

# 26 Embodied Capital and Extra-somatic Wealth in Human Evolution and Human History

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## INTRODUCTION

This chapter presents a theory of brain and life span evolution and applies it to both primates in general, and to the hominid line, in particular. To address the simultaneous effects of natural selection on the brain and on the life span, it extends the standard life history theory in biology which organizes research into the evolutionary forces shaping age-schedules of fertility and mortality. This extension, the embodied capital theory, integrates existing models with an economic analysis of capital investments and the value of life.

The chapter begins with a brief introduction to embodied capital theory, and then applies it to understanding major trends in primate evolution and the specific characteristics of humans. The evolution of brain size, intelligence, and life histories in the primate order are addressed first. The evolution of the human life course is then considered, with a specific focus on the relationship between cognitive development, economic productivity, and longevity. It will be argued that the evolution of the human brain entailed a series of coevolutionary responses in human development and aging.

The second section on embodied capital and extra-somatic wealth discusses humans in a comparative context, beginning with the hunting and gathering lifestyle because of its relevance to the vast majority of human evolutionary history. However, in the past 10 000 years human history traced a series of behavioral adaptations based on ecology and individual condition. The introduction of extra-somatic capital, first in the form of livestock and later in land and other types of wealth and power, radically changed the shape of human life history parameters and produced new patterns of fertility, parental investment, and reproductive regimes as access to extra-somatic capital became a focus of life history strategies.

Finally, modern skills-based, competitive labor markets, combined with reduced fertility during the nineteenth century, mark a returning focus on embodied

capital in the form of skills, education, and training. In past civilizations, going back to Babylonia in the third millennia BC, literacy and numeracy were known but exceedingly rare skills. This pattern continued worldwide until 1800 in Western Europe, including England, where these skills went from rarity to the norm in under a century (Clark, 2007). Labor markets with a particular demand for embodied capital in their workers place new demands on human life history and reproductive strategies in terms of mate choice, fertility, investment in children, and the timing of reproduction in the life course. Once again, human life history radically changed in shape to a new emphasis on the acquisition of skills through training and education, postponement of reproduction to the late 20s, and radically reduced completed family size with the reproductive part of the life course compressed into less than a decade.

## EMBODIED CAPITAL AND THE COEVOLUTION OF INTELLIGENCE, DIET, AND LONGEVITY

According to the theory of evolution by natural selection, organic evolution is the result of a process in which variant forms compete to harvest energy from the environment and convert that energy into replicates of those forms. Forms that can capture more energy and convert that energy more efficiently into replicates of themselves become more prevalent through time. This simple issue of harvesting energy and converting energy into offspring generates many complex problems that are time-dependent (Gadgil and Bossert, 1970).

Two fundamental trade-offs determine the action of natural selection on life history strategies. The first trade-off is between current and future reproduction. By growing, an organism can increase its energy capture capacities in the future and thus increase its future fertility. For this reason, organisms typically have a juvenile phase in which fertility is zero until

they reach a size at which some allocation to reproduction increases lifetime fitness more than does growth. Similarly, among organisms that engage in repeated bouts of reproduction (humans included), some energy during the reproductive phase is diverted away from reproduction and allocated to maintenance so that they can live to reproduce again. Natural selection is expected to optimize the allocation of energy to current reproduction and to future reproduction (via investments in growth and maintenance) at each point in the life course so that genetic descendents are maximized (Gadgil and Bossert, 1970). Variation across taxa and across conditions in optimal energy allocations is shaped by ecological factors, such as food supply, disease, access to mates, and predation rates.

A second fundamental life history trade-off is between offspring number (quantity) and offspring fitness (quality). This trade-off occurs because parents have limited resources to invest in offspring and each additional offspring produced necessarily reduces average investment per offspring. Most biological models operationalize this trade-off as number versus survival of offspring (Lack, 1954; Smith and Fretwell, 1974; Lloyd, 1987). However, parental investment may not only affect survival to adulthood, but also the adult productivity and fertility of offspring. This is especially true of humans. Thus, natural selection is expected to shape investment per offspring and offspring number so as to maximize offspring number times their average lifetime fitness.

The embodied capital theory generalizes existing life history theory by treating the processes of growth, development, and maintenance as investments in stocks of somatic, or embodied, capital. In a physical sense, embodied capital is organized somatic tissue – muscles, digestive organs, immune competence, brains, etc. In a functional sense, embodied capital includes strength, speed, immune function, skill, knowledge, and other qualities such as social networks and status. Since such stocks tend to depreciate with time, allocations to maintenance can also be seen as investments in embodied capital. Thus, the present-future reproductive trade-off can be understood in terms of optimal investments in own embodied capital versus reproduction, and the quantity–quality trade-off can be understood in terms of investments in the embodied capital of offspring versus their number.

### **The brain as embodied capital**

The brain is a special form of embodied capital. Neural tissue is involved in monitoring the organism's internal and external environments and organizing physiological and behavioral adjustments to those stimuli (Jerison, 1976). Portions (particularly the cerebral cortex) are also involved in transforming past and present experience into future performance. Cortical

expansion among higher primates, along with enhanced learning abilities, reflects increased investment in transforming present experience into future performance (Armstrong and Falk, 1982; Fleagle, 1999).

The action of natural selection on neural tissue involved in learning and memory should depend on costs and benefits realized over the organism's lifetime. Three kinds of costs are likely to be of particular importance. Firstly, there are the initial energetic costs of growing the brain. Among mammals, those costs are largely born by the mother during pregnancy and lactation. Secondly, there are the energetic costs of maintaining neural tissue. Among infant humans, about 65% of all resting energetic expenditure supports maintenance and growth of the brain (Holliday, 1978). Thirdly, certain brain abilities may actually decrease performance early in life. Specifically, the capacity to learn and increased behavioral flexibility may entail reductions in “preprogrammed” behavioral routines. The incompetence with which human infants and children perform many motor tasks is an example.

Some allocations to investments in brain tissue may provide immediate benefits (e.g., perceptual abilities, motor co-ordination). Other benefits of brain tissue are only realized as the organism ages. The acquisition of knowledge and skills has benefits that, at least in part, depend on their impact on future productivity. Consider two alternative cases, using as an example, the difficulty and learning-intensiveness of the organism's foraging niche. In the easy-feeding niche where there is little to learn and information to process, net productivity (excess energy above and beyond maintenance costs of brain and body) reaches its asymptote early in life. There is a relatively small impact of the brain on productivity late in life (because there has been little to learn), but there are higher costs of the brain early in life. Unless the life span is exceptionally long, natural selection will favor the smaller brain.

In the difficult-feeding niche, the large-brain creature is slightly worse off than the small-brain one early in life (because the brain is costly and learning is taking place), but much better off later in life. The effect of natural selection will depend upon the probabilities of reaching the older ages. If those probabilities are sufficiently low, the small brain will be favored, and if they are sufficiently high, the large brain will be favored. Thus, selection on learning-based neural capital depends not only on its immediate costs and benefits, but also upon mortality schedules which affect the expected gains in the future.

### **The human adaptive complex**

The human adaptive complex is a coadapted complex of traits, including: (1) the life history of development, aging and longevity; (2) diet and dietary physiology;

(3) energetics of reproduction; (4) social relationships among men and women; (5) intergenerational resource transfers; and (6) co-operation among related and unrelated individuals (Kaplan, 1997; Kaplan et al., 2000, 2001, 2003, 2005, 2007; Kaplan and Robson, 2002; Robson and Kaplan, 2003; Gurven and Kaplan, 2006; Gurven and Walker, 2006). It describes a very specialized niche, characterized by: (1) the highest-quality, most nutrient-dense, largest package size, food resources from both plants and animals; (2) learning-intensive, sometimes technology-intensive, and often co-operative, food acquisition techniques; (3) a large brain to learn and store a great deal of context-dependent environmental information and to develop creative food acquisition techniques; (4) a long period of juvenile dependence to support brain development and learning; (5) low juvenile and even lower adult mortality rates, generating a long productive life span and a population age structure with a high ratio of adult producers to juvenile dependents; (6) a three-generational system of downward resource flows from grandparents to parents, to children; (7) biparental investment with men specializing in energetic support and women combining energetic support with direct care of children; (8) marriage and long-term reproductive unions; (9) co-operative arrangements among kin and unrelated individuals to reduce variance in food availability through sharing and to more effectively acquire resources in group pursuits.

The publications cited above show that the majority of the foods consumed by contemporary hunter-gatherers worldwide are calorically dense, hunted, and extracted (taken from an embedded or protected matrix – underground, in shells, etc.) resources, accounting for 60% and 35% of calories, respectively. Extractive foraging and hunting proficiency generally does not peak until the mid-30s, because they are learning – and technique – intensive. Hunting, in particular, demands great skill and knowledge that takes years to learn, with the amount of meat acquired per unit time more than doubling from age 20 to age 40, even though strength peaks in the early 20s. This learning-intensive foraging niche generates large calorie deficits until age 20, and great calorie surpluses later in life. This life history profile of hunter-gatherer productivity is only economically viable with a long expected adult life span.

### LIFE HISTORIES OF WILD CHIMPANZEES AND HUMAN FORAGERS

To appreciate the implications of the human adaptive complex for the life histories of foragers, it is useful to compare humans with the chimpanzee, another large-bodied, long-lived mammal, and our closest-living

**TABLE 26.1.** Life history characteristics and diet of human foragers and chimpanzees (after Lancaster and Kaplan, 2008).

Life history characteristics	Human foragers		Chimpanzees
	Men	Women	
Maximum life span	~100		~60
Probability of survival to age 15	0.6		0.35
Expected age of death at 15 (years)	54.1		29.7
Mean age first reproduction (years)	19.7		14.3
Mean age last reproduction (years)	39		27.7**
Interbirth interval* (months)	41.3		66.7
Mean weight at age 5 (kg)	15.7		10
Mean weight at age 10 (kg)	24.9		22.5
<b>Composition of diet (%)</b>			
Collected	9		4
Extracted	31		4
Hunted	60		2
<b>Contributions by sex (%)</b>			
Adult calories	68	32	Sexes independent
Adult Protein	88	12	
Caloric support for offspring	97	3	
Protein support for offspring	100	0	

Notes: \*Mean interbirth interval following a surviving infant.  
 \*\*Age of last reproduction for chimpanzee females was estimated as two years prior to the mean adult life expectancy.

relative in phylogenetic terms. Table 26.1 presents major differences in five critical parameters of life history: (1) survivorship to age of first reproduction; (2) life expectancy at the beginning of the reproductive period; (3) absolute and relative length of the post-reproductive period; (4) spacing between births of surviving offspring; and (5) growth during the juvenile period (Kaplan et al., 2000; Lancaster et al., 2000). The data for these analyses are based on published data sets on the only four forager groups for which full demographic data are available as well as food

consumption and production throughout the year for all age and sex categories (Ach , Hadza, Hiwi, and !Kung). The data on chimpanzees are based on studies at the African field sites of Bossou, Gombe, Kibale, Mahale, and Tai. The data and full citation list are presented in Kaplan et al. (2000, Table 1, p. 158).

Human and chimpanzee life history parameters based on data from these extant groups of hunter-gatherers and wild chimpanzees indicate that forager children experience higher survival to age 15 (60% vs. 35%) and higher growth rates during the first 5 years of life (2.6 kg/year vs. 1.6 kg/year). Chimpanzees, however, grow faster both in absolute and proportional weight gain between the ages of 5–10 years. The early high-weight gain in humans may be the result of the earlier weaning age (2.5 years vs. 5 years) followed by provisioning of highly processed and nutritious foods, foods that juvenile chimpanzees could never collect to any extent. Fast growth and weight gain during infancy and the early juvenile period may also represent an adaptation to support the energetic demands of brain growth development, since a significant portion of this weight gain is in the form of fat.

The chimpanzee juvenile period is shorter than that for humans with age at first birth by chimpanzee females about five years earlier than among forager women. This is followed by a dramatically shorter adult life span for chimpanzees. At age 15, chimpanzee life expectancy is an additional 15 years, whereas foragers can expect to live an additional 38 years having survived to age 15. Importantly, women spend more than a third of their adult lives in a postreproductive phase, whereas few chimpanzee females spend any time as postreproductives. The differences in overall survival probabilities and life span of the two species are striking: less than 10% of chimpanzees ever born survive to age 40 and virtually none survive past 50, whereas 45% of foragers reach 40 and more than 15% of foragers born survive to age 70!

Finally, despite the fact that human juvenile and adolescent periods take longer and that human infants are larger than chimpanzee at birth, forager women are characterized by higher fertility. The mean inter-birth interval between offspring, when the first survives to the birth of the second, is 1.6 times longer among wild chimpanzees than among modern forager populations.

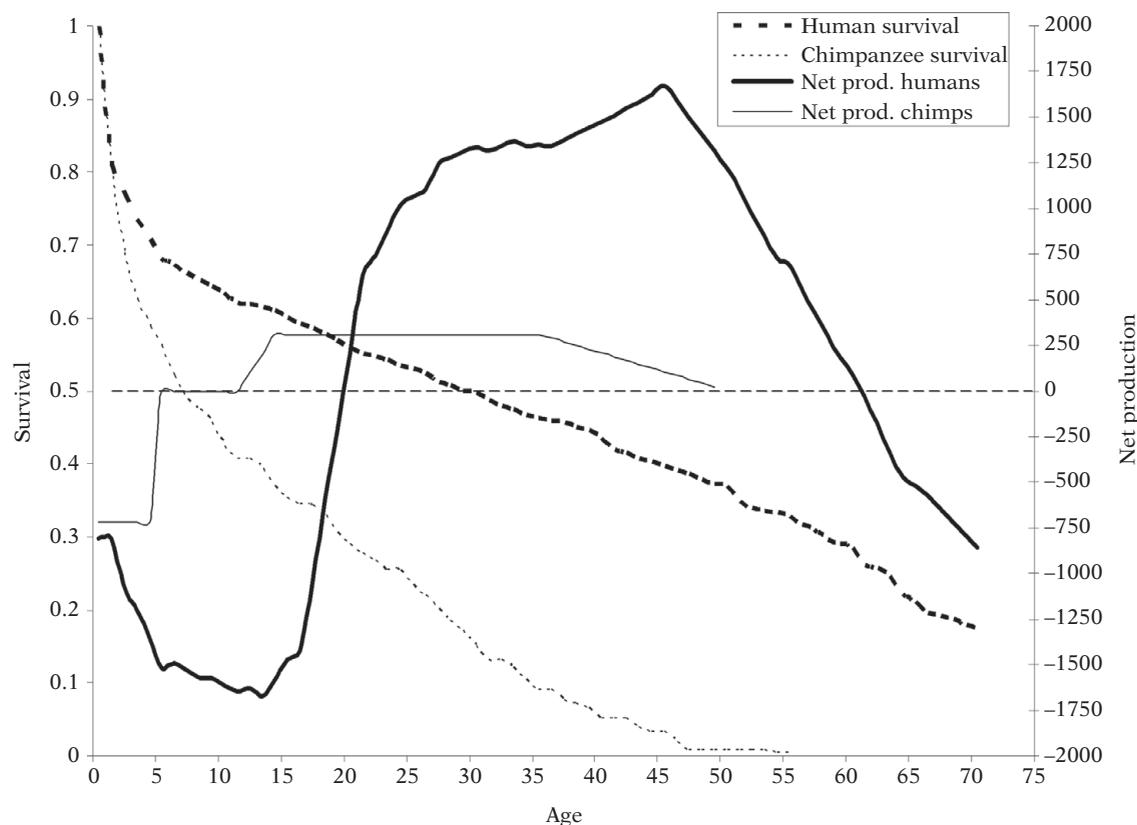
To summarize, human foragers show a juvenile period 1.4 times longer and a mean adult life span 2.5 times longer than chimpanzees. They experience higher survival at all ages postweaning, but slower growth rates during mid childhood. Despite a long juvenile period, slower growth, an equal length reproductive period, and a long postreproductive life span, forager women achieve higher fertility than do chimpanzees.

## CONSUMPTION AND PRODUCTIVITY THROUGH THE LIFE COURSE

Table 26.1 also demonstrates the overlap in component categories of the diets of foraging societies and chimpanzee communities as well as wide differences in relative proportions (Kaplan et al., 2000; Lancaster et al., 2000). For example, hunted meat makes up about 2% of chimpanzee but 60% of forager diets. Chimpanzees rely on collected foods for 94% of their nutrition, especially ripe fruits. Such foods are nutritious and are neither hard to harvest nor learning intensive, at least relative to human resource pursuits. Humans depend on extracted or hunted foods for 91% of their diet. The data suggest that humans specialize in rare but nutrient dense resources (meat, roots, nuts) whereas chimpanzees specialize in ripe fruit and fibrous plant parts. These fundamental differences in diet are reflected in gut morphology and food passage times in which chimpanzees experience rapid passage of bulky, fibrous meals processed in the large intestine whereas human process nutritionally dense, lower volume meals amenable to slow digestion in the small intestine (Milton and Demment, 1988).

Table 26.1 also summarizes the relative contributions of both sexes to the nutritional support of group members through food sharing, one of the critical features of the human adaptive pattern. This table is based on contributions by sex in 10 modern forager societies (Onge, Anbarra, Arnhm, Ach , Nukak, Hiwi, !Kung (2), Gwi and Hadza) where daily adult caloric production of meat, roots, fruits, and other has been documented (Kaplan et al., 2000, Table 2, p. 162). Generally, women produce virtually no animal protein and the carbohydrate calories they produce help to support themselves and male hunters. As described in the next paragraph, calories and protein consumed by children mostly comes from the large surpluses supplied by adult males.

Figure 26.1 presents survivorship and net food production through the life course of humans and chimpanzees (Kaplan et al., 2000). Humans consume more than they produce for the first third of their life course. In contrast chimpanzees are self-supporting by the age of five. Thus, human juveniles, unlike chimpanzee juveniles, have an evolutionary history of dependency on adults to provide their daily energy needs. Even more striking is the steady increase in productivity over consumption among humans into their 30s and early 40s. Forager males begin to produce more than they consume in their late teens, but their peak productivity builds slowly from their early 20s until their mid-to-late 30s and then is sustained for 20 or more years at a level of approximately 6500 kcals per day. In contrast forager women vary greatly from group to group in energy production, depending upon the



26.1. Survivorship and net food production through the life course of humans and chimpanzees. After Kaplan and Lancaster (2003).

demands of intensive childcare (Hurtado and Hill, 1990). In some groups, they consume more than they produce until sometime after menopause, when they are finally freed from childcare demands; whereas in others, such as the Aché, they remain nutritionally dependent on men throughout their lives. The provisioning of reproductive women and children has a powerful effect on the production of children by humans by reducing the energy cost and health risk of lactation to the mother and by lifting the burden of self-feeding from the juvenile, thus permitting a shortened interbirth interval without an increase in maternal or juvenile mortality (Hawkes et al., 1998).

The human adaptive complex is both broad and flexible, in one sense, and very narrow and specialized in another. It is broad in the sense that as foragers, humans have existed successfully in virtually all of the Earth's major habitats. It is narrow and specialized in that it is based on a diet composed of nutrient-dense, difficult-to-acquire foods and a life history with a long, slow development, a heavy commitment to learning and intelligence, and an age-profile of production shifted towards older ages. In order to achieve this diet, humans are very unproductive as children, have very costly brains, are extremely productive as adults, and engage in extensive food sharing both within and among age- and sex-classes.

### EMBODIED CAPITAL AND EXTRA-SOMATIC WEALTH IN THE PAST 10 000 YEARS

For most of human history from perhaps 2 million years until 10 000 years ago, humans depended on investments embodied in their brains and bodies to survive and reproduce. They invested in themselves and their offspring through patterns of behavior that emphasized accessing high energy, hard to acquire foods that demanded skilled, learned performances, food sharing, the feeding of juveniles, and a complementary division of labor between men and women. However, about 10 000 years ago at the end of the last Ice Age, the distribution of resources that humans depended on and the means to access them began to change as a result of climate change and an increase in population density. At the beginning these changes had little effect except to promote population growth. Later their effects were so profound that patterns of marriage, investment in children, and social organization appeared to reinvent themselves.

In the following sections we will evaluate the impact that changes in subsistence base and social organization made on the division of labor, family formation strategies, fertility, and investment in children in response to sedentism, horticulture, the

domestication of large animals, agriculture, extra-somatic wealth, social stratification, archaic despotic states, inheritance, and modern skills-based labor markets and political systems. These hypotheses are generalizations informed by the archaeological, historic, and cross-cultural record of today and the recent past and must remain as our best guesses as to the temporal and causal relations involved.

### **Sedentism and tribal horticulture**

Village sedentism and the domestication of plants had a profound, yet limited, impact on human socioecology. Subsistence based on horticulture rests on land-extensive, slash-and-burn practices on prime resource patches, access to which is maintained by the social group and defended by males against outsiders. (Land intensive horticulture is later in time and very different, being more like agriculture because it is based on long-term improvements such as irrigation in which fields are heritable and represent wealth.) Within the group, access is on the basis of usufruct, a system of land tenure that gives all group members direct rights to the means of production and reproduction (Boserup, 1970; Goody, 1976). People live in small villages, larger than hunter-gatherer bands but similarly scaled in terms of face-to-face, kinship-laden interactions.

There is evidence that sedentism brought a reduction in child mortality compared to hunter-gatherers, as well as higher female fertility, although it is unclear whether the strongest effects are in reduced birth spacing or in higher rates of child survival. Bentley et al. (2001), in comparing the fertility changes associated with the prehistoric transition to agriculture report that, when comparing subsistence modes and fertility rates, forager, horticultural, and pastoral groups had similar fertility rates whereas increases were strongly associated with a higher dependence on agriculture. The potential of deaths from chronic intergroup warfare and raiding increased. Using the archaeological and historic record, Keeley (1996) found that for males the percentage mobilized in war often reached 35–40% and male deaths ranged from 10 to nearly 60%.

Among contemporary horticulturalists, complementarity in the male and female division of labor is complex because of its link to local ecology. Garden production by women using the digging stick and hoe provides the carbohydrate and caloric base of the diet and is easily combined with childcare (Boserup, 1970; Goody, 1976). Males contribute their labor in clearing fields, in animal protein through hunting and fishing, and in protection of the village resource base through defense. The relative contribution, type, and imperative of male help varies by ecological context. For

example, female gardening of high-protein crops on riverine alluvial soils, such as millet and sorghum in much of village Africa (Colson, 1960; Lancaster, 1981), is very different from subsistence based on manioc in the thin, lateritic soils of South America. There, male hunting is critical to balanced macronutrients in the diet and frequent clearing of new fields is necessary.

The critical need for defense of the village resource base is supplied by males as an umbrella benefit rather than to specific wives. However, since neither males nor females produce beyond subsistence needs and the means of production are held in common through usufruct, there is little opportunity for major differences in quality to develop between males beyond their embodied capital (age, health, hunting skill). However, variance in male reproductive success does arise on the basis of success in intergroup raiding that brings certain male warriors numerous captive wives. However, this advantage was much reduced under colonial suppression of tribal warfare and raiding.

Reproduction in land-extensive, horticultural societies is associated with near universal marriage for both sexes with reproduction beginning at sexual maturity for women and extending through the entire period of fecundity. Reproduction for men is somewhat delayed due to the need to access wives through either bride service (local group) or bride capture (outside group); the first being a personal cost in labor contributed to the bride's family and the second a cost in risk. However, the possibility of polygyny extends the male reproductive period as new and younger wives can be added through time.

The high frequency of polygynous husbands associated with horticulture is likely because each wife is essentially able to support herself and her children through her own labor (Murdock, 1967; Lancaster and Kaplan, 1992). Males do not have to ponder whether they can afford additional wives and children, only how they to get and keep them. As White and Burton (1988) found, polygyny is most associated with fraternal interest groups, warfare for the capture of women, absence of constraints on expansion into new lands and, especially for horticulturalists, environmental quality and homogeneity. The frequent practice of widow inheritance by husband's kin also increases the frequency of polygyny (Kirwin, 1979). Sororal polygyny (the marriage of sisters) is at its highest frequency among horticulturalists perhaps due to the ease of closely related women forming collaborative, horticultural work groups and child care (White and Burton, 1988).

Parental investment in horticultural societies focuses on raising healthy children without concern for their marriage market endowments of extra-somatic wealth or inheritance of resources. Birth into a social group provides all the inheritance a child needs to

access the means of production and reproduction. Such concepts as bastardy or disinheritance do not play a formal role in family dynamics. Child labor is valuable to families since horticulture provides a number of relatively low-skilled tasks that older children can perform (Bock, 2002b). In fact Kramer (2005b) demonstrated that among Maya horticulturalists older children contribute at the level of “helpers-at-the-nest,” significantly increasing their parents’ fertility and without whose help their parents could not add additional offspring to the family.

Variance in reproductive success is relatively low for women because marriage is universal, and female fertility and fecundity depend on their own health, productivity, and work effort (Prentice and Whitehead, 1987; Jasienska, 2000; Ellison, 2001). Greater variance among men is possible on the basis of raiding and bride capture but the social system itself is not stratified and individual men cannot amass or control access to resources relative to other men or pass them on to their sons.

#### **Tribal pastoralism and extra-somatic wealth**

For most of human history, humans depended on somatic wealth or embodied capital to fund growth and reproduction. However, the domestication of animals, particularly large herd animals such as cattle, camels, and horses, had a profound effect on human social and reproductive patterns. Large, domesticated livestock have intrinsic qualities that affected human social relationships, marriage patterns, and investment in children. For the first time in human history, men could control a form of extra-somatic wealth that could be held by individuals, thus increasing the variance in male quality based on the resources each can control.

Secondly, herds are the basis of a domestic economy through their products of meat, milk and hides. There are advantages to dependence on such a resource supply: (1) improvements in diets rich in animal protein; (2) stability of diet since animals are stored hedges against fluctuation in annual or seasonal climatic effects; and (3) flexibility due to the divisibility of herds into smaller units that can be moved about the landscape on the basis of the richness and concentration of local resources (Barth, 1961). This improvement in diet may result in higher survivorship of women and children compared to foraging and horticulture, but also results in higher mortality for males due to endemic conflict.

Large-animal herding demands a high degree of complementarity between female processing and child care and male risk-taking in herd management and defense. The products of herds require intensive processing of meat, milk and hides, labor provided by women. In contrast, the very existence of extra-somatic

wealth in large stock in such a readily divisible and moveable form (as opposed to agricultural land) puts a high premium on males as defenders and raiders. We find the warrior complex full-blown, with chronic internal warfare, blood feuds, social segregation of a male warrior age class, fraternal interest groups, a geographic flow of women from subordinate to dominant groups through bride capture, and expansionist, segmentary lineages based on the male line (Sahlins, 1961; DiVale and Harris, 1976; White and Burton, 1988; Low, 2000). Men with strong social alliances are more likely to find at least some of their wives from within their own social groups, whereas men from small or subordinate lineages are less likely to be offered brides and are willing to take more risks in lieu of performing bride service (Lancaster, 1981; Chagnon, 1988, 2000).

The original distinction made by Orians (1969) between resource defense polygyny and harem defense polygyny is relevant here. The chronic warfare of pastoralists (White and Burton, 1988; Manson and Wrangham, 1991; Keeley, 1996) can be understood as resource defense polygyny, as opposed to harem defense polygyny described earlier for horticultural societies. Both types of societies raid to capture women to form polygynous unions (harems), but pastoralists also raid to capture resources that can be used to acquire and maintain new wives and their children. In later socially stratified societies, successful male resource holders do not have to do bride service, pay bride wealth, or capture brides; brides will flock to them and their families will even pay for the opportunity for their daughters to marry such a quality male. In a study of 75 traditional societies, the principal cause of warfare was either to capture women (45% of cases) or steal material resources to use to obtain (39% of the cases), particularly in pastoral societies where bride wealth must be paid (Manson and Wrangham, 1991).

Resource defense polygyny means that males will compete to control the resources that females must have for successful reproduction. A male’s ability to successfully control more resources translates directly into more wives and children (Borgerhoff Mulder, 1985, 1988b, 1989). One extraordinary result of extra-somatic wealth, particularly readily partible wealth, is the institution of a new pawn on the marriage market table, bride wealth. Women and their families come to marriage negotiations with their traditional offers of embodied capital (youth, health, fecundity, and female labor). Men, however, now have to come up with a significant payment of extra-somatic resources in the form of bride wealth as a preferred substitute for bride service. Men who depend on bride service are limited in their polygyny because of the years of service each bride’s family requires. Men who inherit resources can start their families early and marry often.

Bride wealth among pastoralists consists of horses, cattle, or camels with sheep or goats as supplements or lower-valued substitutes. Among African pastoralists the close male kin of the groom help him with his first bride-wealth payment, but the acquisition of subsequent wives is his own responsibility. Livestock used for bride wealth has interesting attributes: (1) it creates conflicts of interest between fathers and sons and among brothers for its use to obtain a bride (Borgerhoff Mulder, 1988a); (2) men from poor families will be more willing to take risks to obtain bride wealth or brides through capture (Dunbar, 1991); and (3) livestock can be inherited.

Investment in children takes a novel form under a pastoralist system. The payment of bride wealth improves health and survivorship among young girls because their marriages bring in resources that can be used by their fathers and brothers to acquire more wives (Borgerhoff Mulder, 1998). Sub-Saharan Africa is notable for the fact that in spite of the patrilineal bias in so many societies, neither a survival nor a nutritional advantage is found for boys over girls (Svedberg, 1990). Furthermore, among the Kipsigis, who are agropastoralists, early maturing (and presumably better fed and healthier) women have higher lifetime reproductive success than late-maturing women. As a result, they command higher bride wealth and hence constitute a higher return on parental investment for their upbringing (Borgerhoff Mulder, 1989). They also represent a better investment for a husband's bride-wealth payment because of a higher return in fertility.

Furthermore, children are able to provide child care of younger siblings as well as low-skilled labor in stock care and the processing of animal products, so they are able to substantially but not completely offset the costs of their rearing compared to foragers (Bock, 2002a, 2002b). Child labor plays an important role in the economies of both pastoral and agricultural societies because their contributions through simple tasks such as carrying water contribute to food production by freeing mothers to become more effective producers (Blurton Jones et al., 1994; Kramer, 2005a). However, this reduction in cost of rearing is countered by the fact the parents of sons now have a new cost to meet; the balloon payment (bride wealth) needed to establish sons on the marriage market. The flow of stock through families who are both bride-wealth receivers and givers helps maintain the system, at the same time that it creates problems for families with unfavorable ratios of sons to daughters (Borgerhoff Mulder, 1998).

Finally and most significantly, there is suggestive evidence that for the first time humans begin to reproduce at levels that may not maximize the number of descendents in association with the appearance of extra-somatic wealth and its inheritance. Among modern East African pastoralists men appear to marry

fewer wives than they could afford in the interests of providing each child with a greater endowment. In other words, male pastoralists may pit quality against quantity of children to preserve a lineage status and resource base and rather than simply maximizing the immediate number of descendents (Luttbeg et al., 2000; Mace, 2000).

### **Social stratification, states, and despotism**

The rise of civilizations, beginning about 6000 years ago in Mesopotamia and occurring at different times and places around the world (for example, Egypt in the Near East, the Aztec and Inca in the Americas, and India and China in Asia) marked a critical shift in how humans organized themselves in social systems and in relation to the environment (Goody, 1976; Betzig, 1993; Summers, 2005). These civilizations appear to have developed independently in response to local conditions without being the products of either conquest or diffusion. In spite of this historical independence, they evidence significant similarities: (1) the presence of large, stratified social groupings settled on particularly large and productive resource patches; and (2) the appearance of social despots, men who use coercive political power to defend their wealth and reproduction and practice warfare to acquire more resource patches and slaves (Betzig, 1986). These two major effects flow from the nature of the resource patches.

The patches upon which the first civilizations were settled had special qualities: (1) they were highly productive but set in environments where there was a rapid fall off to unproductive lands such as desert or forest; and (2) these productive patches could not be intensively utilized without complex political organization as in regional irrigation systems. Political control and organization rested on the power of men. Although female primates often form alliances with their female kin to protect and control access to the resources necessary for their reproduction (Isbell, 1991; Sterck et al., 1997), the reproductive benefits of extra-somatic resources are much greater for men than for women, because of their impact on polygyny. The end result of these environmental conditions associated with early social stratification was that men competed for control of the resources necessary for reproduction, formed despotic hierarchies involving social alliances and stratification, with low-status men 'agreeing' to live under political despotism because they could not readily move to another resource base.

The increased reliability of food resources, the costs of warfare, and the concentrations of large populations into small and sometimes urban areas each had impacts on mortality and morbidity. A cross-cultural analysis of fertility and mode of subsistence found that,

for a 10% increase in dependence on agriculture between two related cultures one of which moves towards agriculture, there is a fertility increase of approximately 0.2 live births per women (Sellen and Mace, 1997). Bentley et al. (2001), in reviewing the cross-cultural and archaeological evidence, suggest a series of multidirectional effects: higher fertility due to more consistent food supply and earlier maturation; increased infectious diseases with regular visitations as well as endemic diseases (malaria and tuberculosis) due to long-distance trade and large urban populations; and a shift in peak mortality from infancy to middle childhood. Furthermore, warfare continues to reduce the numbers of young men in the mate pool.

With social stratification comes a complex division of labor with specialists in war, farming, crafts for the production of goods and services, and war captives and slaves for the hardest manual labor, as well as long-distance trade in luxury goods and slaves. The introduction of the plow in Eurasia, perhaps as early as the sixth century BC, and the need for food production beyond simple subsistence to service urban markets led to significant changes in the division of labor (Goody, 1976; Ember, 1983) and extremely high complementarity between male labor and resource acquisition and female labor and child care. There is evidence of increased workloads for women in spite of the fact that men assume more responsibility for farm labor, because of increased demands for women to process grains or secondary animal products such as milk, hides, and wool (Bentley et al., 2001).

Variance in male fertility in these first civilizations in the Near East, Central and South America, and Asia was probably the greatest it has ever been before or after in human history (Betzig, 1986, 1992a, 1992b, 1993; Summers, 2005). The reason for this is that despotic males had enormous political and social control with the ability to eliminate rivals and their entire families through despotic edict, to wage war to increase personal and state resource bases, to acquire slaves and war captives for labor and reproduction, and to determine political succession for favored sons. This extreme variance in male resource holding inevitably produces social and political instability due to the creation of too many potential heirs (sons of many wives) and too many males (slaves) without access to the means of reproduction. The great wealth to be gained from domination also motivated expansion and intergroup conflict among would-be despots.

Despotic males are an extreme example of resource defense polygyny (Orians, 1969); that is, as individuals they control access to the resource base for reproduction that females require and, with few competitors, polygynous marriages to them become the only family formation strategy option for many women. The mating markets of despotic systems are characterized

by historic extremes in male variance in resource holding and power. As Betzig (1993) notes, the extreme sizes of royal harems ranging from 4000–16 000 women are associated with smaller but still impressive numbers of wives and concubines for the royal relatives and supporters. In the case of the Inca the size of a man's harem was regulated by law and in direct relationship to his social/political rank (Betzig, 1993). Among the Inca there were nine levels of political rankings with polygyny ceilings for each except the top-most. These harems were exclusive holdings of large numbers of young, fecund women with their children and sexual access to them was restricted to their mate and regulated with some sophistication to optimize female fertility. Many of these wives and concubines were collected as tribute or war booty; but others, as principal wives, probably represented important political alliances with their male relatives.

### Variance in male quality and the marriage market

There are two clear outcomes of such extreme variance in male quality. The first is that many men remain unmated or have only one wife, so that male celibacy or at least nonmarital sex is prominent. In the words of Dickemann (1981, p. 427), polygyny in the context of extreme social stratification is "characterized not only by arbitrary sexual rights of lords and rulers but by large numbers of masculine floaters and promiscuous semi-floaters, beggars, bandits, outlaws, kidnappers, militia, and resentful slaves and serfs." Nevertheless, these early despotic states lasted for thousands of years. A second outcome of variance in male resource holding and male mating success is that there tends to be universal marriage for women with only those most severely compromised by health or other personal qualities being unlikely to find a role as secondary wife or in a minor union. For access to the mating market men must bring extra-somatic wealth, power, and land in order to be favorably placed or else get wives as high-risk booty in state warfare (Low, 2000; Clarke and Low, 2001).

Women, too, bring their traditional embodied capital qualities of youth, health, and fecundity along with their labor for access to the marriage market. However, there was a historic shift in how women and their families approached marriage negotiations that has been richly described by Dickemann (1979a, 1979b, 1981) in a series of papers on hypergyny, dowry, female infanticide, and paternity confidence. The extreme variance in male quality created by despotism and harem polygyny forces the families of women to put down more and more value on the mate market table to access a desirable groom or to move a daughter up in the social hierarchy. These extra payments include

actual wealth, in the form of dowry, and guarantees of paternity confidence (bridal virginity and wifely chastity). Guarantees of a daughter's virginity and chastity (a prerequisite for a bride destined to produce heirs to a male lineage holding a reproductive estate) are costly forms of embodied capital, involving female seclusion (special women's quarters, harem guards, chaperones), and female incapacitation (foot-binding and corseting) that bars their daughters from the outside world of productive labor.

Parental concern over the ability of their children to access reproductive estates transformed the nature of the marriage market. Parental investment in these systems varies in relation to the power and wealth of the male's family. As is to be expected, under such conditions where male access to and control of resources is the basis of social stratification, patrilineal descent and patrilocal residence are highly favored since males are the principal resource holders (Hartung, 1982). Resource-holding parents commit to a "balloon payment" in launching their children in marriage. This balloon payment takes the form of endowments and promised inheritance for sons and dowry as anticipatory inheritance for daughters (Goody, 1973, 1976; Dickemann, 1979a, 1979b). For resource-holding families then, the marriage market formed by stratified social systems proved costly in terms of parental investment and forced a focus on endowments for both sexes at the age of marriage. Poor parents, on the other hand, attempted to balance labor demands with fertility, since in agricultural systems children can be productive at low skill tasks or child care and add to the family economy. Thus, they might try to regulate birth spacing to optimize the productivity of already born children before another mouth to feed is added to the family.

Finally, a notable characteristic of the premodern period in many parts of the world is evidence for a growing rural population resulting from higher fertility and an associated growing concern regarding saturation of the resource environment. This is often associated with urban growth, empire building, and expansionism, providing opportunities for migration by noninheriting or low status children to areas of both higher mortality and risk but also with the potential for the acquisition of land, or wealth and power. It also generated a new concern about keeping the family estate intact and about the management of inheritance.

#### **Premodern states and narrowing the pool of inheritors**

With population growth and increased saturation of arable lands, parents adopted patterns of restricted and differential inheritance in order to keep the family

estate intact and maintain the concentration of wealth, or in the case of the poor, to balance food supply with family size. This trend, although it occurred in response to population pressure on existing resource bases all over the world at different time periods, is particularly well documented in premodern Europe. Human evolutionary ecologists in collaboration with historical demographers provide us with a unique record of the relationships between fertility, family formation strategies, and socioecological context during the premodern and early modern periods of European history (Volland, 2000). Their studies, based on heraldic or parish records of births, marriages, deaths, and inheritance of estates, can be used to directly link reproductive strategies with resource holdings. This time period witnessed developments that had began centuries earlier but occurred without the benefit of quantifiable documentation. Boone (1986a, 1986b), for example, traces the historic process of parental investment among Portuguese elites during the late medieval/early modern periods of the fifteenth and sixteenth centuries. Saturation and resource stress are evident with a progressive narrowing of the numbers of claimants to an inheritance, first through monogamy to create a single bloodline of inheritors and bastardy to disenfranchise offspring who are not the product of a legitimate union (Goody, 1976, 1983), followed by a preference for sons over daughters as inheritors, and finally by birth order effects with preference for primogeniture within each sex for access to resources and the creation of celibate children to live as priests, nuns, bachelors, and spinsters (Hrdy and Judge, 1993). For the first time in human history mating and reproduction is no longer a universal for women and siblings of the same sex are pitted against each other in competition for access to reproductive estates. With survival through child- and young adult-hood still quite problematic, ancillary practices develop in which both sons and daughters would be held in reserve in monasteries and nunneries for inheritance and reproduction should their older same-sex sibling die (Goody, 1976, 1983; Boone, 1986a, 1986b). Within the scope of these restrictions that limit half-sibling and sibling competition, parents with wealth raise as many children as they can but endow a select number at adulthood.

During most of this historic period there is a strong correlation between wealth, probability of marriage, younger age at marriage, and completed fertility (Volland, 2000). However, restricted inheritance decreases the reproductive benefits of polygyny. The desire to concentrate wealth also limits the reproductive success of noninheriting sons and daughters. This is a second striking example in which reproductive and parental investment behavior in response to extrasomatic wealth results in outcomes that did not maximize parental fitness. In fact, towards the end

of the period, as life expectancy improved and economic structures became saturated, resource holding groups delayed marriage into the late 30s and early 40s for men and mid 20s for women (Szreter and Garrett, 2000; Voland, 2000).

The family reconstruction studies document very different reproductive strategies according to class<sup>1</sup>. Generally, wealth brings higher probability of marriage, at a younger age, to a younger spouse, and more children. However, as environments become more saturated, local resource competition among siblings differentially affected resource-holding families, as opposed to day laborers, and increased the likelihood of dispersal of later-born children (Clarke and Low, 1992; Voland and Dunbar, 1997; Towner, 1999, 2001). With saturation, the benefits to resource holders of having an above average number of children was offset by more and more intense sibling competition for access to inheritance (Voland, 2000). Parents without resources had no need to manipulate their offspring and were more likely to benefit from opportunistic strategies by their children (Voland and Dunbar, 1995).

Wet-nursing presents a fascinating example of how differentiation in parental investment strategies develops into extreme forms for both the highest and the lowest status groups of women. Throughout human history there has always existed a conflict between production (acquisition of food) and reproduction (lactation and child care) for women, a conflict that in fact troubles female mammals in general. Human women are especially caught in this conflict because they have multiple, dependent young of differing ages and needs (Draper, 1992), which means that true respite never occurs until all children are reared. Cross-culturally women's work is organized by its compatibility with child care (Brown, 1970); however, this compatibility is never complete – only more or less so (Hurtado and Hill, 1990; Lancaster, 1997; Lancaster et al., 2000). As a result of social stratification high status women are able to subvert the physiological capacity of lactation of other women to serve their own reproductive ends. Since intense breast-feeding lowers the likelihood of ovulation, a wet-nurse, even if paid, sacrifices her own fecundity to another (Hrды, 1994, 1999). Typically high status women did not breast-feed their own children but used wet-nurses. This increased the fertility of high status women,

whose main function was to produce heirs, to a nearly annual birth rate (among the highest for any group of women in human history). In contrast, the birth spacing for wet-nurses was closer to four years (Hrды, 1994). A second group of women also used wet-nurses, especially towards the end of this historic period. These were single women working in urban centers or the wives of poor tradesman who found themselves in positions of servitude or trade where the incompatibility between breast-feeding and work was complete. To the great detriment of their infants' survival, these women placed their children with commercial wet nurses at baby farms (Hrды, 1994). In these cases the demands of maternal work far outweighed the needs of infant growth, perhaps to improve the development of weaned, older children.

The past 10 000 years of human history brought many changes to what was originally the forager adaptive niche. As the last glaciers withdrew, humans began to intensify their extraction of resources from the environment by domesticating plants and animals. At first, land extensive horticulture combined with hunting did little to alter the human experience of small groups, face-to-face social networks, and subsistence economies. Family formation practices continued the relatively low rate of polygyny, nearly universal marriage, bride service and bride capture, and the production of children regulated only by the health and well-being of the mother and each child.

The first transformation in human experience followed from the appearance of extra-somatic wealth in the form of large domesticated animals and later land. Extra-somatic wealth has an intrinsic quality, it can be taken by force and stronger individuals and groups can amass or control access to it. This necessarily creates much wider variance in male quality than occurs in forager men dependent on embodied capital investments of health, vigor, and skill. Family formation strategies responded by turning the old rules upside down. Instead of men paying for access to wives with bride service, bride wealth, or the dangers of bride capture, payments in the marriage market reversed direction. As social groups became stratified and wealth differentials increased, women and their families began to bring and more to the bargaining table by offering both dowry and paternity confidence in the form of virginity and chastity. During the final phase of the premodern period, societies became obsessed with the preservation of the family's reproductive estate by successively narrowing the possible number of inheritors. First the line of inheritance went only to the children of the principal wife with others labeled with bastardy, then daughters could only inherit via a dowry lower in value than a son's inheritance, next only the first or a selected son could be endowed with the family estate and the rest had to find other niches

<sup>1</sup> The behaviors of nobility are documented by Boone in Portugal (Boone, 1986a; Kramer, 1998) and Dickemann in Europe, the Middle East, China, and India (Dickemann, 1979b, 1981), and for gentry and land-holding peasants as well as day laborers by Voland and colleagues in Germany (Voland, 1990; Voland and Engel, 1990; Voland et al., 1991, 1997; Voland and Dunbar, 1995, 1997; Voland and Chasiotis, 1998; Voland, 2000), Low in Sweden (Low, 1990, 1991, 1994), Towner in the United States, and Hughes (1986) and Scott and Duncan (1999) in England.

in the society or migrate. Just before the onset of modernization, the world had become full of bachelor and spinster noninheriting children with no guaranteed access to the right or means of reproduction, qualities of life that were part and parcel of the original human adaptive niche.

### **The modern world and embodied capital**

Given rural reproductive and survival rates, the restricted inheritance system discussed in the previous section produced excess adults without access to land and the means of production. Colonization through conquest was one response by males to this situation, especially later-born sons (Boone, 1986a, 1986b; Curtin, 1989). Another response by both men and women was to provide services for others, and migration to cities in search of employment. This supply of labor and of consumers helped fuel the growth of a skills-based, mercantile economy that was to gradually supplant the power- and land-based hierarchies of the premodern period based almost entirely on extra-somatic wealth.

Those conditions set the stage for dramatic changes in reproductive and parental investment strategies. In the early 1800s, changes in the relationship between humans and their economies began in a small part of the world, Western Europe, including England (Clark, 2007). This change has been labeled the “demographic transition.” For nearly all of human history, available evidence suggests that human populations responded to greater resource availability with increased fertility, and reduced fertility when resources were scarce. Women’s reproductive physiology appears well designed to make adaptive responses to increases and decreases in energy availability (Ellison, 2001, 2003).

However, after 1800 with the demographic transition, the size of human families began to shrink, first among the wealthier segments of society, even as standards of living and energy availability were increasing. Unlike before when individuals in good condition had more progeny than individuals in poor condition (just as is the case with other species), higher status humans began having fewer children than did the poor.

This trend only lasted for a time. Today there are remarkably few differences between classes or even ethnicities in completed family size. For example, in the United States today the average US woman produces 1.9 children, considerably below the replacement level of 2.2 children. When broken down by ethnicity, the numbers are 1.7 for Asian Americans, 1.8 for non-Hispanic Whites, 2.0 for Blacks and 2.3 for Hispanics (US Census Bureau Report, 2008). Although the range between the highest and the lowest is three-fifths of a child, the main message from this data is consensus: two children are enough.

Not all the world today has experienced the demographic transition, but completed family size of replacement level or less is typical of modern economies with skills-based labor markets as in Western Europe, North America, Japan, China, and parts of Latin America (Cuba, Chile, Costa Rica, Puerto Rico, and Trinidad and Tobago) (Population Reference Bureau, 2008). Furthermore, for the first time the world population is evenly divided between rural and urban areas, and by 2050 urban residents are likely to make up 70% of the world’s population (Population Reference Bureau, 2008). This reversal in family reproductive strategies from having as many children as possible to only two is related to a strategic shift from quantity to quality, in which quality is most often expressed in education and training to be used for access to resources, not inheritance.

### **Modern skills-based labor markets and the expenditure of extra-somatic wealth to embody human capital**

Changes in the nature of resource production and the economic forces that determine wages in labor markets appear to underlie these changes in reproductive and parental investment strategies, and explain their patterning over time and space. The directional change in the nature of labor markets towards greater wage premiums for skill- and education-based capital over the last two centuries is well documented (Newcomer, 1955; Burck, 1976; Herrnstein and Murray, 1994; Vinovskis, 1994; Clark, 2007). As the extent of the labor and consumer markets grew, along with advances in production technologies, there was a concomitant increase in both private and public investments in education. In a sense, the relationship between embodied capital and production in modern skills-based labor markets is more similar to the foraging life way than to its agricultural predecessor. Rather than generating wealth through control of land, people now invest in learning to increase productivity, and individuals are free to move through the environment in search of economic opportunities because they carry their embodied capital with them.

These increases in educational capital investment and the nature of labor markets were accompanied by improvements in the “technology” of disease prevention and treatment, and by increased public and private investments in health and mortality reduction. During the nineteenth century, there were large changes in the scientific understanding of disease (Preston and Haines, 1991). This led to a dramatic decline in infant, child, and adult mortality rates that continued for close to a century. As scientific advances enabled reductions in mortality rates, there was strong pressure to increase public investments in health and disease

prevention from the protection of the water supply to the development of vaccines and public access to medical care. As a result, infant and child mortality rates reduced dramatically, greatly increasing the probability that investments in children will be realized in terms of productive adulthoods. The length of the productive adult life span, especially when time lost to morbidity is taken into account, also increased significantly. Together, the two shifts in production processes and mortality rates favor increased human embodied capital investment in a way that is reminiscent of the initial dietary shift leading to the hominid specialization discussed above (Kaplan et al., 2002).

This historical process also resulted in much greater labor force participation by women. During the initial demographic transition in the developed world, the breadwinner-homemaker family structure was dominant. With increased demand for labor that requires skill as opposed to strength and with growth in the service sector of the economy, wage-earning opportunities for women increased. At the same time the payoffs to “home” production decreased with labor-saving devices, such as washing machines and refrigerators, and smaller family size reduced the number of years spent caring for small children. Over time the value of male strength through labor and the time women spent caring for small children was reduced; thus leading to a trend from greater to lesser complementarity between men and women so that men and women are now closer to being interchangeable units in work effort.

Although the shift towards an education-based wage structure has been largely monotonic, those changes occurred at different times in the developed and developing worlds and the details of the supply and demand for labor of different levels of human capital have been both historically and regionally variable. Moreover, both within and among societies, there appears to be a great deal of variation in rates of return on investments in educational capital.

The production of human capital is also human-capital intensive (Becker and Barro, 1988) and associated with a reduction of the value of children’s labor as their time is taken up with education and training. To see this, it is useful to think of an “education production function.” In each year of a child’s life the amount a child learns, and the changes in his or her knowledge, reading, writing, logic, and mathematical skills, will depend upon many different inputs, such as the child’s time, prior abilities, parents’ time, and teachers’ time. The value of those inputs, in terms of the educational capital produced, depends on the quality of in those inputs. First, consider inputs of parents’ time. There is significant evidence that the nature of parent-child interaction varies with the educational level of parents (Hart and Risley, 1995; Hoff-Ginsberg and Tardiff,

1995). For example, Hart and Risley report that, by the age of three, children have heard six million words if their mothers are professionals, three million words if their mothers are “working class,” and only one million words if their mothers are on welfare. By the time children enter the public education system there are clear differences among them in school-related skills, and those differences are related to socioeconomic status.

Second, the rate at which a child learns may depend on the knowledge and skills she already possesses. Much of the education offered in schools is based upon the premise that knowledge is cumulative (Cromer, 1993). Basic skills are acquired first, and those skills are used as a foundation for the acquisition of the next set of skills. This implies that the impact of the child’s time inputs would depend upon skills already in place. It also means that the net increase in embodied capital at each age is a function of both the quality of inputs, and the embodied capital acquired at younger ages.

Moreover, those qualities tend to be correlated across inputs. Children with more educated parents also attend better schools with better teachers and better fellow students. At the other extreme, children in developing nations often come from families in which neither parent has had formal schooling and attend schools with very large class sizes, almost no library resources, and teachers with only primary education themselves. Under those conditions, much less is learned per year spent in schooling. For example, in a study of a predominately Black township school in Cape Town, South Africa, Anderson, Kaplan and Lam (unpublished manuscript) found that on average, it took children 15 years to complete 12 grades of schooling. By that age (20–21), only about 10% of students have passed the final matriculation exam and earned a high school diploma. The variance in those inputs leads to an increasing differentiation in educational capital with age.

This within-population heterogeneity in the costs of embodying capital in children means that the environment does not determine diminishing returns to parental investment as it would be in primary production economies, but will be frequency-dependent. Individuals with low levels of human capital are more likely to be unemployed as well as having a lower income, when employed. This is especially true in urban areas in the developing world. The massive rural to urban migration over the last four decades has resulted in very large populations of people with low levels of education competing for a limited number of low skill jobs in the economy. In many places, male unemployment can be as high as 70% or more. This variability in educational capital, along with its impacts on income variation both across individuals and within

individuals over time, has profound effects on family formation and reproduction.

In fact, the link between education and income increased in intensity during the second half of the twentieth century. For example, real wages actually dropped from 1958 to 1990 among men without high school degrees in the United States. In 1958, men with graduate education earned about 2.3 times as much as men with elementary education; by 1990, they earned more than 3.5 times as much. Wage differentials among men with some college education, bachelor's degrees, and graduate degrees also increased substantially. For women, wage differentials among educational attainment levels increased substantially in the 1980s (Kaplan et al., 2002).

### THE HUMAN ADAPTATION: SOMATIC AND EXTRA-SOMATIC INVESTMENTS

Human history is based on a remarkable coevolved pattern of investment in a large brain, slow growth, long life, and access to resources based on skills-based performances. This pattern, along with marriage, a complementary division of labor between the sexes, food-sharing, and the support of offspring well into adulthood, has allowed humans to people the world and control the top of the food chain wherever they go. Most of the human history of the past two million years depended on capital investments in mind and body; embodied capital in the form of skills, experience, immune function, and social networks created the opportunity for adaptations to highly variable socioecological environments. Then, only 10 000 years ago the domestication of animals and plants shifted the value of such investments to the point that social organization, family structure, marriage patterns, status of women, and investment in children all seem obsessed with access, control, and defense of extra-somatic wealth in the form of animals or productive land. It is only in the last 200 years that the pendulum, linked to the appearance of skills-based, competitive labor markets demanding a new form of embodied capital based on education and training for access to resources, has reversed its swing. Today humans are moving into a new, more flexible productive niche based on the investment of extra-somatic wealth to embody human capital in the form of education and training.

### DISCUSSION POINTS

1. Why was the division of labor between males and females such a critical feature in human evolution? How does it differ from feeding and parental

investment patterns typical of most mammals? How did it alter how humans access and distribute food?

2. What is the impact of the socioecological context on human marriage markets and family formation strategies in terms of the distribution of resources and the means to access them?
3. More and more modern societies are experiencing a reduction of completed family size to replacement level (2.2 offspring) or below. Why should this be so when these societies have the highest standard of living known in human history? How might such small family size impact parental investment and family formation patterns?
4. Why does variation in male quality impact the marriage market? What features in male quality have been important in different kinds of economies and social organization? Are these qualities inherent or acquired? How so?
5. What are the factors that have led to a division of labor in which female work is closely linked to compatibility with child care? Are these factors as salient today as in the past?
6. Embodied capital has been critical to human affairs in both the simplest and most modernized societies. What are the similarities and differences in embodied capital in these two contexts?

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