Part III.

INTRODUCTION TO SYSTEMIC INTERACTIONS

Demographic Concepts

Chapter 15. Population Regulation in Human Societies

Society/Society Interactions

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Chapter 15. POPULATION REGULATION IN HUMAN SOCIETIES

> "Population regulates itself by the funds which are to employ it and, therefore, always increases or diminishes with the increase or diminution of capital."
>
> David Ricardo, 1821

O. Introduction to Systemic Interactions, Part III of the course

In the last part of the course, we neglected the details of environmental interactions in order to consider evolutionary processes in the abstract. Now we need to turn back and put some ecological flesh on the evolutionary bones, so to speak.

This part of the course will consider a series of examples of processes that web human populations to environmental processes: population regulation, interaction with other human populations (through crime, trade, warfare, and diffusion of innovations and diseases), and interactions with non-human populations (disease organisms) and ecosystems (environmental deterioration). These interactions will provide us with concrete instances of how evolutionary processes influence ecological interactions, and how ecological interactions, long continued, become evolutionary forces.

I. Introduction

A. What Mechanisms Regulate Human Populations?

Demographers devote much attention to trying to answer this question. It is an extremely complex problem for three reasons. *First,* a host of environmental processes affect demography including weather and climate, soils, prevalence of diseases, routes of transport, presence of non-subsistence resources (e.g. precious metals) by influencing birth, death and migration rates. *Second,* the human response to these factors is affected by subsistence technology (as we saw in some detail in the second part of the class) and a host of more subtle factors that determine the response of human births and deaths to subsistence scarcity[1]. Historically, as early as the 18th Century, North-western Europeans seem to have demanded higher standards of living than Southern and Eastern Europeans and Asians. Northwestern Europeans curtailed births at lower population densities by delayed marriage, giving longer life expectancies (35-40 years), while Asians married earlier, had higher fertility, and larger populations that pressed harder on resources, lowering life expectancy to

1. There is a nice example in the reading by A. J. Coale (1986).

25-30 years. Why did basically similar agrarian societies exhibit such different behavior? (See Coale's Fig. 1.2). *Third*, humans are very long-lived animals, and we have only been keeping decent records for a century or two (4-10 generations) in the developed world, and are just beginning to develop vital statistics in some countries. The data we have available to dissect demographic processes are less extensive and accurate than we might desire.

These are intimidating problems to solve in particular cases, much less in general. This is a good example of how complicated things can get when we try to understand how real systems actually work. Demographers are famous for not having their long-term predictions work out (they are right up there with economists and psychics in this regard). However, there are good data from selected countries for the past couple of centuries; and more data from the more distant past are being made available by historical demographers. Demographers have provided us with a wonderful glimpse into the intricacies of human ecology. They have also been in the forefront of using the simple models approach to dissecting processes.

B. Central Importance of Demography

The issue of population regulation has implications far beyond the narrow regulation question; in some sense it incorporates the whole evolution and ecology of a population. It is no accident that some of the classic "big thinkers" of the past contributed to demography and thought about "other" problems in demographic terms. We have already met Darwin, and will shortly meet another example, the economist David Ricardo.

Consider for example a question of contemporary controversy: is population really limited by a combination of technology and environment, as suggested in the earlier chapter on demography, or do low populations act as a spur to technical innovation? Who would quit hunting and fishing for a living until population densities rose to the point of making the development of agriculture necessary? A number of scholars we'll meet in the last part of the coarse (and this chapter) have reversed the Malthusian idea, arguing that population pressure regulates the rate of technical advance, rather than the rate of technical advance regulating the growth of population. Whatever the truth here, the way competition is generated by the interaction of technology and environment is certainly key to understanding human ecology and evolution.

II. Ricardo's Model of the Stagnation of Economies

A. Relationships Between Population Growth and Economic Growth

The problem Ricardo set out to explain was how population growth would interact with economic expansion. It is an example of how Malthus' ideas could be extended to oth-

er problems through a nice bit of "population thinking." This style of theory development is experiencing a resurgence among economists. Peter Lindert at U. C. Davis and Ronald Lee at U. C. Berkeley are examples of the trend.

Ricardo imagined three sectors in a substantially agrarian economy such as the Britain of his time: laborers, capitalists, and landowners. When he wrote in the early 19th Century, this was a tolerable simplification in such economies, especially where a landed aristocracy is distinctly different from the capitalist manufacturing and trading class. Under Ricardo's scheme things worked like this:

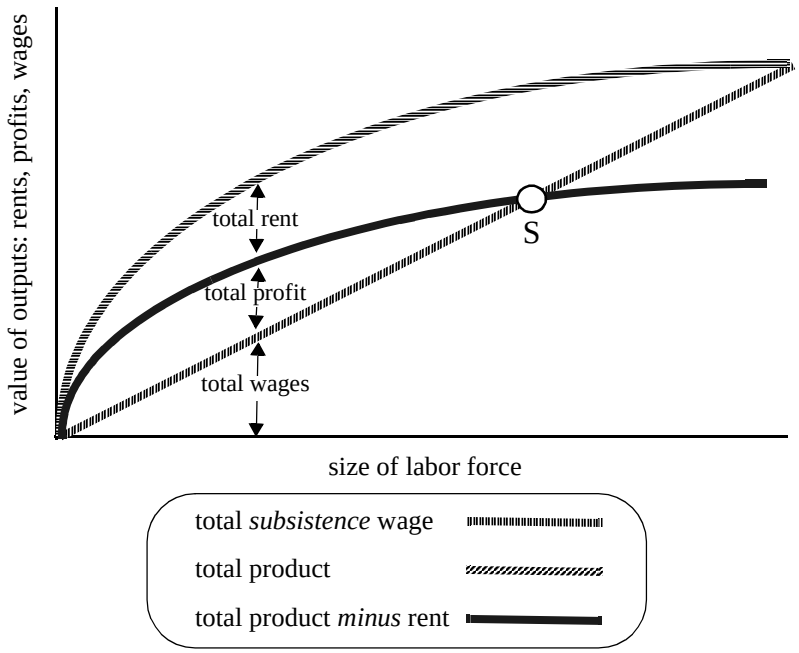
a. Producers (capitalists) compete for land for warehouses, shops, farms, docks, canals, mines, and so forth.
b. After the landlord's share (rent) is taken out, the rest of society's product is divided between labor and capital.
c. Capitalists reinvest profits in new productive capacity and research and development. As long as capitalists have enough profits to reinvest, the economy grows.
d. Workers use wages above some subsistence minimum to, among other things, expand their families. The subsistence minimum is defined as much by cultural as by biological needs, Ricardo was aware of this (and it is supported by the Northwestern European/Spanish difference shown in Coale's graph below).
e. An increasing population meets declining efficiency per unit labor as land fills up. The most productive land is used first, and as population expands, increasingly marginal land must be used for economic activity. Efficiency per hour of labor and dollar of investment falls.
f. Since capitalists must pay at least a subsistence minimum wage to laborers, declining efficiency of labor reduces their profits. As land gets scarce, rents go up as well. Without profits, capitalists can no longer invest in new productive capacity.
g. The final result is a large population, with both workers and capitalists getting minimum returns, but with very rich landlords.

Figure 15-1 illustrates the basic elements of Ricardo's argument:

At point S, the labor force (population) has risen to a point where rents and wages consume the total product, capital accumulation ceases, and the economy stops growing. Note that rents are maximized in a stagnant economy on this model. (How will this picture change if one does away with rents and uses government investment instead of profits to generate investment, as in a socialist system?)

This scenario seems to fit the agrarian states of the past quite well. They seem to have

Figure 15-1. David Ricardo's (1821) description of the interaction between population growth and economic expansion emphasized relations between laborers, capitalists, and landowners. Note that rents and wages consume the total product at point S.



usually been characterized by a poor laboring and artisan class, to lack wealthy capitalists, and to have been dominated by landed aristocrats. Fertility decisions in the short run lead, via a complex chain of events, to an undesirable outcome, economic stagnation and merely subsistence wages.

Is Ricardo's scheme relevant to post-industrial societies? Since the industrial revolution, some societies have been able to keep technological progress rapid enough (and to slow population growth rates) that profits and wages stay high. What is left out of Ricardo's argument is the possibility that investment by capitalists (or government) in research and development might increase the total product available from the fixed land base. Nowadays economists think that research and development (R&D) has rapidly displaced the total product curve upward since the industrial revolution, making Ricardo's brilliant theory obsolete.

But it is not so clear (1) if the industrial countries can keep this up forever or (2) if Less Developed Countries (LDCs) or Third World nations can achieve Western levels of material well-being at current population growth rates. It might be that competition for land on a populous, environmentally degraded planet might one day overwhelm the potential of scientific and technical advance to sustain high real wages. Note that we still argue

the demographic issue in the terms Malthus and Ricardo sketched 150 years ago.

It is interesting that neither of these two scholars saw the potential of the industrial revolution very clearly as it was happening around them! Study figure 15-2 to see how the relationship between real wages, prices, and population for the period 1540-1913 in England. This series from Lindert (1985) spans the important period of the pre-industrial commercial expansion and industrial revolution. Note how up until 1820-30 there seems to be a pretty good inverse relationship between periods of wage decline and rising population. The longer series from Lee (1987), showing the big drop in population and bulge in wages due to the Black Death in the 14th Century, is an even plainer illustration. As far as the information available to Malthus and Ricardo was concerned, population growth did look as if it depressed wages. Both men understandably failed to predict the dramatic effects of the industrial revolution in the late 19th and 20th centuries. Demographic/economic prediction, then as now, is a hopeless business! Note that the rate of technical improvement in the Late Medieval and Early Modern Period in Europe (A.D. 1000-1800) was quite rapid by most standards, it's just that the rate of population growth was more rapid yet. In other words, it is only after the unprecedented technical advances of the industrial revolution that rates of technical improvement have outrun population growth for any sustained period.

III. Basic Data

A. Demographic Transitions

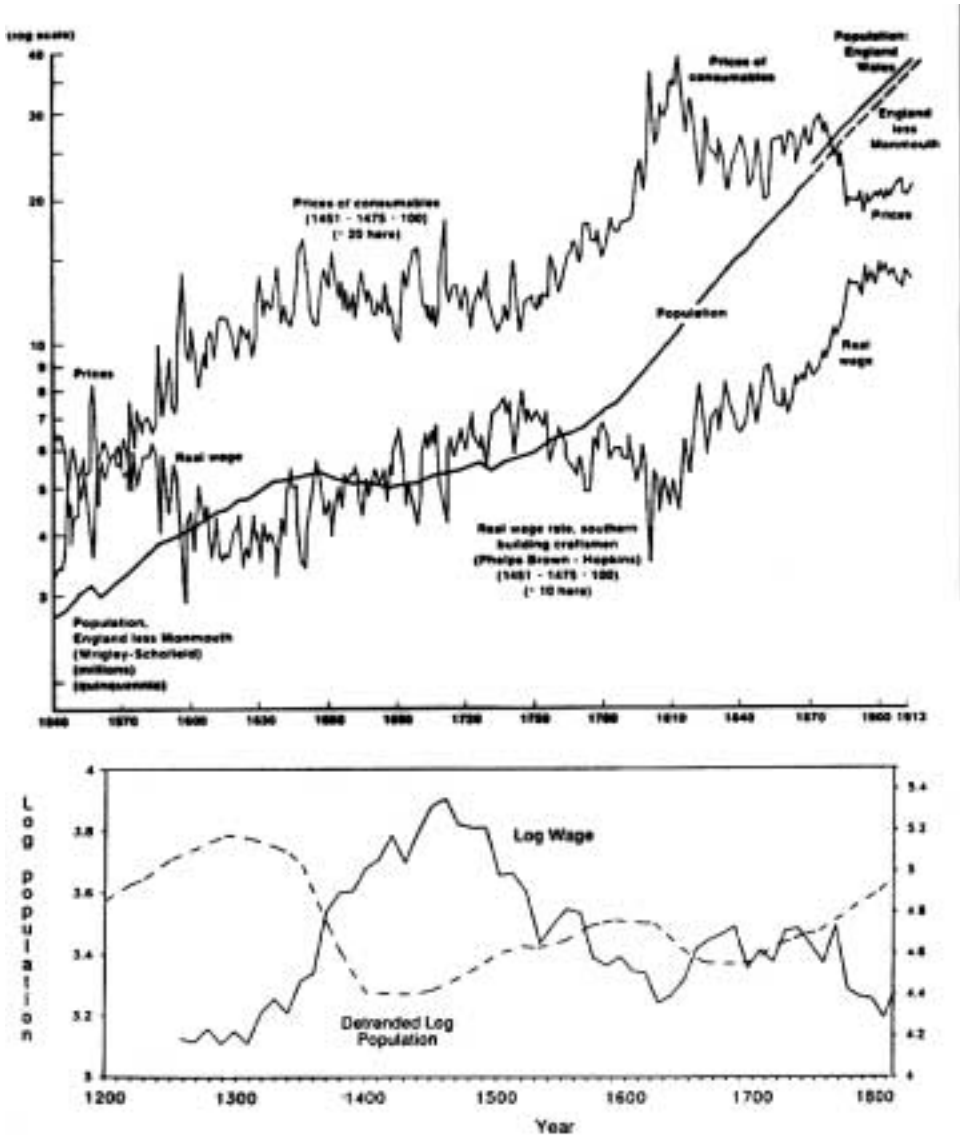
According to rough paleodemographic evidence, human populations have probably experienced many demographic transitions. Figure 15-3 illustrates this idea. This graph was first drawn by Edward Deevey (1960). Deevey's concept was that technical revolutions have generated a series of population "explosions" in human history. First the development of hunting and gathering led to the original expansion of human populations out of Africa. Then, the agricultural revolution 10,000 years ago led to a second jump in human populations. The current industrial revolution has led to the third.

B. Major Fluctuations at any one locale

Human populations are likely to have fluctuated more or less strongly at any one place as disease epidemics, wars, cycles of environmental destruction, and so forth operated. You have already seen the data indicating the effects of the Black Death in Europe. Much of Europe was also depopulated during the disease episodes and political breakdown accompanying the fall of Rome. Archaeological data and crude census information from classical civilizations give us a dim idea of the magnitude of these fluctuations.

The best data for such fluctuations come from China. Chinese rulers conducted peri-

Figure 15-2. Two data series showing relationships between wages and population in Western Europe. The top figure describing real wages, prices, and population in England and Wales, 1541-1913 is taken from Lindert (1985). The bottom figure describing real wages and detrended population size in Europe from 1200-1810 is taken from Lee (1987). {Note the use of log scales on vertical axes; this means that a one unit increase along the vertical axis represents a ten-fold increase in magnitude.}



odic censuses of widely varying quality. Scholars think the data in Table 15-1 are probably trustworthy (UN, 1973: 18.) Note the substantial swings. Political fragmentation, barbarian invasion and disease sets populations back; a sustained trouble-free period with good leadership allows recovery. Not until the modern period did China's population develop a steady upward trend.

Figure 15-3. There is evidence that humans have had many demographic transitions as this graph illustrates (adapted from Deevey, 1960). Note the logarithmic scales along both axes.

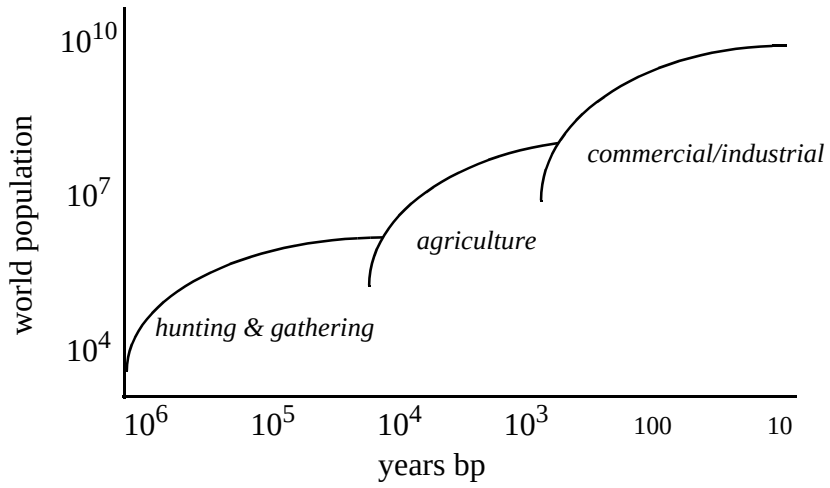


Table 15-1. Historical Data From China

Dynasty	Year (A.D.)	Estimated Population (millions)
Western Han	2	71
Eastern Han	88	62
Sui	606	54
T'ang	705-755	37-52
Sung	1014-1103	60-123
Ming	1393	61
Ch'ing	1751	207

C. Recent Trends in Human Populations

The rate of population growth since 1650 is greater than exponential! As the Table 15-2 shows, **r**, the exponential rate of increase, has itself been increasing! The modern population explosion is illustrated in Figure 15-4. It turns out Malthus had been conservative about population growth rates.

Figure 15-4. World population growth from 1650 to 1950.

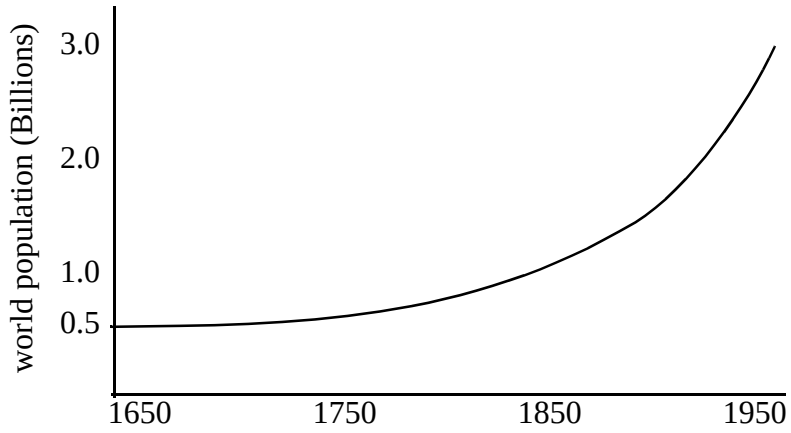


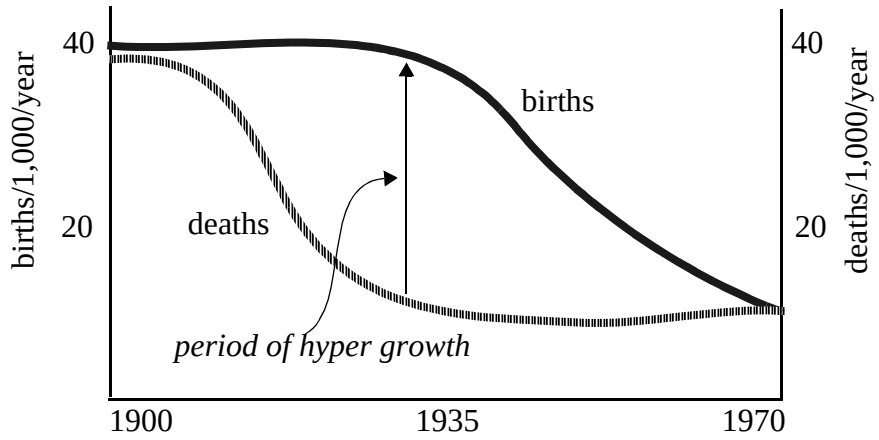
Table 15-2. Changes in population growth rate over time.

Year	Doubling Time
1650	200
1850	150
1950	86
1965	40
1980	slowing

In 1960 Foerster et al. introduced a model in which the rate of increase of population increased as a function of population. This model has the pathological property that population will go to infinity. They fit the parameters of this model to human population data and estimated that human population would approach infinity in 2026. This model is a bit tongue-in-cheek, but it does point out the truly explosive nature of contemporary population increase statistics. This cannot go on for long, and indeed in some populations it has not. Read on!

Since about l850 many populations have undergone demographic transitions. The first modern transitions of this type were in Western Europe, beginning in parts of France around 1800. Figure 15-5 illustrates typical patterns of change in annual birth and death rates., notably that death rates dropped first, followed by a lowering of the birth rate[2]. Later, Britain and the rest of N.W. Europe followed suit, with the U.S., Eastern Europe, Japan,

Figure 15-5. Changes in annual birth and death rates per 1,000 population per year from 1900 to 1970. Hypothetical.



coming along later. Now there are hints of transitions in Third World countries, although only in China and among elites are changes dramatic. There is still little evidence of demographic transition in Africa.

IV. Explanations of Human Population Fluctuations

A.The Malthus-Boserup debate

Very generally, there appears to be a close connection between demographic and technological revolution, at least when we consider things on a large scale. What is at issue is whether technical advance drives demographic change, or vice versa. Here we consider both positions.

Technical revolutions may permit demographic ones. This was Malthus' idea. Population growth will generally be faster than technical improvements, and it will be technical improvements that permit population growth rather than the other way around.

Demographic factors may drive technical revolutions. Esther Boserup reversed the causality in Malthus' model. Boserup suggested that it is population growth that drives intensification and innovation. If people are getting hungry or short of whatever resources they might need, they devise new ways of increasing the efficiency of their current production system. We might think of this as "necessity is the mother of invention". Boserup supports her argument with data from Africa showing that as fallow periods get shorter,

2. Notice that only France largely escaped the bulge in population caused by birth rates falling later than death rates (Coale's figure 1.4).

farmers are prepared to put more labor into food production rather than cutting down on their food intake (Boserup 1965). In a later publication she suggests that these innovations probably arise from the kind of labor specialization that characterizes intensive cultivation; a leisured aristocracy, supported by agricultural laborers and crafts specialists, have the capital and time to invent new ways of doing things (Boserup 1970). Note that Boserup's arguments can be viewed in terms of the cultural evolution models outlined in Chapters 11 and 12: low returns for labor increase the payoffs to innovation, experimentation, and invention.

Cause and effect are difficult to disentangle. As in the chicken and egg problem, is technical advance or demographic change the leading variable? From an evolutionary perspective, the important thing to remember is that both population pressure and technological revolutions have effects on one another.

B. Environmental Factors are Clearly Important on an Intermediate Scale

We will discuss the role of biophysical factors such as disease on population regulation in Chapter 21. In Chapter 19 we will discuss the role played by warfare.

V. Explanations for the Modern Demographic Transition

A. Why Do People in Rich Industrial Nations Reduce Fertility?

There is a huge literature on the causes of fertility decline in the modern world. Economists, sociologists, demographers, historians, biologists and anthropologists have all developed sometimes conflicting, sometimes complementary explanations for the transition. Here we focus on the more evolutionary accounts, noting their links to those accounts developed in other disciplines.

B. Sociobiological Hypotheses

Sociobiologists are somewhat confused by the inverse relationship between wealth and number of offspring in industrialized countries. Remember back to Chapter 10 where we discussed the sociobiological prediction that the wealthy and powerful would have more offspring than the poor and powerless. Sociobiologists have come up with several hypotheses for the transition, two of which we will briefly consider here.

First, in limiting family size people may still be maximizing their overall fitness through increasing the ***quality*** *of their children at the expense of the* ***quantity.*** In a highly competitive environment with high social mobility, in which education and inheritance are critically important to a child's success in later life, it may "pay" (in terms of a parent's fitness maximization) to produce only those children to whom (s)he can give a good start in

life. Models such as those of Harpending and Rogers (1990) have shown it may be worth "placing" one child in the highest social strata rather than more children in the lowest social strata, at least if children in the lowest social strata have only a very small chance of reproducing. Although this hypothesis doesn't explain why so many women nowadays elect to have no children at all, it is appealing in several respects, insofar as it seems to make sense of modern-day parents' values, objectives and concerns - laying away funds for college, etc.

It also dovetails rather nicely with economic hypotheses that emphasize the economic benefits parents derive from children, both as child labor and old age assistance. In traditional populations, and among some sectors of the rural and the poor, these benefits can be substantial (see Chapters 3 to 6). Conversely, modern urban people get no direct labor benefits from children, although they do have opportunities to maximize family income by investing in expensive educations for a few children. (See John C. Caldwell (1982) for an in-depth discussion of this topic.)

Some economists have gone as far as to equate children with ordinary and substitutable consumption items (Becker 1981). If this is true, we'd expect that as people get richer they will consume more of them. Why does this not happen? Becker's answer basically is that prosperous people can afford a whole host of luxury goods, such as boats and ski weekends at Tahoe, that compete with children for time and attention. Much as caviar eaters must generally cut their consumption of beans, so the prosperous must also cut their "consumption" of children. The problem with Becker's hypothesis is that the transition to lower fertility is not perfectly correlated with economic conditions. Sometimes the transition occurs early in economic modernization, sometimes late. Historical demographers and students of modern Third World demography are generally critical of Becker's hypothesis, pointing out that rich people often have more children than the poor.

Other sociobiologists prefer to see the inverse relationship between wealth and number of offspring in industrialized countries as a kind of evolutionary mistake. They like to think of the human psyche and decision-making apparatus as adapted to evolutionary and ecological forces that operated in the past but are now radically altered. As a consequence they suspect that our actions are no longer well suited to the modern environment, representing a school now known as "evolutionary psychology". Burley (1979) argued that cryptic estrous[3] is set up as a trade-off between sexual pleasure and the pain of childbearing, such that in seeking intercourse women could not avoid possible pregnancies. Modern contraceptives allow women to have one without the other[4]. This hypothesis relies on some odd assumptions (see footnotes) and it doesn't explain the facts very well. In many places

the demographic transition started well before effective contraceptive methods became available.

C. Cultural Fitness Hypothesis

The cultural fitness hypothesis emphasizes the evolution of cultural constraints. (This hypothesis is sketched out in the reading for Chapter 12.) The idea here is that modern economies open a niche for the technically sophisticated and ambitious (e.g., teachers, bureaucrats, managers, scientists, and engineers). Achieved social roles therefore become important relative to ascribed ones. These roles are effective for non-parental transmission. That is, the prestige attached to these roles, their inevitable importance in a technological society, and the wide contacts such people tend to have with others inevitably make them effective in non-parental cultural transmission. Moreover, empirical studies indicate that children raised in small families have higher rates of achievement in these modern roles. It seems parents must spend a lot of time and effort encouraging and helping children in order for them to do well in school. Raising children who can compete for prestige roles in such societies is expensive in terms of both time and money. Thus norms for small families spread because of natural selection on asymmetrically transmitted cultural variation[5]. In other words, the kinds of people most commonly admired and emulated (role models) in modern societies are those who have fewest children. When people imitate these role models' life styles, they also copy their small family sizes.

Demographer John C. Caldwell argues that small-family norms are presently spreading to the Third World ahead of significant economic development because the mass media are dominated by industrial norms. This domination is either direct (e.g. Hollywood movies) or indirect (via training Third World elites in Irvine, Moscow, London, Paris, etc.). This observation provides indirect support for the cultural fitness hypothesis.

Knauft (1987) has suggested another way in which elite small family norms might spread through a population, by examining migration patterns in ancient urban societies. Elites in these societies often had low fertility. Ancient cities were also demographic "black holes." In crowded, unsanitary cities with uncertain, expensive food supplies, death rates were typically above birth rates. He gives data for 17th Century London and Ancient Rome.

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3. Estrous (or oestrus) is the period of maximum sexual receptivity, or "heat", in female mammals. It usually occurs coincident with the release of eggs from the ovaries. Human females' estrus is cryptic or hidden. Burley thinks that with cryptic estrous women can't have sex without getting pregnant, because they are unaware of ovulation.
4. Burley's somewhat bizarre argument here assumes that deep down women "don't want" children because of the pain and dangers of childbirth. Hence once contraception becomes reliable they can get sex without babies!
5. Return and study closely the parent-teacher model from Chapter12.

Demographically, city populations in agrarian societies were continually dying away, relative to the countryside. They did not disappear because of immigration from rural areas. Why did people move to unhealthly cities? City people included the elites that dominated the cultural life of agrarian nations. With high death rates, there were always opportunities to rise in competition for elite roles in the city. The pomp and splendor of life in the cities attracted people to them despite the biological hazard. In essence, cities could exist only because parasitic city cultural variants could spread to healthier rural populations and induce them to move to the exciting, high prestige, but unhealthly and "morally degenerate", cities. "Once they've seen the bright lights, you'll never keep them down on the farm."

Coale cites a similar rural example in Hungary, except there the low fertility habits of the "one child system" carried no such success in non-parental transmission and the population just wasted away. Knauft also speculates that many primitive societies that abuse women or engage in heavy female infanticide can persist by bringing female and child captives into a demographically inviable society. Here again, a culturally aggressive, militarily successful society could persist by parasitizing neighboring societies for the personnel to make it all work. These are some of the most plausible examples yet advanced for conflicts between cultural and genetic fitness being important in human affairs.

VI. Conclusions

Over the long haul Malthus was essentially correct. In the very long run, it is clear that technical advance has permitted a series of demographic transitions that have lead to major increases in world population size. Further, on the lines of the Malthusian argument of Chapter 8, it seems clear that population increase is usually fast enough to convert most of the gains into people, instead of more welfare per person; (this conclusion is much less certain: there may be examples in the past we don't know about that parallel the modern fertility reduction transition). However, the rise in the world's population may yet eat up the temporary welfare gains of the industrial revolution, as in Ricardo's model, particularly when we think of the irreversible environmental damage caused by large populations.

Shorter term population fluctuations are more complex with respect to the direction of causality between population growth and technological advance. On a smaller scale, all sorts of environmental and social effects clearly influence population growth rates. In the past, disease and political breakdowns seem to have led to major declines in the populations of agrarian societies from time to time. In our own societies, rapid economic growth, combined with escalating tastes for consumer goods, has sharply cut population growth rates and permitted individual welfare to increase to unprecedented levels in richer nations. It

will be some time before the empirical study of past and present human populations allows a satisfactory understanding of demographic phenomena.

VII. Bibliographic Notes.

References

Becker, G.S. 1981. *A Treatise on the Family*. Cambridge: Harvard Univ. Press.

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. Chicago: Aldine.

Boserup, E. 1970. *Women's Role in Economic Development*. London: Allen and Unwin.

Burley, N. 1979. The evolution of concealed ovulation. *Am. Nat*. 114: 835-858.

Caldwell, J.C. 1976. Toward a restatement of demographic transition theory. *Pop. Dev. Rev*. 2: 321-66.

Caldwell, J.C. 1982. *Theory of Fertility Decline*. London: Academic Press.

Deevey, E.S., Jr. 1960. The human population. *Scientific American* 203(3): 194-204.

Foerster, H.V., P.M. Mora, and L.W. Amiot. 1960. Doomsday, Friday, 13 November, A.D. 2026. *Science* 132: 1291-1295.

Harpending, H. C. and A. R. Rogers 1990. Fitness in Stratified Societies. *Ethology and Sociobiology* 11:497-509.

Knauft, B.M. 1987. Divergence between cultural success and reproductive fitness in preindustrial cities. *Cultural Anthropology* 2: 94-114.

Lee, R.D. 1987. Population dynamics of humans and other animals. *Demography* 24: 443-465.

Lindert, P.H. 1985. English population, wages, and prices: 1541-1913. *J. Interdiscip. History* 15: 609-34.