2

Human Ecology in Continental and Insular East Asia

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> People, plants, animals, the land, and everything else on earth are interlaced in singular and sometimes dysfunctional ways.
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> Daniel W. Gade 1999: 1

Continental East Asia is loosely demarcated by the Tibetan plateau in the west, the Tian Shan and Altai mountain ranges in the northwest, the Yablonevy and Stanovoy ridges in the northeast, several distinct mountain ranges including Hengduan Shan and Fan Si Pan Sa Phin in the south, and the expanse of the Pacific Ocean on the east and southeast (figure 2.1). For *Homo sapiens*, with their capacity to move from place to place, these geographic boundaries are relatively permeable. Nevertheless, during prehistory and early history they circumscribed a conglomerate of human communities that formed an interaction network, an ancient *oikoumene*, within which genes and ideas were traded more freely than with outsiders.

Kwang-Chih Chang proposed the concept of a Chinese interaction sphere[1] to represent the indigenous cultures of the Huang He (Yellow River) and Chang Jiang (Yangtze River) valleys that were interlinked since at least the time of the Neolithic (Chang 1986: 241). However, developments within early human communities across East Asia, including innovations in lithic technology (Sagawa 1998), the transition to farming (Crawford and Shen 1998; Crawford and Lee 2003; Bettinger et al. 2007; Barton et al. 2009; Crawford 2009; Jones and Liu 2009; Ahn 2010; Zhao 2010; Cohen 2011; Fuller and Qin 2011; Zhao 2011), and technological advances in pottery making and metallurgy (Linduff 1995, 1998; Wagner 1999) often involved interaction over a much wider territory, encompassing both continental and insular populations; not all were centered on the Chinese core.

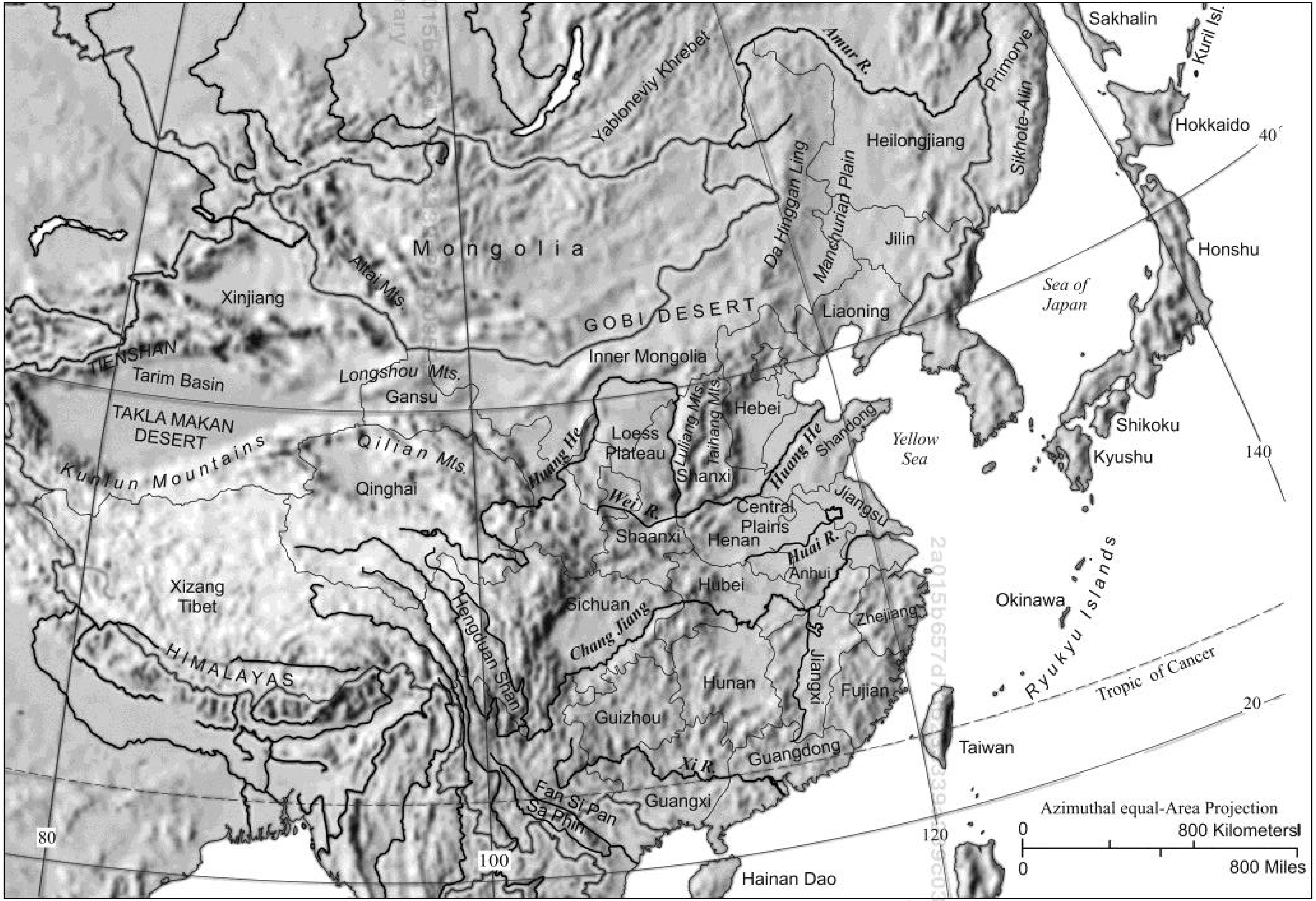

Figure 2.1. Continental East Asia.

To say that an area of over 12,000,000 km^2 encompasses diverse ecological settings would be to state the obvious. The East Asian landscape, often dominated by hills or low mountains, gives ample opportunity for microclimate formation. Ecosystems range from dense subtropical forests in the south to deciduous and coniferous forests in the north, as well as alpine grasslands at higher altitudes. However, when the large extent of continental East Asia is considered, environmental settings are fairly monotonous when compared with the extreme zonality found in the South American Andes, New Guinea, or Madagascar. From southeast to northwest, climate gradually changes from monsoon-dominated subtropics to temperate continental with well-expressed seasonality. This is not to say that climate in the area is stable or predictable, as severe droughts and heavy rainfall causing floods show great interannual variability across the region (Yang and Lau 2004). Limited zonality, overshadowed by considerable climatic change from season to season and year to year, likely favored population movement and did not considerably obstruct the exchange of farming technology and other innovations among distant communities.

Cold boreal climate dominates Manchuria, as well as northern Hokkaido. Japan, with four main islands and numerous smaller ones, extends from the subtropical latitudes in the south (Okinawa, 24° north) to the subarctic north (45° north). Nonetheless, with very limited lowland areas, much of the land falls within the temperate zone. The archipelago is mountainous, extensively forested even today, and experiences very high levels of rainfall. Vegetation ranges from warm, broad-leaved evergreen forests in Kyushu, Shikoku, and the south of Honshu, to deciduous and mixed forests in Honshu and coniferous forests in Hokkaido, with alpine and subalpine vegetation at higher elevations (Aikens and Higuchi 1982: 1–2).

Initial Peopling of the Region

When and in what manner our conspecifics first reached East Asia is a subject of vigorous debate among the supporters of various multiregional continuity, assimilation, and out-of-Africa or replacement models of human origins (e.g., Pope 1992; Aiello 1993; Wu X 1998, 2004; Wu R 1999; Wolpoff et al. 2000; Liu et al. 2010). That discussion is outside the scope of this volume. No scientist would contest that modern humans were well established in continental East Asia by the Late Pleistocene. A mandibular fragment with symphyseal morphology characteristic of anatomically modern humans, found in 2007 at Zhiren Cave (智人洞) in southern Guangxi Province, seems to document that anatomically modern humans entered East Asia very early, possibly at the very beginning of the Late Pleistocene (Liu et al. 2010). Other anatomically modern fossils found in China include a calvarium from the south slope of Xujiafen Hill in Huanglong (黄龙) (Wang and Li 1983) and a tooth from the Changwu (长武) site in the Yaotouguo Valley (Huang and Zheng 1982), both in Shaanxi Province; the perfectly preserved Liujiang (柳江) skull and a hip bone from the Tongtianyan Cave in Guangxi (Wu R 1982; Wu X 1997); and five teeth from Fox Cave (Lidong—狸洞) at Qingliu (清流) in Fujian (Dong and Fan 1996).

Because many of these specimens were recovered during the first half of the twentieth century, there is considerable ambiguity in their dating. Direct AMS dating of collagen extracted from a Xarus Valley human femur, formerly presumed to be a Pleistocene fossil, yielded dates as recent as 300–190 BP (Keates et al. 2007). Uranium series dating of breccias presumed to have been associated with the Liujiang find are suggested to indicate that the skull dates to no less than 67,000 BP and more likely to 111,000–139,000 BP (Shen et al. 2002; Wang et al. 2004). According to alternative stratigraphic assumptions, the same skull may be approximately 153,000 years old (Shen et al. 2002). However, doubts about the precise relationship between the dated breccias and the fossil allow considerable uncertainty about the Liujiang skull's actual age (Brown 1999). *Homo sapiens* crania from the Upper Cave at Zhoukoudian probably date to the terminal Pleistocene or early Holocene. Radiocarbon dates obtained directly from animal bone recovered inside the cave include 10,770+360 BP for bone found in the vicinity of the burials and 18,865+420 BP for a deer bone found in the Lower Recess (Institute of Archaeology–CASS 1991: 17; An 1991).

Through colder phases of the Middle and Late Pleistocene, land bridges formed between continental East Asia and the islands of the Japanese archipelago, both in the north, joining Hokkaido and Sakhalin with outer Manchuria, and in the south, across the Korean strait from the Korean peninsula to the consolidated mass of Honshu, Kyushu, and Shikoku (Aikens and Higuchi 1982: 27–28). Taiwan and hundreds of smaller islands south and east of China were also periodically consolidated with the continental land mass. In eastern Taiwan, the Paleolithic Changbin (長濱) culture in the south and Zuozhen (左鎮) culture in the west mark human presence in that area by 30,000 years ago (Song 1969). The advancement of China's coastline up to 600 km during the Younger Dryas (12,700–11,500 BP), the last glacial maximum of the terminal Pleistocene (Peng et al. 1984), also made that a likely time for human migration from the continent onto what are now islands off East Asia.

A series of Late Pleistocene human fossil material has been recovered in

Japan and its vicinity over the years (see Matsu'ura 1999 for a summary), the earliest of which thus far came from the Minatogawa (港川) Fissure of Okinawa Island and was dated by radiocarbon to between 18,250+650 and 16,600+300 BP (Matsu'ura 1982). These specimens show morphological resemblances to both the Liujiang skull from southern China and later Jomon (縄文) fishers and foragers occupying the Japanese archipelago between 12,000 and 2300 years ago (Suzuki and Hanihara 1982; Baba and Narasaki 1991). However, the pertinent literature emphasizes that the Minatogawa skeletal material does not represent direct ancestors of Jomon people in Japan but instead shared a common continental ancestry with them. Cranial and dental features, in turn, suggest that Jomon people resembled the Ainu (アイヌ) of Hokkaido (北海道) and, to a lesser degree, the Ryukyu (琉球) of Okinawa (沖縄) (Hanihara 1984; Brace et al. 1989; Hanihara 1991, 1993; Kozintsev 1992; Pietrusewsky 2000; Fukumine et al. 2006), as also seen in their mtDNA (Horai et al. 1991). Consequently, indigenous Ainu and Ryukyu are assumed to have retained some of the genetic distinctiveness of the Late Pleistocene migrants from the continent.

The Japanese archaeological record dates back to 25,000–30,000 BP, when edge-ground axes and associated wet-stones appeared in many parts of the archipelago, with the exception of Hokkaido (Imamura 1996a: 24). These are only a little later than the most reliably dated and provenienced edge-ground axes in the world, recently reported from northern Australia at 35,000+410 cal BP (Geneste et al. 2010). The Japanese Late Paleolithic is traditionally divided into pre- and post-Aira-Tanzawa (姶良丹沢) phases (a volcanic ash layer, well dated to 21,000–22,000 BP), with relative lithic artifact homogeneity during pre-AT and more marked regional forms appearing post-AT (Imamura 1996a: 23). Given that Japan lacks an Early or Middle Paleolithic,[2] evidence for the movement of obsidian from the Asian mainland to Japan in the Late Paleolithic, as well as mainland blade lithic precursors to this same technology in the late stages of the Late Paleolithic (Imamura 1996a: 34), is consistent with the likelihood that the Late Paleolithic witnessed the first colonization of the archipelago by anatomically modern humans.

Exactly which continental populations were the first to settle in Japan and via which route is still unresolved, with somewhat different scenarios supported by differing classes of evidence. Strong ties between modern Ainu, Jomon foragers of the early Holocene, and the natives of Polynesia and Micronesia are evidenced by cranial and dental characteristics (Turner and Hanihara 1977; Turner 1979; Brace et al. 1989), which implies that the earliest inhabitants of the Japanese archipelago were Austronesian and Southeast Asian (Hanihara 1991). Classical genetic markers found in modern Ainu and

Ryukyu link Pleistocene migrations into Japan to Northeast Asia (Omoto and Saitou 1997).

A somewhat different scenario for the peopling of Japan is suggested by the distribution of Y-chromosome haplogroups (Hammer et al. 2006). Mutation sequences of Haplogroup D, the most common in Ainu and Ryukyu people, are ultimately traced to Central Asia and offer evidence of geographic expansion into the Japanese archipelago at approximately 20,000 BP. In contrast, Y-chromosome Haplogroup O, the most common in Japan overall, is associated with population expansion in Northeast Asia dated to 4000 BP, culminating in substantial migrations to the Japanese archipelago around 2500 BP (Hammer et al. 2006). These genetic results are supported by cranial and odontometric studies indicating that Jomon foragers were similar to North Asian people (Pietrusewsky 1999; Seguchi et al. 2007), while Yayoi (弥生) agriculturalists, along with the modern population of Japan, are more similar to migrant groups from Korea or northern China (Brace and Nagai 1982; Turner 1990; Nakahashi 1995; Pietrusewsky 1999; Nakahashi et al. 2002).

Following the Upper Paleolithic, population movement and interaction within continental East Asia, as well as between the continent and the islands, became extremely complex. Because these phenomena shaped the morphogenetic, cultural, and linguistic variation of both ancient peoples and their descendants, affected the trajectories of indigenous agriculture, animal husbandry, and technological development, and altered the epidemiological landscape, their accurate reconstruction serves as one of the overarching themes of bioarchaeological research in this area. As such, population movement and interaction are treated in detail throughout this volume. The most prominent routes of biological and cultural exchange followed on periodic invasions of China from the steppe, incessant movement along the Silk Road (Han 1994; Guo et al. 2001; Suzuki et al. 2005; Tan and Han 2007), and the aforementioned expansion into Japan, which began at about 300 BC (Imamura 1996b).

Paleoeconomy

Only a modest number of studies focused on human skeletal remains have considered the possible impacts of the introduction of new types of cooking vessels or other changes in ceramic technology and metallurgy on indicators of diet and health, as well as on cranial and dental morphology (Brace 1962; Scott 1979; Hinton 1982; Kaifu 1999; Eshed et al. 2006; Mahoney 2006). Nevertheless, the development of pottery and—much later—the use of metals for vessel production probably had profound effects on the distribution of skeletal markers. More effective heating and boiling of food in ceramic containers alters its texture and dietary value, while helping to extirpate some pathogens and break down toxins, thus affecting patterns of dental wear, as well as the distribution of dietary deficiencies and parasitic loads. With improvements in pottery technology, more heat-resistant vessels would have allowed prolonged cooking, simmering, or sautéing at higher temperatures (Braun 1983; O'Brien et al. 1994). The sharing of utensils both within and between families may help to propagate certain pathogens and intestinal parasites across a community. Finally, the use of certain metal alloys in the manufacture of cooking vessels can introduce traces of lead and other heavy metals into food.

East Asia was peculiar in its early development of pottery, predating plant and animal domestication by a substantial margin. Pottery appeared during the terminal Pleistocene in the Russian Far East and southern China and only slightly later in northern China and Japan (Kuzmin and Orlova 2000; Kuzmin 2002, 2006; Keally et al. 2004; Wang 2005; Boaretto et al. 2009). In the Amur area and Primorye, containers made of fired clay were recovered from six archaeological sites with radiocarbon dates spanning a time period from 14,510+240 to 9,360+30 BP (Zhushchikhovskaya 2005: 24). In China, at least two centers of early pottery making have been identified. The southern area is represented by early pottery from archaeological sites left by foragers and fishers in Jiangxi, Hunan, Guangxi, and Zhejiang, with radiocarbon dates possibly as early as 17,238+237 BP from Guangxi. The northern area encompasses sites in the Beijing area and in Hebei Province dated to the earliest Holocene (Wang 2005). Nanzhouangtou (南庄头), in Hebei Province, is one of the earliest pottery-bearing sites in the north, with associated radiocarbon dates ranging from 10,815+140 to 9,690+95 BP (Yuan 2007). Even earlier dates (18,300 to 15,430 cal BP) were obtained based on charcoal and collagen from animal bones associated with pottery from Yuchanyan (玉蟾岩) Cave (Boaretto et al. 2009).

During the time of the Middle Neolithic Yangshao (仰韶) (c. 5000 to 3000 BC) and Dawenkou (大汶口) (4100 to 2600 BC) cultures, the technical quality of pottery and perhaps its resistance to heat increased in northeastern China with the development of new pastes and pottery kilns that allowed higher firing temperatures. There was further technological improvement in Late Neolithic Longshan (龙山) (3000 to 2000 BC), with the introduction of the pottery wheel (An 1988a; Liu 2003). Wheel-thrown, thin-walled pottery of the Late Neolithic was probably more heat resistant than earlier wares, affording the use of different food processing techniques or more prolonged cooking (Braun 1983; O'Brien et al. 1994).

Residue analyses of Late Neolithic pots from Shandong indicate that some of them were used for the production or serving of fermented beverages (McGovern et al. 2004, 2005). Further refinement of vessel forms and decoration, as well as the unequal distribution of fine and coarse wares in archaeological sites from the Late Neolithic and subsequent Dynastic period on, marked a shift toward using pottery as an elite good and in rituals (Liu 2003), thus redefining the extent to which these wares were shared among community members and the routes via which pathogens could spread.

Copper and bronze apparently first entered the Yellow River valley from the steppe area via a northwestern route during the Late Neolithic (c. 3000 BC) (Linduff 1998). Among the earliest uses of these metals in northern China was production of drinking vessels imitating those made of clay, as well as to make other utilitarian objects (Liu 2003). Use of these utensils provided ample opportunities for the introduction of toxic residues into human food.

Subsistence

Continental East Asia

Plant and Animal Domestication

Initial experimentation with cereal cultivation in China has generally been thought to have begun about 10,000–9,000 years ago (Wu Z 1998; Xu 1998; Xiang 2000; Yi 2000). However, recent AMS radiocarbon dates determined directly from grains of broomcorn millet (*Panicum miliaceum*) recovered at the Early Neolithic Cishan (磁山) site in Hebei suggest that millet-based food production was already well established in northern China by ~10,400–10,100 cal BP, on the brink of the Holocene (Crawford 2009; Lu 2006). With increasing warmth and humidity during the early Holocene, reliance on domesticated monogastric animals and on cereal agriculture combined with vegetable horticulture and some foraging activities became more widespread (Ho 1977; Liu and Chen 2003; Yan 2005; Jiang and Liu 2006; Flad et al. 2007; Yang et al. 2009). During this favorable climatic episode, cereals were apparently cultivated not only for human consumption but also as support for large numbers of domesticated animals, including pigs and dogs (Pechenkina et al. 2005; Barton et al. 2009).

Staple cereals grown in ancient China included five species of grasses with somewhat complementary qualities. Rice (*Oryza sativa*) is a warmth- and water-loving cereal that is resistant to overwatering. When grown in paddies under favorable environmental conditions, it is probably the most productive Old World cereal, with crop yields as high as 1,290–1,385 kg per ha (Allan

1970). However, when cultivated on dry land, rice yields only about half of its potential. Although the overall protein content of rice is low, it is not as lysine deficient as the majority of other cereals. The two species of millet grown in East Asia, foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*), are among the least fastidious of cereals, resistant to heat, cold, drought, and poor soil quality. Both can produce reasonable crop yields over a short growth season with very little care (Zohary and Hopf 2001: 83, 86; Lu 1999, 2002). Millet grains are tiny and fairly rich in protein (9.5–13 percent of dry weight) but are very lysine deficient, even more so than maize. Wheat (*Triticum aestivum*) is a cereal with a very high output, moderately resistant to cold, but it requires watering, especially during the dry springtime of the north. Wheat is also rich in protein (8–14 percent) (Zohary and Hopf 2001: 19; Zhao 2002). Finally, barley (*Hordeum vulgare*) also has a fairly high protein content and is very cold resistant but gives only modest yields (Zhao 2002; FAO 1972).

During the early Holocene, a warmer climate and increased annual rainfall allowed the spread of wild rice, *Oryza rufipogon*, into the Yangtze Valley (Yan 1989, 1997; Zhao 1998; Zhao and Piperno 2000) and central Henan (Zhang and Wang 1998), much farther north than it grows today. Consequently, a broad front of domestication for this cereal seems possible. Phytoliths of domesticated rice were recovered from the 9,000–10,000-year-old zone of Diaotonghuan (吊桶环) Cave, located in the middle reaches of the Yangtze (Zhao 1998). Rice phytoliths dated to around 10,000 years ago were also recovered from the Shangshan (上山) site, Zhejiang Province, in the lower reaches of the Yangtze (Jiang and Liu 2006). A sequence of rice phytoliths evidencing progressive domestication between 7000 and 5800 BC has been reported from Jiahu (賈湖), in the Huai River area (Chen et al. 1995a,b,c). However, Fuller and colleagues (2007) note that Jiahu rice is small and morphologically similar to its wild progenitor.

Grains of rice morphologically intermediate between the domestic and wild species were recovered from the Yuchanyan (玉蟾岩) site in Hunan Province, with radiocarbon dates ranging between 14,080+270 and 12,320+120 BP. The earliest direct AMS dates on grains of carbonized rice were determined from specimens recovered at the Pengtoushan (彭头山) site on the Lake Dongting plain (7,775+90 and 7,259+150 BP), confirming that rice agriculture was being practiced in that area by over 7,000 radiocarbon years ago (Crawford and Shen 1998). Rice agriculture apparently reached Taiwan via seafaring from southern China around 6,000 years ago, as evidenced by the Dapenkeng (大盆坑) Neolithic tradition on the island (6000–4500 BP) (Chang 1969).

Despite the evidence for early domestication of rice, its role in the subsistence of ancient Chinese is far from clear. Analysis of phytolith sequences from Qingpu (青浦), south of the Yangtze (Itzstein-Davey et al. 2007), suggests that cultivation of domesticated rice in this region did not commence until approximately 300 BC, while collecting wild rice retained its importance for another 250 years. Stable isotope analysis of human bones from Jiahu (Hu et al. 2006) indicates strong reliance on C3 plants, which might include rice, with highly variable amounts of meat and freshwater aquatic resources also being exploited. Poor oral health at this site suggests a heavy emphasis on cereal agriculture (Smith 2005). However, the dental sample available for Jiahu is tiny, and it is not always clear with which strata the analyzed skeletons were associated.

Historically, rice agriculture in southern China relied on paddy construction using the swamp buffalo (genus *Bubalus*) as a draft animal, increasing rice yields and helping to extirpate less water-resistant weeds. Use of paddies for rice agriculture probably became established sometime before 4000 BC, as suggested by preserved features at Hemudu (河姆渡) in Zhejiang (Zhao and Wu 1987; Zhao 1998). Small, shallow depressions found in the vicinity of the Jiahu and Pengtoushan sites, oval or round in shape and dated to between 7000 and 6000 BC, have been commonly interpreted as paddies, although they might have been fishponds or water reservoirs (Liu 2000).

When domesticated buffalo became an integral part of the wetland rice agriculture complex is more uncertain. Chen and Li (1989) proposed that *Bubalus* was domesticated circa 5000 BC, based on common finds of its skeletal elements in early archaeological contexts. Because *Bubalus* remains were recovered at Hemudu, Zhao (1998) argued that buffalo were employed for paddy construction as early as 4000 BC. However, reexamination of bovid remains from a number of archaeological sites and tests of ancient DNA by Liu and colleagues (2006) have resulted in the conclusion that buffalo remains from Neolithic archaeological contexts are of those of wild animals and that domesticated *Bubalus bubalus* was introduced from South Asia as late as 1000 BC.

In the Yellow and Wei River valleys of northern China, millets were the dominant crop plants during the Neolithic. During the third millennium BC, wheat and barley were introduced to northern territories of China from the steppe through the Hexi (河西) corridor (Flad et al. 2010) and then spread into the Central Plains by 1600–1300 BC (Lee et al. 2007). Both foxtail and broomcorn millet were probably domesticated locally, as their earliest appearances in the paleobotanical record of the Old World were in northern China. *Setaria viridis*, the wild progenitor of foxtail millet (*Setaria italica*), still grows there (Lu 2002), whereas the wild ancestor of *Panicum miliaceum* has not been conclusively identified and might no longer exist (Zohary and Hopf 2001: 83). Through the Neolithic, foxtail millet was the preponderant crop on the Central Plains, and broomcorn millet was grown in smaller quantities (Ho 1977; Yan 1992, 2005; Lee et al. 2007).

Carbonized millet and abundant agricultural tools have been recovered from Early Neolithic sites of the Peiligang (裴李崗), Cishan (磁山), and Dadiwan (大地灣) cultures (An 1984; Ren 1994; Lu 2006). In archaeological sites of the Middle Neolithic Yangshao culture, grains of carbonized millet, agricultural tools, large storage pits, and grinding stones are ubiquitous, indicative of a well-developed dryland agricultural regime (Chang 1968). During the Erlitou (二里头) culture, all four cereals were cultivated, possibly to help ensure greater crop stability and caloric output as an adaptation to the onset of more adverse and unpredictable environmental conditions between 1900 and 1500 BC (Lee and Bestel 2007; Liu 2009: 226).

Rice does not grow very well in the north, because of insufficient rainfall and lower temperatures. Nevertheless, rice cultivation apparently spread into the Yellow River valley around 5,000 years ago, where it was probably grown in small quantities near the waterways (Yan 1982; An 1988b; Jiang and Zhang 1998; Lee et al. 2007). Analysis of pottery residues from the Liangchengzhen site in Shandong indicates that rice was the main component of fermented beverages mixed with honey, fruit, plant resin, and possibly other ingredients; millet, while common in the archaeobotanical record of the site, evidently was not used in this way (McGovern et al. 2005). Thus, the rice grown in small quantities in northern China might have been defined by its importance as a component of specific recipes.

The husbandry of monogastric animals (pigs, dogs, and chickens) in China probably developed in parallel with agriculture. On the one hand, cereal agriculture was necessary to generate fodder for these animals. On the other hand, consumption of human food leftovers by pigs and dogs allowed conversion of calories that otherwise would have been wasted into dietary fat and protein. The earliest known domesticated dog, as diagnosed by size reduction, comes from the early pottery-bearing site of Nanzhouangtou (8000–6000 BC), in Hebei (Yuan 2007). Wild boar, native to the forests of ancient East Asia, was probably domesticated independently in several areas of northern and southern China (Zhou 1981; Wang 1985; Yuan and Flad 2002; Yuan 2007).

The Xinglongwa (興隆洼) site in Inner Mongolia (6200–5000 BC), which has produced evidence of early millet agriculture, the Cishan site (6000–5000 BC), and the early rice-bearing site of Kuahuqiao (跨湖桥) (6200–5000

BC) in Zhejiang Province of southeastern China all have evidence of incipient pig domestication (Yuan 2007). The frequency of pig remains in archaeological assemblages increased through the Middle Neolithic, so that by 3500 BC pig bones were predominant in some faunal assemblages from northern China (Yuan and Flad 2002; Ma 2005). When and where chickens were domesticated remains controversial, mainly due to poor preservation of small bones and the difficulty of species diagnosis (Yuan 2001). Nevertheless, finds of chicken bones have been reported from Chinese Middle Neolithic sites, including Beishouling in Baoji Province, Banpo in Xi'an, Jiangzhai in Lintong, and Nanzheng in Longgangsi, as well as Miaodigou in Shanxian and Baiying in Tangyin (Ren 1994).

The modes of millet use during the Neolithic and Early Dynastic periods in China are still being investigated. Judging from abundant grinding stones and some serendipitously preserved millet noodles from Lajia (喇家) (c. 2000 BC), in Qinghai Province, northwestern China (Lu et al. 2005), millet grain was being converted into flour and dough for human consumption in some places by about 4,000 years ago. As previously mentioned, millet also seems to have played an important role as fodder for domesticated animals, such as pigs, dogs, and fowl (Pechenkina et al. 2005; Barton et al. 2009). Studies of oral pathology (Pechenkina et al. 2002; Smith 2005) carried out on the remains of Middle Neolithic farmers from the Wei River valley—presumably engaged in millet agriculture circa 5000 to 4000 BC—found low to moderate frequencies of carious lesions, with a subsequent sharp increase in oral pathologies thereafter. This suggests either that until about 4000 BC millet was only consumed in modest quantities or that millet processing and cooking techniques changed at around that time in such a way as to increase its cariogenicity.

Agriculture and Animal Husbandry in Northeast Asia

North of the Kunlun and Longshou Mountains and beyond the Yellow River valley, a continental climate with low precipitation and harsh winters made plant cultivation both challenging and unreliable. Instead, mobile economies reliant on herding sheep/goats, cattle, and horses became established between 3000 and 2000 BC in northern and northwestern Mongolia (Allard and Erdenebaatar 2005). The Andronovo (Андроново) culture of horseback riders and herders in western Siberia (2300–1000 BC) had a pronounced influence on populations of the Tarim basin, as suggested by the presence there of typical Andronovo implements (Mei and Shell 1999), as well as by cranial morphologies that are usually linked to Andronovo nomads (Han 1986). Hills and mountain ridges separate the area of Xinjiang from northeastern

China. Interaction between peoples in Takla Makan with communities of the Wei and Yellow River valleys likely proceeded via the Hexi corridor, which lies between the Longshou and Qiliam Mountains in Gansu (Flad et al. 2007). Recovery of sheep and horse bones from Qijia (齊家) sites (4200 to 3800 years ago) in the Hexi corridor suggests that some exotic domesticated herbivores were passed on via that route into northeastern China at approximately 2000 BC (Flad et al. 2007).

Cereal agriculture seems to have played a secondary role in the subsistence of pastoralists in Xinjiang and Mongolia. Nevertheless, small-scale cultivation of drought-resistant crops, such as oats, millets, and spring wheat, was apparently practiced in the Tarim basin by sedentary communities incorporated within the range of the nomadic peoples of Xiongnu (匈奴), who controlled the steppe area during the third century BC (Xie 1972; Di Cosmo 1994). Symbiotic or perhaps parasitic relations between the mobile herders of the steppe and neighboring sedentary farmers resulted in exchange of the products of these two subsistence strategies. Barfield (2001: 10) proposed that "shadow empires" were established during the Bronze Age by mobile herders who routinely extracted resources from farming communities in northern China.

Dispersal of Agricultural Crops in, out of, and within East Asia

Millet agriculture reached Korea by 3400 BC, in Middle Chulmun (즐문 or Bit-sal-mu-ni), while rice agriculture arrived within the next thousand years, probably by 2500–2200 BC, during Late Chulmun (Crawford and Lee 2003). In Russian Primorye, north of the Amur River, *Setaria* millet was cultivated as early as 2800–2100 BC (Kuzmin et al. 1998). Millets spread into the Japanese archipelago around 900 BC, where traces of *Setaria* and *Panicum*, along with individual grains of rice, are reported from northeastern Honshu (reported AMS radiocarbon dates are 2540+240 BP and 2810+270 BP) (D'Andrea et al. 1995). This early rice could have arrived in Japan by three different routes: (1) via the Ryukyu Islands from Taiwan, where rice agriculture is documented during the time of the Dapenkeng (大盆坑) culture of the third millennium BC (Chang 1969); (2) from northeastern China into northern Kyushu, either directly or indirectly from southern Korea; or (3) from the Shandong peninsula via the western Korean coast into Kyushu (Kotani 1979). The presence of substantial quantities of dietary carbohydrates in the food of Late Jomonese, suggesting reliance on horticulture and cereal agriculture as early as 1000 BC, is supported by high frequencies of carious lesions documented for human remains from this period (Turner 1979). At the same time, reliance on wild resources continued to be important for the early cereal-growing economies of Korea and Japan, while farming played a fairly minor role (Kuzmin 2002; Crawford and Lee 2003).

While cereal agriculture took a fairly long time to reach Korea, the domesticated soybean, *Glycine max*, entered the paleobotanical record of both Korea and northern China almost simultaneously. Evidence of wild legumes, which are common in northern China even today, is frequently recovered via flotation in soil samples from Late Neolithic sites, but in small quantities and showing no seed size increase that would imply domestication (Lee et al. 2007). Nevertheless, the ubiquity of legumes suggests that they were important in human subsistence networks even before domestication. Morphological changes in the seeds of wild soybean (*Glycine* sp.) suggestive of domestication are documented no earlier than during the Shang dynasty, in paleobotanical collections from the Zaojiaoshu (皂角树) site in Henan, dated to 1900–1500 BC (Luoyang Archaeological Team, 2002; cited in Lee at al. 2007). The earliest known domesticated soybeans in Korea date from about 1000–900 BC (Crawford and Lee 2003).

Within the same time frame as the initial spread of domesticated millets and rice into Korea, Primorye, and insular East Asia, domesticated wheat and barley seem to have trickled into northeastern China. These new plant foods gradually began to surpass millets in their caloric contribution to the human diet (Zhao and He 2006). Liu Li (1996) suggested that intensive interethnic exchanges in the area of the Central Plains were stimulated by climatic fluctuations and changes in the course of the Yellow River that occurred between 3000 and 2000 BC. These changes made the fertile lands of the Yellow and Wei River valleys particularly attractive for the peoples in surrounding areas, resulting in population relocation, and possibly introduction of new crops and small domesticated herbivores (sheep and goats) from the north or northwest during the time of the Late Neolithic (2600–1900 BC). Several individual grains of wheat were reported from the Liangchengzhen site of the Late Neolithic Longshan culture in Shandong (Crawford et al. 2005), while analyses of food residues on pottery from the same site suggest the presence of barley (McGovern et al. 2005). Thirteen charred seeds resembling barley were recovered from another Longshan site, Taosi (陶寺), dated to between 2300 BC and 1900 BC (Zhao and He 2006). However, *Setaria* millet apparently remained the principal staple through the Neolithic, accounting for 70.1 percent of all seeds recovered by soil flotation at Taosi.

Based on analysis of Shang dynasty (商朝) characters engraved on turtle shells, Zhao Zhijun (2002) proposed that millet, rice, wheat, and barley were all grown in the Yellow River valley by approximately 1600 BC. He noted that wheat and barley are complementary staples, because wheat has a high output and is easy to process, while barley gives smaller yields but is very cold resistant. Heavier rainfall and warmer climate during the Shang period may have favored easy adoption of these new cereals. However, it remains unclear what other factors may have contributed to the eventual replacement of indigenous millets, grown in the Yellow and Wei River valleys for thousands of years, by these foreign crops. Considering the importance of millet, not only as a human staple but also as fodder for domestic animals, and the longer growth period of wheat, a substantial restructuring of the subsistence network would have been necessary with a shift to wheat agriculture.

Japan

Developments in the Japanese archipelago were very different from those on the mainland, although the generalized theme of complexity and heterogeneity over time and space was very much apparent there as well. Following the relatively well documented (and real) Late Paleolithic came the Jomon. Perhaps the most important review in recent years of the Jomon, whether in English or Japanese, is Junko Habu's (2004) *Ancient Jomon of Japan*, from which much of the following summary is derived, unless otherwise stated. Habu notes that the enormous wealth of data on the Jomon is a direct consequence of the extraordinary number of large-scale rescue excavations undertaken by cultural resource management (CRM) organizations since the 1970s. While it comes at the expense of research-driven archaeology, which has fluctuated between approximately 100 and 400 excavations per annum as compared to an increase from 1,040 rescue excavations in 1973 to 10,164 in 1995, the amount of available data is unique in global terms.

The emergence of the Jomon is seen by Japanese archaeologists as a function of both the appearance of pottery and change in lithic technologies. Relatively recent efforts at the absolute dating of archaeological sites in Japan indicate that undecorated pottery was used at Odai Yamamoto (大平山元) I, Aomori (青森) Prefecture, northern Honshu (本州), by approximately 16,500 cal BP. This is earlier than the better-known linear-relief and nail-impressed pottery from various layers in Fukui (福井) Cave, with dates in a range of approximately 12,500–15,800 cal BP (Habu 2004: 29). Habu notes that similarly early dates for pottery in the Russian Far East (especially the Amur River region), as well as similarities in lithics, tend to suggest this area as the point of origin, at least for Jomon material culture.

In general, Habu sees the transition from the Late Paleolithic to Incipient Jomon as being associated with a forager subsistence strategy, with a shift to smaller-sized terrestrial game at the beginning of the Jomon. Moreover, there appears to be limited evidence for any significant role of marine/freshwater fish exploitation during this transition, while there are data supporting plant exploitation (particularly grinding technology) in southern Kyushu (九州) and Tanegashima (種子島) Island (Habu 2004: 247). For the most part Habu suggests that the subsistence strategy of much of the Incipient Jomon can be characterized as residentially mobile foraging.

In terms of chronological phases, for the most part dated and distinguished by way of pottery typologies, the Jomon spans more than 10,000 years: Incipient followed by Initial (variously dated up to 6000 or 7000 uncal BP), Early followed by Middle (dated up to 3500 to 4000 uncal BP), then Late followed by Final (dated to the emergence of the Yayoi at approximately 2500 uncal BP) (Habu 2004: 38–41). Despite the Jomon being both temporally and geographically extensive, Habu (2004: 62) notes that there still exists a somewhat simplistic understanding of Jomon subsistence in that a basic calendar of activities was followed: summer marine fishing/hunting; autumn plant/nut collecting; winter terrestrial mammal hunting; spring shellfish collecting. Habu prefers to use Lewis Binford's (1980, 1982) collector-forager model to address Jomon subsistence strategies. Based on reconstructions of Jomon climate, environment, and resource availability, Habu (2004: 63) argues for Jomon communities to have been more collectors than foragers and highly specialized in their organized collecting forays—targeting a limited number of items: "acorns, chestnuts, fish and marine mammals."

However, this is a subsistence economy that developed after the Incipient and Initial Jomon periods, during the Early Jomon. During the Initial Jomon, we see the first intensive exploitation of marine resources, particularly in the Tokyo Bay area. However, this was more the exception than the rule, with much of the rest of the archipelago involved in a residentially mobile forager system (Habu 2004: 249). Exceptions include Hokkaido, where sites with extensive storage facilities suggest a move to the collector end of the forager-collector continuum, and southern Kyushu, where larger settlements and a sophisticated ceremonial material culture were present (e.g., Uenohara (上野原) site #4 in Kagoshima (鹿児島) Prefecture) (Habu 2004: 250). Extensive stable isotopic work by Chisholm and Koike (1999) supports the view of a significant marine dietary input in coastally located Jomon cultures relative to inland communities (see also Akazawa 1999).

The shift to a more collector-oriented subsistence economy is clearly seen in the Early Jomon, with extensive evidence for food storage, earliest at the Higashi-Kurotsuchida (東黒土田) site, Kagoshima Prefecture, southern Kyushu, dated to approximately 13,000 cal BP (Habu 2004: 64). Both wet and dry storage pits have been excavated, with the former generally found to contain various nuts (buckeyes, walnuts, and acorns) on the rare occasion when plant materials are preserved. Wet storage pits may have served to leach out the toxins found naturally in buckeyes and acorns, although this is by no means a certainty. Because dry storage pits are not ideal for the preservation of plant materials, it is unclear what foodstuffs they were used to store. The clear importance of nut collection and storage at Jomon sites has led to speculation that a range of trees (chestnut, oak, beech, buckeye) may have been cultivated/tended (or even domesticated) to some degree. Habu (2004: 251) generalizes the Early Jomon as serial foraging with a focus on bulk exploitation of limited, albeit critical, resources. This trend is associated with a decline in residentially mobile foragers and an increase in site size, as well as site differentiation, and a concomitant increase in ceremonial material culture.

Minagawa and Akazawa (1992) describe the Jomon strategy as that of highly flexible hunter-gatherer-fishers, whereas Crawford (2008) emphasizes the importance of food and resource production for the Jomon people, proposing that they should be labeled neither as foragers nor as farmers. The high density of Jomon sites in southern Hokkaido and northern Honshu, particularly on the coasts facing the Tsugaru Strait, can in part be linked to reliance on anadromous salmon and trout fishing (Yamanouchi 1969: 94–95; Matsui 1996). The zooarchaeological assemblage from the Early Jomon Matsugasaki (松ヶ崎) site in Kyoto (京都) included bones of deer, wild boar, Japanese macaque, and flying squirrel, as well as sea perch, sea bream, and many other species of fish (Matsui and Miyaji 1998).

At more inland sites, highly negative stable isotope carbon signatures imply greater exploitation of terrestrial resources and only limited fishing (Yoneda et al. 1996, 2004). Developed arboriculture and horticulture, similar in some respects to that of prehistoric foragers in the North American Northwest, was already evident by the Initial Jomon (Matsui 1996). Large quantities of nuts were collected and processed through the duration of the Jomon (Takahashi and Hosoya 2002; Hosoya 2011). Depending on the site location, various amounts of sweet Japanese chestnut (*Castanea crenata*), Manchurian walnut (*Juglans mandshurica*), water chestnut (*Trapa bispinosa*), and bitter horse chestnut (*Aesculus turbinata*), as well as acorns were consumed. Cultivated plants included bottle gourd (*Lagenaria siceraria*), burdock (*Arctium lappa* or *Lappa major*), perilla (*Perilla ocymoides*), and goosefoot (*Chenopodium* var. *album*). By the Middle Jomon, barnyard millet (*Echinochloa utilis*), beans (*Vigna* spp.), buckwheat (*Fagopyrum esculentum*), yam (*Dioscorea* sp.) and some other cultivars were added to the repertoire (Crawford et al. 1976; Kotani 1979; Matsui 1996; Matsui and Kanehara 2006).

During the Middle Jomon, large settlement sites were common in the east, which have been interpreted, not as indicating large population sizes, but as exhibiting rather frequent reuse and return to the same sites: a characteristic of seasonally sedentary collectors rather than fully sedentary ones (Habu 2004: 252). At the same time, large sites were not common in western Japan, and this may be interpreted as a more residentially mobile foraging system in comparison to the east. During the Middle Jomon, a generalized intensification and specialization in plant food collecting and a decrease in hunting (as evidenced by a significant decrease in arrowheads) also took place. Further evidence that there was more to subsistence strategies in the Jomon than hunting and gathering (and the possible arboriculture noted above) comes from the numerous domesticated plant species utilized, albeit not as staples. The following cultigens were targeted: "egoma and/or shiso mint, bottle gourd (*Lagenaria* sp.), various beans or green gram (*Vigna radiata*), barnyard millet, buckwheat (*Fagopyrum* sp.), barley (*Hordeum vulgare*), burdock (*Arctium lappa*) and rice (*Oryza sativa*)" (Habu 2004: 59; see also Imamura 1996a: 107–8; Hudson 1999: 106).

Of particular interest is the utilization of root tubers by Jomon communities, particularly given the ostensible association of such tubers with elevated levels of oral disease (see discussion in final chapter). Virtually the only direct evidence for the use of yam comes from a single Early Jomon site, Matsugasaki in Kyoto Prefecture (Habu 2004: 70). Hudson (1999: 155–16) notes that despite common assertions of the presence of taro (*Colocasia* sp.), evidence for its cultivation is scant. Imamura (1996a: 106–9) has argued that chipped-stone axes were used for digging out tubers (likely the indigenous yam, *Dioscorea japonica*) in the Middle Jomon of the Chubu (中部) Highlands and western Kanto (関東). The lack of chipped-stone axes in sites with storage pits, and vice versa, in this region indicates that axes were probably used for other purposes, as tubers cannot be stored for any length of time. Imamura argues that in lieu of any strong evidence for the cultivation of a staple such as buckwheat at this time, the only viable option was yam digging.

Also associated with the Middle Jomon is a general increase in social complexity, as measured by the elevated frequency of ceremonial material culture and long-distance exchange networks. Nonetheless, the end of the Middle Jomon witnessed a significant decline, which has been blamed on everything from climate cooling to the emergence of major epidemics; neither of these putative causes is supported by archaeological evidence. Habu (2004: 255) suggests that this decline, in the east at least, may have been a function of overspecialization, which subsequently rendered Jomon communities more sensitive to minor environmental fluctuations. In western Japan, the situation was quite different, in that oscillations in growth and decline were more the norm, rather than any major unidirectional collapse of extant economic systems. Temple (2007) has argued that elevated levels of physiological stress among western/inland communities relative to the Eastern Jomon gives emphasis to the pitfalls associated with reliance on seasonally available resources, while an increase in caries rates from the Middle to Late Jomon suggests that major dietary changes took place.

In the Late Jomon, eastern Japan saw a decline in the number of large sites, a decrease in site density, and a reduction in subsistence and settlement complexity, albeit in the face of a rise in social complexity (Habu 2004: 255). One exception was the Tokyo Bay area, where more than half of the known shell middens in Japan (of which there are over 1,000) can be found in the Kanto district (Tokyo and surrounding areas) (Habu 2004: 71; Imamura 1996a: 78). Midden size and the time required to accumulate them suggest that shellfish would have provided limited calorific and/or protein value. Middens therefore seem to be the remains of quite seasonal exploitation, and shellfish were unlikely to have formed a staple, even in the areas where middens abound. Evidence for fishing (e.g., bone hooks and pumice floats for line fishing, stone and ceramic net sinkers for netting, bone spears and harpoons, and even the rare weir) is abundant in Jomon sites, particularly in middens.

Regarding terrestrial hunting, Imamura (1996a: 79–88) has argued that the presence of numerous shallow pits throughout the Japanese islands (some with evidence of wooden stakes on their floors) is evidence for a long, and geographically dispersed, history of pit trapping (boar being the most likely victim). Less specific forms of terrestrial hunting were carried out using the ubiquitous arrowhead (Imamura 1996a: 88), which does not appear to have been used in the Late Paleolithic. Other forms of hunting tools include spearheads and tanged points, at least during the Initial Jomon, although they had a longer history in Hokkaido and Tohoku (東北). Imamura notes a significant decline in the number of hunting tools with a major increase in population during the Middle Jomon. Coastally (specifically in Kanto District), an increase in large middens took place during this period, while large inland sites attest to a more terrestrially oriented subsistence economy. Heading into the Late Jomon, again in the Kanto District, there was an increase in the number and density of coastal sites, at the expense of inland sites, which Imamura (1996a: 90) argues was due to overexploitation of inland plant resources. In the Final Jomon of the Kanto District, marine overexploitation led to a resurgence in terrestrial subsistence activities.

The end of the Final Jomon saw the transition to the Yayoi period. While archaeological data on the transition is reasonably robust, very little in the way of human skeletal material exists for the end of the Jomon and Early Yayoi (Nakahashi 1999). The agricultural transition in Korea occurred during the Jeulmum period (3500 to 2000 BC) with the adoption of foxtail millet and rice (Choy and Richards 2009). However, not until the Mumun period (1500 to 300 BC) was there any significant—and in this case far-reaching—influence on Japan, at least in the west. Traditionally, the transitional phase lasted from about 500 to 300 BC, when the Early Yayoi began (300 to 100 BC), but only in western Japan, followed by Middle Yayoi (100 BC–AD 100), and then Late Yayoi (AD 100 to 300). The reasons for the transition are still unclear, but some evidence for a population decline in western Japan may suggest changes in subsistence strategies, which may in turn have favored the adoption of intensive agricultural practices. Until there is clarification of what was happening on the Korean peninsula at the same time, a satisfactory answer may not be forthcoming. Interestingly, evidence collected at Nukdo, one of the largest southern Korean sites of the Mumun period (1500 to 300 BC), indicates that during the Mumun/Yayoi interface, agriculture, terrestrial game, and some marine resources were important in the Mumun diet, while contemporaneous communities in Kyushu had a greater focus on marine-sourced dietary components (Cho and Richards 2009). Given evidence for the early presence of agriculture in Kyushu, the initial transition from the Jomon to the Yayoi in southern Japan may have been more about changing subsistence emphases, rather than wholesale (and wholescale) new and abrupt change.

What is clear, however, is that a major development in terms of human behavior and biology occurred with the transition to the Yayoi. While dryland rice cultivation likely occurred during the Jomon to some degree (Sato 1999), the Yayoi period was characterized by the emergence of wet-rice cultivation, as well as trade in and local manufacture of metal goods, trade and exchange at all levels and ways with mainland polities, and clear social stratification, which was a precursor to the formation of polities that later led to state formation (Imamura 1996a: 127). Whatever the reason for the significant hiatus between the emergence of wet-rice agriculture in China and its emergence in Japan, when it did arrive approximately 500 BC (possibly as early as 1000 BC), it only took around 300 years to travel as far as northern Honshu. The earliest wet-rice fields with clear evidence of water control are found at the Itatsuke (板付) site in northern Kyushu. Evidence for early use of swampy sites (which produce lower yields) also comes from northern Kyushu (e.g., Nabatake 菜畑), which Imamura (1996a: 137) has argued may indicate the use of less optimal but also less labor-intensive sites during the initial stages of the adoption of rice agriculture in Japan.

While the north and eastward spread of wet-rice agriculture was rapid, it did not cross the Tsugaru (津軽) Strait onto Hokkaido, where an essentially marine-oriented foraging system persisted until historic times. Oxenham and colleagues (Oxenham and Matsumura 2008; Oxenham et al., this volume) discuss the human biological costs and responses to subsistence and climate on Hokkaido, which are quite different from the conditions facing their contemporaries in Honshu. Further, the northern boundary crept back to the middle of the Tohoku region, ostensibly because of the resistance of specialized subsistence systems (especially fishing) in northeastern Honshu (Imamura 1996a: 139), although the reason is still essentially unclear. Rice storage in the earlier period of the Yayoi included earthen pits, although these seem to have been replaced by elevated storage structures, which were much more efficient, after the Middle Yayoi (Imamura 1996a: 144). Wet-rice agriculture was not the only form of intensive agriculture seen during the Yayoi.

Evidence for dry farming of foxtail millet, adzuki (小豆) beans, and barley is seen at the Nabatake site, and dry-field farming is assumed to have been common in the more suitable soils of northeastern Japan as well (Imamura 1996a: 144). Moreover, the Yayoi agriculturalists added to the Jomon's repertoire of cultigens and are believed to have grown some 37 different plant forms. Yayoi communities continued to exploit marine resources, with stable isotopic signatures suggesting levels of marine input similar to those of inland Jomon communities (Chisholm and Koike 1999). Finally, there is some evidence for pig domestication during the Yayoi, although horse and cattle seem to have been absent until the Kofun (古墳) period. In terms of physiological stress, Temple (2010) notes that Yayoi communities experienced reduced levels of linear enamel hypoplasia in comparison to earlier Western Jomon populations in the same region. This has been interpreted as reduced stress in the Yayoi in the context of predictable resources brought about by intensive wet-rice agriculture (Temple 2010).

Conclusions

In summary, our understanding of human ecology in ancient East Asia is full of questions and controversies that can be resolved through bioarchaeological inquiry. What effects did complex population movements evidenced by archaeological and genetic studies in this area have on human morphological variation, on the spread of pathogens, and on patterns of violence? Did reliance on multiple cereals and domesticated animals in this area afford more balanced diets than in other parts of the world or help to defray starvation episodes? Was the introduction of new cereals and soybeans beneficial for community health in general, or was it driven by population movement and other interactions, disrupting established subsistence practices and leading to greater stress? Were changes in subsistence practices accompanied by gene flow or population replacement? Were interactions between populations peaceful or violent? Did interactions among communities that brought in new crops and new animals also contribute to the spread of new pathogens in the area? Targeted examination of human remains is pivotal for understanding the processes involved in shaping the paleoeconomies and prehistoric societies of East Asia, as illustrated in the chapters that follow.

Notes

1. Resonant with the "Hopewell interaction sphere" introduced by J. R. Caldwell in 1964.

2. From the mid- to late 1970s until November 2000, a Japanese Early Paleolithic dating back some half a million years was believed by virtually all Japanese archaeologists—and a great many non-Japanese—to be represented at a little under two hundred sites in eastern Japan. While the academic implications of this hoax will no doubt haunt Japanese archaeology for years to come, the reasons behind its long and uncritical acceptance are dealt with exceptionally well by Hudson (2005).

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