East Coast and went to Oregon for her PhD studies. Under the direction of Les Fuchigami, she worked on tissue culture of apples and plums and examined the roles that leaf morphology and stomatal function had on acclimation to life outside the test tube. She completed her PhD in horticulture at Oregon State University in 1981, just as the USDA Agricultural Research Service was completing construction of the first National Clonal Germplasm Repository, which opened in Corvallis the same year.

When Kim was first hired to work for Harry Lagerstedt as an Oregon State University Research Associate to develop a record-keeping system for the young clonal gene bank, microcomputers were just becoming available. The germplasm databases of the day were developed for seed collections and involved workstations, shared centralized computers, and complex programming and query languages. New software programs, such as dBase II, allowed a facility to store database information locally on microcomputers using floppy disks to share information between users. Kim borrowed suitable concepts and structures from national seed databases to design a system to meet the needs of a clonal gene bank. Developing appropriate data resources put Kim in touch with many other germplasm facilities and specialists, and as she collected information for the Corvallis plant collections, she became keenly aware of each plant's history, taxonomy, and characteristics. When the curator position at the Corvallis gene bank became vacant in 1987, Kim Hummer's intimate knowledge about the plant collections and important associations with the U.S. germplasm community put her in a unique position to take on the curator job.

The repository mission to collect, conserve, characterize and distribute the world's diversity for the assigned crops required an initial focus on collecting material before it is lost. Explorations and exchanges have taken Kim to many parts of the world that are either centers of origin for her crops or important places for breeding and production. She has organized expeditions to collect wild berry species and other crops in China, twice to northern Japan and in the Russian Far East, including Vladivostok, Primorye, and Khabarovsk. Closer to home but equally important as sources of wild diversity have been expeditions to the northeastern and southeastern United States. She has collected widely in Alaska and recently has made important progress in understanding ploidy of wild *Fragaria* species by filling in gaps from the mountains of the Pacific Northwest. More than 550 accessions have been added to USDA National Plant Germplasm System collections as a result of Kim's expeditions, ranging from threatened lowchill *Vaccinium* species in Florida, to arctic *Rubus* in Alaska. She has braved bears and bureaucrats to bring back the berries!

Kim has mentored nine graduate students, who have helped to expand our horticultural understanding of *Corylus, Humulus, Ribes, Rubus, and Vaccinium*. She has a special interest in Ribes and has characterized that collection for phenological traits and resistance to diseases, particularly white pine blister rust. Her evaluations have identified important sources of disease resistance and led to the selection and release of disease-resistant and high fruit quality gooseberry cultivars 'Jahns Prairie' and ‘Jeanne’. Her book, titled *Currants, Gooseberries, and Jostaberries:AGuide for Growers, Marketers, and Researchers in North America*, coauthored with Dan Barney in 2005, has become an essential reference for growers of these crops.

Promoting international collaborations and information exchange are some of Kim Hummer.s strengths. She organized the first ISHS international symposium for *Humulus* in 2004, brought together world experts to develop a global strategy for conserving *Fragaria* biodiversity in 2006, was a critical component of the team that convened the ISHS international *Vaccinium* symposium in 2008, and convened a large international symposium on conservation and management of genetic resources in horticulture during the International Horticultural Congress in 2010. With so many different crops at her gene bank and her boundless enthusiasm for so many different aspects of their history, genetics, systematics, adaptation, and production, her publications are as diverse as her crop collections. She has authored or coauthored more than 160 scholarly publications, 6 books or proceedings, and 12 book chapters.

Kimis frequently invited to present at international meetings as well as for community groups and is extremely successful in raising the awareness of crop genetic diversity and the need for conservation. She has been actively engaged withmanyprofessional organizations and has received international recognition for her work. She was president of the American Pomological Society (2005–2006) and served two terms as chair of the Commission on Plant Genetic Resources for the International Society of Horticultural Science (elected in 2002 and 2006). She was selected as a fellow of the American Society for Horticultural Science in 2006 and was awarded an honorary doctorate degree from the University of Sweden in 2009. Kim Hummer was recently elected to the board of International Society of Horticultural Science, where she will serve as vice president and scientific coordinator from 2010 to 2014.

Kim Hummer is married to Richard Hand, and they have four sons. A legend in the field of germplasm preservation, Kim is also a role model for women in horticulture. Her exuberance and spirit are infectious, and Kim holds the distinction of being respected by those who know her.

Joseph Postman

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Chapter 1

Frankincense, Myrrh, and Balm of Gilead: Ancient Spices of Southern Arabia and Judea

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Abstract

Ancient cultures discovered and utilized the medicinal and therapeutic values of spices and incorporated the burning of incense as part of religious and social ceremonies. Among the most

important ancient resinous spices were frankincense, derived from Boswellia spp*.,* myrrh, derived from *Commiphoras* spp., both from southern Arabia and the Horn of Africa, and balm of Gilead of Judea, derived from *Commiphora gileadensis*. The demand for these ancient spices was met by scarce and limited sources of supply. The incense trade and trade routes were developed to carry this precious cargo over long distances through many countries to the important foreign markets of Egypt, Mesopotamia, Persia, Greece, and Rome. The export of the frankincense and myrrh made Arabia extremely wealthy, so much so that Theophrastus, Strabo, and Pliny all referred to it as *Felix* (fortunate) *Arabia*. At present, this export hardly exists, and the spice trade has declined to around 1,500 tonnes, coming mainly from Somalia; both Yemen and Saudi Arabia import rather than export these frankincense and myrrh. Balm of Gilead, known also as the Judaean balsam, grew only around the Dead Sea Basin in antiquity and achieved fame by its highly reputed aroma and medical properties but has been extinct in this area for many centuries. The resin of this crop was sold, by weight, at a price twice that of gold, the highest price ever paid for an agricultural commodity. This crop was an important source of income for the many rulers of ancient Judea; the farmers' guild that produced the balm of Gilead survived over 1,000 years. Currently there is interest in a revival based on related plants of

similar origin. These three ancient spices now are under investigation for medicinal uses.

KEYWORDS: Apharsemon; *Boswellia* spp.; *Commiphora* spp.; Judaean balsam; olibanum; spice trade; traditional medicine

I. Spices and the Spice Trade

Traditionally, spices have had many important uses. Ancient cultures discovered the medicinal and therapeutic value of herbs and spices as well as their ability to enhance food flavors, and incorporated the burning of incense as part of religious and social ceremonies. Currently spices are used mainly as condiments but are also important in traditional medicine, perfumes, cosmetics, and special therapies.

Frankincense, myrrh, and balm of Gilead, three highly regarded biblical spice plants, will be emphasized in this chapter. Frankincense and myrrh were available in the biblical period only in limited parts of southern Arabia and the Horn of Africa. Due to the high demand for these spices, trade routes were developed to carry this precious burden over long distances through many countries to their foreign markets (Keay 2006). Balm of Gilead (*tzori Gilead* in Hebrew) is described in the Bible as the gift that the Queen of Sheba gave to King Solomon. In Judea, it was grown around the Dead Sea for about 1,500 years and achieved fame due to its aroma and medicinal properties. This chapter reviews these three ancient spice plants from a historical, horticultural, and pharmaceutical perspective, emphasizing the trade and routes from the Arabian Peninsula to the foreign markets in the Middle East and southern Europe.

A. Early History and Economic Importance

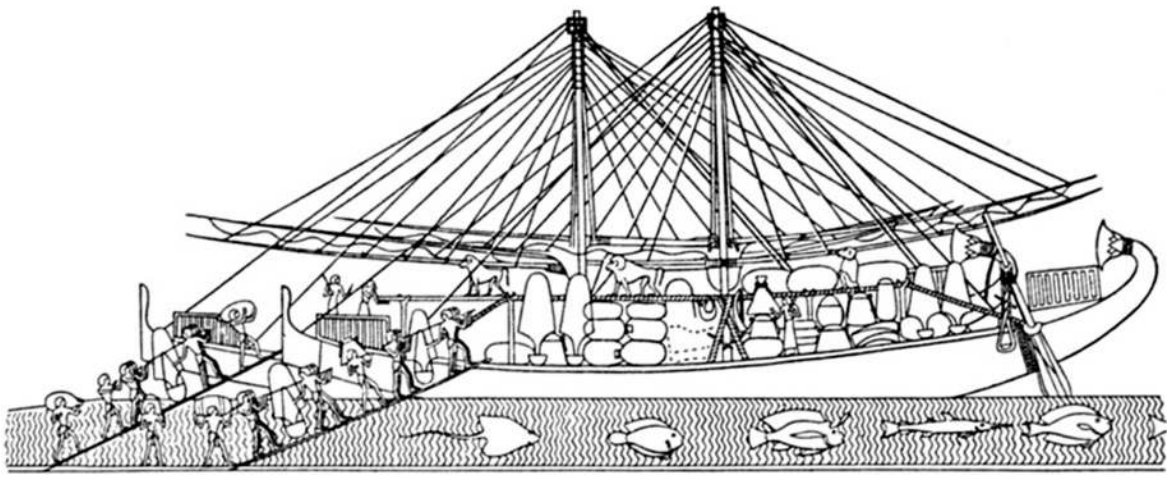
Spices and perfumes are mentioned in the records of ancient Sumer, which developed in the region of Mesopotamia around 3000 BCE. The Sumerian word for perfume is made up from the cuneiform signs representing “oil” and “sweet.” From that early period, and for millennia afterward, spices were added to natural oils to produce perfumes. The Sumerian song “The Message of Lu-dingir-ra to His Mother” refers to “a phial of ostrich shell, overflowing with perfumed oil” (Civil 1964). During the Bronze Age, the consumption of perfumes was confined to the upper and ruling classes. Perfume makers are known to have operated in Mesopotamia in the palace of Mari as early as the 18th century BCE (Bardet et al. 1984; Brun 2000). A growing body of archaeological evidence indicates that the volume of trade between Arabia and the surrounding areas accelerated during the Assyrian Empire. The increased use of drugs of herbal origin in medicine instead of employing surgery was encouraged in Mesopotamia, perhaps because the Code of Hammurabi threatened amputation if the surgeon was unsuccessful and found responsible (Rosengarten 1970). Assyrian documents record a growing interaction with the peoples of the Arabian Peninsula due to Assyrian attempts to control and capitalize on trade emanating from southern Arabia during the fifth century BCE.

Archaeological evidence of trade between southern Arabia and the Mediterranean coast has been found as early as the eighth century BCE in Tel Beer Sheva and Arad in Judea and includes the first appearance of alabaster containers and small limestone incense altars (Singer-Avitz 1996, 1999). The containers were a

preferred means of storing and transporting raw incense resins, according to the Roman writer Pliny (Bostock 1855, Book 36, Chapter 60). New archaeological findings also indicate commercial relationships between southern Arabia and Judea, along the Incense Road. Much commercial activity existed in the Beer Sheva Basin, serving this trade during the seventh century BCE. In Tel Beer Sheva, several covers used for sealing the alabaster containers were found, as well as a stone object bearing the inscription of Cohen “priest” in a South Arabian language (Zinger-Avitz 1999). At Kuntillet Ajrud, located on the Incense Road from Eilat to Gaza, Ayalon (1995) found drawings and inscriptions in two buildings and a large assemblage of Judean and Israelite tools on sites along this incense road. These were dated to the end of the ninth century BCE. Singer Avitz (1996) describes an altar, dated to the eighth century BCE, excavated at Tel Beer Sheva, decorated with a one-humped camel. This trade was greatly expanded at the end of the eighth century BCE under the Assyrian kingdom; its track was through the Edomite Mountains and the south of Judea, where security could be controlled. The Assyrians established several fortifications and commercial centers there, such as Ein Hatzeva south of the Dead Sea, Botzera near Petra, Tell el-Kheleifeh (Ezion Geber) at the northern end of the Red Sea, and other sites along the Mediterranean Sea near Gaza (Finkelstein and Silverman 2006). A broken ceramic seal (7 × 8 cm) found in Bethel with the south Arabian inscription *Chamin Hashaliach*, in south Arabian letters of that period, was estimated to date from the ninth century BCE(Van Beek and Jamme 1958). The archaeologists (Hestrin and Dayagi-Mendels 1979; Dayagi-Mendels 1989) suggested that the seal meant Chamin the messenger.

The ancient Egyptians used spices for their religious ceremonies that they purchased from the Land of Punt, long thought to be in the Horn of Africa (Kitchen 1993). At the beginning of the third millennia BCE, pharaohs went to great lengths to obtain spices, particularly myrrh, from other climes, since they were not grown locally. References to the importation of myrrh to Egypt from Punt, appear as early as the fifth dynasty ca. 2800 BCE under King Sahure and King Isesi; later there were expeditions under Mentuhotep III in 2100 BCE and under Amenenhat II and the Sesostris dynasty. Since the price of these spices was exorbitant, the Queen Pharaoh Hatshepsut organized an expedition to Punt about 1500 BCE to investigate the option of importing the spice plants into Egypt. The famous depictions (Fig. 1.1) of the expedition of Queen Hatshepsut (1473–1458 BCE) are recorded on the walls of the temple at Deir-el-Bahri (Lucas 1930; Phillips 1997). Five ships loaded with many treasures are depicted in the Temple in Thebes. One ship has 31 young trees that some scholars believed to be frankincense in tubs (Hepper 1969; Zohary 1982; Dayagi Mendels 1989). However, Groom (1981) believed them to be myrrh, as, according to his opinion, depictions of trees at that period were mainly schematic, presenting an image rather than a specific plant, and he referred also to the opinion of most previous experts that these trees were myrrh. Some scholars, however, find the trees on the Punt reliefs too conventionally drawn to be of any help in identifying them (Nielsen 1986).

Fig. 1.1. Queen Hatshepsut's expedition in 1500 BCE leaving Punt, northeast coast of Africa, with myrrh plants destined for Egypt. (Source: Singer et al. 1954.)



According to George Rawlinson (1897), the Egyptians entered the incense forests and either cut down the trees for their exuded resin or dug them up. Specimens were carried to the seashore and placed upright in tubs on the ships' decks, screened from sun by an awning. The day of transplanting in Egypt concluded with general festivity and rejoicing. Seldom is any single event of ancient history so profusely illustrated as this expedition, but there is no documentation for the growth of myrrh or frankincense in Egypt following this import. Recently, Punt has been identified as Eritrea and eastern Ethiopia, based on work of Nathaniel Domino and Gillian Leigh Moritz of the University of California, Santa Cruz, with oxygen isotope tests carried out on the fur of two ancient Egyptian mummified baboons imported by Hatshepsut and compared to baboons found in other countries. The isotope values in baboons in Somalia, Yemen, and Mozambique did not match. It was estimated that the mummified baboons dated from about 3,500 years ago, when Hatshepsut's fleet sailed to Punt and brought them back as pets (*American Scientist* 2010).

Spices, an important part of Egyptian life, were used extensively on a daily basis. The Egyptian word for myrrh, *bal*, signified a sweeping out of impurities, indicating that it was considered to have medicinal and, ultimately,

spiritual properties (Schoff 1922). Ancient Egyptians regularly scented their homes and were commanded to perfume themselves every Friday (Ziegler 1932). Idols were regularly anointed with perfumes, and incense became an important element in religious ceremonies; prayers were believed to be transported to the gods by the smoke of incense rising upward (Ziegler 1932). Every large Egyptian temple contained facilities for producing and storing perfumes (Brun 2000). The Egyptians ground the charred resin into a powder called *kohl*, which was used to make the distinctive black eyeliner seen on many females and males too in Egyptian art.

B. Spices in Ancient Israel

The most important spices used in religious ritual in ancient Israel were:

- balm of Gilead, called also Judaean balsam, Hebrew—*tzori, nataf*, or *Apharsemon* (Exodus 30:34)
- onycha, Hebrew—*tziporen* or *shchelet* (Exodus 30:34)
- galbanum, Hebrew—*chelbna* (Exodus 30:34)
- frankincense or olibnum, Hebrew—*levonah* (Exodus 30:34)
- myrrh, Hebrew—*mor* (Exodus 30:23)
- cassia, Hebrew—*kida* or *ktzeeha* (Psalms 45:8)
- spikenard, Hebrew—*shibolet nerd* (Song of Solomon 1:12)
- saffron, Hebrew—*karkom* (Song of Solomon 4:14)
- costus, Hebrew—*kosht* (Critot 6:71, Babylonian Talmud, Yoma 41:74, Jerusalem Talmud)
- calamus, Hebrew—*klufa* (Song of Solomon 4:14)
- cinnamon, Hebrew—*kinamon* (Song of Solomon 4:14)

The identification of these 11 spices was described and discussed in detail by Amar (2002) showing the existing

different versions with their exact botanical identification. These spices were an essential element in the worship of the ancient Hebrews, and incense and perfumed oils containing these spices in proportions exactly described were required in the sacred rituals stipulated in the Law of Moses. This incense, called in Hebrew *ketoret,* was burned on the altar twice a day; it originated in various parts of the world.

The interest of the ancient Israelis in the expensive spices of southern Arabia and the Horn of Africa can be established on the basis of several biblical statements:

> Isaiah 60:6: “The multitude of camels shall cover thee, the dromedaries of Midian and Ephah; all they from Sheba shall come; they shall bring gold and incense.”
>
> Jeremiah 6:20: “To what purpose cometh there to me incense from Sheba.”

From the Book of Nehemiah 3:8, it is evident that the apothecaries (*roqeah* in Hebrew) who mixed spice substances were organized into guilds similar to those known in earlier periods at Ugarit (Neufeld 1971). In the First Temple period (957–587 BCE), incense was widely used in domestic settings to provide pleasant scents in homes, as insecticides, and as protection against disease (Neufeld 1971).

C. Production Sites

1. Myrrh and Frankincense

Although Pliny states that the Romans themselves did not see the plant that produces frankincense and myrrh (Bostock Book 12, Chapter 31), descriptions by contemporary Greek and Roman historians provided information on these plants. At that time, the source of

the incense was from trees that grew wild in southern Arabia and from the kingdom of Sheba, first cited in the biblical description of the visit of the Queen of Sheba to King Solomon (I Kings 10:1–2; II Chronicles 9:1). This nation, Sheba, is in the list of the sons of Joktan (Genesis 10:26–29), and it is interesting that the name of Abraham's last wife was Ketura, meaning “incense” (Genesis 25:1). Furthermore, the names of the children of Ketura are the the names of some of the Arab tribes in Arabia: Sheba, Dedan, Midyan, and Aifa (Genesis 25:2–4). The children of Ishmael, the first son of Hagar and Abraham, were Bashmath and Mibsam (Genesis 25:13), meaning, in Hebrew, “spice” (the Hebrew word *bosem* being the root basis for these two names).

The earliest Greek accounts of the Sabaeans and other south Arabian people are of the third century bce (Groom 1981). Eratosthenes (276–194 BCE), quoted in Strabo XV 4.2 (Jones 1924), indicated that the extreme south of Arabia, opposite Ethiopia, is inhabited by four great nations: the Minaeans on the Red Sea, whose chief city was Carna; the adjacent Sabaeans, whose capital was Mariaba (biblical Mariab); the Catabanes; and, farther east, the people of Hadramut, with their city Sabota. The Catabanes produced frankincense and Hadramut myrrh, and there was a trade in these and other spices with merchants who made the journey from Aelana (Elath, on the Gulf of Akaba) to Minaea in 70 days. The Gabaeans (Pliny's Gebanitae Book 12, Chapter 32) took 49 days to go to Hadramut (Artemidorus, 100 BCE, quoted in Strabo-Jones 1924, XVI: 4:4). The Minaeans formed a political and linguistic island in the Sabaean country. Pliny states (Book 12, Chapters 30, 51) that frankincense was collected at Sabota (the capital of Hadramut) and exported only through the Gebanites, whose kings received custom dues on it (Pliny, Book 12, Chapter 32).

Strabo provides a similar account of the wealth and trade of the Sabaeans and their capital, Mariaba, adding that each tribe received the wares and passed them on to its neighbors as far as Syria and Mesopotamia (Jones 1924 –XVI: 4:19). The Sabaeans also had colonies in Africa. Abyssinia probably was settled by the Sabeans from south Arabia, as indicated by the similar language and writing. This interrelation between the Kingdom of Sheba and the Horn of Africa also contributed to the spice trade, as the plants were grown in both areas (Groom 1981).

The source of these important ancient spices was not commonly known in antiquity, and the Arabians involved preferred to keep this information secret. This led to confusion among classical writers such as Theophrastus, Artimedorus (as related by Strabo), and Diodorus Siculus (of Sicily), a first-century Greek historian, who maintained that frankincense grew in the land of the Sabaeans (Van Beek 1958). In actuality, frankincense grew in the Horn of Africa (Somaliland) and farther east in Arabia, in the region of Dhofar, Oman. The Minaeans and other peoples of the Arabian Peninsula, such as the Qedarites, the Gerrhaeans, and the Nabateans, maintained control over the inland trade routes to the Mediterranean and particularly to Egypt. The trade was never the monopoly of one people. According to Strabo: “Those tribes who live close to one another receive in continuous succession the load of spices and deliver them to their next neighbors as far as Syria and Mesopotamia” (Jones 1924, Book XVI).

Biblical citations allude to Sheban trade in incense and perfumes, gold and precious stones, ivory, ebony, and costly garments (Ezekiel 27:15, 20, 22; Job 6:19). These passages attest to the wealth and importance of Saba (Sheba) from the days of Solomon to those of Cyrus.

2. Other Spices

Evidence from Mediterranean shipwrecks shows that black pepper (*Piper nigrum*) was imported from the East in the second millennium BCE (Parker 2002). This spice, which in ancient times grew only in the tropical climates of southeast Asia, probably first reached the Mediterranean Basin by way of Persia (Crawfurd 1867).

Cassia (*Cinnamomum aromaticum*), a forest tree found throughout China, India, Sri Lanka, Malaysia, and Vietnam, was a substance considered by the Chinese to be of great antiquity, and cinnamon (*Cinnamomum verum,* syn. *C. zeylanicum*), usually derived from bark, appears in the earliest Chinese herbal, by tradition considered to have been written around 2700 BCE (Miller 1998). The word "cassia" apparently is derived from the Chinese word for cinnamon branch, *kwei-shi*, while that "cinnamon" probably derives from the Malay word *kayu mani*s, or sweet wood (Miller 1998). The word "cinnamon" made its way into the Mediterranean world, possibly through the Phoenicians, from where it was adopted by the Hebrew, Greek, and Latin languages. In spite of the superiority of cinnamon over cassia, both spices usually appear together in ancient sources. The earliest classical reference to cinnamon was recorded by the fifthcentury BCE historian Herodotus (Rawlinson 1859, Book I), and by 300 BCE both cinnamon and cassia appear to have become common commodities.

Most experts accept the cinnamon plant to be *Cinnamomum zeylanicum*, which grows in Sri Lanka and India, and was probably imported to Palestine. The Jewish scriptures describe another cinnamon spice that was grown in Jerusalem and other locations in Palestine. Several eminent Jewish sages, including Rambam, Saadia Gaon, and others, suggest that this plant, whose bark has

an aroma similar to that of cinnamon, was known as *Hood Aquilaria agallocha* (Amar 2002).

D. The Incense Road

The connection between the source of ancient spices, mainly the Arabian Peninsula and India to Mesopotamia and Europe, is known as the Incense Road (Fig. 1.2). Archaeologists placed the date of the beginning of the incense trade sometime around 1800 BCE, but it is more than likely that trade commenced earlier (Rosengarten 1970). Much evidence has been collected about the trade of myrrh from Punt to Egypt in the third millennia BCE (Kitchen 1993). At first, primitive donkey caravans transported the merchandise, but they could carry only small loads for short distances. However, around 900 BCE and possibly earlier, a significant revolution took place in this trade, when the undemanding single-humped Arabian camel (*Camelus dromedarius*) was domesticated and used for local and long-distance land transportation (Fig. 1.3). There were three phases in the course of domesticating the camel. At first, the camel served as a source for milk, wool, meat, hide, and feces for burning. Herds of camels, like sheep and cattle herds, moved along the pasture accompanied by nomads. At the end of the second millennium BCE, camels were used for riding and transportation. Regular stables came into use between 500 and 1000 BCE.

Fig. 1.2. Map of the incense trade road from the Arabian Peninsula to their international markets. (*Source*: Wysinfo Docuwebs.)