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Chapter 1: The History of Hemp

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The saga of industrial hemp would be an interesting history if only considering its rise, fall, and possible rise again as a crop of global significance. The growing recognition that *Cannabis* (here, our designation as a genus) has played a consequential role in human development– and arguably has been an important crop for the advancement of humanity– makes its story that much more compelling. To both ends, this chapter sets out to explore the current understanding of industrial hemp's origins and its likely interactions with (and development by) humans as our species moved from living in roving hunter-gatherer clans to settled agrarian societies.

To clarify for the reader, this chapter will use *Cannabis* in its taxonomic sense (capitalized and italicized as a genus), while the term 'cannabis' will be used to designate the crop material undifferentiated by end use. 'Hemp' will linguistically delineate cannabis used as a food and fiber resource. Finally, the term cannabis also will be used in the brief discussion of the plant's history as an intoxicant– both for the sake of simplicity and to recognize the potentially undifferentiated use of the plant in our past.

Although this book largely is about hemp biology and agronomy, some discussion of the archeological literature is presented to explore humanity's long history with the plant. Interested readers will find more detailed discussion of such work in several books on the subject as well as reviews of the literature. And, while the focus of this chapter is on the history of cannabis as hemp, a food and fiber crop, abbreviated exploration of its use as an intoxicating and medicinal plant is warranted given the profound influence that these attributes have played in the genus' global colonization and domestication. Hemp has a fascinating history in terms of its past impact on human society and now has the potential to do so again in our future. As such this chapter aims to trace hemp's use by and relationships with societies (primarily in the West) through its rise, fall, and possible rise again.

Origins of *Cannabis*

The geographic origin of *Cannabis* has been the subject of long-running debate (e.g., see Clarke and Merlin, 2013, Small, 2015). Several locations for the species' nativity have been proposed, with various theories supporting Central, East, and South Asia (Clarke and Merlin, 2013, Liu et al., 2017, Mukherjee et al., 2008).

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doi:10.2134/industrialhemp.c1

Industrial Hemp as a Modern Commodity Crop. D.W. Williams, editor.

Central and East Asia are considered more likely as the birthplace of *Cannabis* and would have allowed for the wide distribution of the species. A South Asian origin hypothesis is challenged by the difficulty the species would have faced to move north or south over the Himalaya and Hindu Kush mountain ranges (Clarke and Merlin, 2013). However, regions outside the point of origin likely were important in serving as glacial refugia for the species (Clarke and Merlin, 2013) during periods of unfavorable climatic conditions.

Humid temperate steppe biomes are thought to have provided the conditions for *Cannabis*' evolution (Gepts, 2004), and most experts consider that cannabis arose out of such conditions in Central Asia (Schultes, 1970, Small, 2015). A Central Asian origin also would have facilitated the wide early dispersal into Asia and Europe that followed as humans began interacting with the plant, although such arguments are not definitive (Clarke and Merlin, 2013). Moreover, recent assertions of an East Asian origin based largely on historical evidence of *Cannabis*' use (e.g., Liu et al., 2017) suggests that this argument (or perhaps claim for the species) is not settled. However, initial DNA analysis has provided support for the idea of a Central Asian genesis (Mukherjee et al., 2008), although cultivation of the crop likely began further east in what is present-day China and spread west from there (Li, 1973, 1974).

Centers of origin (now more typically called centers of diversity) are the ancestral regions that gave rise to the crop species humans have domesticated. Teasing out centers of diversity for a plant species typically involves determining where it grows in its wild form. Such centers are delineated in part by the fact that the crop ancestors in these regions have high degrees of genetic diversity. N. I. Vavilov, the eminent Russian scientist who developed these concepts, considered *Cannabis* to have had three centers of origin (Vavilov, 1951, cited by Clarke and Merlin, 2016). Large-seeded, broad-leaved fiber types (designated *C. sativa*) were thought to have originated in China; narrow-leaved narcotic types (designated *C. indica*) in India and Pakistan; and, a narrow-leaved type also designated *C. indica* (grown for seed) in Central Asia and the Tian Shan Mountains (Clarke and Merlin, 2013). This has been part of the basis for identifying the ancestral "home" for *Cannabis*, but Clark and Merlin (2016) note that the assumption that high plant diversity reflects a center of origin may not be appropriate. The observed diversity may simply reflect "derivative instead of ancestral" variation, or variation due to human interaction compared to natural evolution.

In the case of *Cannabis*, it is more likely that these "centers" are less points of origin and more indicators of early human agriculture, with differences among the types reflecting the regional and human selection pressures for food, drugs, or fibers (Clarke and Merlin, 2013). Present debates over the geographical origins are in part a function of the long association that cannabis has had with humans. However, the degree of human interaction with and the corresponding flow of genetic material between cannabis the crop and any extant wild populations of the genus makes finding truly ancestral forms of the plant extremely unlikely (Meijer et al., 2003, Small, 2015).

As noted above, both species of *Cannabis* may contain narrow-leaved and broad-leaved forms, with each having both low- and high-intoxicant types. Among those "splitters" who separate *Cannabis* into different species, the narrow leaved form is more frequently designated *C. sativa* and the wider-leaved drug type *C. indica*. This terminology is confounded by the fact that scientists and those who use "sativa" and "indica" as colloquial appellations often have different meanings for these designations (Sawler et al., 2015). Additional confusion sometimes arises from the fact that a putative third *Cannabis* type, *C. ruderalis*, was identified in Central Asia by D.E. Janischewsky, a colleague of Vavilov's (Janischewsky, 1924, cited by Hillig and Mahlberg, 2004). The *C. ruderalis* form is shorter and shrubbier and some have considered it a wild ancestor of cultivated *Cannabis*, but chemotaxic evidence instead has indicated that it is a form of *C. sativa* (Hillig and Mahlberg, 2004).

Brief Consideration of Cannabis Speciation and Taxonomy

The challenges of piecing together the historic origins of *Cannabis* and detangling its different taxonomic relationships are intimately linked. Until very recently, genetic analyses have been limited due the inaccessibility of the plant to scientists. Thus, the debates about *Cannabis* and the broader treatment of species within the Cannabaceae are likely to continue for some time to come as the scientific community, long prohibited from easily researching the plant, is just beginning to explore the species with the full complement of genetic analytical tools. Still, an assortment of scientific approaches and historical records across a variety of disciplines have been applied to the question of *Cannabis*' speciation– albeit often with different conclusions.

Using evidence from archaeological, paleobotanical, and palynological records and genetic studies, Clarke and Merlin (2013) rendered up a detailed hypothesis of how *Cannabis* could have emerged as genus with multiple species. The authors concluded that *C. indica* and *C.sativa* should be considered separately and that based on the evidence "*C. indica* cultivars are the most geographically widespread and most widely utilized biotypes today, growing on all continents and used for recreational and medicinal drugs as well as fiber and seed production, while *C. sativa* cultivars are presently grown only for fiber and seed on limited acreage in Europe and North America" (Clarke and Merlin, 2013).

Others take a narrower view of *Cannabis* taxonomy (*e.g.*, Rahn et al., 2016, Small, 2017). Small (2015) noted that "no other species has generated so much misunderstanding, argument and contradictory literature", and has argued for a single taxon, *C. sativa*, with subspecies and varieties based on the biochemical nature of the plant material. This stance was taken because fiber and narcotic types are reproductively compatible (with a great deal of hybridization among them) and with the consideration that observed differences between the types largely reflect divergent selection pressures during domestication. Noting the challenge that taxonomists can face when considering whether to formally recognize a group of organisms (and if so, at what taxonomic rank), Small observed that "those who have espoused... recognition of more than one species…have done so without addressing the theory and practices of classification" (Small, 2015).

It is not the purpose of this chapter to engage in the arguments about speciation– that will be left to those whose expertise is in the precise definition of the genetics of the plant. For our purposes (and for simplicity), this chapter will follow the convention that all *Cannabis* is *C. sativa*. Interested readers are guided to Small (2015; 2017) for detailed considerations of the plant's taxonomy and comparison with other taxonomies, along with a suggested framework for describing subspecies based on plant morphology and chemistry. A contrasting vision of speciation based on a geographic history of the plant is put forward by Clarke and Merlin (2013).

Cannabis Prior to Human History

The family Cannabaceae is thought to have arisen during the Cretaceous period and contains 10 genera (Sytsma et al., 2002, Yang et al., 2013). Cannabaceae includes both *Cannabis* and *Humulus* (common name, hops), two relatively closely related genera. While *Cannabis* is an upright plant and *H. lupulus* is a vine, both utilize similar habitats and produce resinous material from secretory glands. Both genera also bear "seeds" (achenes, technically; an achene is a dry fruit containing a single seed) and have pollen quite similar in form (Small, 2017).

Palynology, the study of spores and pollen grains, often has been used to gain insight into ecosystems of the past. Along with allowing scientists to identify a species' presence or absence, palynology may provide a window into historical climatological and ecological conditions. Palynological studies have provided important insights into the history of *Cannabis* because aside from pollen grains, the fossil record does not provide evidence (and thus accurate dating) to the time of its evolution (Small, 2017).

The reproductive characteristics of *Cannabis* lend themselves well to palynology. Large female plants can bear hundreds of flowers and a single male flower produces hundreds of thousands of pollen grains (Fægri et al., 1989; cited by Small, 2015). The earliest reported evidence of *Cannabis* in the palynological record comes from core samples taken in the East European Plain. These samples indicate the presence of *Cannabis* in Eurasia as early as 150,000 yr ago (Molodkov and Bolikhovskaya, 2006). Readers should note, however, that older studies attempting to ascertain the timing and presence of *Cannabis* in the landscape based on the palynological record should viewed with caution because *Cannabis* and *Humulus* pollen are

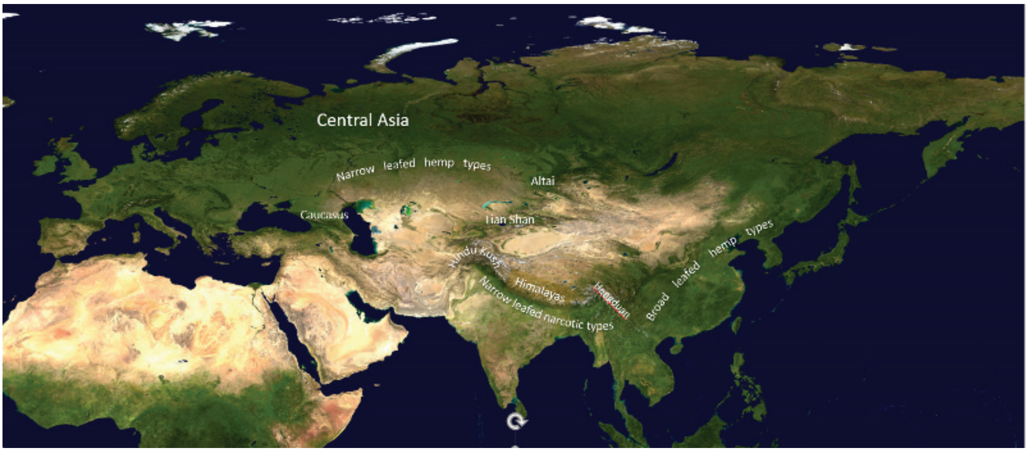

Fig. 1. Proposed regions of natural origin for Cannabis include Central Asia (between the Caucasus and Altai Mountains), South Asia (largely in the Himalayan Mountains) and East Asia in the Hengduan-Yungui region (Clarke and Merlin, 2013). Although some consider the Caucuses Region hemp's likely region of origin, each of these regions likely played important roles in Cannabis evolution and domestication. A central challenge for understanding hemp's origin arises from the intermingling of the different types, their advance and retreat in the face of a changing climate, and their ultimate use, transport and development by humans. Central Asia and Europe fostered largely narrow-leaved hemp types that were carried to North and South America for fiber production. Broad-leafed hemp types were common to East Asia and cultivated for food and fiber. A pocket of broad-leafed narcotic strains is localized to the Hindu Kush. Narrow leaved narcotic strains were more common around the Himalayas and spread from South Asia to Africa and on to the Western Hemisphere and narrow-leafed hemp strains reached the Western Hemisphere from Europe. More detailed discussion of these issues and of cannabis' migratory patterns is presented in Clarke and Merlin (2013).

quite similar in appearance (Fleming and Clarke, 1998). A recent (2013) summary of *Cannabis* pollen discoveries reported from around the world suggests a large gap exists in the Eurasian palynological record (or at least in the literature) in the period between 150,000 and 10,000 BP (Clarke and Merlin, 2013). More frequently, the bulk of early evidence of hemp pollen in the palynological record dates from around 10,000 BP (Clarke and Merlin, 2013). The palynological evidence for presence beginning from around that time likely reflects the advent of human interventions with the plant, but prior to the advent of human interaction *Cannabis* surely must have had some way of expanding out from its points of origin.

Conditions for Growth and Means of Distribution

While the palynological record delivers evidence for a site's ecological history, the distribution of today's wild or feral plant populations provide strong indicators of the climatic and edaphic conditions from which *Cannabis* would have evolved and been adapted. In this regard, *Cannabis* grows best at rather moderate temperatures– between about 59 °F and 81 °F (15 °C and 27 °C)– which could be expected for *Cannabis* in pre-history as well (although modern cultivars can tolerate quite low temperatures (Ehrensing, 1998). Edaphically, hemp is best suited to well-drained soils with high fertility and has little tolerance for waterlogged or poorly drained sites (Clarke and Merlin, 2013). The need for nutrients and moisture on well-drained sites also points to origins within river valleys along stream banks, lakeshores, and alluvial fans. It is telling that in North America, feral hemp often carries the moniker "ditchweed", linguistic evidence of such site preference.

Prior to humanity's interactions with *Cannabis*, its primary vectors of distribution likely would have been moving streams, birds, and mammals. Although strong winds might transport seed, this would be an ineffective mechanism because the small round shape of the seeds is not well suited to windborne dispersal. Birds may have been particularly important to the spread of *Cannabis* as many species readily consume the seeds, and some avian species have appellations taken from the name of the plant. *E.g.*, the species designation of the common (or sometime "hemp") linnet (*Linaria cannabina* L.) in Europe is derived from *Cannabis*, and field sparrows (likely *Passer montanus* L.) in China often are called 'hemp bird' (꩜꩜; Clarke and Merlin, 2013).

Although birds may break seeds in the process of consumption, some species swallow seeds whole, and these can be stored in the bird's crop prior to processing and further digestion (e.g., Darwin, 1869, Zheng et al., 2011). In such cases, birds may have regurgitated viable seeds or they may have been killed by predators, with the seed dispersed before they were processed and digested. Darwin (1869) observed that birds (with seeds in their crops) could be blown several hundred kilometers off their course and noted that tired birds were subject to predation by raptors. Moreover, he reported that seeds of *Cannabis* (and other plant species) had germinated following residencies of up to 21 h in the stomachs of birds of prey.

Large ungulates likely also were important as vectors of *Cannabis.* Equids and cattle are known consumers of grains, including hemp. Equid mobility is such that they could disperse seeds over many kilometers in a day's time (Hampson et al., 2010). Although the fossil record is mute on this point, it is plausible that now-extinct ungulates and megafauna from hemp's home range would also have eaten and distributed hemp seeds over some distance. While a majority of seeds likely would lose viability during passage through the digestive tract, the smaller seeds of wild hemp are variable in hardness and germination (Small, 2015). Passage of viable seeds has been described in a number of situations with horses and ruminants (Aper et al., 2014; Nishida et al., 1998, Quinn et al., 2008, Rahimi et al., 2016), and colonization post excretion could have occurred even with a low percentage of excreted seed being viable.

Evidence of *Cannabis* in Human Pre-history

Human interaction with *Cannabis* likely began well before the evidence is available in the archaeological record. Some have even speculated that early humans carried seeds of the plant with them as they retreated from the last ice age 50,000 to 70,000 years ago, although proof for this is lacking (Clarke and Merlin, 2013). The point in time at which *Cannabis* entered human consciousness as a preferred species will always be ambiguous, but it was likely early in our history. Certainly, our nomadic ancestors would have recognized the plant's versatility as a food and fiber resource and probably as a medicinal or psychotropic herb used in shamanistic healing rituals. Interaction with humans would give the adaptable invader new opportunities for expansion, and the global distribution of *Cannabis* today is essentially a function of humanity's historic use of the species.

Early on, the sites where conditions were best suited for *Cannabis* likely would have been along trails and by the dung piles left by animals, particularly those near water sources and drainage ways. As humans used these trails and made new encampments, they would have created areas of disturbance, all the while depositing their own wastes and leaving trash heaps. Thus, the process of habitat expansion for humans would have created disturbed sites with elevated nutrient levels that would have been ideally suited for the plant given its preference for sunshine and well-drained sandy-loam soils of high fertility (Johnson, 1999, Schultes, 1970, Small, 2015, USDA, 2000). Because humans and plants utilized the same sites along streams and lakes, the two species likely would have been in frequent contact, facilitating *Cannabis'* collection, use, and spread during its early days as a "camp follower" (Schultes, 1970, Small, 2015).

At what stage in the course of human development *Cannabis* transitioned from being a weedy opportunistic vagrant to an actively collected and nurtured crop is another open question, but such entry to the path of domestication is common. In this regard, *Cannabis* is no different from "probably the majority of the world's major domesticated crops (which) are related to, or are known to have originated from (weedy, opportunistic) plants" (Small, 2015, see also Harlan, 1965). Early utilization could have been due in part because it was readily accessible (Clarke and Merlin, 2013), and Small (2015) conjectured that "it was almost certainly associated with humans in very early times".

Cannabis and the Pollen Record in the Age of Humans

Palynological studies detail the presence of *Cannabis* in Europe from after about 10,000 BP, coincident with human activities. Pollen records indicate *Cannabis*' presence in East Asia from about to 7000 BP (Japan) to 4500 BP (China) but the evidence is limited to a handful of studies (Clarke and Merlin, 2013). Earlier dates in China would be expected given our knowledge of the plant's long use in the region. Similarly, of the more than two dozen palynological studies that (Clarke and Merlin, 2013) cataloged, none gave evidence for *Cannabis* in South Asia. This is surprising since *Cannabis* had migrated to South Asia by around 3000 BP, carried south and west from Central Asia by nomads and traders (Fleming and Clarke, 1998). A strong pollen signal would be expected given the plant's well-recognized history of use within the region, but absence of evidence is not evidence of absence, and the lack of record may simply reflect limited research on this subject.

The palynological record indicates that *Cannabis* spread throughout Europe from west to east over northern and southern routes (Fleming and Clarke, 1998). *Cannabis* pollen found in Italy was dated to the late Pleistocene (Mercuri et al., 2002) while pollen finds along the northern route to Europe are signposts that *Cannabis* had reached the Baltic region by at least around 7600 BP (Poska and Saarse, 2006). Larger pollen peaks appear from the time of the Roman Empire (Fleming and Clarke, 1998) and testify that hemp played a role in the dramatic landscape-scale changes humans made to European ecosystems during the Iron Age (*e.g.*, Cyprien et al., 2004). Pollen finds closer to the present and associated with lake sediments indicate when and where Europeans had begun practicing water retting (described in **A history of Hemp as a Fiber Crop-***Hemp Fiber Production and Processing*) for fiber processing (Andresen and Karg, 2011, Brombacher and Hecker, 2015).

Cannabis Seed Finds

Of the plant constituents (pollen, seeds, fibers) found in the archeological record that could testify to early *Cannabis* use, seeds provide the strongest direct witness. Fibers of *Cannabis* purportedly have been found at many archeological sites but they present more challenges for definitively determining the species (as mentioned below). Seeds, in contrast, provide clear indication of past use.

The earliest seed-based evidence that humans used *Cannabis* comes from sites found in Japan (Kudo et al., 2009, Okazaki et al., 2011). The seeds were found along with pot shards which also had cord markings, giving circumstantial evidence that *Cannabis* may have been used as a fiber resource about 10,000 BP by the Jōmon people. Although seeds and cordmarked pottery do not definitively speak to *Cannabis* use as a fiber material, in this case such findings do present additional evidence of even earlier plant–human interactions. We know this because *Cannabis* is considered to have migrated east out of Central Asia, making its way with humans via land bridge to Japan about 18,000 BP (Clarke and Merlin, 2013). More recent seed-based evidence from northeast Asia dated to about 2000 BP has been linked to hemp fabrication in the region (Jia, 2007).

In Europe, seed-based evidence has been found in two burial pits within the Danube Valley region of Romania. These sites, dated to about 4000 BP, each contained vessels with carbonized hemp seeds (Rosetti, 1959), suggesting that *Cannabis* may have been burned or smoked as a component of incense. Another interpretation is that these vessels were ritual food containers used in a feast for the dead (Sherratt, 1981, cited by Clarke and Merlin, 2016) which would provide evidence that *Cannabis* was being used for food. Interested readers are directed to Clarke and Merlin (2013) and Long et al. (2017) who provide several additional references for *Cannabis* seed finds in Asia and Europe that point to various food and ritual uses from the Holocene to modern times.

String, Cannabis, and Early Human Advance

The use of string, cloth, and cord predates the rise of civilization, dating from about 30,000 BP (Adovasio et al., 2007, Barber, 1992) and fiber technologies have been fundamental to the advancement of humanity. Converting fibers to string had profound effects on the advancement of early human societies because of the myriad ways in which this technology could be used. Some consider the development of textiles second only to the use of cereal grains in the founding of human culture (Li, 1973, 1974). Thus, it is worthwhile to briefly digress from the *Cannabis* story to consider what more broadly has been called the “string” or “fiber revolution” (Adovasio et al., 2007; Barber, 1992).

Although much of the study and description of prehistory is immersed in the language of stones (Adovasio et al., 2007), the advent of fiber technologies made possible a number of human advances– including, in many cases, the use of the stones themselves. Fiber technologies would have made it possible to create a number of tools: for example, to weaponize a stick with a sharp stone point (a spear) which could be jabbed or thrown at enemies and prey. Coupled with a bow “spring”, fibers could be used to propel smaller weaponized sticks (arrows) over distances and with great speed and force. Fiber technologies also would support more nurturing uses. The ability to lash together materials for shelter, to strap on a child, or to create new modes of clothing or baskets for carriage; all would have provided opportunity to expand humans’ range and habitat, by reducing labor needs and opening up new possibilities for discovery and invention.

More recent interpretations of the anthropological record suggests that fiber development and use had more profound effects on human advancement than did any technical progress in making weapons, scrapers, and other stone tools (Adovasio et al., 2007). This connection of fibers to human development also points to the critical role that women played in our advancement as a species. Women often have been given bit parts in narratives of our early history because the tools of their craft, degradable fibers, are the first evidence to be lost from the archeological record; however, they were the likely leaders and innovators in early fiber technology development (Adovasio et al., 2007);

Development of new fiber technologies accompanied and supported the transition from nomadic to settled lifestyles. The invention of mesh and line technologies provided humans the capacity to catch, trap, and hook fish and waterfowl, ultimately resulting in supplies of protein for the community that would have been more stable. This in turn would allow for more extended periods of settlement at a given site (Clarke and Merlin, 2013). As nomadic existence gave way to life in transhumant or permanent settlement along riparian transportation routes, such changes in lifestyle would free both temporal and cognitive resources. This would allow for new pulses of creativity and innovation– just as such changes continue do in the present (Bertinelli and Black, 2004). Experimentation with and domestication of plants and animals and development of new agricultural technologies would have supported and reinforced this transition. Considered in this context, it is easy to see how cannabis might have been an essential crop for early human societies. A species capable of supplying seed for food, medicinal and psychotropic compounds for healing and religious ritual, and strong fibers for a variety of tools could be a key resource.

The role cannabis played as the fiber resource for textiles, nets, and cords at these early junctures in our history remains a mystery. Certainly many fiber sources would have been available and utilized by our ancestors. Although the preponderance of fibers found in the archaeological record have come from Asia (Clarke and Merlin, 2013), the evidence for *Cannabis* as the source material frequently has been “based on the geographical and historical contexts in which the fiber remains were found. In almost all cases, no actual laboratory identification of the plant fibers has been provided” (Clarke and Merlin, 2013). The lack of analysis may reflect the difficulty of correctly identifying cannabis fibers from among other potential bast fibers. Sources such as flax (*Linum usitatissimum* L.), ramie (*Boehmeria* spp.) or nettle (*Urtica* spp.) often were available to and utilized by our ancestors.

Some of the earliest confirmation of fiber use derives not from actual fiber remains but from the forms that they cast. Imprints of fibers on earthen floors, in clay pottery, and on bronze surfaces (which had been wrapped in cloth) all have been ascribed to cannabis (Fleming and Clarke, 1998). Indirect evidence in cordbased pottery in Central European sites have been dated to about 25,000 and 27,000 BP and were thought to be used as netting to capture birds and small game (Pringle, 1997). However, the source of the impressions has not been positively identified. Cord marks on 12,000-year-old pottery artifacts may have been made by, or intentionally *with*, cannabis fibers (Chang, 1968, cited by Clarke and Merlin, 2013) and slightly younger evidence of intentionally cordmarked pottery comes from the Jōmon site **Fig. 2**. in Japan (Kudo et al., 2009). The fact that seeds were found with pottery shards does not provide definitive proof that cannabis fiber was the source of the marks, but it likely increases one’s confidence in such conjecture. As with other “signals” of

Fig. 2. Incipient Jōmon pottery (14th–8th millennium BCE). Tokyo National Museum, Japan. Figure in public domain.

Cannabis presence and use, Clarke and Merlin (2013) have provided a detailed discussion of the historical record based on fiber finds and a number of references for fiber-based findings reported in the literature.

As noted before, much of the record of early fiber use comes from East Asia. *Cannabis* provided the only herbaceous plant fibers for the region that stretched from what is now northern China into eastern Siberia (Li, 1974). Proto-Chinese peoples utilized these fibers for clothing and fabrics and the materials for spinning the strands into thread are a common constituent of settlement artifacts found in the region (Cheng, 1982, cited by Clarke and Merlin, 2013. In contrast, evidence of cannabis fibers in the South Asian archaeological record appear limited despite the plant's occurrence there (Clarke and Merlin, 2013). However, these strains more typically were the diminutive psychotropic forms unsuited for fiber production, and other plant resources such as kudzu (*Pueraria montana* [Lour.] Merr.), abaca (*Musa textilis* Née), jute (*Corchorus* spp.) and ramie (*Boehmeria nivea* [L.] Gaudich.) were readily available and likely preferred as sources of fiber (Fleming and Clarke, 1998).

History of Cannabis in Religious and Medical Traditions

Although the focus of this text is on the use of Cannabis for fiber and food, a description of the plant's history without mention of its use in religious and medicinal traditions would be remiss. The very brief treatment that follows is necessarily short because our purpose is merely to consider the evidence for human use of Cannabis and the manner in which these uses helped support the plant's global expansion. Curious readers also will find a range of books and reviews on the topic. Some may consider the use of Cannabis as illicit or at least anathema (aside from industrial purposes). Indeed, that has informed U.S. policy regarding the plant for nearly a century. However, the circumstances and conditions of human living prior to the advent of modern medicine warrant consideration and contextualization. Nature's pharmacopoeia, historically has been (and for some cultures remains) the essential source of medicines for healing and pain relief. The relationships between humans and psychoactive animals, plants, and fungi began early in our history and probably served as the inspiration for early religious experience and practice (Clarke and Merlin, 2013). Some hypothesize that humans specifically sought such materials when moving into new areas to rise above normal states of consciousness or to communicate with ancestors or other parts of the spirit world. Discovery of such effects from Cannabis likely happened early in humans' interactions with the plant, given that the seeds are surrounded by flower bracts rich in psychoactive resins **Fig. 3.** Although research on the adaptive purposes of cannabinoids is limited, some have considered that Δ9-tetrahydrocannabinol (THC; the intoxicating compound in these resins) has little apparent benefit for preventing plant disease or predation. As such, others argue its presence may be for another adaptive purpose– attracting humans or other animals– and thus principally a human artifact (Schultes and Hofmann, 1992).

Evidence for *Cannabis'* pre-historic medicinal use has been traced back to 4000 BC with carbon-14 dating techniques (Russo, 2004, cited by Warf, 2014) and some of the earliest pharmacopeias from China chronicle the plant's medicinal and psychological effects (Li, 1974). Both the Chinese and Vedic (Indian) texts that discuss cannabis trace from older oral traditions, suggesting much earlier awareness and use of the plant (Clarke and Merlin, 2013).

Early recreational, religious, and medicinal uses that developed in East and South Asia have been accepted or punished by various societies, depending on the religious and political hierarchy of the day. In China, cannabis was used in Daoist religious ceremonies until those customs fell from grace around the sixth century CE (Li, 1974). This decline corresponds with the rise of Confucianism, a philosophy that rejects the role of the spiritual in human life. In contrast with China, pressures against the use of cannabis were limited if even extant in India, and the plant continues to be used today as part of some Indian religious traditions (Clarke and Merlin, 2013).

Cannabis also may have a biblical connection. Benet (1975) posited that the term 'cannabis' can be found in Jewish scriptures but that the original wording was lost when the Bible was (mis)translated into Greek. Benet (1975) considered 'cannabis' to derive from the earlier Semitic terms 'kaneh' (hemp) and 'bosm' (aromatic) and suggested the biblical context surrounding 'kaneh-bosm' indicate that it was used both for fiber and for religious ceremony.

Cannabis also was known in the Middle East, perhaps 1000 years or more before the rise of Islam. Consumption of hashish (the dry cannabis resin) receives no mention in early Islamic texts and apparently did not warrant mention until the 10th century (Clarke and Merlin, 2013). The drug was compared with alcohol (which is prohibited in Islam), but attempts to quash its use typically failed, despite penalties for use that historically have been quite stiff. In time, Arab traders carried cannabis to North Africa and down the continent's eastern coast, where it was used for psychotropic and euphoric properties (Warf, 2014). These materials dispersed across the continent and eventually would make their way to the Caribbean with East Indian workers who migrated from British East Africa following the end of slavery (Clarke and Merlin, 2013).

In Western Europe, descriptions of cannabis from early Greek and Roman civilizations appear limited largely to fiber and medicine. The Greek scholar Herodotus indicated its use in ritual by Scyhtian nomads to the east (Dewey, 1914), and some suggest cannabis was used at Greek oracles to facilitate communication with the dead (Bremmer, 2002, cited by Clarke and Merlin, 2016). Other writings from Greece and Rome suggest it was used recreationally (Clarke and Merlin, 2013), although such interpretations of these writings (particularly from Herodotus) have been questioned (Duvall, 2014). Pope Innocent VIII's 1484 papal bull "*Summis desiderantes*", a proclamation against witchcraft, is viewed by some as a statement against the use of cannabis, but the papal bull (Pope Innocent VIII, 1484) makes no such mention of the plant.

Cannabis has a more recent history of use in Western medicine following its (re)introduction to the West from India in the late 19th century (Clarke and Merlin, 2013, Small, 2017). Use declined in the early decades of the 20th century, however, because obtaining consistent results from plant materials and preparations that had variable potencies proved difficult. Passage of the 1937 Marihuana Tax Act put further pressure on cannabis use and it was removed from U.S. Pharmocopoeia in 1942. Healers back to antiquity have treated a variety of ailments with cannabis and modern medical interest in the plant and its chemistries greatly increased following discovery of cannabinoid receptors (Devane et al., 1988). Efficacy and mechanisms of these treatments needs verification, and Western science and medicine are just beginning to tease out what our ancestors knew or sensed about the medicinal properties of the species.

Cannabis in our Language

Along with the various artifacts and historical records, one can hear the echo of human interactions as facilitated by *Cannabis* sounding through our different languages. Etymology, the study of word origins and their changes over time, can provide clear evidence of different cultural exchange and interaction among peoples. Plant names are important for etymological study because typically they belong to ancient word groups (Ignatov et al., 2010) and can be used to test similarities among languages, thus providing linguistic linkages of peoples back across space and time. The similarities of words among different peoples can help reveal the origins and travels of humans and plants alike. Original terms for fiber (*cana*) and psychoactive (*bhang*) lines have understandably evolved over time with movement of the crop from region to region and people to people. Those interested in the linguistics of

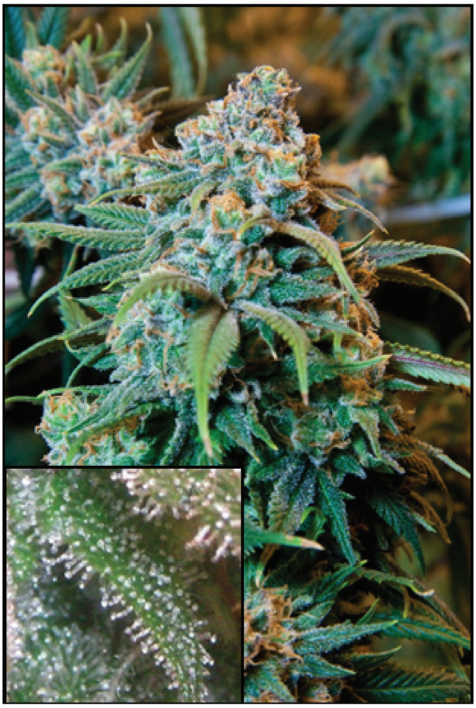

Fig. 3. A medicinal cannabis plant in flower has a glossy appearance due to resin-laden flower bracts (inset). Figures in the public domain.

psychotropic cannabis will find such treatment in Clarke and Merlin (2013). A brief primer on the linguistics of fiber cannabis follows here.

The Chinese term for hemp, *má*, is depicted as ◎ (Li, 1974). Although hemp as food grain would be displaced by other crops by the 10th century (see the next section on hemp grains and oils), its appellation, '*má*' remains embedded in the Chinese language as the radicle (or root) of several other words. Words such as grind (hemp + stone) and porridge (hemp + rice) indicate the practical agronomic relationships of humans and hemp. *Má* also is the root for 'narcotic', 'numb', 'tangle' and 'troublesome' among other words, pointing to its psychotropic and medicinal effects. Similar linguistic relationships are found in the Korean language, indicating the various properties of cannabis were well known to the peoples of northeast Asia.

As noted above, the Latin 'cannabis' may trace to *kaneh bosm* from early Semitic languages which still can be heard in the Turkish *nasha* and Arabic *kannab* today (Benet, 1975). The term śā◎a or *cana* (from Sanskrit) likely gave rise to *kenab* (Farsi/Persian) and these words have links to *kannabis* (Greek), *konopli* (Russian) and *konopj* (Polish). *Cañamo* (Spanish), *cânhamo* (Portuguese) and *chanvre* (French) all derive from Old Latin (Benet, 1975, Dewey, 1914). In turn, connections among Northern European languages may be seen in *cainb* (Gaelic), *hanf*, (German), *hennup* (Dutch) *hampa*, (Danish), *hamp* (Swedish) and *hemp* (Dewey, 1914).

In modern English, the crop's broad use and representative nature for long fibers also resulted in something of an inverse phenomenon etymologically. That is, the word 'hemp' has been used (and likely misconstrued) as a generic name for several other long fiber sources including Indian hemp (or jute), sisal hemp (*Agave sisalana* Perrine), and sunn hemp (*Crotalaria* spp.) among others (Dewey, 1914). Of course, 'cannabis' also gave rise to "canvas", reflecting this important use of hemp fibers (Harper, 2019).

Hemp Grains and Oils in Historic and Modern Contexts

Historical Uses of Hemp as a Food Crop

Scholars consider Northeastern China the cradle of hemp cultivation and suggest the first harvests from wild hemp plants occurred many as 8500 years ago (Li, 1974). Active cultivation likely began from about 6000 BP (Chen et al., 2009), when hemp was among a handful of foundational grains that included millets (*Setaria italica* (L.) P. Beauv. and to a lesser degree *Panicum miliaceum* L.*)* and buckwheat (*Fagopyrum esculentum* Moench) (Lee et al., 2007, Li et al., 2010, Li et al., 2009, Yang et al., 2012). Classical Chinese literature such as Shi Ching (Book of Odes) and Li Chi (Book of Rites) from about 2100 or 2200 BP provides some of the earliest written evidence and instruction on growing the crop for fiber and grain (Li ,1974b). The subsequent domestication and introduction of upland rice (*Oryza sativa* L.), soybean (*Glycine max* (L.) Merr.) and probably wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) (Lee et al., 2007) led to hemp's long-term decline as a food crop in the Far East. Although scholars differ on the timing, consumption as a grain staple in China likely ended sometime in the first millennium CE (Keng, 1973, Li, 1974). Today, Chinese citizens consume the grain as snacks, in geriatric diets, or as medicinal foods (Clarke and Merlin, 2013). Archeological records, and in some cases, modern consumption by peasants, suggest hemp seed likely was a routine dietary constituent for the peoples of Korea and Japan as well as those in Central and Southwestern Asia (Clarke and Merlin, 2013).

Europeans also consumed hemp, although the historical evidence for this use appears more limited. Traditional European hempseed recipes point to its long use from centuries past (Leson, 2013) and Clarke and Merlin (2013) provide a number of anecdotes and resources that point to its use as a food grain. While peoples across European social strata probably consumed hempseed (Clarke and Merlin, 2013), the crop likely more frequently sustained those living in poverty or served as a food resource in times of famine (Small, 2017).

Hemp produced specifically as a grain crop has precedent, although it historically occurred only within Russia (Small et al., 2007), unless birdseed production (in Canada, Europe and the United States [see Dewey, 1914]) also qualifies as such. Dewey (1914) tested Russian landraces and described these experimental plants as short, with compact seedheads that could be harvested similar to other seed crops, but which had little value for fiber. To date, most of the crop improvement efforts intending to yield grains have been geared toward "dual purpose" varieties that also could yield fibers. Short-statured, short season (60 to 90 d) grain cultivars have been developed for more northern latitudes (Callaway, 2003, Small and Marcus, 2002) and this is likely to be an area of research effort if hemp rejoins modern cropping systems.

New Consideration for Hemp as a Feedstuff

Despite the past association of hempseed with poverty feeding, renewed interest in hemp as a grain crop for feeds and food products has arisen largely out of the evidence of hemp seed's quantifiable nutritional value. Hemp seeds may serve as a source of protein and are relatively energy-dense, typically containing between 27 and 38% oil (Bócsa et al., 2005, Callaway, 2004, Kriese et al., 2004, Oomah et al., 2002, Vonapartis et al., 2015). Use of hemp oil both as food and fuel has been described in Chinese texts from about a millennium ago (Whitfield, 1999). Just as with hemp use as food staple, consumption of hemp-based food oils in China fell from favor over time. Other seed crops had preferred oil qualities, although hemp remained a superior feedstock for lamp oil (Clarke and Merlin, 2013).

Interestingly, some practices described in the early Chinese texts, pressing the seeds for food and fuel oils and feeding the remaining press "cake" to fatten livestock– show that for hemp, the past may indeed be prologue. Feeding such residuals following the primary extraction of seed oils is a common practice in modern livestock production systems. Early studies show that hempseed cake is suitable for use in this manner (Hessle et al., 2008, Karlsson, Finell et al., 2010).

Researchers also have tested the feeding of full fat hemp seed to cattle, but performance results have been mixed. For example, including hemp seed at up to 14% of dietary dry matter animal did not affect growth metrics. Meat fatty acid profiles had both increased trans and saturated fats (generally considered a negative response) but increased conjugated linoleic acid (Gibb et al., 2005), an important dietary anticarcinogen. Other reports of altered milk chemistry and meat fatty acids (Cozma et al., 2015, Mourot and Guillevic, 2015) suggest that feeding hemp oil and seeds to livestock may have positive consequences for the human end consumer due to improvements in nutritional profiles. Although some have had concerns over animal products potentially having THC levels above safe standards (EFSA, 2011), this is unlikely to be of much concern (EFSA, 2015).

Given the value of the oils (see next section), future use of hemp products in animal feeds may be limited to the byproduct cake produced during extrusion. Still, adding such cakes to animal diets has potentially positive human nutrition implications. In one study, calf weight gain did not differ between hemp- and standard soybean- and barley-based diets (Hessle et al., 2008), but both greater concentrations of mono- and polyunsaturated fatty acids and a better n-6/n-3 ratio were reported for the hempseed-fed steers (Turner et al., 2008). The higher level of polyunsaturates in muscle tissues (Woods and Forbes, 2007) may represent a storage and handling issue, however, due to their greater potential for oxidation. Hempseed cake also has been fed in dairy diets with variable effects on milk yield, but quality responses in terms of fatty acid profiles were not reported.

Some suggest hempseed oil content and fatty acid profiles stand to give hemp strong market value and may create the opportunity for the plant's renaissance as a grain crop (*e.g.*, Small, 2017). However, while hempseed oil may prove beneficial to humans as food and nutritional supplements, such uses alone would only create opportunity for hemp in specialty or niche markets. Entry into the much broader food and feed system may prove challenging if hempseed cannot compete on price and value when pitted against traditional grain commodities.

Hemp Seed and Essential Oils for Human Food and Consumer Products

Historically, hempseed oil was used in a number of industrial products such as paints and varnishes (Small, 2017). These applications may again be revived as part of the 'green' (or not) products industries, but given current production scales, hemp's potential value likely will be greater in products for human use or consumption, that is, for foods, soaps, supplements, and cosmetics (Small, 2017). Such uses may well dwarf potential markets for use for industrial purposes and animal feedstuffs (Leson, 2013).

The recent history of demand for 'natural foods' in U.S. markets suggest significant future opportunities exist for hemp and have propelled the resurgent interest and efforts for grain production (Leson, 2013). Growth in this market is not surprising given that hemp seeds are considered a functional food. As noted previously, hempseeds have positive nutritional profiles and the fatty acid profile may be particularly nutritious. Hemp has a 3:1 linoleic to α-linoleic ratio, considered optimal for human health (Oomah et al., 2002) and γ-linolenic acid, which is not found in other major food grains. The seeds also have relatively high levels of vitamin E, insoluble fiber, and an array of minerals (Oomah et al., 2002, Small, 2015).

For centuries, humans have used dietary hempseed to treat various disorders (Callaway, 2004; Woods and Forbes, 2007). While full of promise as a nutraceutical food, the current excitement should be tempered by the fact that research regarding its benefits is limited and somewhat variable. Further, much of the work has been conducted with animal models. For example, in a comparison with fish oil, flaxseed oil, and hempseed oil, research found hempseed oil had no effects on plasma fatty acids in healthy adults over a 12-wk period (Kaul et al., 2008), and none of the treatments affected platelet aggregation or inflammatory markers. In contrast, research with rabbits (*Oryctolagus cuniculus*), indicated that animals fed elevated levels of cholesterol had normal platelet aggregation when supplemented with hempseed meal (Prociuk, Edel et al., 2008). Hempseed meal hydrolysates also have been found useful in maintaining blood pressure of hypertensive rats (*Rattus* spp.). In a small human study, subjects that consumed hemp oils had better serum high density lipoprotein (HDL)-to-total cholesterol ratios relative to those who consumed flaxseed oil (Schwab et al., 2006).

More work is needed to verify various claims about hemp's efficacy for addressing any number of ailments. Compounds derived from various parts of the plant are being used in treatments as diverse as hypertension and oxidative stress (Girgih et al., 2014a, b) to inflammatory bowel disease (Parian and Limketkai, 2016), to cancer (Pathak et al., 2016). In addition to grains, hemp inflorescences stand to be a good source of essential oils (to include terpenes and cannabinoids) for medicinal compounds (Fernández-Ruiz et al., 2013) as well as for flavorings and fragrance additives (Bertoli et al., 2010). Hemp terpenes have moderate antimicrobial and insecticidal activities (Górski et al., 2009, Novak et al., 2001, Thomas et al., 2000) and a raft of studies have begun to evaluate cannabinoid efficacy against a number of diseases (Coetzee et al., 2007, Fernández-Ruiz et al., 2013, Radu and Robu, 2014, Rieder et al., 2010, Vera et al., 2012, Woods and Fearon, 2009).

A History of Hemp as a Fiber Crop

Fibers and Empires

As described previously, humanity's use and production of hemp fibers goes deep into our history. Evidence of hemp fiber in Central Asia dates to at least 4000 BCE (Li, 1974). Hemp-based fiber technology is probably much older and would have been shared through trade and invasion. These technologies would spread westward from Asia, likely carried by Thracians and

Scythians across Eurasia to lands east of the Caspian Sea (Dewey, 1914). Although the Scythians probably brought hemp to Europe around 1500 BCE, the plant did not receive recorded mention until about 450 BCE by Herodotus, perhaps suggesting the plant largely was unknown to the Greeks and Romans prior to that time (Dewey, 1914). Subsequent Roman conquest and colonization continued hemp's spread into Europe and the Mediterranean during the early centuries of the Common Era. After the fall of the Roman Empire, hemp's move across Western Europe carried on as various peoples mastered the techniques required for its production and use. The plant reached Northwestern Europe by around 1000 CE, if not before, evidenced by canvas beginning to replace woolen sails in Norway (Clarke, 2002); adoption in the region was further facilitated by Norse trade (Duvall, 2014).

Fibers that provided strong, durable textiles and cordage were essential to national empires built on feats of military, industrial, and agricultural engineering and to personal empires built on commerce. As such, hemp became a critical commodity in Europe. Countries, city-states, and merchant networks sought to control its production and use as a means to accumulate power and wealth (Duvall, 2014) and this played out in the interaction of the social hierarchy. Those interested in the social aspects of cannabis production and use (both as fiber and psychotropic) and its relationship to social power structures in historic and present-day contexts will find absorbing discussions in Warf (2014) and Duvall (2014).

The demand for hemp fibers, important for rope and fabrics in medieval Europe, expanded significantly, as nations developed navies and advanced sailing technologies. For example, hemp fibers were a critical resource for the Venetian city-state (Duvall, 2014), which dominated much of the eastern Mediterranean during its existence during the 13th to the 19th centuries. Venice imported the raw fibers it needed from the surrounding region, and a vigorous state-controlled industry developed to process them into textiles (Duvall, 2014). This helped guarantee needed supplies for its navy, the source of the city-state's power.

Few European countries produced sufficient supply to meet their needs, despite hemp's being widely distributed and cultivated in Europe. A flourishing fiber production industry did develop around the Balkans (largely in present-day Germany, Poland, and Baltic states) that supplied hemp to parts of Europe from the 13th to 17th centuries, and political and social changes allowed Russia to enter these markets in the 18th century (Duvall, 2014). Many countries would supply their navies with high quality, low cost fiber from the Baltic, but routinely struggled with their reliance on foreign resources.

The rise of England, Spain and Portugal as maritime powers particularly increased the need for hemp imports into Western Europe. Sailing ships required tons of fiber to yield the yards of sails and the miles of line and cordage which powered and secured them. By the 1700s, a man-o-war might carry over 65 km (40 mi) of rope in active service and storage **Fig. 4.** As with Venice, however, these seafaring nations did not produce sufficient fiber to meet their own demands and their efforts to produce hemp economically met with variable (and usually limited) successes. Given the problems of being reliant on hemp from the Baltics, these countries made development of colonial hemp sources a priority.

Hemp as a New World Fiber Crop

Fiber hemp first arrived in the New World in the 1500s, brought by the Spanish to Mexico in the 1530s and to Chile in 1545 and by the Portuguese to Brazil by the 1600s (Campos, 2012, Duvall, 2014, Husbands, 1909). Spanish and Portuguese efforts to grow hemp both at home and in the colonies were driven by their sailing fleets' needs for cordage and cloth. Although Spain did grow some hemp, each country ultimately became dependent on Russian supplies. In Chile, a small, local industry developed based on production of rough fiber and seed and still exists today, but efforts to grow hemp in Mexico largely proved fruitless (Duvall, 2014). The Spanish also subsidized hemp production in present-day California during the late 1700s and early 1800s, but farmers largely stopped growing the crop when the subsidy ceased, coincident with the Mexican War of Independence.

France and Great Britain were the primary contributors to industrial hemp's production in Colonial-era North America. As with Spain and Portugal, each country's

Fig. 4. Images of the USS Constitution. Rigging and sails were critical for the development of commercial and naval fleets. Images in the public domain.

needs for fiber largely were driven by the demands of naval and commercial sailing fleets, which required many tons of rope and cordage for each ship. Along with efforts in North America, British colonists also attempted to grow hemp in South Africa, Australia, and New Zealand, which would all would prove fruitless (Duvall, 2014).

France was better positioned than Britain to meet its own fiber needs from within Europe, but at times its policies either encouraged or discouraged French colonists from growing hemp. French encouragement of hemp production began in Québec and Nova Scotia and met little success as colonists there found the crop unprofitable (Duvall, 2014). Growers apparently had better success in Louisiana; however, in the early 1700s, France prohibited commercial hemp production in the territory to protect its industry in the homeland (Gray and Thompson, 1933). The French would again encourage hemp production in the mid-1700s; second-hand accounts suggest that by the century's end, New Orleans had active ropeworks producing quality cordage (Gray and Thompson, 1933). Whatever hemp industry had developed proved short-lived, however, and by the time of the Louisiana Purchase (1803) the region's primary fiber was cotton (Duvall, 2014).

North American Hemp in the Colonial Era

Early efforts to grow hemp in the English colonies of the Atlantic Seaboard appeared more promising. Within a decade after the Virginia Company founded the Jamestown settlement in 1607, John Rolfe reported that Virginia's hemp and flax crops were as good as those in England and Holland (Gray and Thompson, 1933). In 1619, hemp production became "compulsory for all (Virginia) colonists having sufficient seed" (Gray and Thompson, 1933). Often the available seeds from Europe were no good due to poor storage during the trans-Atlantic transit, (Duvall, 2014; Herndon, 1963). Because of this, shortages of seed was a routine complaint, likely because farmers felt compelled to get seeds only from reliable neighbors (Herndon, 1963). New England colonists would try the crop around 1645 (Small and Marcus, 2002), and governments in 10 of the 13 colonies ultimately made policies to encourage hemp production (Duvall, 2014).

Despite these inducements and the crop's potential productivity, agronomic and economic conditions largely rendered hemp a crop for domestic use and it was never exported in large quantities (Gray and Thompson, 1933). Hemp required large amounts of nutrients, and this field preparation was no small task. For example, Virginia farmers typically worked the seedbed three times (fall and spring plowing and pre-plant harrowing) Herndon (1963). As well, harvesting and processing were extremely laborious, backbreaking and sometimes dangerous routines, as is discussed later. The labor demands for successful hemp production also put it in competition with production of food and cash crops, and the limited pool of labor was a frequent complaint of early colonial landowners (Duvall, 2014, Gray and Thompson, 1933). High labor costs, coupled with high freight charges and inferior processing methods, meant that colonial hemp generally was of lower quality and more expensive than the hemp reaching western Europe from the Baltic region (Gray and Thompson, 1933). Although the colonists were reported to have skilled textile producers (Gray and Thompson, 1933), trade law prevented shipping finished products to Europe (Duvall, 2014). Thus, early plantation owners generally shied away from growing the crop as a commodity.

Along with these competitive disadvantages, hemp as commodity crop likely faced a bigger challenge. The historical evidence suggests that the value of tobacco was a particular impediment to large-scale hemp production. This changed whenever tobacco prices fell, but growers reverted to tobacco production as soon as the market rebounded (Gray and Thompson, 1933).

Although limited as a commodity, hemp had wide usage domestically (Herndon, 1963) Weaving technologies introduced in the early 1700s allowed colonists to provide cordage and textiles for themselves and not be tied to expensive and variable finished goods imported from European markets. Thus, prior to the American Revolution the crop was widely grown, if not produced as a commercial crop. The revolutionary period was a notable exception (Herndon, 1966) Hemp production increased due to the lack of available British goods and was preferred to tobacco as a means of purchasing supplies during the war (Gray and Thompson, 1933; Herndon, 1963; Herndon, 1966).

Hemp as a Fiber Crop Following the American Revolution

As the United States expanded, settlers carried hemp further into North America, and a commercial cordage industry developed and flourished in Kentucky after 1775. This would assist the decline in eastern hemp production, and the industry would spread west to Missouri and Illinois through the mid-1880s (Roulac, 1997, cited by Fortenberry and Bennet, 2001).

Ironically, the rise of another fiber crop, cotton (*Gossypum hirsutum* L.) would support hemp's commercial success (Duvall, 2014). Hemp producers in Kentucky supplied the cotton industry with the textiles and cordage needed to bag and bale the crop. Geopolitics also were important for the new industry, as Europe's Napoleonic wars in the early 1800s helped raise the value of Kentucky hemp to the point that it was a staple crop for the state by 1810. Although the industry suffered once European hemp imports rebounded and hemp was subject to large fluctuations in value, it remained the principle market crop in Kentucky for several decades and would grow in importance in surrounding states (Gray and Thompson, 1933). However, in the 1840s and 1850s, some Kentucky growers began changing to alternative crops due to competition, limited labor, and deteriorating soils (Gray and Thompson, 1933).

In 1855, Kentucky hemp growers also suffered stand losses due to poor weather and in turn tried a variety of seed sources to reestablish the crop (Duvall, 2014). During this period, highly productive Chinese hemp cultigens were introduced and became the preferred plant material for fiber cropping (Duvall, 2014). Maintaining a supply of domestic seed was problematic, however, as the taller Chinese material frequently crossed with feral hemp strains; seed imports from China thus remained a necessity (Duvall, 2014). Thus, the term "Kentucky hemp" does not represent a cultivar, but a "conceptual centrality of (Kentucky's place) in U.S. hemp history" (Duvall, 2014).

In 1859, Kentucky and Missouri still produced over three fourths of U.S. hemp (Gray and Thompson, 1933), but war and its consequences would again play a role in the crop's future during the 1860s. Secession of the Southern states during the U.S. Civil War ushered in the beginnings of hemp's decline. Producers in the Midwestern (Union) states could no longer sell their fibers to their principle market, Southern cotton growers (Duvall, 2014). That market, in turn, already had an interest in using other means of binding cotton and the industry shifted to metal ties following the war (Duvall, 2014). Government subsidies for hemp production also ceased during the Civil War, as, thankfully, did the right to hold humans in bondage. Following war's end, newly freed men and women had much less compulsion to return to the toils and suffering from the same labors as those experienced during their oppression (Duvall, 2014). Hemp was not a profitable crop in the absence of free labor. Consequently, hemp farmers in Kentucky and other states that formerly had significant slave populations necessarily turned to other, less labor-intensive crops.

Hemp would see a brief U.S. rebound in the 1880s as new lands opened up on the Great Plains (Duvall, 2014). Increased grain production drove the demand for cordage and burlap to ship the commodities, and a binding machine that could tie cord was developed, increasing the need for strong fiber. Regional hemp production in the Great Plains duly followed, although this period was short-lived.

Markets for hemp at the turn of the 20th century faced long-term declines in demand as sailing ships gave way to steam and fossil-fuel powered vessels, thus reducing the need for rope and cordage (Fortenberry and Bennet, 2001, USDA, 2000). Cheaper imported fibers such as jute and abaca further cut into the hemp market (Dewey, 1914) and synthetic fibers loomed just around the corner. Still, at the turn of the century hemp was considered critical to the U.S. interest and USDA research supported its continued viability in the coming decades.

Hemp Fiber Production and Processing

As noted above, growing and processing hemp has at best been demanding and, at times, could be lethal. For centuries, the bulk of the work for producing hemp fibers was performed by hand. Such was the labor required that Venetians had called hemp "(the plant) of a hundred operations (processing steps)" (Schaefer, 1945, cited by Duvall, 2014). The lack of mechanization largely persisted until the early 20th century and placed hemp at a disadvantage relative to other fiber crops.

Multiple steps for cultivation and seeding were typical for hemp production (Herndon, 1963). In some cases, the plant's requirement for nutrients meant that "dunging" was needed if fields were not on river bottoms that received occasional replenishment by floods. Then there was the harvest and processing. Harvests historically occurred twice in a season, as male plants were removed around the time of pollen shed and females after going to seed (Clarke and Merlin, 2013). At harvest, hemp was cut close to the plant crown or pulled up from the soil, arduous work even for the strongest men (Duvall, 2014). Cutting with a hemp knife (versus pulling up the roots) was a step forward when hemp made its way to Kentucky, and mechanized harvest was a novelty in the late 1800s (Dodge, 1896).

Following harvest, the plants had to be dried and retted before the long fibers could be extracted. Retting (a different way to say 'rotting') involves the microbially mediated decay of the bonds between the short inner fibers (hurd) and the long outer (bast) fibers in the hemp stem. The retting process removes lignin, pectin, waxes, and minor compounds and disaggregates "the pectin–lignin matrix that bounds the elementary hemp fibers and created fiber bundles" (Sisti et al., 2016).

Historically, the highest quality fibers have been obtained by water retting. This involves soaking hemp stalks in stagnant ponds of water and yields fibers with greater strength, lighter color, and greater consistency (Herndon, 1963) than obtained with other retting methods. Although the water retting was the typical method for processing hemp in the Baltics, the process was both tedious and unpleasant. French farmers considered water retting poisonous (Duvall, 2014), and U.S. producers seldom deployed it. The anaerobic conditions of the ponds created a putrid, noisome, and unhealthy environment for workers and surrounding communities. Producers in the United States wanted little to do with the process. In the 1840s, to improve the supply of naval-grade cordage, the Federal Government provided incentives for water retting but the added value of the fiber was not economical in the face of the lives of bondsmen lost to the endeavor, and the practice was abandoned (Bidwell, 1925).

A second method, summer retting, involved spreading the crop on the ground each evening to collect dew and bunching the material together the next day to keep the material moist. This practice was repeated until the fibers were suitably retted– but it was the method least employed by hemp growers given the high labor demands and the interference with concurrent duties associated with other crops (Herndon, 1963). More commonly, hemp was winter retted in the English colonies. At harvest, the crop was bundled into sheaves and placed along fences or left standing shocks. These later were spread on the ground after the warm season had ended, allowing the fibers to break down over the course of two or three winter months (Herndon, 1963).

Following retting, the stalks were stacked in shocks and dried again before decorticating. The decortication process, that is, the breaking the stalk's long outer bast fibers from the short interior pith or 'hurd', traditionally was done by hand with a hemp brake (**Fig. 5).** This required some amount of strength and skill to break the stalks without damaging the long fibers (Wright, 1918). The "broken" fibers then were "scotched" or scraped to remove the bulk of the hurd before the combing or "hackling"' process was used to straighten the bast fibers and remove residual impurities. Once fibers were satisfactorily extracted and straightened, they were spun into thread or yarn for woven products or cordage.

Clearly, hemp production was extremely physically demanding. The reasons why the industry so long remained reliant on outdated technologies and practices seems less apparent. Where mechanization had begun to supplant human labor and lower costs for other plant fibers, the hemp industry remained slow to change. As an early USDA report noted, "hemp is cleaned in the field, the cumbersome slat brake…in use for a hundred years or more in Kentucky being still employed" (Dodge, 1892).

Recognizing the need for mechanization, USDA supported research in Wisconsin and California (**Fig. 6.**) in the early 1900s. As one researcher mused, "no progress with hemp could be made as long as the crop was dependent on hand labor" (Wright, 1918). Application of engineering technologies to hemp production (assisted by declining European supplies following World War I) would help hemp to flourish in Wisconsin before political circumstances began to stifle the industry.

Hemp's Fall in the West

Early 20th century efforts of researchers such as Lyster Dewey at USDA and A.H. Wright at the University of Wisconsin would make significant progress for bringing hemp production into the modern age. Wright worked to develop cropping rotations, mechanize production practices, and support centralized processing centers (within regions suited for the crop) to economically supply Wisconsin processors (Wright, 1918). Dewey's breeding program created several hemp varieties and made substantial progress in stand yield (Dewey, 1928).

Despite these engineering and breeding advances, hemp's downward trajectory soon began due to conflation of the industrial crop with psychotropic strains of cannabis. Concern about the effects of recreational cannabis use came to the attention of the U.S. Federal Bureau of Narcotics and President Franklin D. Roosevelt, who supported legislation to restrict the production of psychoactive cannabis varieties (Ehrensing, 1998). In spite of opposition from the American Medical Association, the Marihuana Tax Act (MTA) passed in 1937, and it was from this point that the moniker "hemp" would begin to give way to marihuana/marijuana for all things related to cannabis. The MTA placed cultivation of all *Cannabis* under control of the U.S. Treasury Department (USDA, 2000) and required growers to register and obtain licensure from the federal government. It was not an outright ban, but certainly a powerful effort to significantly reduce hemp production.

There is no small irony in the fact that in the subsequent year Popular Mechanics

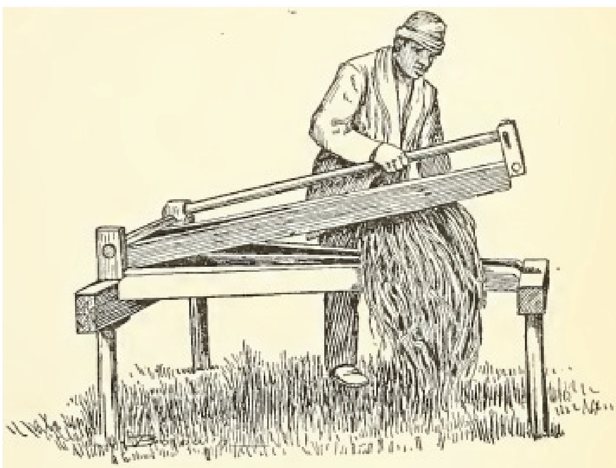

FIG. 38.—Kentucky hemp brake.

Fig. 5. Image of a hemp brake for decorticating hemp. Image from Dodge (1897).

Fig. 6. Hemp production was tested in California around the turn of the 20th century. By the early 1900s California became the third largest hemp producer in the US, following Kentucky and Wisconsin. Image from the 1903 Yearbook of Agriculture (Dewey, 1904).

(Anonymous, 1938) published an article suggesting hemp would be the "new billion dollar crop." A billion dollars at that time was unimaginable to persons of almost any means, and the article declared "over 25,000 uses for the plant ranging from dynamite to cellophane." Hemp was coming into its own as a viable crop for North American farmers and a potential resource for literally thousands of consumer goods at just the wrong time.

Although some production persisted in Wisconsin, the constraints of the MTA effectively stifled the crop in the United States until fiber supplies to this country were interrupted by events during World War II. Several thousand farmers were thus recruited to grow "Hemp for Victory" (Johnson, 1999) and the USDA's Commodity Credit Corporation contracted War Hemp Industries, Inc. to construct several processing mills in the Midwest. Production peaked in 1943 to 1944 (USDA, 2000), only to decline again in the face of competition from cheaper imported fibers, the development of synthetic fibers, and renewed legal restrictions after the war.

Hemp in Eastern Europe and its Western Revival

Although numerous claims and conspiracy theories can be found concerning the reasons for hemp's demise in the west, these mostly are overblown (Duvall, 2014). In reality, hemp fibers faced the same challenges in Eastern Europe and Russia through the middle of the 20th century (Duvall, 2014). Demand for hemp declined in the face of cheaper alternatives and new synthetic filaments; new celluloid-based adhesive tapes also reduced the need for packaging twine. These issues, coupled with the restrictions surrounding hemp's potential for drug use were effective at suppressing the crop's production in the West.

Perhaps because of the long history of use or because of the fewer apprehensions about misuse as a drug (indeed, the low levels of THC may not have made this a concern) cultivation of hemp did not die in Eurasia. Breeding programs continued in attempts to develop uniform hybrids and monoecious (having both male and female flowers on the same plant) varieties. Much of this work, conducted from the 1930s through the 1960s, occurred in the former Soviet Union and Communist Block countries (ArynŠtejn and Hrennikova, 1967; Bócsa, 1958; Breslavec and Zaurov, 1937; Davidjan, 1963; Grecuhin and Belovickaja, 1940; Nevinnyh, 1962; Nikiforov, 1958; Rjazanskaja, 1963; Sizov, 1934). Hemp did not completely die in the west, either, as research continued in Italy from the 1930s to address issues related to agronomic practices and fiber quality (Zatta et al., 2012).

Although Western European countries had legal grounds for allowing hemp research in the 1970s (EC, 1971), efforts to revive industrial hemp as an agronomic crop in areas further to the west largely arose during the 1990s (Health Canada, 1998, EC, 1998). Production has been allowed in the European Union and in Canada provided hemp varieties contained less than 0.2% or 0.3% THC (Europe and Canada, respectively Since that time a raft of studies have evaluated a variety of items from agronomics to breeding to production and processing systems and end uses (*e.g.*, see Fike, 2016).).

It is interesting to note here the modern and entirely artificial definition of hemp ($\leq$ 0.3% THC) versus marijuana (> 0.3% THC), as both are clearly members of the species, *Cannabis sativa*. As is obvious throughout this chapter, hemp has been the most common reference name of *Cannabis sativa* until the passage of the MTA. We often refer to the founding fathers of the United States (e.g., George Washington and Thomas Jefferson) as hemp farmers and even as vigorous supporters of hemp production. At that time, there was no understanding of the biochemistry of the species that now defines cannabinoids. We did not know what THC was; only that some hemp plants were intoxicating. Yet, we often refer to the cannabis grown during that era as hemp, even though it seems far more likely it would have produced levels of THC that exceeded our definition of marijuana today. Did Jefferson and others both promote and grow marijuana? Most would agree they most certainly did, based on the standards used to define these crops today. At this writing and in all but two developed countries (Uruguay and Canada), it is still wholly illegal grow marijuana, but in these same and other countries, it is also legal to grow hemp.

In the United States, grassroots lobbying efforts helped state governments to recognize undue restrictions on hemp. Although several states authorized feasibility studies to determine its potential value as a crop (USDA, 2000), restrictions imposed by the U.S. Drug Enforcement Agency (DEA) initially impeded this work. DEA's continued treatment of hemp as a Schedule I controlled substance, regardless of its THC content, made work with hemp as a crop all but impossible, particularly at a commodity scale.

The political winds buffeting hemp production have changed markedly in the 21st century. In the United States, hemp as a potential commodity crop largely has been rehabilitated with support from both ends of the political spectrum. Passage of the U.S. Farm Bill (signed into law as the Agriculture Act of 2014) created room for hemp study through section 7606, on "The Legitimacy of Industrial Hemp Research" (U.S. Congress, 2014). Several states now are actively engaged in hemp research and even vigorously supporting the development of hemp industries. Although answers to questions of "when" (rather than "if") hemp's outright legalization will occur remain unknown, these changes to the law bode well for hemp to legally return to U.S. production fields with the support of the federal government.

The Future for Hemp?

Much has been made of the potential for industrial hemp. Indeed, the crop's genetic potential to produce high quality seeds and fibers and the multitude of products (Fig. 7.**)** for which its constituents can be deployed certainly warrants the renewed exploration. Whether it can live up to claims of being "[h]umankind's savior" (!) (see Cherney and Small, 2016) undoubtedly is overblown and unlikely (and frankly, unnecessary and perhaps even counterproductive). The growing number of potential industrial applications for the plant give testament to the fact that hemp could exist once again as a valued member of the pantheon of agricultural crops. Conspiracy theorists that suggest "conniving industrialists and politicians… defeated hemp in the 1930s to favour competing industries…neglect much economic history" (Duvall, 2014). Ultimately, economics will again arbitrate the place for hemp, assuming growers, industry, and consumers have the ability to pursue such opportunities and uses to their full potential.

Summary

Cannabis is thought to have originated in central Asia. From the time of human interaction and intervention with the species, bands, clans, and tribes drove its dispersal across Asia and into Europe. The plant's seeds and fibers have played significant roles in meeting the basic needs of humans and it was an important plant material for ritual and religious experience. Cannabis played an important role in the advancement of human societies through its contributions to "string technologies" and likely contributed to the development of agriculture. Over time, Cannabis would become critical to European empires and nation-states that depended on its fibers as a means of obtaining wealth and power. From the 1500s, European nations carried the crop to the western hemisphere in efforts to expand supplies. Historically, hemp fiber systems were slow to mechanize and economically successful fiber production largely was based on captive (feudal or slave) labor. Use as a "war crop" also features prominently in hemp's history in the United States, with demand driven both by need and by lack of access to cheaper, imported fibers. Restrictions on

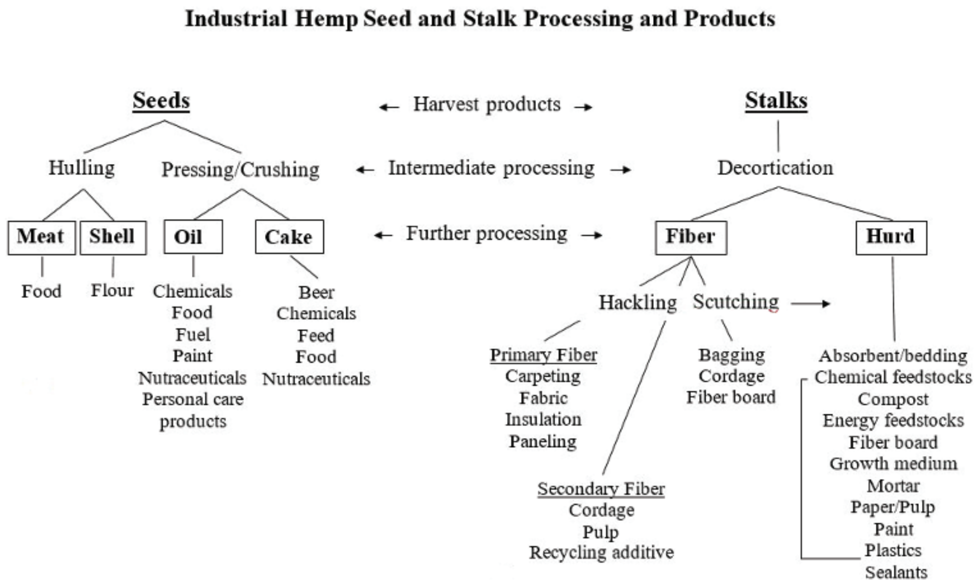

Fig. 7. Industrial hemp products and processing routes. Modified and adapted from Kraenzel et al. (1998). Decortication breaks the inner fibers from the long outer 'bast' fibers of the phloem. Scutching, a scraping process, removes the inner core fibers, or 'hurd'; hackling involves "brushing" and aligning the fibers prior to processing for textiles (Small, 2015).

hemp production occurred during the middle quarters of the 20th century in much of the West, put in place based on concerns over recreational drug use. Production and plant improvement efforts that continued with hemp during that time were largely attributed to the Soviet Union and countries of the Communist Bloc. Growing recognition of the distinction between fiber and recreational cannabis (and perhaps a changing of attitudes toward recreational use) have helped rehabilitate hemp as a commodity crop in the West. Hemp's primary use, historically, has been as a fiber crop and new process methods and uses are being found for the plant's fiber fractions. Production strictly as a grain crop is largely a 20th century construct. Growing recognition of the potential nutritional and health benefits of hemp seeds and essential oils from flowers contributes significantly to making this an important part of the hemp production portfolio. Hemp may have much to offer as a food, feed, fiber, fuel, and nutraceutical crop, but it remains to be seen how it will compete as a commodity crop. Ultimately, and provided that government interventions no longer hinders its use, economics will be the final arbiter of hemp's success as a commodity crop; a very simple matter of supply and demand.

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