

## Lectures 12–13

# History of Agricultural and Horticultural Technology in Asia

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### Abstract

The beginnings of agriculture in eastern Asia date to Neolithic times, 7000 to 9000 years ago, with rice cultivation about 4000 BCE. Agricultural origins in the Indus valley occur about the same time. In North China and Manchuria, a civilization was established about 2000 BCE and by the Zhou dynasty, 1000 BCE, there is evidence of canals and extensive irrigation. The writings of Confucius (551–470 BCE) mention 44 food plants including horticultural crops such as peach, plum, Japanese apricot (*Prunus mume*), jujube, chestnut, mulberry, quince, Chinese cabbage, bottle gourds, and various melons. First century agricultural manuals describe intensive production of crops, pretreatment of seed, irrigated rice with circulated water, ridge cultivation, pot irrigation, crop scheduling, composting, and iron tools. Books on agriculture and horticulture are produced between 221 and 550 CE. Ornamental horticulture became embedded in the culture of China and spread throughout Asia with the development of rural retreats and urban gardens of the emperors. Flower cultivation became one of the seven arts and assumed mystic importance. Exchange of crops and technology through trade and conquests between East and West has an ancient and continuing tradition as is evidenced by silk strands on Egyptian an mummy in 1000 BCE. The biblical trade in spices involved both sea routes via India and the Mideast as well as overland routes (the Silk Road) through Persia, and it is by this route that the peach, mulberry, and citrus reached the West. European incursions in the Americas in the Age of Exploration increased direct East-West contacts and New World crops such as hot pepper, maize, sweet potato, potato, and peanut become important crops in China. Recent Asian innovations in horticultural and agricultural technology include advances in plastic culture through the development of energy saving greenhouses, grafting technology for vegetable production, and the development of hybrid rice.

### INTRODUCTION

Asia is one of the continents in which civilization first developed and where humans learned to live by cultivating plants (Fig. 12-1). In fact, more than half of the world's edible food crops originated in Asia. Despite the fact that Asian agricultural technology has and continues to have an enormous impact on the world, its agricultural history has seemed mysterious to the west and ignored.

The huge continent we call Asia is often lumped with Europe and the Mid-East as Eurasia but there is no precise demarcation to this large landmass. However, Eastern Asia, which is known to the West as the Orient is ecologically separated from the western part of the continent by formidable boundaries: deserts and massive mountain ranges. Although contact between East and West is very ancient, it was largely indirect through trade by sea via India and Arabia and overland through the Silk Road. The Western orientation of archeological research in the Mideast has resulted in a fixation in that area as the "Garden of Eden" from which all ideas originated. This may be an inaccurate reading of history.

Of the seven World Centers for the origin of crop plants delineated by the great Russian bio-geographer N.I. Vavilov, three are Asian: Center I, the Tropical South Asiatic Center which includes India and south eastern Asia; Center II, the East Asiatic Center, which includes parts of China and Japan; and Center III, the Southwestern Asiatic Center, referred to now as Central Asia (Reading 12-1). Many of the world's traditional agronomic and horticultural crops (Table 12-1) must be considered as a gift from Asia. In contrast, as a result of glaciation during the Ice Age, the northern areas of the world such as Siberia, Northern Eu-



**Fig. 12-1.** Independent origins of agriculture. Source: Smith 1995

rope, Canada, and the Continental United States contain few native species and have contributed relatively few world crops; pasture grasses, sunflower, and some small fruits such as strawberries and vacciniums (blueberry, cranberry, and lingonberry) are examples. As a consequence, Asian germplasm resources must be considered for future crop improvement. Despite the reciprocal exchange of many crops between Asia, Europe, Africa, Oceania, and the Americas that has taken place over the centuries, not all were included, opening up the possibility of new exchanges.

Table 12-1. Some important world crops originating in Asia (Janick, 2001).

Type of crop	Crop
Beverage	Tea
Cereal	Barley, oats, rice, wheat
Flower	Asiatic lily, astilbe, anemone, camelia, chrysanthemum, hollyhock, hosta, iris, peony, rose, tulip
Grain legumes	Adzuki bean, chickpea, fava bean, lentil, mungbean, rice bean, sesame, soybean, urd bean
Industrial crops	Abaca, bamboo, hemp, indigo, sugarcane
Landscape	Asian crabapple, ginkgo tree, Japanese pagoda tree, Japanese plum, Maidenhair tree, mimosa, Sargent cranberry bush
Medicinals	Ginseng, opium poppy
Nuts	Almond, candlenut & tung, coconut, pistachio, walnut
Pseudocereals	Buckwheat
Root and tuber	Carrot, radish, taro, turnip, yam
Spice	Black pepper, cinnamon, clover, ginger, mustard, nutmeg
Temperate fruit	Apple, apricot, cherry, fig, grape, orange and most citrus, peach, quince, pear, pomegranate, tangerine
Tropical fruit	Banana & plantain, carambola, breadfruit, jackfruit, lychee, mango, mangosteen, pumelo,
Vegetables	Chinese cabbage, cucumber, eggplant, garlic, onion, pea, radish, spinach

There are two theories on the origin of agriculture: a single origin with diffusion vs. multiple independent origins. The single origin plus diffusion concept is articulated in a thoughtful essay by George F. Carter (1977). However, the presently accepted dogma is that agriculture arose as independent inventions in various parts of the world at different times. There is evidence that agriculture originated in the Mideast over 10,000 years ago. Sauer (1952) has long speculated that the origin of plant domestication occurred in southeastern Asia but archeological evidence for agriculture appears later than that of the Mideast. Chester Gorman (Reed, 1977), based on evidence of crop remains in the Spirit Cave in Thailand, has pushed the evidence for agricultural beginnings as early as 10,000 to 14,000 years ago, but this is probably excessive (Charles Heiser, pers. commun.) and it is unclear if these plant remains were cultivated. There is now consensus that plant and animal domestication emerged in China at least 7000 to 9000 years ago. Of course, even with an independent origin, diffusion of information and germplasm strongly influenced agricultural development.

This chapter on the history of horticultural technology in Asia will include a brief summary of the rich history of China and India in an agricultural context. It will emphasize the exchanges of technology and crop species between East and West, an exchange that still continues with positive interactions for both cultures.

### **DYNASTIC HISTORY OF CHINESE CIVILIZATION AND TECHNOLOGY**

The rise of the ancient Chinese dynasties begins in the fertile, silt-enriched lands of the middle Yellow River basin. Political institutions beginning about 2000 BCE, revolved around the royal city with evidence of writing, bronze, harnessed carts, and divination by bones and tortoise shells. The ancient kingdoms of Xia (21–16 century BCE), Shang (16–11 century BCE), Zhou (1066–221 BCE), and warring states (Qin, Zhao, Wei, Han, Yan, Qi, Song, Chu, Lu) were eventually unified by 221 BCE in the Qin dynasty (221–207 BCE). A period of major public works by the emperor resulted in the construction of a network of roads radiating from the capital, irrigation canals, defensive walls, and gigantic palaces and tombs. The Great Wall (221–207 BCE) was constructed and later greatly expanded as protection against the warring northern tribes. During the Han dynasty (206 BCE–220 CE), Korea was annexed followed by conquest of the whole of Central Asia. Major industries included silk and iron with the expansion of trade to the West. A brief outline of China history (Encyclopedia Britannica, 1970) emphasizing technological advances is chronicled by dynasty below:

**Neolithic:** Discovery of Agriculture, bronzes; carving in stone, jade, marble, bone, and ivory.

**Zhou** (1666–221 BCE): First canals, extensive irrigation.

### **MIDDLE PERIOD**

**Qin** (221–207 BCE): First emperor; glazed pottery, roads supplement canals.

**Han** (206 BCE–220 CE): Parks and gardens of emperor; construction of Great Wall; empire exceeded Rome in size.

**Three Kingdom to Northern & Southern dynasties** (221–581): Transitional; Buddhism popular; biological control of insects in the culture of orange and litchi; books on agriculture, horticulture, and animal husbandry, 20 editions after printing in 1023–1031; tea introduced from Burma; welding of hard and soft steel, mica for lanterns, water mills, wheelbarrow, equine collar harness and stirrup in general use, value of pi calculated.

**Sui** (581–618): Extension of waterways that formed Grand Canal; Great Wall rebuilt; failure of excursions into Korea and Mongolia.

**Tang** (618–907): Reopened war with Korea, annexed in 660s; Confucianism again flourishes; required study for civil office; foreign missionaries include Nestorian Christians and Manichaeism but the religions fail to take hold; Buddhists made pilgrimages to India and Ceylon; advances in astronomy and cartography; arts include calligraphy, poetry, painting, and the famous three-colored ceramic horses and camels.

**EARLY MODERN**

**Song** (960–1279): Paper currency, planned cities, granaries, ship building; Canton had large non-Chinese settlements; silks and porcelains shipped to Japan and Egypt; advances in explosive power (fire arrows, flame throwers, bombs, grenades, proto-muskets, and cannon); experiments with moveable type; inoculation against small pox, pharmacies, astronomical clock; introduction of cotton, sorghum, green lentils (mungbean) from India, drought resistant rice from Champa; grain stored against shortages. Temujin (ca. 1155–1227) leader of Mongols in 1206 and proclaimed “Genghis Khan,” pushed into north China and takes Jin (Beijing) in 1215; annexed Jin empire, penetrates Szechwan; Grandson Kublai Khan established the Yuan dynasty beginning in 1271. Beijing becomes the capital and is rebuilt by a Muslim architect, succeeds Karakorum as principal centers of world attention. Puppet and marionette shows; restored Grand Canal extends from Hangzhou to Beijing; China fails to conquer Japan in 1274; fleets assembled for expeditions.

**Ming** (1368–1644): Treasure boats, six expeditions to South Seas, Annam, Ceylon, near East and Africa; boats armed with cannon forced payment of tribute, Prince in Sumatra and King of Ceylon seized and transported to capital. Mecca and other states acknowledge China’s might. Navy reduced by successors, merchants discouraged from going abroad; encroachment by foreigners, Portuguese enter the south in 1521; dangers of Japan’s pirates along the coast and threat by Japanese via Korea. Grand canal deepened, Great Wall repaired; era of paintings and porcelains, bookmaking, and encyclopedic works, *Yung-ki ta tie*, consists of 11,095 volumes, preservation of ancient books by reprinting, rise of academies. Roman Catholic missionaries led by Jesuit Mateo Ricci introduce Western Culture (Fig. 12-2). European encounter with the Americas brought new crops which were rapidly adopted, especially maize, sweet potato, peanut, and tobacco.

**Qing** (1644–1911): Literary compilation and suppression of critical works; decline, deterioration, and revolution; struggles against expansion of Great Britain resulting in Opium Wars (1839–1844) and 1856–1860; rebellion, many foreign pressures; Catholic and Protestant missionary activities. Chinese students sent to US in 1870 but recalled; Chinese-Japanese War 1894–1895, Boxer uprising 1900; Sun Yat Sen and Republic.

**HISTORY OF CHINESE AGRICULTURAL TECHNOLOGY**

The earliest evidence of agriculture is found in northern China from 5000 to 7000 BCE. The *P’ei-lo-kang* and related cultures occupied the loesslands, and domesticated foxtail millet (*Setaria italica*), panic millet (*Panicum miliaceum*), pigs, dogs, and chickens. The first permanent villages took root in the 5th and 4th millennium BCE on the Yellow river. Large Neolithic villages (Yang-shao culture) have been uncovered yielding pottery, hoes, polished axes, and weights for digging sticks (Fig. 12-3). Neolithic cultures flourished from Manchuria to Vietnam and large settlements began. Artifacts include beautiful painted pottery including storage jars with seed. Crops include bamboo for shoots, persimmon, grass seed, walnut, pine nut, chestnut, and mulberry.

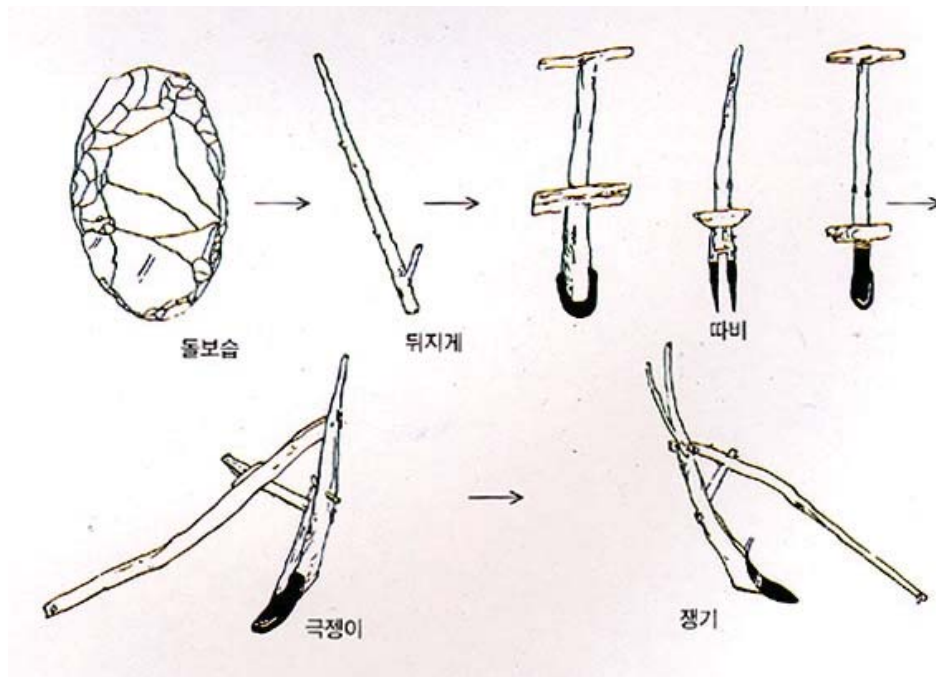
By 4000 BCE there were large farming villages; life was rich and varied. Cattle and horses appear at this time. Evidence of rice cultivation appeared in the lower Yangtze Valley. Chinese civilization was to be based on rice and millet. *Brassica* seeds were found in pots; hemp (*Cannabis sativa*) was grown as an edible seed and as a fiber plant for clothing; the anesthetic properties were known. Mulberry and silkworm culture begins, the first known domestication of insects, predating honeybee culture by thousands of years.

Agriculture spread to Manchuria by 3500 BCE. Millets predominate. Rice was farmed from Taiwan to central India before 2500 BCE. The water buffalo was domesticated by 1400 BCE. Melons, sesame, broad bean (*Vicia faba*) are cultivated. Wheat and barley are introduced from Afghanistan.

The Chinese developed a legendary history, somewhat analogous to the legendary chronicles of the Hebrew Bible in Genesis. Thus, the founder of Chinese agriculture and medical botany is the mythical emperor Shen-Nung (traditional dates, 2737–2697 BCE) (Fig. 12-4). Cited in the first millennium he is known as the “Divine Cultivator” of the five grains, inventor of the plow, soil tests for suitable crops, and the originator



**Fig. 12-2.** Christianity reached China through the Jesuits, who were sufficiently diplomatic to conform to Chinese manners in dress and behavior and to recognize the values of Confucianism. The three figures above are the resourceful Jesuit pioneer Matteo Ricci, with Adam Schall and Ferdinand Verbiest, both of whom aided the emperor with their astronomical knowledge and talents for diplomacy. Schall wears the mandarin's White Crane plaque on his chest. At the bottom is Ricci's most famous convert, Hsu Kuang-ch'i. Hsu, who took the name of Paul at baptism and, like Ricci, saw no inconsistency between Christianity and Confucian observances, is pictured with his granddaughter. Source: Toynbee 1993.



**Fig. 12-3.** Development of agricultural implements.

of ceremonials associated with sowing vegetables and grains. He is considered to be the “author” of the renowned pharmacopoeia, *Pen T'sao Ching (The Classic Herbal)*, compiled in the 1st century.

### Traditional Agricultural Technology

By the 6th century BCE, row cropping was developed. A treatise in the 3rd century BCE (*Master Lu's Spring and Autumns Annals*) explains: *If the crops are grown in rows they will mature rapidly because they will not interfere with each other's growth. The horizontal rows must be well drawn, the vertical rows made with skill, for if the lines are straight the wind will pass gently through.*

Cast iron hoes were available in the 6th or 5th century BCE. The greatest invention during this period was the iron plow (ard) with a shallow plowshare that produced a narrow furrow. The introduction of this plow had a great influence on the agriculture of the West but the curved moldboard used in China was not adopted in Europe until the 18th century.

K'ung Fu Tzu (Latinized as Confucius—Tsu means “master”) (Fig. 12-5) lived from 551–470 BCE, and considered the author of *Books of History*, *Book of Changes (I Ching)*, and *Book of Songs*. The latter book includes 300 traditional songs of the Zhou Dynasty (1066–221 BCE) with hundreds of references to food, providing an agricultural picture of the age. Mention is made of clearing artemisia (mugwort, wormwood, sagebrush), thistles, and weeds. Fiber crops were silk, hemp, and kudzu; the staple food was millet. *Book of Songs* mentions 44 food plants (as compared to the Bible which names 29). These include:

**Grains:** millets (*Panicum* and *Setaria*), barley, rice.

**Vegetables:** kudzu (*Pueraria lobata*), hemp (*Cannabis sativa*), Chinese cabbage (*Brassica* sp.), Chinese chives (*Allium tuberosum*), daylily (*Hemerocallis flava*), bottle gourd (*Lagenaria*), melon (*Cucumis*



**Fig. 12-4.** The legendary emperor Shen-Nung was given a date equivalent to 2737-2697 BCE.



**Fig. 12-5.** K'ung Fu Tze (Confucius) 551-470 BCE. The *Book of songs* mentions 44 food plants (Bible mentions 29)

*melo*), soybean (*Glycine max*), lotus (*Nelumbo*), yarrow (*Achillea siberica*), mugwort (*Artemisia*), motherwort (*Leonurus*), mallow (*Malva verticillata*), huanlan (*Metaplexis stauntoni*), plantain (*Plantago major*), poke (*Phytolacca acinosa*), huo (*Rhynchosia*), cocklebur (*Xanthium strumarium*), sweet flag (*Acorus gramineus*), water plantain (*Alisma plantageo*), water fern (*Marsilea quadrifolia*), elm (*Ulmus*), and bamboo (*Bambusa*).

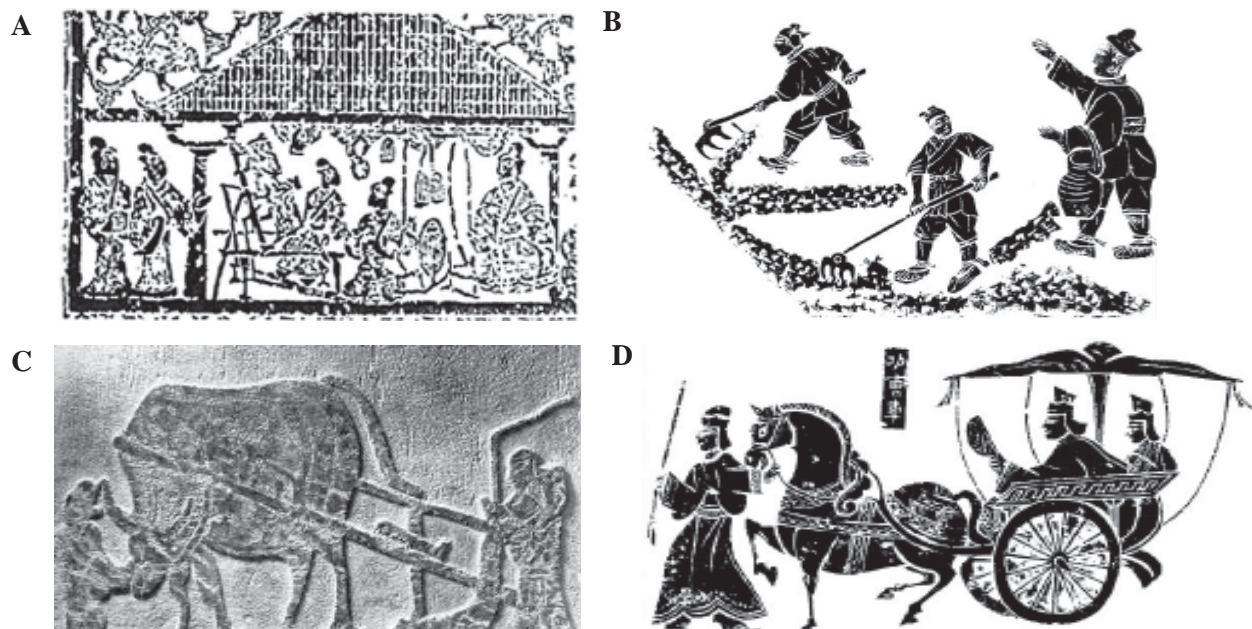
**Fruits and Nuts:** peach (*Prunus persica*), pear (*Pyrus* spp.), plum (*P. salicina*), Japanese apricot (*P. mume*), Chinese jujube (*Ziziphus jujuba* and *Z. spinosa*), raisin tree (*Hovenia dulcis*), Chinese chestnut (*Castanea mollissima*), white mulberry (*Morus alba*), oak (*Quercus*), pine (*Pinus*), brown pepper (*Zanthoxylum piperitum*), and quince (*Chaenomeles japonica*).

In the 4th and 3rd centuries BCE the Chinese developed the trace harness in which the weight of a load is borne by the horse's chest and collar bones. The throat-and-girth harness used in the West was inefficient because it choked the horse. The trace harness arrived in Europe by way of Central Asia in 568 CE and rapidly spread throughout Europe. Between the 4th and 1st century BCE, the collar was invented in China, which greatly increased the traction power of the horse.

From 3rd to 2nd century BCE there is increasing complexity in culture. A machine to winnow grain was invented in the 2nd century BCE. The separation of chaff and grain was controlled by a machine where air movement was generated by a fan. Various types of wheelbarrows, unknown in the West until the 11th or 12th centuries appear in China in the 1st century BCE. At this time, seed was sown by hand along ridges with extensive hoeing to destroy weeds and create a soil mulch to conserve moisture. A multi-tube seed drill dates to this period.

### Han Dynasty (206 BCE–220 CE)

In the 1st century, Fan Sheng-chih's *Agricultural Manual* describes intensive production (Fig. 12-6). This includes multiple cropping, (winter wheat or barley followed by millet); pretreatment of seed (steeped in fertilizer made from cooked bones, manure, or silk worm debris, to which aconite or other plant poisons added); irrigation of rice, water trapping for dry land fields in the north; cultivation in pots and pot irrigation; ridge cultivation; scheduling of fertilization, watering and planting; organic matter recycling; soil adaptability to crops; and iron tools.



**Fig. 12-6.** Ancient Chinese technology is depicted in the Han dynasty. A. Silk industry; B. Hoeing with iron tools in rows; C. Plowing with water buffalo; D. Trace Harness.

Han crops and foods mentioned include wheat, barley, glutinous and spiked millets, soybeans, rice, hemp, and *Vigna*; also gourds, taro, mulberries, *Artemisia*, melons, scallions, perilla, sesame, and elm (leaves and seeds eaten), mustard greens (Chinese cabbage), mallow (*Malva* sp.), leeks, onions, water peppers (an aquatic green similar to watercress), and unidentified herbs. Other Han foods include lotus, longan, litchi, cinnamon, fagara or Chinese pepper (*Zanthoxylum*), magnolia buds, peonies, rush shoots, galangal, daylilies, true oranges, grape, chestnuts, water caltrop (*Trapa bicornis*), bamboo shoots, sugarcane, honey, assorted wild herbs and wild ginger. Small beans appear to be adzuki bean or red bean (*Vigna angularis*).

By the late Han, pickling and salting were key techniques. Fermentation of soybean to produce milk and cheese-like products, and grain to produce ale was perfected. Noodle technology was developed. During Han and throughout Chinese history the boundary between medicinals and food was vague. Chinese medicine took a modern shape; from magic and conjuring it developed into a rational scientific logical system in which nutrition played a key role.

Peasant agriculture was based on small, walled communities with contiguous fields. Ploughs were made of wood, stone, and then iron but the basic tool was the hoe. Soil was amended with natural fertilizer including “night soil.” Irrigation was provided by canals, water lifting with *shaduf* made of bamboo.

Cereals were chiefly rice and millet with some wheat and barley. The major beverage was tea, first used as a medicinal, but a ubiquitous beverage by the Tang dynasty, a habit to be adapted in Europe in the 17th century. Vegetables were widely consumed including soybean and its sprouts, garlic, onion, many crucifers, and berries and fruits including peach, and pear (Asian types).

Many but not all Asian fruits became a major part of Western horticulture. Animal protein was based on fowl, chicken and especially duck, pork, and fish. The soybean was adapted to produce milk and cheese-like products from fermentation.

Cooking was to be developed into an art form. Delicacies included grasses, seaweed, sharks fins, birds’ nests, grasshoppers, grubs, silkworms, horses, mules, rats, watersnakes, cats, and dogs, but the sustaining food for the masses was rice (Fig. 12-7), millet, and vegetables. Exploding populations and limited land resulted in famines. A combination of avaricious landlords and aggressive warlords led to turmoil and revolution.

### Medieval to Early Modern China

The agricultural development of China after the Han period was influenced by the influx of new crops from Central Asia and India such as tea, first used as a medicinal, but by Tang a ubiquitous beverage to be widely adopted in Europe in the 17th century. Intoxicating beverages such as beer and hallucinogenic drugs became widespread; dairy products such as yogurt and cheese were introduced from Central Asia. By the Tang dynasty (618–906), the Golden Age, crops such as spinach, sugar beet, lettuce, almond and fig entered China from Central Asia and the Mideast while palm sugar (jaggery), date, yam (*Dioscorea*), new types of rice, taro, myrobalan plum, citrus, cassia, banana, *Canarium* and litchi entered from the South. Distillation, a Chinese invention, appeared and is spread to Europe by Arab cultures. In the Song dynasty (960–1269) food production became rational and scientific. The great Chinese cuisine developed during this period. New crop cultivars were introduced including short season rice (Champa) and green lentils (mungbean) from India. Watermelons and sorghum became mainstays of North China’s dry landscape. Cotton from Central Asia was widely grown and used. Sugarcane grew in importance. Intensification of agriculture led to ecological problems that contributed to deforestation and erosion.

At the end of the Ming dynasty (1368–1644), New World crops became well known throughout China; maize, sweet potato, potato, tomato, peanut profoundly affected Chinese agriculture. China’s food stabilized by the end of the Ming dynasty, rice made up approximately 70% of grain cultivated, wheat and millet the remainder.

By the Qing period (1644–1912), intensive agriculture produced food in surplus. Root crops such as sweet potato and potato became increasingly abundant. Maize and tomato cultivation increased. Specialty cropping increased and China became fertile ground for plant hunters such as Robert Fortune (1847, 1857), Frank King (1911), and Frank Meyer (1911). Indigenous Chinese species, particularly ornamentals such as





**Fig. 12-7.** Water has been the source of life throughout China's history. But China's rivers are treacherous, subject to flooding and catastrophic changes of course in which millions have perished. The rice plant, having been raised from seed, is transplanted in ground flooded to a depth of 2-4 inches. (A) and harvested by hand, penicily by penicily (B). Source: Toynbee 1973

the tea rose, but also food species such as *Actinidia* (*yantao*, renamed Chinese gooseberry and later kiwifruit) and Asian plums enter the West.

The Chinese system of organic production, once derided for its dependence on "human night soil," was to have an important influence on present day Western agriculture. The key to the system was recycling of all nutrients. Everything organic including bones, leather, manure, straw was recycled. As population continued to increase, lack of innovation resulted in the stagnation of agriculture technology. Famines produced in times of bad weather were exacerbated by erosion and deforestation. Despite the fact that yields were higher than in the West, much of the population lived on the edge of starvation.

### Ornamental Horticulture

Horticulture became embedded in the culture of China through the establishment of rural retreats and urban gardens. Cultivating flowers was considered one of the seven arts and assumed mystic importance. The peach blossom became the emblem of spring, the lotus of summer, chrysanthemum of autumn, and the narcissus of winter. Plum blossoms symbolized beauty and bamboo stood for long life. Lotus and peony were especially prized. By the 11th century, there were 39 cultivars of tree peony and 35 cultivars of chrysanthemum.

China established the tradition of naturalism in garden architecture. Unlike the ancient Egyptians, who developed formal gardens based on invented landscapes, the Chinese had beautiful landscapes for inspiration (Fig. 12-8). Lien-Tschen, an ancient writer, set forth the Chinese philosophy regarding naturalism in gardens: *The art of laying gardens consists in an endeavor to combine cheerfulness of aspect, luxuriance of growth, shade, solitude and repose in such a manner that the senses may be deluded by an imitation of rural nature. Diversity, which is the main advantage of natural landscape, must therefore be sought by a judicious choice of soil, an alternation of chains of hills and valleys, gorges, brooks and lakes covered with water plants. Symmetry is wearisome, and ennui and disgust will soon be excited in a garden where every part betrays constraint and artificiality* (Wright, 1938, p. 137).

Japanese gardens arose from Chinese culture via Korea but developed into an abstract art form to become one of the fine arts. Traditional Chinese elements were used but organized in a new form involving symbolism with great use of stone and sand (often raked into patterns), and the development of schools of tradition. There was a creative use of water and rocks, love of aged and gnarled trees, and new uses of non-traditional plants such as mosses. In the 10th century, landscape gardens were influenced by Zen, a religious and philosophical movement. High development of garden art include the famous Ryoanji temple, *ikebana* (flower arrangement based on symbolic use of flowers), *sakai* (miniature landscapes), and *bonsai* (miniature tree specimens).

## INDIAN SUBCONTINENT

### Historical

The origin of the subcontinent is based on an ancient collision of a landmass with Asia to produce the Himalayas, a natural boundary between China and India. The name *India* (a Greek word) derives from the Sanscrit *Sindhu* (Persian *Hindu*), and refer to the 1000 mile river that bisects this enormous, populous, polyglot subcontinent. The climate varies from the wet monsoons to deserts, from the snows of the Himalayas to the hot jungles of the south.

India is not now, and never was, a single nation. Some of the original invaders were called Aryans or plowers, who derive from peoples from the shores of the Caspian Sea, whose western branch populated Europe. Local populations are called Dravidian. India enters Western consciousness after Alexander's invasion of Western India (327–325 BCE).

Early polytheistic religious beliefs (*Veda*) developed into Hinduism, incorporating many gods with a personal relation between the devout and the divinity. Buddhism, founded by Gautama Siddhartha (563–483 BCE), an offshoot of Hinduism, would spread to central and eastern Asia where it became a dominant religion. Society developed in a hereditary caste system: *Brahman* (religious specialists), *Ksatriya*, (warriors and political leaders), *Vaisy* (farmers, craftsmen, and merchants) and *Sudra* (servants to the other three); the system still persists despite modern attempts to eradicate it.



**Fig. 12-8.** In *Dreaming of Immortality in a Thatched Cottage*, 16th century, a sage, asleep at a table sees himself as an immortal floating over the landscape.

India was greatly influenced by two incursions from the 7th to the 13th centuries. The eastern sweep of Islamic warriors which started a few centuries after the Arabian prophet Mohammed (570?–632) and the invasions of the Mongols (Moguls), part of the conquests of Genghis Khan (ca. 1115–1227). The two incursions were to coalesce when Timur Lenk (Tamerlane), a Mongol invader, adopted Islam and raided Delhi in 1398.

As a result of Islamic incursions, the Indian subcontinent was split into a series of Muslim and Hindu kingdoms and principalities that existed in relative prosperity. These were essentially plucked by Britain in the 19th century through colonial domination. British India was divided between the Muslims (Pakistan and the noncontiguous East Pakistan) and the Hindus (India). The countries of the subcontinent now consist (from West to East) of Afghanistan, Pakistan, India, and Bangladesh (formerly East Pakistan) with Nepal and Bhutan nestled in the Himalayas.

### Indian Agriculture

The Indus Valley is considered one of the areas in which agriculture was discovered (Fig. 12-9). Agricultural beginnings appear in the 6th millennium BCE. The remains of ancient cities rivaling those of Sumer, Babylonia, and Egypt are found in two sites, Mohaenjo-dao and Harappa that date about 3000 BCE. They include pottery, dice, chessmen, coins, seals that bear undecipherable inscriptions, carvings, weapons, implements, and ornaments, and a huge granary on a brick base with an air-drying system. Tools were made of stone, copper, and bronze. The original peoples of southern India were agriculturists who tilled the soil, raised crops of barley, wheat (rice was a later introduction), and cotton and domesticated horned animals, poultry, and probably elephants. The later Hindu prohibitions against meat suggest a scarcity probably due to an increase in population. Hindu prohibitions against meat have left much of the Indian subcontinent vegetarian but dairy products are used.

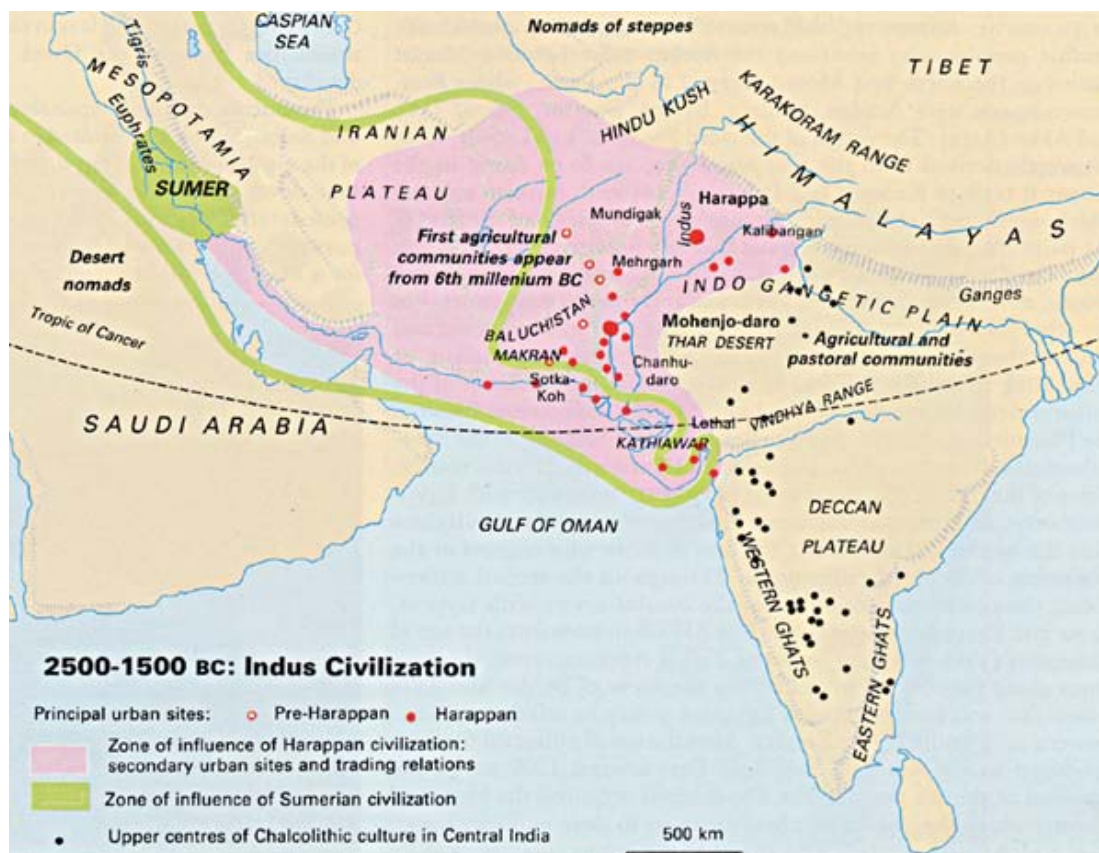


Fig. 12-9. Origins of agriculture in the Indus Valley. Source: Harper Atlas of World History.

From these beginnings, cultivation in India extended to rice, pulses, millet, vegetables, and fruits. Dams for irrigation were constructed as early the 1st century. An Indian cuisine developed that is rich in spices such as curry, ginger, cloves, and cinnamon, culinary treasures sought by the Europeans. One of the early crops was cotton, known to the ancients as tree-grown wool. Many of our names for fabrics are derived from India (*muslin* derives from cotton weavers of Mosul, *calico*, from Calicut). The rugs of India are still prized. Trade in Indian goods was extremely vital in the ancient world; Indian cheetahs, tigers, elephants assisted in the bloody Roman gladiatorial games. The wealth of India became legendary, reaching its zenith in the 14th century.

India made contributions to medicine. Two systems were developed, one based on Hinduism (*Ayurveda*) and the other Moslem (*Unani*). In the *Ayurveda* system, drugs are mainly from plant origin (herbal medicine), while the *Unani* system, developed later, also incorporates drugs derived from animals.

### CONTACTS BETWEEN EAST AND WEST

Contacts between East and West have a continuous but sporadic history. Exchange of populations appears to have marked the prehistoric period; in fact the original incursion of Cro-Magnon humans into Europe derive from Asia. Subsequently contacts between East and West have been of two types, a relatively peaceful one generated by trade and an aggressive one impelled by confrontation and conquest.

Trade between Asia and the Near East is very ancient. Evidence of silk strands in an Egyptian mummy in the 10th century BCE suggests very early exchanges of goods between China and Egypt probably from overland routes that included Persia (Fig. 12-10). We know of the ancient spice trade between the Far East and Egypt from the biblical story of Joseph in Genesis and repeated allusion to spices such as cinnamon and cassia. These valuable spices, which originated in the Maluccas or Spice Islands (presently part of Indonesia) reached the Near East overland or by sea via India.

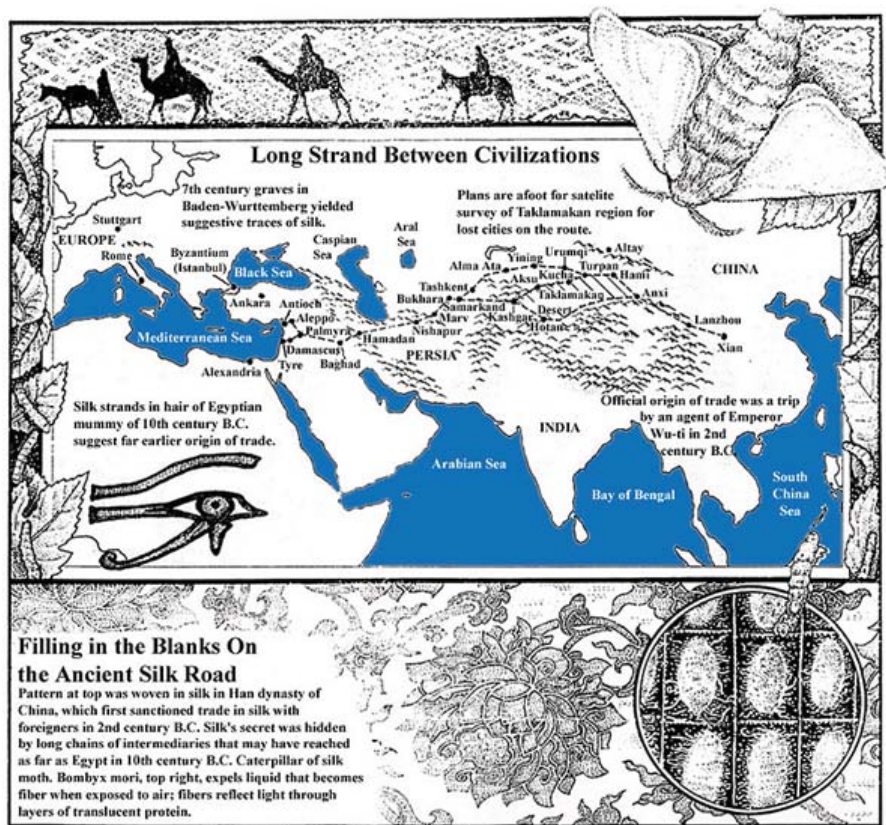


Fig. 12-10. Ancient trade routes from East to West.



Strands of silk on Egyptian mummy hair 1000 BCE.



Empress Hsi Ling-shi.

In the 4th century BCE, the armies of Alexander (Fig. 12-11) conquered Persia and extended through Turkistan, Afghanistan, Pakistan, and northwestern Indian including the Indus Valley (Fig. 12-12). Greek settlements and commercial posts were founded between the Mediterranean and India along the western section of the trade routes, which became known as the Silk Road. Alexander's campaign led to increased botanical knowledge concerning herbs and spices. With the conquest of Egypt, the new city of Alexandria became the most important trading center between the Mediterranean and Indian Ocean and the Gateway to the East.

The Silk Road was undoubtedly the route of Asian crops such as citrus and peach to the West. In fact, the peach, domesticated in China 3300–2500 BCE (Faust 1995), is so named because it sojourned in Persia on the way and mistakenly thought to have originated there (Fig. 12-13). It was imported to Rome during the 2nd century BCE.

China sanctioned official trade in silk with foreigners in the 2nd century BCE. An embassy, sent by the Roman Emperor Marcus Aurelius in 166 CE returned from China with a gift of Chinese dwarfs for the Roman emperor and, perhaps, it is no coincidence that dwarf statuary long remain popular as garden art. Continued contacts were made. Monks in the 6th century are reported to have brought back mulberry leaves and caterpillars to introduce the silk industry to the West. Sugarcane drifted to the West via the Arabs, an exchange that was to have an enormous effect on the history of the New World by the development of the plantation system based on African slaves.

The aggressive mounted tribes of Central Asia (deprecated as barbarians by the Greeks), consisting of Turks, Mongols, and Tibetans, became a dominant power as they moved west, eventually conquering the vast area of the Greco-Roman World. Unstable empires of the steppes eventually reunited under Temujin (ca. 1155 to 1227) who took the name Genghis Khan in 1206 (Fig. 12-14). The Conqueror of the World formed a Mongol empire, stretching from the Pacific to the Black Sea, from Northern China to the Siberian Taiga, the Volga Plain and Persia and marched to the gates of Vienna before being halted in 1241 (Fig. 12-15). Mongol invasion into India was a decisive turning point in the subcontinent.

The Venetian Marco Polo visited the court of Kublai Khan (1271–1295), grandson of Genghis Khan, and returned home with fabulous stories, considered imaginative fancies but later shown to be accurate. He reported the deer park of the summer residence of the Great Khan at Xanadu, the palace at Kambalu, and the Green Hill, constructed from residue of an artificial lake, and containing a collection of trees planted in a naturalistic manner, the first arboretum, as well as orchards, hunting parks, and fishponds.



Fig. 12-11. Alexander

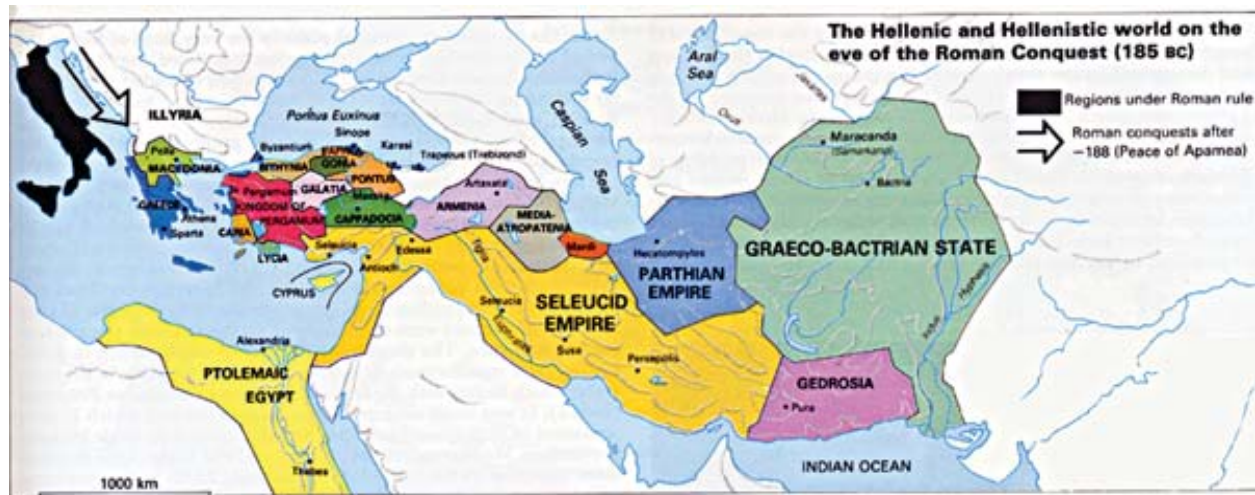


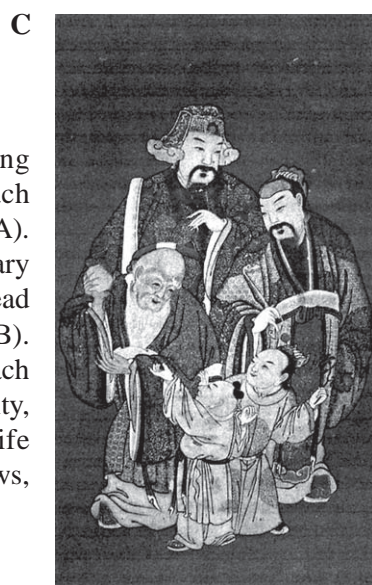
Fig. 12-12. The conquests of Alexander. Source: Harper Atlas of World History

In the 1400s, China had expansionist interests. The Chinese Admiral Cheng Ho (a Muslim eunuch!) conducted seven expeditions (1405–1433) for diplomatic as well as commercial interest, exploring the China Sea, Southeast Asia, India, and Africa! Giraffes were brought back to the Emperor. Ho almost succeeded in rounding the Cape at the same time the Portuguese were going in the reverse direction. However, fearful of conquest from the North, the Emperor pulled back, destroyed the fleet, and the Chinese withdrew to their own borders leaving the vigor of exploration to the West.

The movement of crops was not one way. During the Age of Exploration in the 16th century colonial excursions of the West on the East was pursued by Portugal which established trading centers in India as a result of the voyage of Vasco da Gama (1429–1624). The contact of Portugal with Japan was also established in the middle of the 16th centuries. (*Arigato*, the Japanese term for “goodbye,” derives from the Portuguese “*obrigado*,” or “obliged”; *tempura*, a Japanese dish based on deep-fat frying, is clearly a Portuguese introduction.) Spanish and Portuguese introduced New World crops, which spread rapidly, mostly from Manila. Sweet potato introduced in the latter half of the 16th century was the most important introduction and was well known by 1594 as *camotl*, the Aztec name, or by Chinese names such as *calle chin-shu* (golden tuber), *pai-shu* (white tuber), *fan-shu* (barbarian tuber), or *kan-shu* (sweet tuber). Peanut is first mentioned about

1538; maize in 1555. Other New World crops included tobacco and various crops prefixed by the word *fan* (southern barbarian or foreign devil) including tomato (*fan eggplant*), guava (*fan pomegranate*), papaya (*fan quince*), dicama and yam bean (*fan kudzu*). Encounters between East and West is summarized in Fig. 12-16.

In the 19th and 20th centuries encounters between East and West had profound consequences for the political shape of the world. Western incursions into China for trade advantages initiated direct conflicts such as the infamous Opium wars when England insisted on trading Indian opium instead of English



**Fig. 12-13.** Picture of Dongfang Shuo, the person stealing a peach branch from the tree of longevity (A). Painting of Zhong Kui a legendary character. The peach above the head of Zhong Kui signifies long life (B). Portrait of the “Three Stars” peach in the hand of the God of Longevity, Shouhsing also signifies long life (C). source: Horticultural Reviews, Volume 17



**Fig. 12-14.** Genghis Khan.

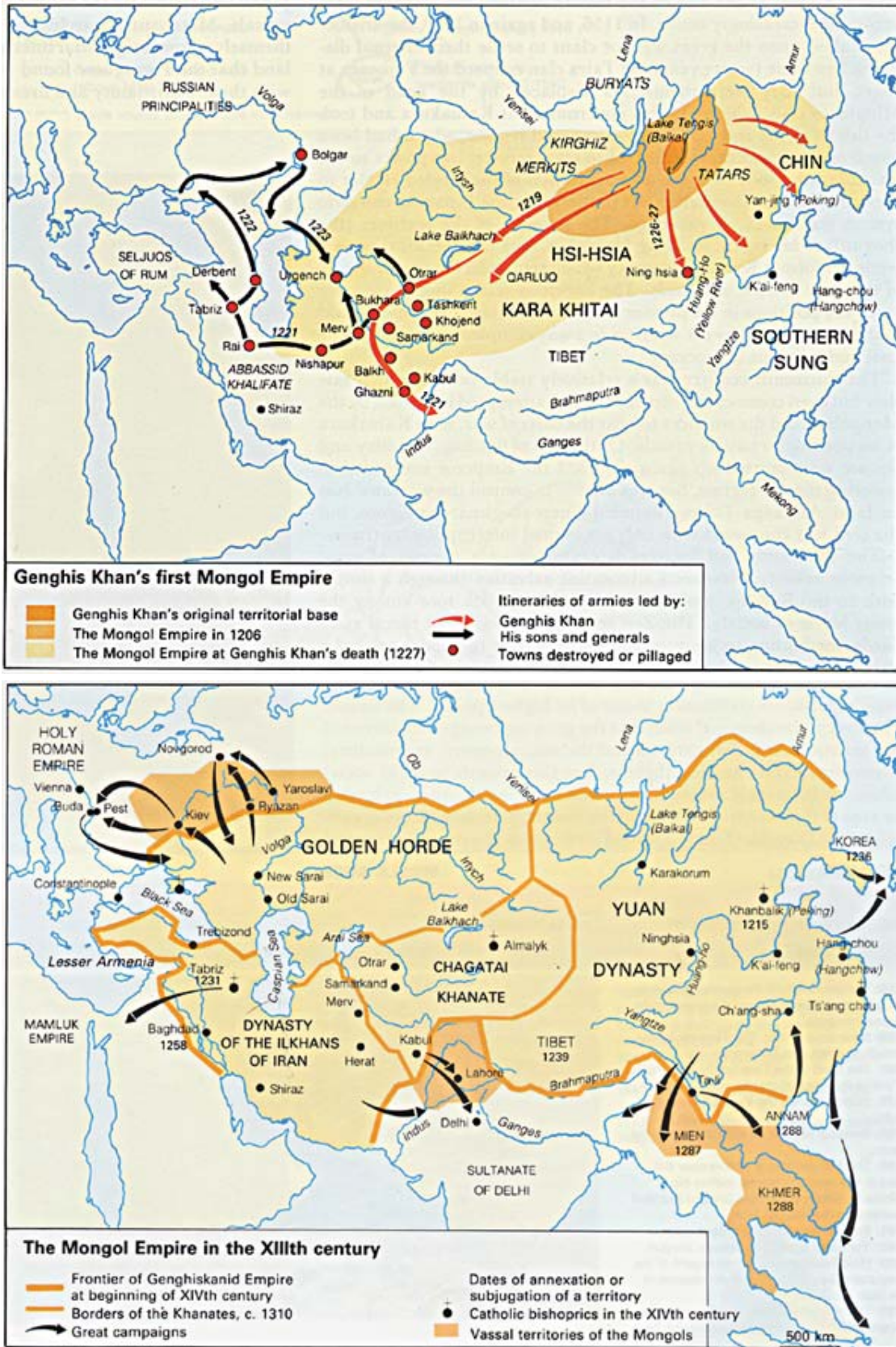


Fig. 12-15. The Mongol Empire of Genghis Khan. Source: Harper Atlas of World History



Fig. 12-16. Encounters between China and the West. Source: Harper Atlas of World History

gold for tea. Missionary activity in China, very strong at the end of the 19th and early 20th century, was considered by the Chinese as an extension of confrontation between East and West. The Russo-Japanese war in the early part of the 20th century made the world aware of the emerging power of Japan, World War II pitted the US as an ally with China against Japan but this alliance split and the Korean and Vietnam conflicts were tragic for all parties. Throughout the centuries there has been a continuous exchange of plant material, germplasm, and agricultural information.

### MODERN AGRICULTURAL TECHNOLOGY

Globalization has greatly affected innovation in horticultural technology. In the last half of the 20th century, Asian agriculture has incorporated Western innovations responsible for the mechanical, chemical, and biological revolutions that have characterized modern agriculture. This involves the widespread use of fertilizers, pesticides use of tractors, protected horticulture, and advances in genetic improvement. Recently, Asian agricultural scientists and technologists have been involved in three outstanding achievements that are indicative of the progress that can be expected in the future: energy-saving plastic greenhouses (Jiang et al., 2004), vegetable grafting (Lee and Oda, and hybrid rice (Li and Yuan, 2000).

#### Energy-saving Greenhouses

Protected horticulture has a long history in China as it does in the West. In the Han dynasty China grew alliums in heated structures in the winter and in the Tang dynasty natural hot springs were used for vegetable forcing. In the Song dynasty, simple greenhouses were made using translucent oiled paper as covers to grow vegetables and flowers. During the 19th century, glasshouses were imported but these proved to be too expensive in terms of capitalization costs and heating, except for high-priced ornamentals produced in a few large cities.



The development of plastic covers in the 1950s in the United States was the technological breakthrough that made protected horticulture suitable for China. The plastic greenhouse industry grew rapidly in the 1980s, and China is now the leading country for protected horticulture (Table 12-2) including multi-span greenhouses, plastic tunnels, and a specially devised energy efficient lean-to greenhouse (Jiang et al., 2004). This latter structure (Fig. 12-17) was developed in Liaoning province of northeast China and adapted for vegetable production without heating. This greenhouse is now found in all of north China from 33° to 47° on over 200,000 ha. The greenhouse (300 to 800 m<sup>2</sup>) is essentially a half Quonset in which the north back wall and sidewalls are heat absorbers composed of brick and thermal materials. Curvature of the ribs is designed for maximum light penetration in the winter. In winter afternoons, when the air temperature inside the greenhouse falls below 17° to 18°C, an insulating mat is rolled down the plastic cover to prevent heat loss. This greenhouse, without supplemental heating can grow vegetables under conditions when outside temperatures dip to -20° to -10°C since the continental climate of China from 33° to 47° receives high winter solar radiation.

### Vegetable Grafting

Grafting of herbaceous vegetable crops was described in the 5th century in China. In the 17th century in Korea, a technique to obtain large gourds is described by approach grafting four root systems to a single shoot. The bottle gourd (*Lagenaria siceraria*) was used as a rootstock for watermelon in the 1920s to overcome yield decline from soil-borne diseases associated with successive cropping. The development of plastic films in the 1960s led to widespread production of grafted vegetables in Japan and Korea of solanums (tomato, eggplant, and pepper), cucurbits (watermelon, melons, and cucumber), and ornamental cactus (Table 12-3). The choice of appropriate rootstock permits resistance to soil-borne diseases, promotion of scion vigor and yield, and incorporation of stress tolerance. Skilled workers can graft 800 to 1200 seedlings per Table 2. Protected area in China (Jiang et al., 2004).

Year	Greenhouse area (ha)					Total
	High tunnel	Low tunnel	Heated	Solar lean-to	Energy-saving solar lean-to	
1981	1,253	4,940	300	706	—	9,180
1985	11,766	46,473	2,296	6,760	420	69,700
1990	30,273	98,213	3,800	18,380	8,286	160,942
1995	186,620	333,893	4,793	69,413	104,413	701,127
1997	190,580	424,160	6,806	78,200	141,340	843,083
1999	459,773	568,586	14,660	152,293	200,000	1,397,311

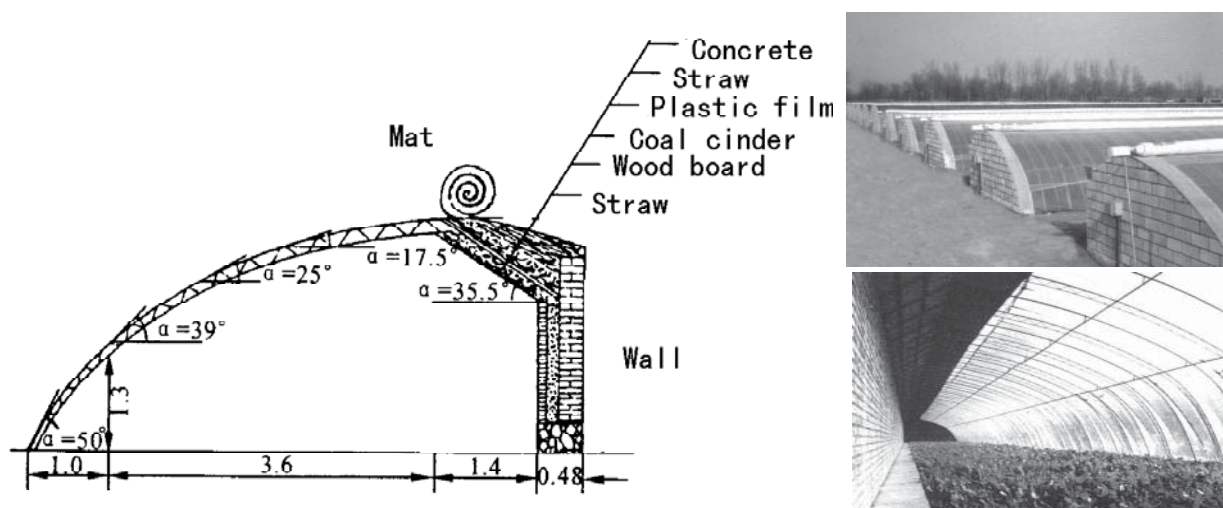


Fig. 12-17. Energy-efficient greenhouses developed in China (Jiang et al., 2004).

day, but robots and grafting machines have been developed in Japan and Korea that can successfully make 400 to 1200 grafts per hour (Fig. 12-18). Graft technology of vegetables seedlings now has been adopted in Europe.

### Hybrid Rice

Plant breeding technology has been enthusiastically adopted in Japan, China, and Korea. A number of unique advances were achieved including seedless watermelon developed by Hitoshi Kihara in Japan (1951), anther-culture technology to produce inbreds from doubled haploids and the development of hybrid rice by Longping Yuan (Fig. 12-19) in China (Li and Yuan, 2000). Hybrid rice represents an extraordinary achievement since wisdom had considered the incorporation of heterosis impractical in self-pollinated crops. It was successfully developed and released after the discovery of male-sterile cytoplasm at Hainan Island in 1970. The three-line system uses a male sterile or A line, a maintainer or B line, and a restorer or R line. The first hybrid rice combinations were put into commercial production in China in 1976. The area under hybrid rice increased from 2.1 million ha in 1977 to 15.3 million ha in 1997 with a yield advantage of 20–30%

Table 3. Cultivation area of some vegetables in Japan and Korea, 2000) including percentage of grafted plants (Lee and Oda, 2003).

Crop	Japan				Korea			
	Field + Tunnel		Greenhouse		Field + Tunnel		Greenhouse	
	Area	Grafted	Area	Grafted	Area	Grafted	Area	Grafted
Watermelon	14,017	92	3,683	98	13,200	90	1,299	98
Cucumber	10,160	55	5,440	96	1,728	42	5,964	95
Melons <sup>z</sup>	6,142	0	8,258	42	1,047	83	9,365	95
Tomato	6,459	8	7,141	48	258	0	4,752	5
Eggplant	11,815	43	1,785	94	650	0	413	2
Pepper <sup>y</sup>	2,684	- <sup>x</sup>	1,468	-	75,574	0	5,085	5

<sup>z</sup>Include field and greenhouse melons in Japan and melons and oriental melons in Korea.

<sup>y</sup>Mostly sweet peppers in Japan and green hot peppers in Korea.

<sup>x</sup>Data not available.



**Fig. 12-18.** Grafting vegetables. A. Manual grafting in Korea. B and C. Korean and Japanese machines developed for grafting (Lee and Oda, 2003).



Fig. 12-19. Lingping Yuan, father of hybrid rice.

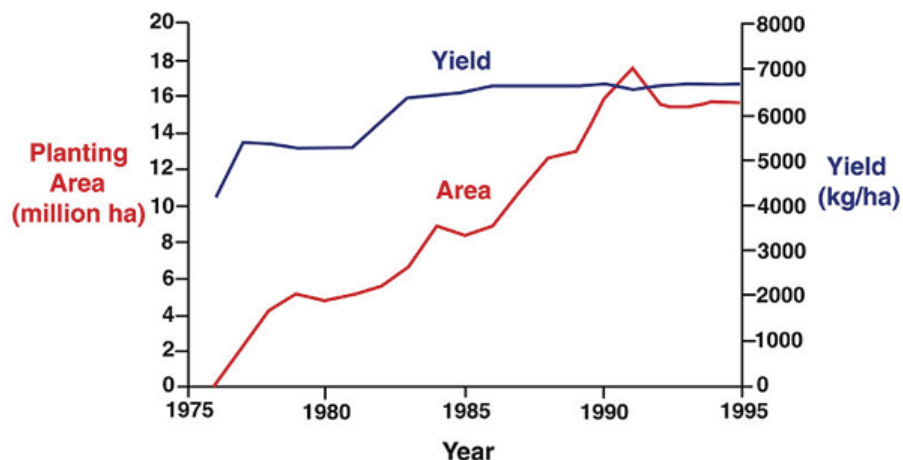


Fig. 12-20. Area and yield of hybrid rice in China (Li and Yuan, 2000).

over non-hybrid cultivars (Fig. 12-20). Recently, hybrid rice has yielded 6.6 t/ha compared with 5.0 t/ha for conventional cultivars, a yield increase of 32%. Hybrid rice technology has now expanded to India.

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