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From Chinese bronze bells to Californian bathrooms: what is a significant technology?

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In my presentation today, I argue that anthropology and non-Western history offer indispensable insights that can help us to think more creatively about the *significance* of technologies in our own society.

Technology is a modern concept, a product of the industrial world and its ways of seeing. In common parlance technology denotes imaginative inventions; engineering skills translated into sophisticated machinery; artifacts and activities that underpin the sustained progress of modern societies by producing ever more effective solutions to material problems. It is a concept associated with "breakthroughs" and radical transformations of the social order (the "industrial revolution", the "digital revolution"). As a discipline, the history of technology emerged initially as an enterprise that charted the roots and the rise of the modern West. The technological domains that were considered *significant* were those which had most clearly helped build the world of industrial capitalism: engineering, time-keeping, transport, the conversion of energy and the production of commodities like metal, food and textiles. The most successful and significant technologies were those that catalysed economic and social transformations. *Significance* thus had two dimensions: a technology was significant if it played a key role in structuring the economy and in defining the stock of knowledge; it was also significant if it served as a vector for change in these domains.

Not long after the founding of SHOT, Lewis Mumford complained that the dominant tendency `to identify tools and machines with technology' was `merely to substitute a part for the whole'. The material effects of technology, Mumford claimed, were actually secondary: man [*sic*] engages in technical activities `less for the purpose of increasing food supply or controlling nature than for utilizing his own immense organic resources ... to fulfil more adequately his superorganic demands and aspirations'.[1] `Too often,' observed Thomas Hughes forty years later, `technology is narrowly equated with computers and the Internet … Having cultivated technology impressively, Americans, especially, need to understand its complex and varied character in order to use it more effectively as means to a wide variety of ends.'[2]

In emphasising the cultural *meaning* or *significance* of technologies, Mumford and Hughes take a position on the relations between material techniques and social or cultural values that has been familiar to anthropologists since Malinowski's analyses of Trobriand farming and fishing.[3] In recent years historians of technology have responded to the challenges of Marxism, feminism and cultural studies in a series of magnificent studies that rethink and relocate the significance of technology in the modern West. It is the feminist scholar Autumn Stanley who has argued most explicitly for the importance of `redefining technology' and `redefining significance' as a way to a less biased understanding of the part technology has played not simply in Western but in human history.[4]

The new feminist, cultural or user-centred approaches have transformed the assumptions of historians of technology and scholars in STS. Yet to an anthropologist and specialist of pre-modern China like myself it is clear that historians of technology still have a way to go in pushing the boundaries of the discipline beyond Western models. Can the discipline successfully account for, let alone integrate, the experiences of other civilisations, given

that what is most interesting about non-Western societies is that the material worlds they produced did *not* embody the same values as our own? As George Basalla puts it, a human technology is a `material manifestation of the various ways men and women throughout time have chosen to define and pursue existence'.[5] How did other societies see their world and the human place in it, what were their needs and desires, and how did the technologies they developed serve to fulfil them?

I suggest that a focus on *significance* can be very useful here. As I suggested earlier, from the perspective of the historian the concept can usefully be applied at two levels, which anthropologists would call *emic* and *etic*. First, it draws our attention to the different goals and values expressed within a society, and to how technology was used in their pursuit. Secondly, it highlights the characteristics which distinguished that society from others, or that shaped its long-term history.

In the three cases that follow, I explore the significance of a technology both emically, as an expression of a society's own goals and values, and etically, as a characteristic that shaped that society's historical development. The first two examples are from pre-modern China; the third is from the USA today.

1. Chinese bronze bells

My first case looks at bronze making in ancient China, and the significance of bronze bells in particular. One of the most sophisticated technologies of the earliest Chinese dynasties, the Shang (ca. 1650 to 1050 BC) and the Zhou (ca. 1050-256 BC), was bronze-casting. In no other bronze age civilisation was bronze as abundant as it was in Shang and Zhou China, and this abundance was made possible by the presence of large copper and tin deposits in central and northern China. But although vast quantities of bronze were produced, involving the labour of thousands of workers, the ownership and use of bronze artefacts were restricted to rich and powerful families. Bronze was the badge of rule: only powerful aristocrats had the resources to organise the production of bronzes; only aristocrats were entitled to possess or bestow these treasures; and bronzes played a central part in the expression of aristocratic identity. Ritual bronzes circulated between aristocratic families through networks of political exchange: they were bestowed by sovereigns on their feudal vassals, given as tribute to by the lesser aristocracy to their overlords, or exchanged between noble houses as gifts cementing alliances. Many bronze pieces were handed down from generation to generation, but it was also customary to bury bronzes with the dead; graves often included as many as 200 items.[6]

The members of ruling lineages held ritual feasts to communicate with the spirits of their ancestors, and to conduct political business with other nobles. Musicians played solemn music on bronze bells and other instruments to accompany singers and dancers, and this music summoned the ancestral spirits to join the feast. Speaking through spirit mediums, the spirits then issued blessings and help. The food and drink were served in sets of intricately decorated bronze vessels: wine beakers and goblets, steamers and cauldrons. Some of the vessels cast were enormous; the largest found to date is a rectangular food cauldron from the Shang capital at Anyang, which is 133 cm high and weighs 875 kg. One

tomb excavated at Anyang in 1976 was that of Lady Hao, the consort of King Wu Ding, dated to c. 1250 BC. The tomb, which unusually had not been plundered by grave-robbers, contained the remains of sixteen sacrificed humans as well as Lady Hao and her grave goods. These included about 7,000 cowrie shells and 600 jades, objects of pottery, bone and ivory, and 468 bronze artefacts (not counting bronze buttons), of which 210 were ritual vessels. The combined weight of the bronzes was over a ton - 1,625 kg.

Bronze bells are among the most beautiful of the ancient bronzes, and among the most significant badges of rule. Sets of bronze bells were part of royal orchestras as early as the Shang dynasty, along with musical stones. It was said that in early Zhou times the king alone was entitled to hang rows of these instruments on all four sides of the courtyard of his ancestral temple; the lords who governed the surrounding states were entitled to three rows, ministers to two rows on opposite sides of the courtyard, and ordinary noblemen to a single row. In 1977-78 archaeologists excavated the tomb of Marquis Yi of Zeng, a small state located in what is now Hubei province, dated to about 433 BC. The tomb was built to resemble a palace, and in the ritual hall they found a set of sixty-five bronze bells with gold-inlaid inscriptions.

Music was believed to be not only the medium for communicating with ancestral spirits, but also a potent instrument of government by which the ruler mediated between human society and the cosmos: though music was played inside the palace, its resonances induced social harmony throughout the realm. According to one ritual text:

> With rites and music, [the Minister of Rites] adjusts the transformations of Heaven and Earth and the production of all the material things, so as to serve the ghosts and spirits, to harmonise the multitudinous people, and to bring all the material things to perfection.

Music that was played in the wrong tones could cause cosmic and social disruption. Unlike stringed instruments, bells did not go out of tune, so they set the standard within an orchestra. Thus tuning each individual bell to maintain consistency within and between sets of bells was of the utmost cosmic and political importance.

According to the philosophy of the high Zhou period, between about 1000 and 500 BC, only those of high moral worth as well as social rank were fitted to play musical bells, and the cosmic power of the music produced by the bells warranted devoting huge resources to their design and production. But by the time of Confucius, around 500 BC, many people were starting to criticise such huge investments in bell-sets as an unnecessary luxury; rather than an essential practice of rule, listening to bell-music began to be thought of as a sensuous self-indulgence that distracted rulers from their proper duties. Soon after the death of Marquis Yi the production of bronze bells became less sophisticated. By imperial times they had been discarded from orchestras, to be replaced by stringed and wind instruments.

Let me now turn to how the early bronzes were produced. In other bronze age societies bronzes were hammered or made by the lost wax process. The Shang and Zhou bronze

workers, however, cast their bronzes using intricate negative moulds, a process that Lothar Ledderose calls "casting bronze the complicated way".[7] First a clay model of the object to be cast was made and fired. Then a layer of wet clay was applied to the outer surface, and removed in several sections. These sections were fired in their turn to form the outer mould, then clamped together around a clay core. The molten bronze was poured into the space between the mould and the core. The moulds for the simplest bronzes involved several sections. It has been calculated that 126 components were used in the casting of one of Marquis Yi's bells.

Two characteristics of late neolithic pottery-making had contributed to developing this elaborate casting process. First, neolithic potters had developed fine clay mixes and high-temperature firing techniques which allowed them to produce elaborate decorative designs that retained their sharp outlines after firing. The delicate and complex geometrical patterns characteristic of Shang and Zhou bronzes, as well as the legibility of the intaglio or relief inscriptions, depended on high-quality ceramic technology for the accurate reproduction of fine detail. Secondly, late neolithic pottery in China was notable for many *modular* types of pot, complex forms consisting of multiple components, made separately then neatly fitted together before the final firing. As described above, the moulds for bronzes were made through an extension of this process: a single shape was first disassembled into components, then reassembled to permit casting the vessel in a single piece.

Modular pottery production required abstract thought, planning, standardisation of components, specialised divisions of labour and probably the presence of a supervisor to coordinate the work. In late neolithic China this form of production was typical of regions where social stratification was marked, and the ownership of such artefacts was restricted to a distinctively elite class. The technologies of modular production are quite distinct from what is called *holistic* production, where a single person makes an artefact from start to finish. In holistic production the maker is free to invent or improvise as he or she goes along, or to adapt the design to the characteristics of the material. In modular production the need for coordination and fit tends to restrict or at any rate channel possibilities for originality and variation in design. But modular production is faster, since several people are working simultaneously on producing components of the final artefact, and the need to fit components together accurately is a form of standardisation and quality control. In fact what we see in these fine neolithic pots is a first step towards mass production, which was to emerge in late Zhou and early imperial China.

Centralised control and modular organisation of production were further developed in the bronze workshops of the Shang. Part of the city excavated at Anyang was occupied by industrial workshops specialising in jade and stone, in bone, pottery or bronze; the workers lived nearby in small pit-houses. One workshop site yielded several hundred bronze-casting moulds and several tens of crucibles, and two to three hundred craftsmen must have worked together to produce such huge and elaborate objects as the 875 kg cauldron also found at Anyang, or the sets of vessels, including fifty-three wine-goblets alone, found in the tomb of Lady Hao. This scale of bronze production required control of ample supplies of valuable resources including copper ore, clay and fuel, as well as the authority

to command the labour of large numbers of workers. In early China only rulers had the resources to run bronze foundries, and lesser aristocrats had to rely on gifts, exchanges, or warfare for their supplies of ritual vessels. A ruler who promoted a commoner to aristocratic rank would bestow bronzes as part of the enfeoffment ceremony. In other words, bronzes served to reinforce the feudal structure of society. Their production was concentrated at the top of society, but the bronzes themselves trickled down through elite ranks, and the gift of a bronze was a necessary part of elevating a deserving commoner to minor aristocratic status.

One far-reaching implication of modular production in China was the division of knowledge between experts and generalists. Unlike the master craftsmen of medieval Europe, who learned to practise every step of their craft, each Shang craftsman was a specialist in one or two standardised micro-processes. The overall supervisor was a manager of labour and resources, who did not need to be personally skilled in the technology. He did need a general understanding of the complete system of processes involved, and he needed to be able to read and write, to keep records and organise flows of materials, labour and components. Although the production of spectacular bronzes had dwindled by the foundation of the first Chinese imperial dynasty, the Qin, in 221 BC, modular production in state-controlled manufactures continued to play a key role as a tool of governance throughout the two thousand years of imperial rule. The principle was applied to the mass-production both of utilitarian objects like bronze crossbow triggers and iron crossbow shafts, cooking pots and plough shares; and of luxury goods like lacquer-ware and silks. We normally associate mass-production with uniformity, but modular production in China frequently achieved a remarkable degree of variety and apparent spontaneity through permutations based on a few variant forms of each component. Probably the best-known and most spectacular example is the terracotta Magic Army of the Qin First Emperor's mausoleum, created between 221 and 210 BC. There are several thousand figures in this army. Each is astonishingly life-like, and each appears to be the portrait of an individual soldier. In fact they were assembled like potato-men, from a few variants of legs, torso, arms, hands, heads, and facial features.[8] Eighteen centuries later, the modular system was applied to the painting of porcelain in the factories of Jingdezhen, which exported millions of pieces to Europe each year in the early seventeenth century. The painters applied a limited number of decorative motifs in an almost unlimited range of combinations, so that no two pieces were exactly alike.[9]

Within the worldview of the time, bronze bells were significant as badges and instruments of rule. They constituted a crystallisation of political, social and cosmic power. Bells communicated with the ancestral spirits, calling down their blessings upon the living. Their notes were unchanging, symbolising constancy and transmitting a cosmic order that resonated through the human world. Their production required the organisation of vast resources knitting together the state (ruler and subjects) through a closely controlled system of production that enforced the social hierarchies of a feudal world. What, then, was the historical significance of "making bronze the complicated way"? The bronze bells were among the consummate products of the bronze-maker's art, and epitomised the complexity and sophistication of modular production of the era. While the feudal society of Shang and Zhou was displaced, modular production, initially developed to supply an

elite, was developed into a tool of imperial rule and a catalyst of commerce, shaping Chinese patterns of production right through to the modern era.

2. The house in late imperial China (ca. AD 1100 to 1700).

Historians of technology have usually considered that really significant technologies are those which catalyse radical transformations. They give very high marks for change and low marks for continuity (often labelled "stagnation"). Comparing the technological dynamism of early modern Europe to China at the same period, the questions they ask have all too often been: what was missing? what went wrong? Yet the goals of the Chinese state, as of most governments past and present, were to maintain the social and political order, often in the face of almost overwhelming pressures for disintegration. Between 1100 and 1700 China was twice conquered by foreign armies; its population quadrupled; the state fought against pirates and rebels, and struggled to protect its population against floods, droughts and famines. Commerce developed dramatically, and a largely subsistence economy was transformed into networks of provincial, national and international trade. In the early part of the period an aristocratic elite was replaced by an educated meritocracy of landed gentry; by 1500 the gentry were fighting against the pretensions of merchant families buying or studying their way into the elite. Technologies of various kinds served to counter these fissile tendencies. Some were consciously viewed in this way and deliberately deployed by the state and its officials. Water control, state printing houses, communal granaries, roads and canals, and of course the army are examples. At a more everyday level, the material design of the house, and the normalisation of domestic spatial practices, effectively worked to draw increasing numbers of Chinese families into a shared social order.

> When a man of virtue builds a house his first task is always to set up an offering hall [ancestral shrine] to the east of the main room of his house.[10]

This prescription for house design has not usually been thought of as a technical text, let alone as a key document for the history of Chinese technology. However, in an essay published in *Osiris* in 2000 I proposed it as such, arguing that in the context of Chinese society of the late imperial period (between about 1100 and 1700) domestic architecture was a normalising technology of significance comparable to that of machine-tool design in the nineteenth-century United States, which shaped and cemented the values of the Fordist world.[11] One institution that profoundly shaped late imperial society and culture was the patriarchal lineage, constructed around an architectural feature: the domestic altar. I analysed the domestic shrine as a core element in the formation of a pervasive, flexible and enduring sociotechnical system, a material artifact around which crystallized a characteristic ideology. I demonstrated that in the course of the late imperial period, the shrine served as an effective instrument for incorporating increasingly broad sections of the Chinese population into the social order.[12]

The architecture of Chinese houses varied with climate, building materials, and of course wealth. In the dry northwest peasant houses had flat earthen roofs, in the south roofs were tiled, steep-pitched with upcurved eaves. Anyone who could manage it built his house

facing south, the most auspicious direction from which *yang* energy emanated, and in the preferred layout buildings were set symmetically about the north-south axis, so as to form one or more courtyards. In the north courtyards ran north-south to trap the winter sun; in the south they stretched east-west for maximum summer shade. Most houses were constructed on wooden frames, but some had brick supporting walls, some were cave-dwellings, and in the forested southwestern mountains people built log cabins.[13]

Despite the great variety in material form, however, by the late Ming houses of all classes across China shared common ritual and geomantic structures,[14] and corresponding spatial practices. These helped naturalise orthodox values among rich and poor alike, contributing to social stability in a period of rapid change. This section examines what we might call the normalisation of Chinese domestic space, focusing on two crucial material features of late imperial houses: the ancestral altar and the separation of the women's quarters.[15]

Nineteenth- and twentieth-century Western observers remarked that every Chinese house, whether of peasant or gentleman, was first and foremost an ancestral temple: the entire structure was centered on the shrine, and when a household divided, each brother set up an altar of his own in his new dwelling. Though it seemed that such customs were immemorial, in fact peasants - and even scholars - had not always been entitled to their own ancestral altar. The domestic shrine was originally a privilege strictly confined to the aristocracy. But during the Song (960-1279) a new elite, the educated gentry, established dominance over government and local society.[16] To underline their elite status they formed their own patrilineal descent groups and set up ancestral shrines within their homes.

The medieval aristocracy had protected their status by exclusion, by marking themselves off as different. In contrast, the social theories of neo-Confucianism, developed in the course of the Song by the new elite, imposed authority through inclusion. Originally "commoners" themselves, the Song ruling class were distinguished from the masses of the "common people" not by blood but by the degree-holding titles which they had won through educational achievement. As representatives of a meritocracy, they treated society as a ranked continuum rather than as separate castes. For them the performance of rituals served not as a badge of difference, but to unite people in a common goal or set of beliefs while reaffirming the proper social hierarchies; ritual gave concrete expression to differences in rank and status within the group. Instructing the people in ritual, wrote the statesman Ouyang Xiu (1001-1072), `not only would prevent disorder but also would teach them to distinguish superior and inferior, old and young, and the ethics of social relations' - including recognizing the authority of the educated.

In 1169 Zhu Xi, one of the most eminent and influential neo-Confucian thinkers, composed a compendium of domestic rituals for use among gentry families, the "Family rituals" (*Zhuzi jiali*). Over the centuries this text was deployed by gentry and by the state to disseminate orthodoxy. By the Ming (1368-1644) it was illustrated, popularized, excerpted in popular encyclopedias, and imperially mandated as the official guide to family ceremonies.

Zhu Xi represents the house as a ritual space with the ancestral shrine at its heart. The first chapter begins with the construction of the offering hall or shrine: `When a man of virtue builds a house his first task is always to set up an offering hall to the east of the main room of his house.' Zhu Xi states that this section comes first in his book because it is fundamental to all that follows, not only in moral and metaphysical terms but also for the inculcation of proper deportment. The first chapter `provides the basis for understanding the fine points in the later chapters concerning movements and postures, for walking here and there, getting up and down, going in and out, and facing various directions.' This is an important point: neo-Confucian thought stressed the connection between body and morality; the proper physical performance of a ritual was a training in the proper feelings and appreciation of relationships that the ritual celebrated; the same was true of the mundane routines of everyday family life. Where practice led, belief would follow, hence the moral significance of material objects like architectural features.

Zhu specifies the general principles of construction of the shrine or hall, but makes allowances for disparities of wealth. Ideally it should be three bays wide, with chests to keep family genealogies and ritual utensils, but poor families could make a shrine just a single bay wide, or even just use the east end of the main building.[17] Zhu also makes allowances for other material inadequacies, such as the lack of a south-facing main building: `Here and throughout this book, in organizing the room, no matter which direction it actually faces, treat the front as south, the rear as north, the left as east, and the right as west.' The absolute requirements of orientation are thus reformulated as a *set of transformations*, so anyone can perform the liturgies correctly even if their house is too poor to offer the ideal architectural features.

One very important feature of shrine construction was the east and west steps of the room. Family members ascended and descended the steps in ranked order (according to generation, birth order within the generation, and sex), passing from daily world up to the holy level of the ancestors and back; men and women were distinguished by using the eastern and the western steps. Here let us note that the basic unit in the liturgy is the married couple: every act a man performed was matched by a complementary act by his wife. Family ceremonies reinforced patrilineal descent principles: daughters (who joined their husband's lineage on marriage) did not participate, nor did servants, nor concubines (who unlike legal wives were not presented to the ancestors when they came into the family).

In the neo-Confucian ideal, all family life and events were organized round the altar: the ancestors were informed of comings and goings and of success and failure, new brides were presented to them, dying family members were set down beside the shrine to breathe their last. The senior couple in the family occupied the room closest to the shrine, as befitted both their rank within the family, and their closeness to death and ancestral status. If robbers broke in or there was a fire, the first things you should save, said Zhu Xi, were the ancestral tablets and family documents, leaving jewels and money till later. (One suspects that this injunction was often ignored in real life.)

The branching patrilineal descent group and its associated rituals served as effective devices allowing the neo-Confucian elite to control and maintain its status in local society. Rich and poor were tied together in loyalty as descendants of a common ancestor - which meant that the poor had to have descent (and ancestors, and altars, and history) too. The dissemination of domestic shrines and rituals among commoners was fostered by their incorporation into lineages. This process began in the Song, but during the Ming lineages sprang up everywhere. Commoner families received ritual instruction or training when for example they celebrated a wedding or a funeral: lineage seniors would be invited as sponsors and made sure the proper procedures were followed. Popular familiarity with orthodox ritual was also fostered by legislation: the fourteenth-century Ming *Legal Code* stipulated that Zhu Xi's liturgy must be followed if a marriage was to be considered valid. From the mid-fifteenth century another important factor in disseminating ritual knowledge was the explosion in publishing. Almost every family bought the yearly almanac (which contained not just a calendar showing auspicious and unlucky days for important activities, but also sections on morality and etiquette); household encyclopedias, including sections from the *Family Rituals*, were popular among families aspiring to genteel status, and some ritual guides were produced specially with women in mind.[18]

The altar was one concrete symbol of the patrilineal organization that knit Chinese society together; another was the seclusion of women. The Confucian social order supposed a fruitful complementarity between men and women in which each had their own domain and their own kinds of work and responsibility, men outside and women inside. Although men and women were equally indispensable to the creation of social order, cosmology told them that male (*yang*) leads and female (*yin*) follows, which was why brides came to live in their in-laws' house, and why men had authority over women. Included in Zhu Xi's *Family Rituals* was a book of etiquette by Sima Guang (1019-1086) of which the following is probably the most famous passage:

> In housing, there should be a strict demarcation between the inner and outer parts, with a door separating them. The two parts should share neither a well, a wash room, nor a privy. The men are in charge of all affairs on the outside, the women manage the inside affairs. During the day, without good reason the men do not stay in their private rooms nor the women go beyond the inner door.

Yuan Cai (1140-95), the author of *Precepts for Family Life*, comments: `This is over half of what is needed to manage a household'. As neo-Confucian values disseminated through society, the seclusion of women became an increasingly widespread sign of respectability.

To Westerners today the seclusion of women appears unambiguously oppressive, but in the culture of Ming China the effects and implications were more ambivalent. Dorothy Ko has argued that among late Ming literati families seclusion gave women freedom and dignity; men admired the moral purity they cultivated in their exclusive domain. A conservative patriarch, penning family instructions for the edification of his offspring, usually saw the door to the inner quarters as shutting off the troublesome women who threatened harmony between related men. His daughter-in-law - to judge from frequent complaints that brides resisted handing over their dowry to the communal family fund - appreciated the fact that

her father-in-law could not intrude into the private domain of her chamber and her dowry chests.

Several historians have documented the widespread obsession with female virtue that characterized the late Ming and early Qing, and have linked it to the worries and uncertainties which arise when a hectic market economy generates social instability and the blurring of class distinctions. The wealthy, including numerous Ming merchant families, affirmed their orthodoxy by building separate inner quarters in their mansions. There wives, concubines and daughters lived in charming and luxurious surroundings. The separation of male and female space provided ample marketing opportunities for makers of furniture and other fine goods. Late Ming writers of guides to tasteful consumption reminded their readers that a truly masculine and cultivated person preferred austerity and sobriety to the flower-patterns and lively colors which women liked.

Poor families couldn't afford separate wings for their women, indeed many couldn't even afford a separate room, but if male guests arrived the family's dignity was preserved by having the women withdraw behind a curtain. Poverty did not prevent a family from gaining respect for the strict seclusion practised by its women, and if a family wanted their daughter to marry well they kept her hidden indoors. It seems that female seclusion, stressed by neo-Confucians as a pillar of the moral order, must have held particular attractions for men of low rank or few means, first as a low-cost badge of respectability, and second because of the domestic authority it gave them. And where women were no longer proclaiming their womanly virtue through proper work, namely weaving, it was at least reassuring to know that their activities were confined to the proper woman's place, in the inner quarters or the back room.[19]

The sixteenth and seventeenth centuries were a time of change and uncertainty. House architecture provided a moral template, shared across classes, that helped maintain neo-Confucian values despite the considerable tensions unleashed by the expansion of production and the commercialization of the economy. The ancestral altar and the separation of the women's quarters celebrated the respectability of families who knew their place in society and strove for higher blessings than material success. The material features and physical practices of domestic space - orientations, steps and doors, patterns of coming and going - constituted powerful devices for maintaining social stability by offering respectability and a stake in the social order to even the humblest of families.

In emic terms, then, the design of the late imperial house embodied and disseminated the values of patrilineal descent, most notably (1) filiality and the ancestral cult; (2) proper relations between male and female with their resonance not only in family fertility but also in cosmic harmony; (3) hierarchies within the household kin group experienced through spatial practice. In terms of historical significance, this machine for living facilited the transition from aristocracy to meritocracy, and served as an instrument of social inclusion by gradually extending ancestors and altars to all Chinese families. It was not essential to possess the precise material layout of the ideal ancestral hall: what was important was knowing the principles for reading and enacting space. These spatial and social norms could thus be steadily extended to the whole population, drawing first commoners and then

poor families into the norms of virtuous behaviour. This normalisation of the house was a key factor in producing the "shared Chineseness", spanning class and region, that so forcibly struck foreign visitors to late imperial China.

3. The Californian bathroom – or rather, the toilet

If the house was a key technology in the dissemination of Chinese imperial values across its territories, the adoption of the flush toilet is a marker across the globe today of an individual's, or nation's, adherence to the values of cosmopolitan modernity. Sometimes aspiring families in poor countries will install a porcelain pedestal in their house as a demonstration of their modern mindset, even if there is as yet no piped water connected to make it work. As soon as it won the bid for the 2008 Olympics, the Chinese government began an intensive campaign to bring toilet facilities around the country up to international standards, and to provide instruction for its citizens on the practicalities and etiquette of using Western-style toilets. Although in the 1930s only 30% of American houses had indoor flush toilets, in the economic boom following WWII a fully-fitted bathroom, then later multiple bathrooms, became standard even in modest American homes. American has been a recognised leader in developing sophisticated bathroom equipment for over a century, and in many parts of the world people still yearn to own American kitchens and bathrooms as proof that they have arrived.[20] I have labelled this section "Californian bathrooms" because I have twenty years' experience of living in California, have myself almost gone native in acquiring Californian toilet habits, and have documented California toilet matters assiduouly. But in what follows I use Californian materials to generalise about the USA – please correct me if I have presumed too much.

Any American asked to name the most significant technology in the United States today would probably fix on the computer industry, biotechnology, nanotechnology or aerospace engineering. Yet a Martian or a visiting anthropologist might well fix on the flush toilet as the technological object that best encapsulates the modern American way of being-in-the-world. Americans are famous for, and proud of, their high standards of cleanliness and hygiene. Among the many household technologies designed to maintain these standards - showers, washing-machines, dish-washers, vacuum cleaners, disposable diapers and deodorants to mention just the most obvious - the flush toilet is the most indispensable. It keeps us clean and fragrant and spares us all direct confrontation with the unpleasant by-products of our consumption. Defecation is taken for granted as the most private of activities in the United States, yet individual privacy depends on a vast infrastructure of water and sewage networks maintained at huge and usually unconsidered public cost. Male and female have different toilet practices and separate public toilets with different hardware. And when we venture abroad the inadequacy of foreign toilets reaffirms our sense of American superiority. A technological history of twentieth-century American society that took the bathroom as its key focus would not invalidate the interpretations that studies of electrification or the rocket industry suggest, yet it might tell us as much if not more about ordinary, everyday life and values.[21]

If you are homeless in America today, among the greatest challenges are keeping clean and finding somewhere legitimate to relieve yourself. In terms of the material facilities they

provide and the activities they are expected to facilitate, houses or homes across human societies are, among other things, devices for ordering space and for sorting activities and people. As such they are places which are kept clean and tidy, and where dirt is removed from family members and from their clothes and other effects. But what constitutes cleanliness? Are the limits defined by technology, or by culture? Ruth Schwartz Cowan has brilliantly demonstrated how domestic technologies contributed to a steady raising of American standards of cleanliness and a concomitant burden on the housewives whose burdens these innovations were ostensibly designed to relieve.[22] Equipped with washing machines, driers and biological detergents, most Americans now expect to change their clothes at least once a day, just as they would feel dirty if they failed to shower and wash their hair daily. Yet, paradoxically, there are limits to just how far we are prepared to push progress in this field. American toilets lag farn behind the ultimate that technology can offer today in fundamental cleanliness, technical sophistication and hygienic efficiency.

The Japanese, and notably the Toto company, have developed adjustable multi-tasking toilets that will help you sit down and rise up again, that wash you and dry you while playing your favorite music, or even analyse your excreta to check on your health. The Toto Washlet has been on the market since 1980, and has been continuously refined and improved since then. Over 50 per cent of Japanese homes owned Washlets in 2004,[23] but then, as a Toto advertisement proudly declares, `the Japanese are a people who like to wash their bottoms'.[24]

In American culture we pay great attention to the outer contours of bottoms, but what lies between the cheeks is unmentionable, or even unthinkable. We love most multi-tasking gadgets –coffee machines that wake us in the morning, telephones that take photos and check e-mail – but we reject multifunctional thrones as somehow disgusting. Though Americans are usually delighted to adopt the latest in technical improvements, in this case it seems we feel the pursuit of cleanliness can be carried just too far. Despite sophisticated advertising by Toto to Americans to become happier, more confident and healthier by washing their bottoms, there has been near-zero response to their invitation to luxuriate in discreet, precisely directed streams of warm water and air, controlled by electronic panels to meet your exact need of the moment.[25]

American technophilia is well-known: the boundless appetite for innovations, the firm belief in the technological fix, the awe of the technological sublime. Americans tend to think of themselves as the archetypal innovation-oriented, high-efficiency society, the world leader in pushing technology forward. Yet where toilets are concerned, the basic design has not changed for decades. In the last twenty years some progress has been made in making American flush toilets more efficient in the consumption of water; but curiously the device that is standard in Japan and Germany, where the push-button offers two levels of flush for urine and faeces (i.e. requires us consciously to categorise the materials we have just eliminated), is very rare in the USA. US toilets are physiologically inefficient since the seats are mostly too high for easy evacuation (the squat toilet, derided as "primitive", is – not surprisingly – far better suited to the human anatomy). And where cleanliness, hygiene and environmental impact are concerned, we are way behind the Muslims and the Japanese, since we still use a hand to scrub at ourselves with bits of paper

that then are flushed away to clog up the sewers.[26] Yet toilet design in the United States has not changed for decades, although in many respects it is basically dysfunctional. Why? The best answer that my friend the sociologist Harvey Molotch could extract from engineers and designers was that the toilet is resistant to redesign because it is "unmentionable".[27] In other words here as in other contexts, technological efficiency is not a universal absolute: to some extent it is also a political or cultural judgement.[28]

The significance of the toilet and toilet practices as emblematic of American self-image (not to mention as emblematic of American attitudes towards consumption and its connections to waste disposal, or towards the connections between personal privacy and public provision of infrastructure) is evident. In terms of etic significance, the case of the American toilet highlights both the cultural specificities of supposedly universal values such as cleanliness, and the need to explore, even within technophile societies, the contours and limits of commitment to technological progress.

Conclusion.

Mumford's elegant term *technics* emphasises that a society's technical artefacts and practices are the products not only of material, but also of political and cultural logics. In the cases presented here I have argued that technology is most usefully addressed in critical, anthropological terms that marry material effects with social or symbolic efficacy. I have suggested that the work that any technology performs is as much the making of subjects and the production of meaning as the making of objects and the mastery of nature. I have proposed the concept of *significance* as a method for linking *anthropological* investigation into the uses and meanings of various technologies within a particular society, with *historical* evaluation of how specific technologies shaped a society over time.

How can we identify a technology as being significant within a society's own terms, without simply projecting back our own modern preconceptions? I would say that it helps to think of any technology as a network of objects, activities, knowledge and meaning, comprising: goals to be met; tasks to be done; artefacts made for these purposes; the uses (material, social or symbolic) to which the artefacts are put; the material processes by which they are produced and made available; and the skills, knowledge and organisation mobilised in these processes. We may deduce that a technology is significant within a society if one or more elements in this network are highly visible in the historical record, whether as material remains; explicit subjects of description or debate; or taken-for-granted components of key activities. Modern Californians are most likely to recognise how important their toilet habits are to their identity only when they encounter unfamiliar arrangements on a trip abroad. Ancient Chinese rulers used bronze bells extensively and valued them for their cosmic powers and their importance in ritual; they had no interest in bells as technology, yet the organisation of ancient Chinese society was profoundly marked by the nexus of symbolic imperatives embodied in the bells. Neo-Confucians wanted to promote morality and consolidate the social order; although they did not think of house design as a technology in the modern sense, they deliberately mobilised the house as a tool, a material construction designed to channel everyday life into virtuous patterns. Thinking in terms of *significant technologies* is also attractive because it invites multiple

perspectives on a single society. Looking at how technologies served to express gender offers one set of insights on late imperial China; looking at how they were deployed for purposes of governance generates another set, that sometimes coincides, sometimes takes us into another scale of time and space entirely.[29]

It is easy to see what the history of technology in a non-Western societies like China has to gain from rethinking its objects and methods, but I think the attractions for historians of Western technology should be no less evident. If we allow ourselves to think more imaginatively about what a significant technology might be and the kinds of social or symbolic work it performs, if we conceive of technologies as forms of cultural expression and thus key instruments in the creation and transmission of ideology, we open up a whole range of new possibilities for understanding not only the past but also the present.

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[1] "Technics and the nature of Man", *Technology and Culture* 7 (Summer 1966), p 306; Mumford had already explored this theme in his periodized study of technology in human history, *Technics and Civilization* (New York: Harcourt Brace, 1934).
[2] Thomas P. Hughes, *Human-Built World: How to Think about Technology and Culture*, Chicago, University of Chicago Press, 2004: 1.
[3] Bronislaw Malinowski, *Coral gardens and their magic: a study of tilling the soil and of agricultural rites in the Trobriand Islands*. London: Routledge & Kegan Paul, 1934; Bryan Pfaffenberger, `Social anthropology of technology', *Ann. Rev. Anth.* 21 (1992):491-516; *idem*, `Symbols do not create meanings - activities do: or, why symbolic anthropology needs the anthropology of technology', in M.B. Schiffer (ed.), *Anthropological perspectives on technology*, Albuquerque: Univ. of New Mexico Press, 2001: 77-86.
[4] Autumn Stanley, *Mothers and Daughters of Invention: Notes for a Revised History of Technology*, New Brunswick NJ, Rutgers University Press, 1995 (2nd ed): xxxi.
[5] George Basalla, *The Evolution of Technology*, Cambridge, Cambridge University Press, 1988: 15.
[6] Lothar von Falkenhausen, *Suspended Music: Chime-Bells in the Culture of Bronze Age China*, Berkeley, University of California Press, 1993; Lothar Ledderose, *Ten Thousand Things: Module and Mass Production in Chinese Art*, Princeton, Princeton University Press, 2000; Robert Bagley (ed), *Ancient Sichuan: Treasures from a Lost Civilization*, Seattle Art Museum, Princeton University Press, 2001.
[7] *Ten Thousand Things*: 25-50.
[8] *Ibid*: 51-74.
[9] *Ibid*: 88-101.
[10] *Zhuzi jiali*, tr. Ebrey 1991: 5.
[11] See for instance Carroll Pursell, *White Heat: People and Technology* (London: BBC Books, 1994).
[12] `Technics and civilization in late imperial China: an essay in the cultural history of technology', *Osiris* 13 (2000): 11-33.
[13] Domestic architecture has been treated like a poor relation by many architectural historians, but fortunately we have the marvellous studies of Liu Dunzhen (1980) and Ronald Knapp (1986, 1989, 1998) on ordinary houses. Only a few Ming houses survive

(e.g. Zhang 1957), but as Knapp points out many rural houses continued to be built according to almost identical concepts, layout and technology until very recently. Knapp 1989 is of especial interest here since he looks specifically at sericultural houses in Jiangnan.

[14] Geomancy involves the manipulation of cosmic energy to human benefit. On the interweaving of geomantic and orthodox values in the spatial constructions and practices of the Chinese house, see Bray, `Technics'.
[15] I develop the analysis of the relation between house form, neo-Confucian orthodoxy, patrilineal kinship relations and gender identities further in Bray 1997: chapters 1 to 3; anyone interested in the gendered segregation of space will probably want to consult the longer work.

[16] The examination system had been introduced in the ninth century as a way of recruiting worthy men to state service. In the Song education and success in the exams were definitively established as the principal route to political office, and to the social status and material resources that went with it.

[17] A bay is the space between two pillars supporting a roof-beam, and is generally about three or four metres across.

[18] The quotation from Ouyang Xiu is given in de Bary 1960: 443. Zhu Xi's instructions on where to build the offering hall are translated by Ebrey 1991: 5; his instructions on deportment and the transformations of direction are on p.8; the orders to save the tablets before the jewelry are also on p.5. Family rituals as a device for defining family membership and differentiating female status are discussed in Bray 1997: 102 and 360-62. On the Ming Code see Ebrey 1991a: 151. Palmer 1986 explains the popular importance of the almanac. On Ming scholars' concern to involve ignorant rustics and women in orthodox ritual, see Ebrey 1991a: 181 ff.

[19] The passage from Sima Guang is from Ebrey 1991: 29, Yuan Cai's endorsement from Ebrey 1984: 286. Ko 1994 and Mann 1997 discuss the positive sides of seclusion for literati women; Bray 1997: chapter 6 examines the ambiguities of seclusion, and also discussed its attractions for poor families. T'ien 1988 and Mann 1997 are among the authors who note the obsession with female virtue in seventeenth- and eighteenth-century China. On how male and female styles were characterized, see the works of Clunas.

[20] Krisztina Fehérváry, 2002, "American kitchens, luxury bathrooms, and the search for a `normal' life in postsocialist Hungary", *Ethnos* special issue, *Consumers Exiting Socialism*, 67, 3: 369-400.

[21] Francesca Bray, `American modern: the foundation of Western civilization', http://www.anth.ucsb.edu/faculty/bray/toilet/ , posted 11 April 2001.
[22] Cowan, Ruth Schwartz, 1983, *More Work for Mother: the ironies of household technology from the open hearth to the microwave,* New York, Basic Books.

[23] `Toilets in Japan', Wikipedia contributors, *Wikipedia, The Free Encyclopedia*, updated 3 September 2007, http://en.wikipedia.org/w/index.php?title=Toilets_in_Japan&oldid=155411626 , consulted 7 September 2007.

[24] Alan Chun, `Flushing in the future: the supermodern Japanese toilet in a changing domestic culture', *Postcolonial Studies* 5, 2 (2002): 153-170, p. 154.
[25] www.washlet.com/ consulted 7 September 2007.
[26] Rose George, `Diary', *London Review of Books*, 11 May 2006.
[27] Harvey Molotch, *Where Stuff Comes From: How Toasters, Toilets, Cars, Computers, and Many Other Things Come to Be As They Are*, New York, Routledge, 2003: 108.
[28] Michael Dutton, Sanjay Seth and Leela Gandhi, `Plumbing the depths: toilets, transparency and modernity', *Postcolonial Studies* 2 (July 2002): 137-42.

[29] Francesca Bray, *Technology and Gender: Fabrics of Power in Late Imperial China*, Berkeley, University of California Press, 1997; `Instructive and nourishing landscapes: natural resources, people and the state in late imperial China', in Greg Bankoff and Peter Boomgard (eds), *A History of Natural Resources in Asia: the Wealth of Nations*, New York, Palgrave Macmillan, 2007: 205-225.