April 20, 2006

The Neolithic Revolution: Paradise Lost?

Focus: *The Neolithic or "New Stone Age" is marked by the beginning of agriculture about10,000 years ago in the Fertile Crescent. It is now fairly evident that the Neolithic revolution and its political and social ramifications resulted in a decline in the material quality of life for most people and especially for women. The neolithic diet was deficient in many respects and the disease and parasite burden on people living in dense populations in unsanitary conditions and in close proximity to animals increased greatly.*

Women were severely impacted by the social and political changes following the change to agriculture and the associated development of pastoralism. Once free to divorce, to keep her children and remain with her family, women were now unable to divorce, engulfed in the cult of virginity, forced to move away from her family and live as a virtual slave in the household of her husband who now owns her children.

It is a matter of some controversy as to why people adopted agriculture. It seems reasonable to implicate some catastrophic environmental factors associated with the end of the Ice Age which necessitated that humans find a way to raise the intensity with which they exploited their environment. The gathering-hunting mode of production may have continued to serve small numbers, but for most a change had to be made - a change that had long been resisted because of the great deal of work it required. The lower orders had to work harder because of the fixed costs of agriculture and they had to feed a parasitic class of elites.

They have made worm's meat of me - Mercutio, Romeo & Juliet - William Shakespeare

There was a time out of memory when the Goddess Earth lay sleeping under a shining blanket of ice. In those times beings fled south to find shelter from the wind, and many lands were hidden. One day the Goddess began to wake. Her glaciers melted, and bright streams of clear water ran everywhere. Flowers bloomed on slopes where no flowers had bloomed for countless generations, and the world was dizzy with the scent of the Great Spring. But, human beings were frightened. They had grown used to their frozen world, and melting was a terror in their hearts. "How shall we live now that the great beasts we have always hunted are disappearing?" they cried. Hearing their prayers, the Goddess Earth took pity on them and sent three of her daughters to teach them new ways. To some, the divine sisters taught the art of fishing, to others the art of weaving and pottery making, and to others the magic of taming animals and planting grain. So for over a hundred generations human children lived in peace and prosperity, praising the Goddess Earth and calling Her by many names. - A teaching story of the Sharatani people, Black Sea Coast, Fifth Millennium, B.C. quoted by Mary Mackey, 1993.

The Neolithic Revolution

Human prehistory in Europe is divided into three stages: the paleolithic, the Mesolithic, and the neolithic. The root "*lithic*" means stone age. The prefixes *paleo*, *meso* and *neo* mean old, middle and new respectively. The paleolithic period began when the first tools were made from "river

pebbles" and ended about 12,000 B.P.. The paleolithic period included the life experience of at least 40,000 "human" generations [Harris 1975 p.180].[1] The paleolithic terminated at the end of the Pleistocene period (ice age). The Mesolithic was characterized by dramatic local ecological change which required human cultures to adapt to new environmental conditions. The neolithic begins with the domestication of plants and animals, i.e. the invention of agriculture in the period 10,000 B.P. to 2000 B.P..

Humans began making primitive stone tools about 2 million years ago. Fire and cooking were mastered by about 500,000 years ago. The basic tools of the hunter and gatherer - the digging stick, the spear thrower and the carrying container had also been invented by this time. The world offered food in such abundance that no methods of storage, transportation or preservation were necessary. Thus, for the bulk of its prehistory the human race lived as foragers taking food as they found it if they needed it. As humans moved out of the African cradleland into Europe about 730,000 years ago, life became more difficult. Plant life was not as bountiful and the hunting of the large game was very difficult. Each of these problems was exacerbated during the ice ages that drove glaciers as far south as London and the French Riviera. In these periods, in the tundra environment of the ice age, humans *in Europe* became almost totally dependent on hunting reindeer, wooly mammoth, bison and wild horses [Ponting 27].

Throughout the paleolithic human technology advanced considerably, nevertheless the basic human subsistence activities remained virtually the same as those of it immediate ancestor, *Austrolopithicus*. Humans obtained their food from hunting, fishing, and gathering wild plant foods.

The composition and the quality of the human diet changed as environmental perturbations produced a series of cycles of ice ages followed by warm periods. As the glaciers advanced animals were driven south, plains became tundra, forests became plains or turned to deserts and deserts bloomed. All went in reverse as the glaciers retreated [Harris 1975 p. 186]. But something happened at the end of the last ice age that broke the cycle. Humans had been through many of these cycles and sustained the gatherer-hunter infrastructure, but that was to change.

Theoretical Frameworks

The adoption of agriculture constitutes the greatest technological revolution in the human experience. The cultural changes following the change to agriculture were no less tumultuous or significant. Why the change happened, after forty thousand human generations of gathering and hunting is, therefore, a matter of great importance; especially for women.

There are a number of theoretical frameworks directed toward explaining the Neolithic Revolution: the cost/benefits theory of Cultural Materialism, Idealist theories, Malthusian theories and the Marxian theories.

The Idealist theory posits that animal domestication and agriculture were great ideas of some great genius. Humans had only been enduring their depraved existence "in waiting" for someone

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[1] Human would include Homo erectus, neanderthal and Homo sapiens. Neanderthaloids and "other archaic" Homo Sapiens appeared at about 100,000 B.P.. Neanderthals were present until at least 55,000 B.P. [Harris 1975 p. 179]

to figure out how they could improve the quality of their material life. Once these technological ideas occurred they were adopted with alacrity. Implicit in this view is the "solitary, nasty, brutish and short" and "prisoner of primitive technology " stereotype of human life in the Pleistocene; that humans were trapped in "savagery" by inferior technological ideas. An example of such a theory is that of the American Institutionalist economist, Thorstein Veblen. Integral to Veblen's perspective is the view that humans have "primal urges" or:

> "instincts and propensities to develop more effective methods of meeting their generic needs (food, shelter, health and so on). That is, evolving technology is rooted in human nature and is indeed the main driving force in human history [Ramstad p. 366].

This new technology comes to be implemented only if it proves "serviceable, that is, does it allow the community to satisfy a generic need more effectively or with less effort?" [Ramstad p. 366] Idealistic theories, such as Veblen's appear to be teleological as they presuppose that "primal urges conduce to the betterment of the human condition." [Ramstad p. 366].[2]

The Cultural Materialist or "economic model" claims that humans do not have a propensity or instinct to solve problems that they do not have. Humans look at benefits and costs. As long as the GHMPR proved sufficient to meet "generic needs," which it appeared to do for several hundred thousand years, and still does for what few indigenous gatherer-hunter peoples are left, with a reasonable expenditure of energy, humans appear to have been satisfied. Of course, civilized people could never understand how people who had so little could have been anything but miserable and in a constant state of wishing for a technological "messiah" to show them how to grow more food. Without the presumption of existential misery of the savages, a theory of change, then, must account for the deterioration in the efficiency of the GHMPR and a decline in the GH state of well-

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[2] Professor Ramstad, a professor of Economics at the University of Rhode Island, is a distinguished "institutional economist." The cited material does not necessarily represent his personal view. The quotes cited a from a paper Professor Ramstad prepared on the institutional economist, Thorstein Veblen. The views are Veblen's. I did not want to convey the impression that Ramstad held these views nor do I want to leave the impression that Veblen was an unguarded optimist regarding the human future.

Countering the progressive instinct for workmanship, as he called it, was so-called ceremonial behavior which was rooted in the "predatory instinct." Briefly this means progressive changes cannot be implemented if they are contrary to the agenda of vested interests (we would call them macroparasites) [Ramstad p. 367].

I should also note that Veblen was the intellectual father of a discipline in economics called evolutionary economics. Advocates of evolutionary economics claim their theory of technology is not teleological. All I can say is, that Veblen, despite his advocacy of a Darwinian, non-teleological evolutionary economics, built teleology in to his system with his conception of the "instinct for workmanship." As Veblen Scholar, Doug Dowd puts it, Veblen sometimes "allowed wish to take the place of thought." [Dowd p.26]. It is also worthy of note that I know of no attempt by evolutionary economists to explain the emergence of agriculture. Most writers confine their discussion of technology to modern economies.

being. The positing of a *deus ex machina* to drive the system perpetually, if not without resistance, toward progress cannot achieve this goal. Moreover, regarding the transition to agriculture, it is clear that "less effort" was not part of the bargain. Nor were generic needs serviced more effectively; the health, security and freedom of neolithic peoples was considerably below that of paleolithic "primitives." In short, the neolithic revolution was not progressive in terms of meeting "generic needs."

The Marxian theory is no less teleological than the idealist model. The *deus ex machina* Marx installed to drive his system was the "dynamic" of the "forces of production." It is premised on the same idea as Veblen's "instinct for workmanship," namely that humans are trapped in a deficient living standard by inadequate technological ideas. Thus, humans always strive to improve technology. Marx (and Veblen) paved the road to social perfection with blocks of resistance from reactionary classes who stood to lose from technological change. In Marx's terminology reactionary classes were a "fetter" on the dynamic productive force. Marx, thus saw history as a series of "class struggles" between progressive and reactionary classes. The adoption of a new technology requires a progressive class as its advocate so as to over come the inertial forces of reaction.

It is difficult to apply the Marxian model to the transition to agriculture because before the adoption of agriculture there was no social stratification i.e. no classes to struggle. Groups living within the GHMPR were egalitarian, kin-based groups. While there may have been a war of the sexes, or the usual misunderstandings of youth by elders, there were struggles against other groups, but there were no internal battles. Marx and Engels were well aware of this. Indeed, there was much about primitive communism that Engels admired, most especially their egalitarianism. Nevertheless, Engels believed primitive communism inferior to civilization citing the "cruelty of warfare, religious superstition, the stunted productive forces, and the power of nature over people" [Gandy p. 17]. Marx, on the other hand, was no admirer of primitive communism, he saw its termination as the beginning of progress. Primitive communities, he believed, "restrained the human mind within the smallest possible compass, making it the unresisting tool of superstition, enslaving it beneath traditional rules, depriving it of all grandeur and historical energies"[Quoted in Gandy p. 18]. Marx's idealism is apparent as he clearly saw freeing the human mind as a precondition for developing the productive force; humans must escape bad ideas before they can progress.

Of course, Marx and Engels had a peculiar conception of progress. Following their escape from savagery and barbarism, according to Marx and Engels, humans "progressed" to the stage of slavery. Eventually, with the advent of agriculture, society reached a point where increases in labor power became desirable. In previous epochs (male) war captives were killed as they produced no benefits to people who had to constrain population size. Now that captives, thanks to agriculture, could produce a surplus over what was needed to feed them without degrading the environment, it now made sense to turn them into slaves. The era of classical slavery was born [Bober p. 49]. Marx and Engels saw the elimination of GHMPR and the emergence of slavery as historically "necessary." Just as they would later deem it necessary that the European and Indian peasantry be eradicated in the name of progress. Indeed, it was precisely in the spirit of Marx and Engels that Joseph Stalin murdered some two million "reactionary" Russian peasants.

In the final analysis Marx could not explain, but only wished for the demise of GHMPR. Neither Marx or Engels posited any "contradiction" in the mode of production of primitive communism or any developments of the productive forces that drove the system toward agriculture. The primitive commune allegedly broke up because of the emergence of private property, but

Engels admits to ignorance as to why this happened. It would appear that Marx and Engels simply assumed that the productive force naturally continued to progress: a pure teleology.

The teleological, idealist theories of Veblen, Marx and Engels are refuted by the fact that extant gatherer-hunters understand the basic principles of agriculture, but choose not to apply them to their lives. Among anthropologists now it is clearly understood that the "ignorance [of GH people] of the basic [agricultural] principle is almost inconceivable" [Harris 1980 p. 86]. Agriculture was probably, for millennia during the paleolithic, an idea whose time had ***not*** come: it involved more work and it was simply not necessary. The adoption of agriculture would come only when it became a better cost/benefit deal than gathering and hunting.

The driving force behind the adoption of agriculture was definitively material; climate change combined with human predation of Megafauna changed that the ecological conditions in the heart of the *Infrastructure*. Agricultural technology was a passive player, a bench warmer waiting for an active player to get injured. Judging from the decline in the human standard of living when it entered the game, his position on the bench was well deserved. Nevertheless, we must give him credit for keeping the game going.

The Malthusian perspective, the so-called overcrowding hypothesis, claims that agriculture was instituted because every viable ecosystem was filled up so "population pressure made the switch to agriculture unavoidable." [Harris 1980 p. 87]. But, this view does not allow that massive faunal depletions and the loss of land mass certainly altered the GHMPR benefits/costs, not to mention the effect of the loss of animal protein on the population-limiting efficacy of lactation. *It was not that population outgrew the carrying capacity of the environment. Rather the carrying capacity of the environment, as accessed through the GHMPR, declined. Humans now had to expend more energy to gather and hunt food that produced a smaller energy benefit.*

The simplistic notion that population inevitably grows is inconsistent with the paleolithic experience. Why did the cultural practices that had controlled population growth for millennia suddenly fail? Whether a population is too big is a relative question; it depends on the carrying capacity of the ecosystem. One must, therefore, ask how exogenous shocks to ecosystem dynamics may have contributed to the population becoming "too big."

Les Gens heureux n'ont pas d'histoire.

An old French proverb has it that "happy people do not make history." Today we would say "if it works don't fix it" or "necessity is the mother of invention" [Rifkin 1980 p.62]. In other words, people do not change their accustomed ways unless forced by circumstances to do so. Humans had lived as gatherer-hunters for thousands of millennia. With hunting of Pleistocene Megafauna no longer a subsistence option, humans were forced to rely more heavily on plants and on new forms of hunting. Hunting small, quick game such as elk, deer, and wild pigs in the new forest environment presented new challenges. Just finding these animals was a great challenge. Human hunters were forced to develop an entirely new ethnozoology and new hunting techniques and weapons. The new human "secret weapon" developed for hunting in these circumstances was the hunting dog. Sometime about 10,000 B.P. humans domesticated the dog from wolves and thus began "the long and successful symbiosis between people and dogs." [Harris 1975 p. 187]. Utilizing the dog's sense of smell, hunters could find otherwise elusive prey in the dense forest. However, even with the new technology, (improved bows and hound dogs) hunting productivity declined compared

to that when large slow animals could be found by the thousands and killed easily and the dogs had to be fed.

Humans turned to "broad spectrum" subsistence strategies that increasingly included, depending on local fish, shellfish, birds, snails, nuts, wild legumes, and wild grains [Harris 1978, p. 30-31]. The addition of this last item is especially significant. In the good old paleolithic days, humans could capture solar energy by eating the flesh of grass eaters (ruminants), now under different environmental conditions they had turned to eating grasses (wild grains) directly. Grains while high in carbohydrates and calories are low in protein. Women who nursed their children to space births now found it a less effective method of contraception as the high carbohydrate load of their diet gave them too many calories and hence too much fat.

The Transition from Gathering and Hunting to Agriculture

We have to answer two questions: 1/ why did the switch from GHMPR to AMPR happen? 2/ why did it occur all over the world at about the same time (10,000 -2,000 B.C.? An "economic" analysis of the transition from the gatherer-hunter mode of production/reproduction (GHMPR) to the agricultural mode (AMPR) is framed in terms of cost/benefits. Quite simply it is presumed that the cost/benefits of GHMPR fell to the point where it was no longer superior to that of AMPR. The timing must be related to the end of the last ice age which flooded many land areas[3], and combined with over hunting, led to the extinction of Pleistocene Megafauna.

Fixed vs. variable costs

The AMPR was unattractive relative to GHMPR because of the fixed or "start-up" costs. Fixed costs[4] are those that must be incurred before a single unit of output is produced. For example, consider a modern airplane factory. Before a single plane is produced huge structures to contain the assembly area must be built, then the production equipment installed. Engineers had to spend millions of man hours designing the product, plant and equipment, materials, information systems for quality control and inventory control. The start-up costs are enormous. Recently a consortium of European nations formed a company called Airbus to produce commercial aircraft. The company needed support from England, Spain, France, Germany and Italy to cover the $26 Billion in start-up costs that had to be advanced before a single plane was built. Moreover, every year resources must be devoted to maintenance of the factories to prevent them from depreciating.

When actual production begins variable costs enter the picture. Variable costs include labor,

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[3] In Southeast Asia the available land area was reduced by one-half!

[4] Fixed costs are commonly called "overhead" costs. Often the term infrastructure is used to indicate the physical structures and equipment a company or society must have in order to function e.g. highways, airports, communication systems, police, fire and judicial systems etc.. We avoid this usage here for obvious reasons. The term infrastructure is used here to mean the mode of production and reproduction which is vastly more inclusive that the term in its conventional usage.

materials and energy costs that vary as output varies, but are zero when output is zero.

We can now apply these cost concepts to the group of GH considering agriculture. The GHMPR involves only variable costs. GHMPR need not do anything in preparation for harvesting plants or animals beyond expending energy in the search for them. Agriculturalists must clear ground by cutting down trees, prepare the ground with a plow[5] or a hoe, plant seeds or tubers, cultivate to keep down the growth of weeds, expend energy to keep animals out of the fields either by building fences or using children to scare away birds and other animals. Then they may expend energy on the harvest. They harvest must be stored in some sort of man-made structure and protected from raiders. The fixed costs can be enormous and I have not mentioned the possibility that a great deal of energy may have to be expended to build some sort of irrigation works (dams, dikes, canals, wells, sluices etc) where rainfall is inadequate.

As to domesticated animals, they must be fed and protected (from predators and rustlers) to maturity, before they can be harvested. In some cases animal feed will cost humans very little. For example, pigs supply a good part of their own food by foraging in the forest or by eating human excrement. They are no cost to humans because they eat things humans do not eat. Cattle can graze on grass. However, often animals have to be fed what humans eat e.g. the grains fed to horses and cattle in the winter months when grazing is not adequate. Feeding grass to cattle and horses can also be costly to humans if it means they must forgo planting food crops on grasslands used for pasture.

It was great while it lasted...

The deterioration of costs/benefits of GHMPR is evident in the wide spread switch to "broad spectrum" systems. In the absence of readily available Megafauna meat people began to supplement their diet with small mammals, birds, mollusks, reptiles and insects [Harris 1980 p.87]. The reader should rein-in her ethnocentric dietary preferences that consider bugs, worms, and grubs unpalatable. The broad-spectrum diet did not constitute a deterioration in costs/benefits of the GHMPR for reasons related to "tastes." The broad spectrum strategy simply returned fewer calories per unit of energy expended. It takes more time and energy to find, then chase a small deer through the woods than to hunt a giant mammoth and one is rewarded with considerably less meat. It is, therefore, likely that human protein consumption fell in this period. This presented another problem.

The GHMPR depended on prolonged lactation to space out children. A high protein diet is essential to the success of this method. If women have a low quality diet, that is they must consume a great deal of calories to get necessary protein, they will get sufficiently fat to ovulate even when nursing a child. The diminished efficacy of lactation as a deterrent to ovulation will result in more children and thus more labor for mothers who must carry them or more abortion and infanticide with the attendant psychic costs [Harris 1980 p. 87].

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[5] Where a plow is used provision must also be made for the production and maintenance of the plow and draught animals.

While the archaeological evidence[6] far from definitive, it strongly suggests that "the Broad Spectrum Revolution was most often accompanied by declining stature, declining nutrition, and steady or increasing rates of episodic stress." The evidence also points toward an associated decline in rates of population growth indicating a decline in "reproductive success"[7] [Cohen p. 68]. With the adoption of agriculture the population exploded, but the quality of human life continued to deteriorate in every other dimension.

Studies that compare the health of paleolithic gather-hunters and emergent farming populations invariably find the farmers relatively worse-off. For example, sedentary farming populations suffered higher rates of staph and strep infections, infectious diseases such as TB, and yaws/syphilis and they are more likely to be loaded with intestinal parasites. The bones of neolithic farmers also reveal that they were less well-nourished than gatherer-hunters. While it may have sustained larger populations, the switch to cereals, particularly maize, constituted a decline in the quality of the human diet. Diseases caused by mineral and vitamin deficiencies such as rickets and scurvy while common among farmers, were virtually unknown among gather-hunters [Cohen p. 68-69]. Of course, gathering and hunting was not paradise, the evidence indicates frequent periods of mild, seasonal "stress events" Farmers, on the other hand, were subject to "less frequent but severe stresses" such as famine and epidemics [Cohen p. 70]. But, all did not share the decline in the quality of life equally.

The existence of macroparasitic elites followed the transition to agriculture both in the Old World and in Mesoamerica. The elites were able to establish "entitlement structures" that usually provided them with more food than the producers. Not surprisingly, archaeological evidence reveals "conspicuous health differences...between Kings and commoners" [Cohen p. 71]. If the emergence of early civilization had any salutary effect on human health it was probably restricted primarily to the elites [Cohen p. 73].

All the way with Yaweh

In those days the world teemed, the people multiplied, the world bellowed like a wild bull, and the great god was aroused by the clamour. Enhil [counselor to the lord of the firmament] heard the clamour and he said to the gods in council, "The uproar of mankind is intolerable and sleep is no longer possible by reason of the babel." So the gods agreed to exterminate mankind...For six day and six nights the winds blew, torrent and tempest and flood raged together like warring hosts.. All mankind was turned to clay. The surface of the sea stretched as flat as a roof-top - The Epic of Gilgamesh

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[6] The evidence comes from primarily from the study of skeletal characteristics and dimensions and of the teeth. Patterns of skeletal growth and deformities can indicate periods of starvation, malnutrition, and disease. The teeth show deformities and "scars" that reflect nutritional stress during childhood.

[7] Population growth during the Paleolithic is estimated to have been about .01% per year. Mesolithic rates are estimated to have been about one-third as high (..0033%). Following the adoption of agriculture population growth exploded to .1% per year [Cohen p. 73]

At the peak of the last ice age some 18,000 years ago the level of the sea was some 500 feet lower than it is now. As the continental shelf is modestly sloped the lower sea level left a great deal of land exposed. Indeed, at the peak of the ice age there was 40% more dry land than there is now. By 8000 years ago, with the glaciers in serious retreat, the sea began to reclaim the land. Little wonder then that no fewer than five hundred of the world's people have mythologies that include a great flood [Tudge p. 274-276]. In one such myth a man warned by a dream that a flood was coming loaded his family and his livestock and wild animals as well and his gold into an ark. After the storms and flooding ended the ark came to terrestrial rest on a recently uncovered mountaintop. The story sounds remarkably like that of the Hebrew Noah, but is actually the tale of Utnapishtim in the Epic of Gilgamesh. It is most likely that Abraham picked up this story when he was in the Sumerian city of Ur which is not far from the city of Uruk where Gilgamesh reigned. That Ur suffered from a great flood some 5000 years ago is beyond question. At Ur there is a deposition of sand and silt that is nine feet deep, "the spoor of a huge flood" [Tudge p. 275].

Surely many people had taken up residence in the estuaries of great rivers and the seashore This was Eden. As the sea level rose they were forced out and had to find another way to produce food. The book of Genesis places Eden at the head of four rivers, one of which is the Euphrates. These rivers no longer visibly converge, but if the ancient point of convergence is traced it is found several kilometers offshore under the Persian Gulf [Tudge p. 276].

The epic of Gilgamesh suggests that the flood had cured an overpopulation problem. When Enhil is asked "how could you so senselessly bring down the flood he replied:

> Would that a famine had wasted the world rather than a flood?
> Would that pestilence had wasted mankind rather than the flood?

Were it not for the flood, in other words, other catastrophes would have reduced human numbers. If there were a population problem it was surely exacerbated by the advancing sea levels.

In the Book of Genesis, a vengeful Yahweh (God) casts Adam and Eve out of paradise for "eating of the tree of knowledge." It does not seem unreasonable to interpret the story of Adam and Eve in terms of a people lamenting their fall from foraging in paradise to the life of nomadic pastoralism, agriculture and then slavery in Mesopotamia (Babylon) and Egypt.

> Unto the women he said, **I will greatly multiply thy sorrow and thy conception; in sorrow shall you bring forth children.**.. And unto Adam he said, Because thou hearkened to the voice of thy wife, and hast eaten of the tree, of which I commanded thee, saying Thou shalt not eat of it: cursed is the ground for thy sake; in sorrow shall you eat of it; cursed is thy life...Therefore, the Lord God sent him forth from the garden of Eden, **to till the ground** from whence he was taken [emphasis added].

Thus, women were condemned to have more children which was fortuitous for men as they needed them to till the soil. Children were not significant producers in gathering and hunting groups, but proved to be a good benefit/cost deal among tillers of the soil. Children were useful in weeding, harvesting, herding, and retrieving dung for fuel. A farm could easily use 4 or 5.

It had been traditionally assumed that the slow rate of growth during the Paleolithic was a consequence of so-called "Malthusian forces" i.e. the control of population by means of starvation

or epidemic. But the archaeological data reveal that neolithic populations were much more exposed to these "Malthusian forces yet had a population growth rate 100 times higher than during the Paleolithic period when the people were much healthier. Clearly, cultural factors, i.e. changes in the mode of reproduction and the benefits/costs of children are at the root of the matter.

Mesopotamia and Egypt were totalitarian societies where the bulk of even the nonslave the population worked endlessly, were malnourished, endured diseases never encountered by foragers, and were actual or virtual slaves. Thus, human life for the Israelites and many other groups did become, if not solitary, at least more nasty, brutish and short. Civilization was the reason. The ancient Hebrews were a microcosm of humanity's fall from the state of grace in which 90% of humans ever born lived - and they knew it. It was now their task, to till the soil and to be "fruitful and multiply."

Agriculture and Microparasitism

the Neolithic Revolution that we are accustomed to regarding as a giant step upward on the ladder of progress was, in terms of human health, a backward tumble that transformed tall and robust hunter-gatherers into shorter, weaker farmers - Kenneth F. Kiple

Microparasitism passes through a series of stages: epidemic, endemic and commensal or mutual. When a microparasite enters a "virgin" population, that is, one with no previous exposure to it and, thus, no systematic defense against it, it causes serious illness and produces high death rates in victims of all ages; it produces an *epidemic*. The surviving population, however, has individual characteristics that were, by luck, effective defenders from the predation of the parasite. The next generation will be better defended and so, over time, the population becomes resistant and what was once a plague becomes a disease that is serious only for the weakest in a population, children and the elderly. Children, usually survive and then are immune for life. The Microparasitism is now *endemic*. In this process the humans evolve, but so do the microparasites. The most virulent strains kill all of the hosts and so die out. Those that only infect, but do not kill will survive in the host population. Ironically, humans have not had an epidemic of Ebola virus because it kills all human hosts very quickly giving the virus little opportunity to spread. Finally, some micro-organisms may come into a mutualist relationship with a host from which both parties benefit.

Before the invention of agriculture humans had already passed through a number of stages of Macroparasitsm as they changed environments and subsistence strategies. When, about 5 million years ago, our ancestors descended from the trees to the African savannah they had already suffered from viral diseases similar to polio or meningitis. Once on the ground they probably became infested with parasitic worms that they acquired from savannah animals either through contact with animal wastes or by eating animal flesh. They probably also suffered from sleeping sickness [*African typanosomiasis*] spread from the animals to them by the Tse Tse fly [Karlen p.21]. Homo erectus probably suffered from bubonic plague, acquired by hunting small animals and trichinosis from larger animals like bears, foxes, and of course pigs. And of course, there were always the lice

and fleas. One expert, notes that "considering the number and severity of zoonoses"[8] confronted by Homo erectus it "may seem amazing" they survived at all [Karlen p. 23].

Several factors related to the Gathering-hunting mode of production contributed to the success of the species. First, migration to colder climes where the parasite burden was lighter was fortuitous. Second, Gathering-hunting groups were small and moved frequently. They did not stay long enough in a single place to foul the water and soil. Gathering-hunting people did not "live with heaps of garbage and feces or with polluted water [Kiple 1997 p. 8]. The population density was too low to sustain "crowd diseases" that infected the large herd of herbivores. Truly, in this regard, "Homo erectus was physically much better off than billions of people in the third world today" [Karlen p. 25-26].

The transition to agriculture was a revolution in terms of the magnitude of the changes it presented to human life, but surely not in terms of the time it took. With the decline of the Pleistocene Megafauna humans began to use broad-spectrum gathering methods. Over millennia one food source after another was depleted and replaced and each time new diseases were encountered. For example, eating fish and shellfish infected humans with fish tapeworm and the lung fluke *Paragonimus* [Karlen p. 33]. During the broad-spectrum Mesolithic, the quality of human life began to slowly spiral downward. Studies of human skeletons reveal the Mesolithic human was a full two inches shorter than the paleolithic hunter [Karlen p.34]. Things did not improve in the neolithic, because of a "vicious synergy" of occupational, nutritional and infectious diseases [Karlen p. 34].

Farming is backbreaking work and neolithic skeletons show it. Arthritis[9] and stress fractures on load bearing joints and the lower spine are ubiquitous in neolithic skeletons. The skeletons of neolithic peoples also show a loss of stature, and a bending and thinning of bones that suggests rickets and tuberculosis.

The skeletons of men and women also reveal the deleterious effects of hours of daily grinding of corn and grains. One could call them neolithic repetitive stress injuries. Early Egyptian skeletons show arthritic and deformed bones in the lower back and toes that is related to the positions assumed (on the knees, bending over milling stones, with toes curled under) when grinding grains [Tudge 266-67]. Indeed, the injuries to the knees, toes and backs of female skeletons observed at Abu Hureyra, an early neolithic village in Syria indicate that "the preparation of grain for eating was the most demanding and labor-intensive activity of the settlement."[Molleson p. 72-73].

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[8] Zoonoses are animal infections that can be spread to humans.

[9] Arthritis has plagued humans since australopithecine times as has pyorrhea and dental caries. Each of these problems did get worse with the neolithic [Wood p. 26]

Grain could not be eaten directly by humans; it has to be ground into flour. The grinding process produced a coarsely ground grain that was full of hard kernels and small stones. Until humans invented the sieve these items produced fractured teeth. The fine powdered stone from the grindstone was very abrasive and caused teeth to wear down [Molleson p. 73]. The teeth in the skulls of Native Americans who lived on ground maize reveal teeth worn down to stubs from the grit in the maize. Toothaches were surely a common ailment among these people.

Agriculture produced more food, but a lower quality of food. Starchy carbohydrates such as maize, rice, wheat, potatoes, yams and manioc produce calories but are deficient in important vitamins and minerals. The result is diseases like rickets, anemia, and tooth decay. Neolithic skeletons were shorter still than the Mesolithic and life expectancy fell from 40 to 30 years [Karlen p.36-37].

Anemia is a disease of sedentism and civilization. The osteological evidence gathered in the Americas shows, "with crystal clarity," the absence of anemia in gatherer-hunters and its "overwhelming presence" in sedentary agricultural populations [Kiple 1997 p. 9]. There are three sources of anemia in any population: genes, parasites and diet.

Anemia results in the lessened ability of the blood to carry oxygen and thus for the body to produce energy (ATP) in the mitochondria. It is thus a very debilitating disease. The genetic variant of the disease is common in Africa (sickle-cell anemia) and Greece Southern Italy (Thalassemia). In these cases the hemoglobin in the red cells is below normal. This condition is the result of biological adaptation to a malarial environment.

Acquired anemia is the result of iron-deficiency which interferes with the ability of the body to make red blood cells. Iron deficiency can be caused by parasitic infections such as hookworm and schistosomiasis. Hookworm disease is spread by feces and schistosomiasis is spread by a snail that prospers in irrigated fields. Flooded fields keep down the growth of weeds, but they are an ideal habitat for the blood fluke which causes the disease and the snail that harbors the blood fluke.

Diet can also be a source of anemia. Iron is best obtained in a diet of meat, poultry and fish. Iron found is found in plants in abundance, but iron from these sources is less efficiently absorbed. Some foods contain substances called phytates which inhibit iron absorption; nuts, maize, rice, whole wheat and legumes contain them.

The combination of a limited cereal diet and a heavy parasite load surely contributed to the heavy anemia burden in ancient populations and continues to plague modern populations. Some 500 million people, 10% of the world population suffer from this disease. [Larsen in Kiple ed. P. 10].

Evidence of anemia is revealed in ancient bones by a condition known as porotic hyperostosis. Lawrence Angel's Angel's study of 2,200 skulls shows that anemia exploded in the Mesolithic period (10,000 to 6,000 years ago) among sedentary populations, particularly in the eastern Mediterranean. The principle cause was hereditary anemia that resulted a biological adaptation of the red-blood cells to a malarial environment. The cuneiform writing of the Sumerians reveals that malaria was a common problem in the ancient world and the disease plagued Greece and Rome. The plagues of malaria that struck the ancients were no doubt due to the human creation of malarial environments, swampy marshlands, through the process of deforestation[10] and the willingness of humans to live in dense populations quite close to them. Irrigated fields were also an ideal habitat for the mosquito that carried the malarial plasmodium.

> Populations in malaria environments adapted biologically to the disease. In both Africa and the Eastern Mediterranean a genetic mutation evolved that prevented the malaria parasite from effectively invading red blood cells. In Greece and Southern Italy the mutation was on the gene that codes for and enzyme (G6PD) that facilitates energy extraction from red blood cells. One writer likened these mutations as the body's "scorched earth tactic" to prevent efficient use of the body's energy resources by the parasite. Although the body's capacity to produce energy is diminished, overall, in the malarial environment, the mutation is beneficial - most of the time. In some cases, when the mutation is inherited from both parents, serious anemia known as Thalassemia and Sickle-cell anemia result. Thalassemia is often know as the "Greek disease" and sickle-cell anemia is common among African-Americans.
>
> Similarly, among Northern Europeans, a certain mutation of an intestinal enzyme protects people from Typhoid. Should a person get the gene mutation from both parents, however, the contract cystic fibrosis. The same mutation that prevents S. Typhi from attaching to the walls of the intestine also thickens the mucous lining of the lungs reducing the size of air passages, traps pathogens, and reduces the ability of the lungs to clear infections.
> - Gregory Cochran & Paul Ewald, *Natural History,* 2/99 p. 40]

Sedentary agricultural populations in the new world were spared from malaria as apparently the plasmodium that causes it did not make it across the land bridge during the migrations that brought humans to the new world. Ancient Americans, nonetheless, suffered from high rates of *acquired* anemia due to the near total reliance on maize for food. At Chaco Canyon, for example, 71% of the skulls examined had the characteristic patterns of porotic hyperostosis [Larsen p. 13]. The patterns of porotic hyperostosis found in bones at the Mississippian site of Cahokia revealed that elites were far less likely to suffer from the disease [Larsen p. 13].

The neolithic diet improved when porridge could be made from the grains. Cooking grains required the invention of pottery. Cooked cereals were tastier and easier to digest. Porridge could also be fed to infants in place of breast milk. These factors produced a demographic disaster.

Porridge is a high calorie food rich in carbohydrates so women probably carried more fat. Women also stopped nursing sooner. The population control efficacy of prolonged lactation was undoubtedly diminished, birth intervals shortened and more children were born. The evidence of more infant births following the invention of pottery at Abu Hureyra is in the infant skeletons; they become more numerous in the "pottery layers" of the excavated settlement. It appears more children were born, but more also died. The skeletons of the children show signs of anemia that was

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[10]Deforestation increases soil erosion. The silt is then deposited at the mouth of rivers creating marshy deltas - an ideal mosquito habitat.

probably the consequence of long term parasite infestation [Molleson p. 74].

Neolithic villagers came into intimate[11] contact with dozens of animals ranging from dogs, cats, bird, pigs, horses, oxen, goats and sheep. The result was an exchange of diseases. At the moment it is estimated that humans share a multitude of diseases with animals.[12] People often lived under the same roof with these animals, in close contact with their wastes. They ate animal flesh, wore animal skins and ate animal eggs and milk. From these practices humans acquired anthrax, trichinosis, salmonella and a wide variety of helminths (wormlike parasites) such as filarial worms (African river blindness, elephantiasis) hook worm, and tapeworms. Thus, as the quality of the human diet deteriorated, the poor beings had to share it with a growing number of intestinal guests. Exactly such a synergy plagues the descendants of the Maya in Mexico and Guatemala to this day and may have played role in the sudden decline of the Maya civilization [Karlen p. 38].

Another "classic disease of sedentary life" is typhoid which emerged when humans lived near water sources for sufficient time and in numbers enough to pollute them [Humphreys, in Kiple p. 14]. Typhoid is caused by a member of the salmonella family, *salmonella typhi*. While various forms of salmonella plague other animals and can harm humans when ingested, typhoid is a strictly human disease. The *salmonella typhi* has a special "protective coat" which hide it from the human immune system [Humphreys p. 14]. Typhoid is particularly dangerous because it can persist in asymptomatic carriers who can spread the disease.[13] The disease is spread by fecal contamination of water, hence "typhoid spreads best in unsanitary surroundings full of crowded, dirty people [Humphreys p. 14].

As humans transformed the landscape with axes and plows they also created new habitats of pathogens. As farmers cleared land for the timber or for pasture or planting they encountered animals they rarely encountered before such as mosquitoes and monkeys. Land clearing in Africa created a perfect environment for the *anopheles gambiae*, an assertive mosquito, with a strong preference for human blood, that just prospers in standing water on cleared land. The *anopheles gambiae* transmits a virulent form of malaria; one that accounts for 95% of all malaria deaths [Karlen p.41]. The first contact with AIDS probably came as land-clearing Africans contacted disease bearing monkeys [Karlen p.39]. Even now in Central and South America logging operations have exposed urban populations to yellow fever. Yellow fever bearing mosquitoes that inhabit the rainforest canopy fall to earth along with felled trees. They feed on the lumberjacks, infecting them with yellow fever. The lumberjacks take their minuscule paychecks and the yellow fever back to urban areas [Karlen p. 20]. Ebola virus and hemorrhagic fever, the newest threats of potential

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[11] One supposes this term to be used figuratively, but it can also be interpreted literally. Otherwise the biblical injunction in Leviticus forbidding sex with animals would not make much sense.

[12] The tally is Dogs (65), Cattle(45), Sheep, goats (46), Pigs (42), Horses(35), Rats, mice (32), Poultry (26). [Karlen p. 39].

[13] Mary Mallon, an Irish immigrant housekeeper and cook spread the disease among rich New York families in 1906. The infamous "typhoid Mary" was kept in jail for three years, set free, and then incarcerated for the rest of her life because she refused to cooperate with public health authorities. She died in 1938. [Humphreys p. 17].

pandemics, are probably contracted in the same manner as Africans push further into untouched areas in search of pasture and farm land [Karlen p.39].

The new agricultural technology also produced other health threats to neolithic peoples. Irrigation produced an ideal habitat for malarial mosquitoes and for the schistosome, a parasite that lives in snails. When the enter humans they "weaken and kill in many unpleasant ways" [14] [Karlen p. 41]. When humans began living in great numbers along rivers, irrigated fields, flood water basins and irrigation canals they created an ideal environment for the perpetuation of the disease. The Nile River Valley was infected 7000 years ago. The calcified eggs of the schistosome were found in mummies dating to 1000-1100 B.C. [Farley p. 22]. Over the years, as more irrigation facilities were built the incidence of the disease had increased. It was estimated that about ½ of the entire population of Egypt was infected in 1937. Today so many young Egyptian boys carry the disease with its classic symptom of bloody urine, that it is "popularly regarded as the male equivalent of menstruation" [Farley p. 20]. The practice of fertilizing fields with human waste only exacerbates the vicious cycle of infection. The parasites enters humans from the snails. Human feces carrying the schistosome, used as fertilizer, then reinfect the snails. Schistosomiasis now infects about 100 million people around the world, at 20 million Egypt alone [Karlen p. 41-42].

Southern China is infected with a particularly virulent form of Bilharzia. The female of the *S. japoincum* variation of the schistosome produces 10 times more eggs that the Egyptian variant. The disease is so ghastly it has become part Chinese folklore. In the tale of "village of Widows" acres of land went untilled as people, to debilitate to work starved to death [Farley p. 23].

Schistosomiasis or Bilharzia did not infect either India or the North America. The disease did spread to South America via the slave trade, but never penetrated North America or India due to the absence of a compatible snail [Farley p. 23].

Women and Agriculture

It is most likely that farming techniques such as the domestication of plants were discovered by women. Since women were the gatherers of plants it is most probable that they were the individuals who observed the behavior of plants [Eherenberg p. 78] It is equally probable that women had an important role in horticultural activities, and consequently considerable prestige and influence in early neolithic societies. Men continued to spend much of their time in hunting wild animals so much of the horticultural work was done by females. Men were only occasionally needed to clear a field. As they did not plow or use manure, horticultural societies kept few animals; if any were kept they were probably tended by the women [Ehrenberg ch. 3].

The archaeological evidence suggests these early neolithic societies were both matrilineal and matrilocal. Research suggests a relationship between residence size and residence patterns after

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[14] The disease is actually caused by the worm's eggs which become lodged in the liver, spleen, gut, bladder, ureters, the lungs and the brain. The eggs set off immune responses that produce inflammations and organ dysfunction. The disease is not usually fatal. The disease is sometimes called Bilharzia after the man Theodor Bilharz who was the first to see the worms [Farley p. 20].

marriage and between type of marriage (polygamy, monogamy) and residence shape. In matrilocal societies, women stay in the same settlement following marriage and men move in, houses are larger than in patrilocal settlements. In matrilocal societies people tend to live in large extended families headed by maternal grandmothers. In patrilocal societies, smaller nuclear families, headed by fathers, appear to be the norm. Ethnographic research finds houses in matrilocal societies average 80 square meters while those in patrilocal societies average only 30 square meters. The research also finds that in matrilocal societies house tend to be rectangular [Ehrenberg p. 94]. Hence, matrilocal residence is strongly indicated by the "great size" of the houses found at early neolithic excavations in Central Europe [Ehrenberg p. 95]. On the basis of the high degree of female participation in horticulture and the patterns of matrilineal descent and matrilocal residence one can reasonably speculate that women in the early neolithic had higher status and were less "dominated by men" than they would be in later periods [Ehrenberg p. 97]. Indeed, Margaret Ehrenberg has argued that there are many similarities between gender relations in early neolithic Europe and those of the Iroquois - "one of the best documented societies in which women had high status and quite a degree of power" [Eherenerg p. 98]. The horticultural system was the same; the land was owned communally and was farmed by women. In both instances matrilineal descent and matrilocal residence were followed and both cultures built large long houses to accommodate entire extended families. Food supplies in the extended families were under the control of and were distributed by the matron [Eherenberg p. 98].

"The secondary products revolution or the great male takeover bid" [Eherenberg p. 99].

In his book, The Origin of the Family, Private Property and the State, Frederich Engels, Marx's great collaborator, wrote of the "worldwide defeat of the female sex." As we have observed the status of women among paleolithic gatherer-hunters and among early neolithic horticulturalists was certainly higher than Engels observed in 19th century Victorian England. At the time Engels wrote women were considered to be intellectually and emotionally little more than children; presumptions which were apparent in their legal and economic status. Women were the virtual property of their fathers and then of their husbands and toward the end of their lives, of their sons. Women were totally dependent on and dominated by men. They had no right to own property, participate in the economy or in politics. To Engels, and to legions of socialist, and even more radical feminists who would follow, bourgeois marriage was a gilded cage, within which a woman's only function was to produce a legitimate heir.

After reading Lewis Henry Morgan's ethnography of the Iroquois, Engels sought to explain the material forces that brought about the decline of the female sex. He identified monogamy and the rise of private property as the culprits. As far as he goes Engels is probably correct, the process that reduced women to property certainly involved monogamy and private property, but these are structural elements that are contingent on infrastructure. We need to seek an explanation rooted in the basic techno-environmental forces of the mode of production and reproduction.

By the time that humans in Europe had begun writing about themselves, agriculture was dominated by men. In parts of the world where women are still dominant in agriculture animals play a small role in their economies. It seems reasonable then to postulate that the changes in women's roles from the early neolithic to the time of writing had something to do the changing role of animals in the agriculture of neolithic Europe which seemed to occur in many areas of Europe around 3000

B.C. [Eherenberg p. 99-100].

Over time people came to be more dependent on domesticated animals as stocks of wild game were surely depleted. As population grew farming also had to become more intensive. At about the same time, the fourth millennium B.C. we find evidence of the use of the plow and the use of milk and the herding of milk cows. Cattle, in the early neolithic, were used only for meat, not for traction for carts or plows or for milk.

The human consumption of milk products required two technological innovations. First, someone had to figure out how to milk a cow; cows do not by nature give up milk to creatures other than their own calves.[15] Second, since most humans were [and are] lactose intolerant they had to develop the technology of processing milk into yogurt and cheese, which breaks down the complex, and for many indigestible, lactose molecule into the simple digestible sugars, glucose and galactose. The technology of milking was of no small consequence; milking provides as much as five-fold more protein and energy from cattle than does their use as meat [Eherenberg p. 101]. Indeed, this invention makes possible a whole new subsistence strategy, nomadic pastoralism, which, in Asia, would make its own technological advances, namely the domestication of the horse. The horse, in turn, be integral to a reign of terror, promulgated by mounted pastoralists, all over Old Europe, China and India.

As the scale of animal herding increased and as agriculture shifted from horticulture to plow agriculture women disappeared from food production. Herding of animals required sustained absences from home base and thus was done by males. It appears also that "raiding" the cattle of neighboring groups was a significant means of capital accumulation and thus one would expect it to fall into the domain of males. Indeed, warfare and cattle raising are closely related in history [Ehrenberg p. 105]

It appears that plowing was also done by males. This is not to say that women were displaced into idleness. The division of labor had to change as a new "product mix" was developed. Milk, for example, had to be processed into cheese and yoghurt. Wool had to be processed, spun into thread and the woven into fabric. Each of these tasks requires special skills, and is very time consuming, but can be done while cooking and caring for children [Eherenberg p. 103]. All of this considered, however, it does not follow, as asserted by Ehrenberg [p. 105], that women's status declined simply because they were less involved in the direct production of food. Women continued to make significant economic contributions to food processing, preservation, preparation, and to craft production. Here we encounter, once again, the problem of trying to predict women status on the basis of *their economic contribution to production*. Neolithic women, like gatherer-hunter women were economically important but still labored under male domination. Women continued to be dominated by men because of their role in *reproduction*.

Something very fundamental happened when males came to see the land and their accumulated herds as personal property. The problem of inheritance was never significant before improved arable land became scarce and when men never accumulated wealth. The clearing,

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[15] Such techniques commonly practices by west Asian pastoralists included the use of a straw-stuffed calve effigy, blowing into the anus [using a long pipe and avoiding inhaling] and milking from behind [Isaac p. 453]. Modern milk cows are bred for milking so such exotic practices are no longer needed.

plowing, irrigating, and fencing land required by intensive agriculture took a great deal of labor expenditure. Protecting one's herds from animal and human predators, and raiding to enhance them was a very risky business. The similarities to warfare are obvious. Hence the wealth in land and herds a male accumulated tended to become considered personal property. The question of the inter-generational transmission of this wealth became a matter of some importance to individual males. A male farmer will teach his son how to farm and tend animals and expects his son would inherit his wealth. It is not unreasonable for the son to want this also since he would have played a not inconsiderable role in the accumulation process through his contributed labor and warrior functions. Obviously, the matrilineal descent rule would produce an undesirable outcome from the perspective of the father and son as it would send the father's wealth to the household of his sister where it would come under the control of her brother. The son would be disinherited. The son may only inherit from his mother's brothers. By breaking the connection between labor, risk and reward the matrilineal system appears both unfair and inefficient. What incentive does a son have to help his father when it is his uncle's property he will inherit? Why should his uncle inherit the product of his labor? Not surprisingly, "there is a very strong ethnographic correlation between male-dominated farming and patrilineal descent and patrilocal residence" [Eherenberg p. 106] When Engels lamented the "world-wide defeat of the female sex" he was actually referring to the replacement of matrilineal descent and matrilocal residence with the patriarchal versions of each. Engels, presuming that matrifocal institutions lent women status, power and prestige, saw the decline of the female sex as caused by the emergence of private property.

Engels - Monogamy and private property

In the 19th century, the belief that primitive man lived in an unbridled state of sexual license or, put another way, "sexual communism" was common. It was believed that promiscuity and group marriage was followed by polygamy, then by patriarchy and monogamy [Weiner p. xxv]. It was also widely held that "savages" did not believe in physical paternity [Weiner p.xxvi]. Hence, since the fathers were unknown (due to promiscuity) and their biological role not understood, a person's lineage was traced through their mother; a system known as matriliny today, but called, quite mistakenly, matriarchy then.

We will never know directly how people lived in the state of nature, but we do know that there are a great deal of cultural variations on the theme of sexual relations. In some cultures there are no restrictions on pre-marital sex, in some there are no restrictions on pre-marital sex or post-marital sex. Indeed, in many instances sex and marriage have nothing to do with each other. Marriage in most of the world's cultures is not concerned with biological parentage, but rather "who will have the right to control the child's destiny."[Harris 1975 p. 321] As Malinowski put it, marriage functioned not to license sexual access, but to "license parenthood" [Weiner xxvii].

Victorians, obsessed as they were with sex and its repression, and 'legitimacy' could not see marriage in any other but rights to sexual access and right to inherit. Most cultures are unconcerned with legitimacy, but rather with the assignment of the responsibility for the child. Women who have children without making the proper arrangement for the child' s care is punished, but rarely is the child deprived or ostracized [Harris 1975 p. 321].

Kathleen Gough's study of the Nayar (a matrilineal, matrilocal[16] group in Karala, India) is instructive. Nayar girls go through a four day ceremony which links then with their "ritual husband;" the man who with be the father of her children, regardless of who the biological father might be. After the ceremony she is free to have as many "visiting husbands" as she wishes provided she does not break any rules regarding caste or incest. Any visiting husband leaves his weapons outside her door, to warn others who may wish a visit that he is there and spends the night only. The Nayar men are generally unable to identify their children and care little about them. Their energies were devoted to controlling their sisters and their children [Harris 1975 p. 345]. The Nayar are a matrilineal, matrilocal group for the typical reason; the extended absence of males for long-distance warfare. Nayar men were a warrior caste in the service of the King of Malabar [Harris 1975 p. 348].[17]

All of this said, however, it is important to emphasize that extant practices of band and village people do not approximate the universal sexual communism believed to be the case in the 19th century. In the vast preponderance of cases marriage does entail some restrictions, however, loose on sexual access. In some cases, for example, a man need merely ask for access to another's wife or a husband may make the offer as "hospitality" to a visitor, but in each case the rules of reciprocity apply [Harris 1975 p. 360]. Clearly, however, inheritance by biological children is irrelevant, as is the question of legitimacy.

As the mode of production shifted from gathering-hunting to agriculture the mode of reproduction shifted from anti-natal to pro-natal. Women were valued now for their ability to bear children as well as their economic productivity. But, the quality of women's lives did not improve and indeed may have deteriorated. The change in Infrastructure brought with it changes in the Structure. Under the new institution of monogamous marriage women lost their sexual freedom and in many cases were restricted to the strict confines of the household. The cult of virginity and the crime of adultery emerged out of the desire of men to control the sexual behavior of their wives. With the overthrow of the commune by the new elites men came to view property, primarily land, cattle, women and slaves as their personal, private property.

In traditional societies, as we know, descent was sometimes followed through the mother. In this case, should a man acquire any property it would pass not to his children, but to his sisters and brothers and his children's cousins. Before men could acquire personal property, biological fatherhood, even if it could be determined, was irrelevant- all the men cared for all the children. Moreover, all lands were owned in common so inheritance itself was irrelevant. Under the regime of private property men want their biological children to inherit their property. In any case, ***now***

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[16]Matrilineal and matrilocal systems are rare because males are reluctant to relinquish control of their sons to the kin of their wives as their sons move away after marriage. Moreover, men so not like moving to a wife's village where he becomes a "stranger." Such institutions emerge only when men are forced to be absent for extended periods of time [Harris 1975 p. 344].

[17] The Nayar no longer practice this system one would guess because their warrior function has ceased.

paternity mattered. The institution of monogamy, the obsession with virginity, and the crime, punishable by death, of adultery followed from what is called patrilineal inheritance: children inheriting from their fathers.

Monogamy established only one legitimate producer of heirs. Should a man father children outside of this relationship they would be "illegitimate" or "bastards" with no inheritance rights. To insure a woman bore only her husband's children she faced the capital crime of adultery. If the woman ever had sex with another man before marriage - she would simply never marry. The woman became, in effect, just another head of breeding stock, and asset, along with the cattle, slaves and the land. Indeed, marriages were made as alliances oriented not toward love and passion, but toward the accumulation of more wealth. A man had unlimited opportunities for sexual diversions and even intimate relationships with concubines and slaves - and did not have to worry about the death penalty unless he chose to consort with a married woman and commit adultery. Married men could not offend their wives with their dalliances, but they did violate the property rights of another man when he consorted with his wife, either consensually or by force. Rape was not an offense against a woman, she, like slaves and children, had no legal existence, but against her husband, father or brother.

Genital mutilation - The high price women pay for inclusion.

Circumcision for both males and females is a "rite of passage" into adulthood and is practiced all over the world. For males the practices offers little but a minor bother, For females, it can be a traumatic, painful process, that deprives them of sexual pleasure and may pose a threat to their health. These practices Are most prevalent in at least 28 African and many Islamic countries [NY Times 10/5/96]. As Africans and Moslems have migrated into countries where such practices are considered barbaric, there has been a great deal of pressure on African nations to prohibit the practice. Hillary Rodham Clinton, speaking to the Fourth Wold Conference on Women, called it a brutal, "painful and degrading practice," [NY Times 10/5/96] All to little avail as the practice is deeply entrenched in the traditions of these people.

One should not infer that there is any similarity, beyond the social function, between male and female circumcision. Males lose a small piece of foreskin. Females, at the very least, part of the clitoris, and usually the labia and the entire clitoris. In its most extreme form, infibulation, the remnants of the labia are sewn together leaving only a small opening for urine and menstrual blood to exit. Ironically, most of the girls that submit to the procedure do so willingly, indeed joyfully. Like young girls everywhere, African girls dream about marriage to a perfect man [NY Times 10/5/96]. Since uncircumcised girls cannot marry, young girls see the ceremony as as necessary. Also, the ceremony involves a big feast, lavish gifts from parents and family and instant status as an adult. Uncut women are regarded as "unclean, promiscuous, and immature." Should they have children, both the mother and child become outcasts. One Samburu mother, who "bowed to social pressure" to have her child cut, said the Samburu believe that uncut women"become like prostitutes, looking for men here and there." The loss of sexual pleasure by the females is inconsequential compared to the need of the community. There is a pervasive fear that a young girl will become pregnant and "bring shame on the family" Such fears drive many "uncut" pregnant women to induce abortions [NY Times 10/5/96]. In some tribes, such as the Yacouba, the father is not permitted to speak at the village assembly if he has a daughter of age who has not been circumcised.

In the final analysis the social and economic pressure on young girls to have the mutilation is enormous. In Kenya a young girl told NY Times reporter, James McKinley:

> For me, I feel I am still a child. It is painful but even if I an scared, I have no other alternative. I have no choice but to obey. I depend on my family for everything [NY Times 10/5/96] .

The reality is women that cannot survive economically without a husband or father to care for them as they have no other way of accessing the economic resources controlled by the family and the community..

Men have ambivalent feelings about the practice. They complain that sex with their wives is less than satisfying as cut women are difficult to arose; all prefer sex with uncut women. How to arouse circumcised women is a matter of constant discussion at their frequent gatherings [NY Times 10/5/96].

The Neolithic Mode of Reproduction

Bio-psychological constants

While we reject the "telologiocal" aspects posited by Marx and Veblen, we must specify some minimum human behavioral postulates. We might begin by assuming that people are rational. Broadly speaking this means people act in their best interests. More specifically, it means that when making decisions they calculate marginal benefits and costs and choose the option that is the best benefit/cost deal. Thus, we can assume that when confronted with a task they prefer to use less rather than more energy to accomplish it.[18] People will prefer a diet that offers more protein and calories than one that offers less [Harris 1980 p. 63.] We also assume that humans are "social animals," that is, "they need love and affection in order to feel secure and happy" [Harris 1980 p. 63].

Finally, since population growth is such an important matter we must make some assumptions about sex. We assume people are "highly sexed" and thus enjoy regular "heterosexual" intercourse and, under certain conditions, homosexual sex as well. The nature of the "superstructure" i.e. religion, ethics, laws will shape to a great degree the kinds of sex we enjoy by determining the benefits and costs of the activity. The superstructural elements will depend on the modes of production and reproduction that make up the infrastructure.

I will make thee a multitude of people; and will give the land to thy seed after thee for everlasting possession -Genesis 49:22

Many of the "sorrows" women bore consequent to the emergence of agriculture are related to their roles as mothers. The Gatherer-Hunter Modes of production and reproduction- GHMPR.-

[18] In modern jargon, people seek cost-effective means to achieve their goals.

required women to "space" children and often to engage in some form of infanticide. The Agricultural MPR required women to reproduce children at their biological potential. We can see this in the various biblical injunctions against masturbation, contraception(e.g. coitus interruptus), abortion, infanticide, bestiality and homosexuality. Indeed, one can see the origins of most of the reproductive policies of the modern mainstream religions (Judaism, Christianity, Catholicism, and Islam) and even some of our secular attitudes toward sex, in the reproductive imperatives of the new Agricultural mode of reproduction (AMR).

Under the regime of the AMPR population growth must be maximized in order to insure adequate supplies of labor are available to do the additional work required by agriculture. In the Book of Genesis, Yahweh's command to "be fruitful and multiply" appears at least a dozen times Thus, neither womb nor "seed" could be wasted. The Bible in the tale of Onan warns Israelites not to "spill" their "seed" on the ground (Genesis 38: 9-10). This story has often confused the sin of Onan or Onanism with masturbation [Harris 1981 p. 109]. Seen in context, however, Onanism is actually *coitus interruptus*. Onan's action was condemned because hew failed to perform his Levirite duty of impregnating his brother's wife. Should a man's brother die he was obliged to take the woman as his wife; a womb is a terrible thing to waste when you have much need of labor and are trying to build, and defend a nation. Thus, when Onan withdrew and "spilled his seed on the ground" he wasted both his seed and a womb.

Other ways of wasting seed and wombs included to "lie with a beast" (Leviticus 18:23) or for a man to "lie with mankind, as with womankind" (Leviticus 18:22). As it wasted neither seed nor a womb, there is no corresponding proscription of Lesbian sex. The condemnation of homosexual behavior is not the manifestation a universally held human ethic. Homosexual behavior is not only permitted in many human groups, it has been institutionalized. Greek men engaged in homosexual activity with boys as part of a mentoring relationship. These actions were considered neither effeminate or repulsive [Harris 1981 p. 104]. For men like Socrates, Plato and Xenophon " sex was an integral part of the educational process intended to facilitate the transfer of knowledge from an active loving teacher to a passive junior student" [Harris 1981 p. 104]. In many cultures such as the Azande, homosexual relationships are integral to the training of warriors [Harris 1981 p.105]. The Etoro of New Guinea believe that the only way a man can acquire semen is to drink the semen of another male. This transfer is accomplished by *fellatio* of an older male by a younger male [Harris 1981 p. 105]. If there were no strong social sanctions it appears that homosexuality would be more widely practiced. Thus, all of these Biblical injunction were passed for more than symbolic purposes, that is, these practices were widespread enough to concern the Patriarchs. As Leviticus 18:27 unequivocally states, "For all of these abominations have the men of the land done."

It seems quite obvious that most of our "modern" sexual ethic is derived from the pronatal ethic that emerged as part of the transformation of GHMPR to AMPR. The AMR required a new "superstructure;" one that contained religious, ethical and legal rules conducive to high population growth rates. As the shift from AMPR-AMR to the Industrial Mode of Production has progressed, these attitudes, ethics, religions and laws have changed. Sodomy is no longer a crime anywhere in the United States. Contraception and abortion are more widely accepted, but infanticide, at least in the United States and the developed nations is not. And, our attitudes towards homosexuality are becoming more tolerant. The pattern of change is clear; the more industrialized and urban a nation becomes the more liberal its attitudes toward sex, birth control and homosexuality become.

Costs and Benefits of children

Economists study any human behavior that involves a choice. Most of the time economists study prosaic choices such as whether to buy bananas or blueberries, to buy stocks or bonds, to buy a home or rent one, to use machines or workers to produce goods, how to finance health care for the elderly, to mention just a few. Economists also study significant life-altering decisions such as the choice to marry, to divorce, to work or play, to have children or not, to let children live or not.

Economists have an instrument called "rational choice models" to analyze such choices. Basically economists presume that individuals make choice based on the rational calculations of benefits and costs of each choice alternative. For example, as noted above, children provide economic benefits to farmers in the form of labor services to the farm and in the form of old age security to the parents. But, having children is not a "free lunch," the benefits of children must be weighed against the costs. Children require and investment of mother's time and energy during and after pregnancy. Children also directly consume many calories themselves before they provide a calorie of energy to their parents. Each child must be evaluated in terms of the additional benefits and costs the engender. For example, the first child may produce great benefit as it insures and heir for the land and "security" for the parents when they are too old to work. A second child may be valuable as insurance against the contingency that the first does not survive. Indeed, modern economic demography posits that the desired size of families is directly related to the expected rate of child mortality. This relationship produces perverse behavior in poor countries. Poverty raises child mortality. Higher child mortality raises the desired size of families. Larger families exacerbate the poverty problem. Each family is acting rationally to provide for the old age of the parents and for an adequate supply of farm labor. However, collectively such practices lead to larger numbers of children as poverty worsens; a vicious cycle of poverty creating more poverty. As more children die of malnutrition the desired number of children rises and people have more children. Individual rationality does not always produce collective rationality. The vicious cycle of poverty breeding more poverty would disappear if farmers could be convinced by their government that they will be cared for by the government when the are elderly. But, the governments of poor countries do not have the resources to do this. Ironically, then the poorest countries have the highest population growth rates. In modern, affluent industrial nations government provided social security for the elderly and disabled leads to a reduction in desired family size. Moreover, the better nutrition and public health that affluence buys lowers child mortality and reduces desired family size further.

Finally, in modern industrial societies the population is urbanized. Children have little economic value as farm labor and are quite costly to rear primarily because they are educated by specialists and must cared for by specialists if mothers are employed. In rural contexts children are cared for by other children or elderly relatives at little or no marginal costs. Rural children are trained with relatively low cost "learning by doing and observing" rather than through formal instruction.

Economists distinguish between total cost and marginal cost and total benefit and marginal benefit. The total benefit of children is the sum of the benefits derived from all the children. Marginal benefit is the benefits that would be derived from an additional child. When deciding whether to have another child, parents will balance marginal costs against marginal benefits. Marginal benefit can be presumed to fall as the number of existing children rises. Even if marginal

costs remain constant (they probably rise) some optimal family size will be determined where marginal benefit equals marginal cost.

As nations modernize the benefits/costs ratio for children tends to fall and the society, at least a larger part of it, becomes anti-natal or at least less pronatal. Families decide to have fewer children and therefore will ignore or challenge superstructural elements that inhibit them for seeking their well-being. For example, the traditional opposition of Christians to homosexuality, contraception and abortion, if not infanticide, is weakening. Muslim's on the other hand, for the most part remain locked in the third-world where the old rules apply and still proclaim that Allah wants as many new Muslims as possible.

Boserup revisited

In the Malthusian scheme population growth is considered to be a dependent variable, that is, the growth of population is constrained by the growth of the supply of resources and the technologies that enhance the productivity of those resources. In this framework population can grow only if agricultural output is increased by the addition of "new or virgin land" or increases in the productivity of existing lands. Thus, population growth depends on the extraneous factors that govern the growth of agricultural productivity i.e. technological change and the supply of virgin land. Boserup insists that productivity enhancing technical change, that is the development of new tools and the intensification of agriculture is a consequence of growing population density, not its cause. In short, Population growth is the independent variable and technology the dependent variable.

The inexorable "law of diminishing returns" invoked by the first Malthusians, and the Neo-Malthusian idea that population growth "leads to the destruction of the land" are, according to Boserup somewhat "misleading because they tend to neglect the evidence we have of growing populations which managed to change their methods of production is such a way as to preserve and improve the fertility of their land." While "it is not to be denied, she writes, that "the food potential of the world has been narrowed down by populations, who did not know how to match their growing numbers by more intensive land use without spoiling the land for a time or forever" this outcome in not inexorable or inevitable [Boserup 1965 p. 22]. People have learned fertilize to protect soil fertility , to irrigate dried-up lands and to terrace to prevent erosion.

Esther Boserup, an agricultural economist, who has studied agricultural systems in both India and Asia has presented a view quite to the contrary of that of Malthus, the classical economists in general, and for the most part, even contemporary development economists. Boserup's concern is that western economists are offering development advice to the "developing nations" based on their classical understandings of agricultural development. The classical understandings, however, were derived "at a time when the almost empty lands of the Western Hemisphere were gradually taken under cultivation by European settlers, and it was therefore natural that they should stress the importance of reserves of virgin land and make a sharp distinction between two different ways to raise agricultural output: the expansion of production at the so-called extensive margin by the creation of new fields, and the expansion of production by more intensive cultivation of existing fields" [Boserup 1965, p. 12].

Boserup finds this conception of agricultural expansion "over-simplified" and "unsuitable

for a general theory of agricultural development." The classical Malthusian theory, culture bound in the contemporary Anglo-Saxon experience, is therefore a poor guide to understanding the experience of the developing nations or for that matter even the historical agricultural development of England and Europe. For all but the most recent periods of history, for the most part "primitive" agriculture made no use of "permanent fields," but shifted cultivation from plot to plot.[19] In such systems "there is no sharp distinction between cultivated and uncultivated land" [Boserup 1965 p. 12-13]. In these systems of shifting cultivation the term "new land" or "uncultivated land" has no meaning as all the land has been cultivated at some point in time. The important variable, according to Boserup, is not the quantity of land but the "frequency with which the land is cropped" i.e. the length of the fallow period [Boserup 1965 p. 13]. The less frequently land is cropped the greater its fertility. As population densities rise, land is cropped more often and its fertility falls. Hence, soil fertility is not a fixed initial endowment of nature, but is dependent on population density and agricultural methods. It is dangerous then to imagine that land currently uncultivated is not being used. Although not in current use for agriculture, it is in use for hunting, pasture, or, of course, fallow. Should the frequency of cropping rise, Boserup warns, "the purpose to which [the land] was hitherto used must be taken care of in a new way"[Boserup p. 14].

The European presumption that uncultivated land was not in use proved disastrous to the indigenous people of the tropical areas invaded by Europeans. Under colonial rule vast ranges of apparently uncultivated lands were "expropriated for the use of European settlers or plantation companies or they were declared restricted forests where natives were not allowed to clear plots for cultivation." As the natives were cultivating land when the Europeans arrived "it was assumed that no damage was done to the native population" as a consequence of these expropriations. However, with their "long-fallow" reserves of land taken away the natives were forced to shorten the fallow periods which sometimes led to the exhaustion of the soil [Boserup 1965 p. 18].

It is common today to view economic systems as "adaptations" to their geographical environment i.e. climate, soil type and other natural features of the area. According to Boserup, however, "systems of land use are not permanent features of a given locality" but depend instead on the population density. Agricultural methods then depend not on either autonomous processes of technical change or geographical conditions, but rather on the density of the population [Boserup 1965 p. 117]. Rather than facing inexorable Malthusian constraints, Boserup contends that "population within a given area can double several times without having to face....starvation [Boserup 1965 p. 117].

Boserup contends that as population densities rise a series of changes occur in the "systems of land use" and in the associated tools. The land use pattern begins with the most extensive long-fallow or forest fallow system to the very intensive multi-cropping system. Tools change from fire and simple digging sticks to extensive irrigations systems and terracing.

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[19]In large parts of Africa, Latin America and Asia land is used for two years then allowed to "fallow' for at least twenty years. Of course, in areas where alluvial soils exist and irrigation [e.g. ancient Egypt] is used several crops may be produced from the same land every year. In tropical areas shifting agriculture predominates. In temperate areas such as Europe, shifting extensive agriculture gave way to intensive agriculture (annual cropping) in the middle of the 18th century [Boserup 1965 p. 15-17].

The "long-fallow" or "forest fallow" method gets it name from the fact that the land, after having been planted for several years, is left fallow for "long" enough for a secondary forest to grow back. After some 25 years the trees are cut and the area is burned to ashes. Nothing more than superficial clearing is necessary. The roots or seeds are planted in the fertile ashes using a simple digging stick. The soil is loose and free of weeds so hoeing is not necessary. After two seasons the nutrients in the ashes are exhausted so the land is left to rest for another several decades. As long as population densities are low the productivity of this system is more than adequate. The labor requirements of this system consist mainly of the "clearing of the forest" and as the "fire does most of the work" output per man hour is quite high [Boserup 1965 p. 30].

In the "bush fallow" system the length of the fallow period is shortened say to 6-10 years. Forest does not have time to grow in such a short period. At best, the land is covered by bush or small trees or even worse some grasses may have intruded. Now as there is less organic matter to be burned there are less nutrients are available for crops so yields can be expected to fall. Furthermore, the system requires more labor input as the ground now requires hoeing before roots or seeds can be planted. In this system a greater portion of the available land is under cultivation so a more dense population can be supported but at a greater cost - output per man hour falls as labor input increases and yields fall. Boserup notes that this process "can hardly be described as economic growth in the generally accepted sense of this term, since the proximate effect upon output per man hour is to lower it" [Boserup 1965 p. 118].

Should fallow period be shortened further, say to one or two years, the farmer will have to contend with grass; too little time passes for the grass to be crowded out by bush and trees.[20] Burning will not kill the grass roots and even hoeing may prove ineffective to remove them. Boserup comments that when the transition is made to short-fallow the work effort must increase because "fire, the most powerful weapon primitive man ever invented in his struggle against nature" was ineffective against grass [Boserup 1965 p. 33]. When grass intrudes ploughing may become necessary. Ploughing, of course, requires the use of plough animals which in turn require fodder, either natural grasses or fodder crops. The animals, in return provide manure for fertilizer which combined with human waste and the waste of other domestic animals and compost can sustain the fertility of the soil under the short-fallow routine. Intensive weeding is required to protect the land from invasion by weeds and grass. Obviously, the labor requirements of this system are much greater as labor is now required to plough, care for animals, fertilize the soil, weed the area. Little wonder then, Boserup comments, that the "general experience" is that "primitive cultivators usually refuse to abandon the cultivation of forest plots by means of fire" even when such activity is prohibited by governments worried about erosion and forest fires or even when the are offered free ploughs and draught animals [Boserup 1965 p. 33]. [21]

In his observation of "Stone age" societies Marshall Sahlins noted the underutilization of

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[20]Grass cannot grow in the shade of heavy brush or trees.

[21]In areas like Mesoamerica where plough animals were not available short-fallow systems were not feasible [Boserup 1965 pp. 25]. Under such conditions people may practice intensive agriculture using fertilizers and irrigation but they must "accept more steeply diminishing returns to labor than if they had been able to shift to plough agriculture [Boserup 1965 p. 41-42]

resources that characterized these groups. Indeed he judged their underproduction to be the basis of their affluence:

> ...primitive economies are underproductive. The main run of them, agricultural as well as preagricultural, seem not to realize their own economic capacities. Labor power is underused, technological means are not fully engaged, natural resources are left untapped. So understood, "*underproduction" is not necessarily inconsistent with pristine affluence. All the material wants might still be easily satisfied even though the economy is running below capacity*. Indeed, the former is rather a condition of the latter [Sahlins xxxxxx]

Similarly, Boserup's analysis is consistent with the notion that people operate according to the "law of least effort," that is they will only produce what is needed to feed the existing population even though they are aware of methods that would allow them to produce more. There seems to be no impulse to produce for the sake of producing more. Sahlins writes:

> .The [primitive] hunter...is "uneconomic man."...he is the reverse of that standard caricature immortalized in a *General Principles of Economics*, page one. His wants are scarce and his means (in relation) plentiful... It is not that hunters and gatherers have curbed their materialistic "impulses;" they simply never made an institution of them.

The same can be said of Primitive agricultural peoples. Boserup writes:

> usually consider both hunting, fishing and food collection as pleasurable activities, while food production is resorted to only to the extent that the other more agreeable activities fail to provide sufficient food. The effort devoted to food production is often seen to be limited to the bare minimum hours necessary to avoid starvation [Boserup 1965 p. 54]

Anthropological studies of primitive peoples, she notes, make "it difficult to believe that they fully utilize their capacity for work...The members of sparse tribes of primitive agriculturalists usually work much shorter and less regular hours than members of densely settled peasant communities " [Boserup 1965 p. 45] For example, she notes that the rapid growth in population in western Europe is usually considered to be the consequence of an "autonomous technical revolution" namely the "use of crop rotations" that eliminated fallow periods and mixed food and fodder crops "of which some were leguminous."[22] Actually, this method was well known long before it was but to use and had been widely used in the ancient world [Boserup 1965 p. 38]. Thus, just as gatherer-hunters resist agriculture because of the work involved even though they are aware of the technologies, agriculturalists resist moving to short- fallow methods to avoid the extra work entailed. Only under the pressure of increasing population densities will such changes be made and new technologies

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[22]Legumes tend to replenish the soil with nitrogen. Bacteria that live on the roots of these plants "fix" atmospheric nitrogen (gas) as a chemical in the soil making it use ful to nourish plants.

utilized. The increasing population density provided the demand for food and the extra labor needed for intensive cultivation [Boserup 1965 p. 38]. It is important to note, however, that in many cases rising population densities may have occurred among people who had no knowledge of intensive agricultural methods. Such cases, while the surely happened are not often observed as "this constellation would typically lead to [shorter fallow periods and] a decline in crop yields and sometimes to an exhaustion of land resources" [Boserup 1965 p. 41]. Such groups would have then starved in place or migrated to another location.

Energy costs/benefits in food production[23]

There are only four sources of energy available to humans: the daily solar flux, the solar energy stored in living flora and fauna and in fossil flora (oil, coal, gas), the energy that binds fundamental particles in matter (nuclear), and geothermal energy. The use of fossil fuels, geothermal and nuclear power by humans is a relatively recent phenomena. For most of human history energy has ben restricted to solar stocks and flows. It is safe to say that virtually "all life on earth has depended on solar energy" [Teller p. 28].

Solar energy is the foundation of life in its most recognized terrestrial and oceanic forms. The production of chemical energy through the process of photosynthesis is essential for all carbon-based life forms. About 520×10^{22} J (joules) of solar energy strike the top of the earth's atmosphere every year. However, only 60×10^{22} J reach the earth and are available for photosynthesis [Simmons p. 10-11]. Plants use some energy to sustain their biochemical processes and convert some 170×10^{19} of this energy into plant mass, a good deal of which is ocean phytoplankton [Simmons p. 11]. Only about .001 of the solar energy that strikes the earth is utilized by plants [Teller p. 42]. This is because much solar radiation hits the earth where there are no plants and plants convert only about 1% of the solar energy they get into chemical energy [Teller p. 42].

The energy fixed by plants ends up as food for the flora and fauna that do organic decomposition (bacteria, fungi, etc) or as food for a plant-eating animal and maybe a carnivore if the herbivore is eaten. In either case, energy is lost to heat in decomposition, and energy needed to move ruminants and carnivores around [Simmons p. 11]. Eventually, all of the solar energy will end up as heat, so dispersed, that is, bound, that it can do no work and therefore can not be usurped to sustain life of any kind. "The lesson learned here is a fundamental one; all forms of energy on the earth end up as heat which can do no work" [Simmons p. 13].

Biological Productivity

The earth's biota do not efficiently capture solar energy; only about .2% of solar energy is converted into organic matter. The actual amount of organic matter produced from solar energy per unit area per unit time is called biological productivity. The rate for plants is called the net primary productivity (NPP) and for animals the secondary productivity (SP) [Simmons p. 14]. NPP varies across ecosystems. For example forests produce 1570 grams/m^2 /yr of biomass while deserts produce only 103. Wetlands produce 1783, lakes and streams 400 and oceans 254 (a "virtual

[23] This section follows Harris [1975] Ch. 12 no further citation will be used.

desert"). Cultivated land is less productive than forests, woodlands and wetlands at 937, but, of course, produces biomass that humans prefer. Secondary productivity is much lower. Herbivores, for example, expend energy looking for food and maintaining body temperatures, hence no more than 10% of an area's NPP will be converted into herbivore tissue [Simmons p. 14]

Human Food Production Efficiency

Humans must expend energy (calories) in order to get energy. We can characterize various "modes of production in terms of their energy efficiency: the amount of energy it produces divided by the amount of energy (calories) needed to produce it. The formula is:

$$\mathbf{E = m \times t \times r \times e}$$

where E= total energy produced; m is number of producers; t is hours worked per producer; r is calories expended by producer per hour; e= energy efficiency. Perhaps and example would help.

The !Kung San live in small nomadic groups. The subsistence strategy is gathering-hunting. In a group studied by Richard Lee the average total calories produced by a day of gathering and hunting[24] was 64,200. The average number of participants (m) was 7.4; the average period of work (t) was 6 hours; and the average participant expended 150 calories per hour (r). Thus, a total of 6,600 calories was expended each day (7.4 x 6 x 150). **e** then is equal to 64,200/6,600 = 9.6. The !Kung get 9.6 calories back for each one expended. The "workers," of course, do not consume all of these calories themselves, but share them with children and elders and others who may be needy. They must also feed their hunting dogs, build up fat for the lean season and for the occasional festivities where all the adults "dance from dusk to dawn" [Simmons [p. 63].

Lets compare !Kung efficiency to that of a sedentary agricultural group, the Genieri in Gambia, West Africa. The Genieri raise peanuts and several types of cereals (Cherrios, Raisin Bran, Lucky Charms - just kidding). They till their fields with hoes and depend on rainfall for water. The Genieri are more numerous than the !Kung so need to produce more total calories per year. Annually the Genieri need some 460,000,000 calories compared to the 23,000,000 needed by the !Kung but have 334 workers instead of 7.4. The Genieri's 334 producers each supply 820 hours per year and expend, like the !Kung about 150 calories per hour. The formula produces a value of **e** of 11.2 which is only slightly higher than that of the !Kung. Looking at such numbers one might wonder why humans ever switched to agriculture. But, the Genieri live in a degraded environment; the product of centuries of slash/burn agriculture with ever shorter fallow periods made necessary by rising population densities. Such conditions are surely inferior to those that humans faced at the end of the Pleistocene where better land was available and population densities were lower.

The first agricultural system adopted by humans was probably a system called Swidden or

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[24] I do not use the term work or labor here because the latter terms have specific meanings to students of economics. Labor refers to a specific social relationship of capitalism. The term "work" applies to the context of alienated labor or more broadly where there is some element of compulsion or exploitation. In the GHMPR there was no compulsion of exploitation so we will use the term expenditure of energy rather than work or labor (unless I slip up).

slash-and-burn which is much more efficient than either GO or the Genieri system. The name comes from the practice of creating land for gardens by killing trees, cutting them down and then burning them. The ashes from the burned trees fertilize the land. Swidden was the method used the Maya, and the native Americans of the Northeast and North Central United States. Swidden is still used by indigenous peoples in the rain forests of South America, the Philippines, Southeast Asia and New Guinea. It was certainly the method used in old Europe, the middle east and North Africa as the barren, but once densely forested landscapes of these regions grimly attest.

Swidden produces and energy efficiency of about 20. Roy Rappaport estimates that e=18, for the Tsembaga Maring in the highland of New Guinea. The Tsembaga who number 204 souls, plant taro, yams, sweet potatoes, manioc, sugar cane, and several other crops. Rapport's calculations indicate the Tsembaga have an easy life producing all they need in calories with only about 380 hours per year of work [146 workers, 150 calories per hour, e=18 to produce 150,000,000 annual calories]. However, the efficiency of the Tsembaga has increased following the introduction of steel axes. Tsembaga men expend 1/5 the calories cutting down a tree with a metal axe compared to a stone axe. Thus, stone age efficiency no doubt would have been somewhat lower. However, cutting down trees is a sporadic activity. Gardens are planted for two or three years before they lose fertility and then allowed to revert to forest. Unlike the Genieri, the Tsembaga environment had not been degraded when the study was done in the late 1960s. At the time of the Rappaport study the Tsembaga were using only about 42 acres of land for gardens at any given time. Since they had over 800 acres available they could allow suitable fallow periods. Over the past three decades the Tsembaga have dramatically increased the intensity of production as a consequence of the desire to feed more pigs. But pigs are not a good energy deal.

At the peak size of the pig herd (160), the annual weight gain was about 50 pounds per pig or 8000 pounds or 5,252,000 calories. But, it took 66 Tsembaga women 758 hours each per year at 150 calories per hour to produce these calories (they grow yams to feed to pigs) which produces an **e** of only .7. Obviously the women subsidize the pigs and those who eat them. Even worse, as land is used more intensively (shorter fallow) to feed more pigs, there has been a significant degradation of the Tsembaga lands. The information conveyed in the original Tsembaga energy formula (380 hours per year) understates the work load of the Tsembaga considerably, most especially for the women.[25]

Among irrigation agriculturalists production efficiency rises to about 50:1. Irrigation based agriculture has been the economic foundation of all the great early civilizations in the river valleys: Mesopotamia (Tigris & Euphrates), Egypt (Nile), India (Indus), China (Yellow), Southeast Asia (Mekong). Irrigation was also central in the Meso-American civilizations of Teotihuacan, Tenochtitlan, several Mayan cities, the cultures of the Hohokam and the Anasazi (Pueblo) of the American Southwest and the Inca Empire in Peru. These systems were based on river or spring fed

[25] 66 women constitute 45% of the labor force of 146. Women thus contribute 45% of the 380 hours to food for humans and another 780 for food for pigs. The total is 951 hours per year.

irrigation water dispersed with canal and aqueduct systems.[26]

The increase in the quality of life (more food less energy?) for producers under irrigation regimes is not what it appears to be. Consider the village of Luts'un in Yunnan Province. Anthropologists estimate about 75% of the output is rice, the rest is corn, soybeans, manioc and potatoes. The population numbers about 700 so to supply 2,500 calories per day, about 638 million calories need to be produced. The 418 producers put in 1129 hours per year, 150 calories per hour, with an **e** of 53.9. Total output is, therefore, 3.788 billion calories. What happened to the surplus of 3 billion or so calories? Well some food was sold in the local market and exchanged for goods; some went to local, provincial and central governments in the form of taxes; some went to rent; and the rest went to feed children.

Also take note of the fact that although irrigation agriculture is energy efficient, the producers worked some 800 more hours per year than the average Tsembaga. This is because the worker had to support macroparasites like tax collectors, landlords, and bureaucrats.

Compared to gathering and hunting and swidden, irrigation has the advantage of allowing intensification without degradation. The nutrients in the soil are constantly replenished by the flow of nutrient laden irrigation water from the major rivers. Every year the floods would deposit fertile silt washed off of deforested mountain sides into the river system onto the river valley flood plain. Spring fed irrigators would have to add nutrients to their land in the form of animal or human dung or decayed plant materials (compost or peat).

How efficient is American "industrial" agriculture?

The productivity of American agriculture has grown impressively since the end of World War II. For instance, corn yield per acre rose from 26 bushel per acre n 1909 to 87 in 1971 with most of the change coming since 1950 [Pimental et al p. 131]. The growth in productivity was a consequence of the use of hybrid corn (20-40%) and of an great increase in the use of energy (60-80%) [Pimental et al p. 131]. In 1970, American corn farmers used the energy equivalent of 80 gallons of gasoline per acre [Pimental et al p. 137].

An Iowa corn farmer puts in 9 hours of labor per acre of corn and gets 81 bushels and an **e** of 6,000! But labor is far from the only "energy input" into corn. Farmers use more petroleum than any other industry. Industrial agriculture relies on heavy inputs of energy from the accumulated stocks of solar energy called fossil fuels i.e. coal and oil. These substances provide fuel for tractors and petrochemical fertilizers, pesticides and herbicides. They also provide the energy to make the tractors, combines, trucks, and railroad cars needed to produce and move the crop to market. The produce the electricity needed to run irrigation pumps and other farm equipment.

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[26] Even though Tenochtitlan sat on a lake it needed to build aqueducts and dams for irrigation. The waters of Lake Texcoco were brackish so the salt density had to be reduced. The Aztec built a dam in the lake and pumped fresh water from distant springs via aqueduct into one side. The (impermeable membrane) dam prevented diffusion (osmosis), thus allowing a concentration of fresh water to persist on one side of the dam. The dam also prevented flooding (most of the time) of the city. If not for these constructions Aztec *chinampa* agriculture would have been impossible.

In addition to increased direct inputs of energy, industrial farming requires many indirect inputs. For example the production and processing of one pound of nitrogen fertilizer requires 8,400 kilocalories (kcal) of energy. Thus, all inputs considered, including labor, the annual kcal input for the corn crop of 11970 was 2,286,800. The kcal content of the corn crop in 1970 was estimated to be about 8,164,000 kcal producing an energy efficiency (e) of a mere 2.82! [Pimental et al p. 136 table 20.2]. The 1970 figure compares unfavorably with the 1945 figure of 3.7. But hold on it gets worse.

The energy efficiency calculated above is misleading for several reasons. It is most important to remember that Americans for the most part do not consume corn directly:

1. 3/4 of the crop land in the U.S. is devoted to growing fodder crops (animal feed for those of you who missed 4H). When corn is fed to animals 90% of the calories are lost. When allowance is made for the additional energy required to produce the cattle, process them
and get them to market the energy efficiency figure is surely negative.

2. Corn is also now being used to produce ethanol which is mixed with gasoline to produce energy. The practice is heavily subsidized by the federal government as obviously the ethanol contains less energy than it took to produce it.

It is said (mostly by farmers) that every farmer feed 50 people. Hogwash (does anybody know what that means?). There is a great deal of hidden labor on the American farm. For example, it takes labor (Marx called it dead labor when it was embodied in machines) to produce tractors, combines, trucks, oil and gas, pesticides, herbicides, and fertilizers. As we have seen all these inputs add up to 2.89 million calories of energy per acre per year. And, no one has a clue about how much human and other energy is used to make all these products. All told, it may be that U.S. **e** may not be any higher than that of ancient Egypt and is probably lower.

The Second Law of Thermodynamics - The Entropy Law

Industrial agriculture has greatly increased the output of food by usurping the energy stored in the inherited stock of fossil fuels.

The term entropy was first used by Rudolf Classius in 1868. In 1827 a french engineer noted that the ability of a steam engine to "work" was based on heat differences in two parts of the engine. Should no father energy be applied to create heat, eventually the heat will be uniformly distributed in all parts of the engine; in short, the energy had dissipated [Goldsmith p. 382-83].

The fist law of thermodynamics holds that matter and energy can be transformed but cannot be destroyed. The second law asserts that matter and energy can change in one direction only - from ordered to disordered. When a ruminant eats grass, part of the solar energy captured in the grass is used to make the ruminant work, part is stored in its flesh and fat (negative entropy), and part is lost to entropy - heat. Humans eat the flesh and fat, use some of the energy to make their bodies work, store some as flesh and fat and lose some to heat. When the human dies it becomes the body of worms (remember poor Mercutio), bacteria and other decomposers and heat. Sooner or later it is all heat.

Of course, nature stores solar energy in the form of fossil fuels. Thus, when coal or oil are

burned they are transformed into energy that produces work and some energy, while not destroyed, cannot be used to perform work in the future -it is "bound" in the form of dispersed heat [Rifkin 1980 p. 34-35]. In brief, "entropy is energy no longer capable of conversion into work [Rifkin 1980 p. 35]. Everything in the universe, all ordered structures be they trees, mountains, or humans are destined to dissolve into dust and heat waste. Humans cannot escape the laws of thermodynamics which:

> control, in the last resort, the rise and fall of political systems, the freedom or bondage of nations, the movements of commerce and industry, the origins of wealth and poverty, and the general physical welfare of the race [Rifkin 1980 p. 8].

However, radical ecologists question the validity of the entropy law. Indeed they doubt virtually all the canons of modern science. Edward Goldsmith notes, for example, that the idea of entropy is disproved by the fact that in 3000 million years the world "has not ceased to develop in complexity, diversity and stability." Indeed, the world has behaved "in a manner diametrically opposed to that in which it should have behaved had it been governed by the entropy law" [Goldsmith p. 383]. Goldsmith and other doubters claim entropy applies only to closed systems; systems that get no influx of energy. But, the earth with its daily influx of solar radiation is not a closed energy system [Goldsmith p. 384]. The entropy theorists respond that the apparent growth in complexity and order is produced at the expense disorder elsewhere in the system. For example, the increased loadings of carbon dioxide and other gases released by combustion of fossil fuels, the pesticides that flood our waterways, and the greater levels of heat trapped in the atmosphere, in short, pollution, is the disorder side of the complexity coin. The greater the complexity we build the more energy we must absorb from the surrounding environment, some of it becomes part of the system (our bodies, our homes etc) the rest is dissipated as heat. It remains a matter of conjecture whether human complexity will disintegrate toward "equilibrium" because it runs out of the energy or negative entropy it needs or because the entropy (pollution) so changes the natural environment that humans cannot live in it.

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