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Culture, Urbanism and Changing Human Biology

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Abstract

Anthropologists have long known that human activity driven by culture changes the environment. This is apparent in the archaeological record and through the study of the modern environment. Perhaps the largest change since the paleolithic era is the organization of human populations in cities. New environments can reshape human biology through evolution as shown by the evolution of the hominid lineage. Evolution is not the only process capable of reshaping our biology. Some changes in our human biology are adaptive and evolutionary while others are pathological. What changes in human biology may be wrought by the modern urban environment? One significant new change in the environment is the introduction of pollutants largely through urbanization. Pollutants can affect human biology in myriad ways. Evidence shows that human growth, reproduction, and cognitive functioning can be altered by some pollutants, and altered in different ways depending on the pollutant. Thus, pollutants have significance for human biologists and anthropologists generally. Further, they illustrate the bio-cultural interaction characterizing human change. Humans adapt by changing the environment, a cultural process, and then change biologically to adjust to that new environment. This ongoing, interactive process is a fundamental characteristic of human change over the millennia.

Keywords

pollution; culture; growth; polychlorinated biphenyls; phthalates; lead

In 1936 the famous archaeologist V. Gordon Childe published *Man Makes Himself*, a volume that is a milestone in the history of anthropology and the study of environment-human interaction. The title recognizes the role of human activity in shaping human settlement and human destiny. In 1936 Childe could not fully foresee the extent to which humans would reshape the globe and particularly the biosphere. Our impact is no longer limited to clearing forests for timber and creating caverns through massive mining operations, but extends to changing the planet's atmosphere and climate.

As we confront the changes we have made to the environment, we also are becoming more aware of how the environment shapes us. We respond biologically and socially to the environment even if we are not aware of responding. Thus, as we attempt to adapt to the biological and social challenges of the human-made environment, we indirectly shape ourselves. We make our world and it makes us in return.

Our current environment is not the environment that forged our human biology. We recognize that many features of our human biology evolved over a period beginning with the origin of primates. For some 60 million years we evolved the primate characteristics of sociality and intelligence. Of those 60 million years, our ancestors evolved distinctive hominid characteristics for perhaps 4 million years. Thus, for millions of years we were evolving and perfecting our bipedal, social and tool making adaptation that was the foundation for the hominid hunting and gathering way of life.

The migratory hunting and gathering way of life began to change into a much more settled existence when agriculture began approximately 10,000 years ago. With the transition to agriculture and the abandonment of a migratory existence came the development of both occupational specialization and social stratification. From the two new features there developed more substantial differences in the allocation of risk and resources in society.

The urban landscape and the related “health-scape” changed continuously since our agricultural transition and the course of change has been different in different cultures. In Europe, for example, changes in urban economy and society over the last five hundred years have dramatically changed human biology and health (Schell, 1988). Most notable of these changes were the increase in population size and the expansion of trade routes that connected distant populations. Increased population size and long-range trade facilitated the maintenance of endemic infectious diseases and the spread of epidemic ones. Even more recently the onset of industrialization changed cities immensely through industrial pollution, unsanitary waste disposal, contamination of the food chain, and crowding. The worst excesses of the industrializing cities have largely been addressed through sanitary systems and regulations regarding housing, work, and food. However, modern cities are concentrations of pollution, psychosocial stress, unbalanced levels of energy expenditure and energy capture, and very steep socio-economic differentials with their associated differential health risks (Schell & Ulijaszek, 1999). Thus, the modern urban environment appears quite different from the environment and lifeways of the hunters and gatherers.

Clearly our 60 million year evolutionary heritage prepared us to some extent for our current urban lifestyle. The evolution of mammalian features, primate features, anthropoid features, and ultimately hominid features, facilitated human survival and reproduction to the present. The growth of the human population proves this point. However, the theme of this text is not how well we have been prepared by our past. Rather, this essay concerns how our evolutionary “preparation” has fallen short in some respects revealing the challenges that have been and are now the most difficult for our evolutionary heritage to overcome.

Urban Growth

Since the beginning of humans’ sedentary life the growth of the urban population has been nearly continuous. The size of the European population increased steadily, except for temporary stoppages due to a very few devastating epidemics such as the Black Death. Since the advent of industrialization, the European population has grown very dramatically (Bogin, 1988). In 2000 it was estimated that more than 60 per cent of the world population would be living in urban places by 2030 (Department of Economic and Social Affairs,

2000). Importantly, this trend is not due to only the urbanization of the already more urbanized nations but to rapid urbanization in the less economically developed nations where the rate of urban growth is faster. By 2030, 84 per cent of the population will be urban in the developed areas, and in the lesser developed areas, 57 per cent of the population will be urban (Department of Economic and Social Affairs, 2000).

Some authors have pointed to a new epidemiologic transition in which previously controlled infectious diseases become epidemic again and new diseases develop such as AIDS (Armstrong et al., 2005; Barrett et al., 1998). However, HIV infection and AIDS, which have had a substantial impact on many countries, have not halted urban growth. Infectious disease might be considered a challenge to further growth, but in the past and in many places today, urban populations have grown despite infectious disease. Thus, disease does not appear to be a barrier to continued urban growth.

At the same time, emigration from the countryside to urban areas continues. The advantages seem to be economic, just as they were in Europe during the 18th and 19th centuries. However, unlike those earlier times, urban immigration is not offset by a high urban death rate that keeps the urban population from growing rapidly (Bogin, 1988; Weber, 1967).

The base of urban population is large and increasing, and the average annual increment in numbers of persons is steadily becoming larger. From 1990 to 1995, 59 million new urban dwellers were added to the world's population. Of these, 98 per cent were in less developed countries. These changes occurred during a period with a relatively low rate of urban population growth. Thus, the greatest growth of urban centers will occur in the less economically developed countries, the very ones that anthropologists often study. By 2030, the less developed countries will contain 80 per cent of the world's urban population (Department of Economic and Social Affairs 2000).

The question that confronts anthropologists, urban planners, geographers and policy makers is whether we are biologically and socially equipped to survive and prosper in the new urban world. The remainder of this essay describes some of the challenges of modern urbanism to human biology, focusing on pollution.

Pollution

Pollution has been defined as material or energy that is thought to be detrimental for life, especially human life. It exists in a variety of forms. The most commonly used categorization has two main classes: forms of energy (for example, noise and radiation), and materials. Of the materials there are metals (for example, lead, mercury and cadmium) and organic compounds. The organic compound sub-class includes both purpose-made industrial chemicals such as polychlorinated biphenyls, herbicides, pesticides (for example, DDT), and unintended productions such as dioxin. The material pollutants enter the air and the food chain and ultimately are absorbed by us.

There are numerous ways to assess the effects of pollution on biological systems. A classic approach is from toxicology. Toxicity can be judged by difficulties in reproduction, substandard growth of immature organisms, weight loss among the already mature,

morbidity and premature mortality. In this essay the focus is on subadults, particularly their growth and development. Of special importance is the development of the reproductive system as this is crucial for the survival of the species. Materials that can disrupt development and sexual performance through altering the function of the endocrine system are termed endocrine disruptors.

Pollution: Metals

The most intensely studied metal is lead. Like many metals, the level of lead in the environment has increased substantially since the industrial revolution (Patterson et al., 1991). Most recent exposure to lead has been through the use of lead as an additive to gasoline and in paint in some countries. With the removal of lead from these two products, lead levels appear to be falling. However, the effects of lead are substantial, even at levels that were once thought to be inconsequential.

Lead has no positive role in normal human physiology. Its neurotoxicity is well established. Very high lead levels in the blood can cause death, and high levels cause encephalopathy. Much lower levels slow nerve conduction and affect intelligence. The level of lead in a child is related to the child's performance on IQ tests and other measures of intelligence and development such as success in school. The lead level of a pregnant woman is related to the cognitive performance of her child. Recently studies have shown that even very low levels of lead (well below 10 micrograms per deciliter) are injurious to a child's nervous system and are associated with lower IQ (Canfield et al., 2003).

Lead also affects growth and reproduction. Higher levels of lead are associated with less growth in infants (Schell et al., 2009a) and older children as well (Ignasiak et al., 2006; Little et al., 2009). The deficit is usually not large but because of the widespread exposure to lead, the effect itself is large when summed across all children exposed. Lead slows the development of sexual maturation. In studies of the US population lead was associated with later age at menarche (Selevan et al., 2003; Wu et al., 2003). In one study of a Native American population, lead levels that were twice the sample mean were associated with a delay of about 6 months (Denham et al., 2005).

Lead is also known to affect prenatal development. Many studies from many different countries have shown reduced birth weight in relation to relatively low levels of lead in the mother but not all studies have reported such a relationship (Andrews et al., 1994; Srivastava et al., 2001; Odland et al., 1999; Uryu et al., 2004; Bellinger, 2005; Zhu et al., 2010). Lead also is known to reduce gestation length (Falcon et al., 2003; Jelliffe-Pawlowski et al., 2006). In ancient times it was sometimes used in high doses as an abortifacient.

Lead also can have a direct effect on reproduction (Schell, 2010). Lead is related to male fertility, particularly sperm quality or function. This has been established through studies of humans and using rodent models. High levels of lead that can be found among workers in some industries can affect sperm quality (Lancranjan et al., 1975). Sperm count and concentration of workers at a lead-zinc smelter were significantly related to the concentration of blood lead especially (Alexander et al., 1996).

To understand the effects of lower levels of lead that characterize much of the modern urban population, it has been useful to study couples seeking childbearing who are using assisted reproductive technologies, most commonly in-vitro fertilization (IVF). One study found that in such couples, seminal plasma lead levels were related to decreased human sperm function (Benoff et al., 2003b; Benoff et al., 2003a) and decreased success with IVF. These results agree closely with findings from studies of laboratory animals (as reviewed in Benoff et al., 2003b; Benoff et al., 2003a). Another study found that pregnancy status of couples using IVF was related to lead levels in follicular fluid (Silberstein et al., 2006).

In conclusion, exposure to lead during prenatal or postnatal life has several negative effects on human biology. Most exposures today are low and chronic and the size of each of these effects is not large. However, when you consider how widespread is the exposure to lead, then the effect is large. Other heavy metals with no known benefit to human functioning, such as mercury and cadmium, also have negative effects on human development but other possible effects of exposure have not been studied comprehensively.

Pollution: Organic materials

This category contains a large variety of materials. Among those that have received attention and concern are the phenols (especially bisphenol-A), phthalates, halogenated biphenyls (particularly polychlorinated biphenyl), DDT (dichlorodiphenyltrichloroethane), dioxins and dibenzofurans. A comprehensive review of effects from all these materials is not possible due to the number of studies and the diversity of exposures and effects. An important realization from reviewing many studies of these materials is that effects on human health and growth vary considerably. Furthermore, although students of human growth expect growth will be inhibited or reduced by exposure to detrimental influences such as pollution generally, some of these materials can exert stimulating effects on growth and development (Schell, Gallo, & Burnitz, in press). Both stimulation and inhibition can be considered a deviation from the normal pattern of development.

Among the most studied of these materials are polychlorinated biphenyls (PCBs). These were manufactured for use in a variety of contexts where heat stability and resistance to weathering was valued. Manufacture and use is now prohibited in the US and most other countries. PCBs can reduce performance on cognitive tests and reduce physical growth, depending on the dose and time of exposure (Schell, 1999). Inasmuch as all exposures to children and pregnant women are accidental, the level of exposure must be reconstructed in any study of health effects. Therefore, exposure assessment is usually imprecise but functional. Studies of Japanese children exposed to rice oil contaminated accidentally with PCBs showed reduced physical growth (Fujisawa & Fujiwara, 1972). A later episode in Taiwan of food oil contamination with dibenzofurans and PCBs affected children while in utero, who showed negative effects on cognitive performance as well as on physical development (Guo et al., 1994a; Guo et al., 1994b; Guo et al., 1995b). Other studies of chronic low exposures also showed negative effects on cognitive performance, and for some tests the effect was primarily in boys (Guo et al., 1995a). Finally, PCBs levels in humans are related to sexual development and endocrine levels (Denham et al., 2005; Goncharov et al., 2009). Close cousins of PCBs are the polybrominated biphenyls (PBBs), and effects of

PBBs on the sexual maturation of girls are very similar to effects of PCBs (Blanck et al., 2002). Effects of other toxicants on growth have been described (Schell et al., 2009b)

Pollutants: Others

Recently there have been several publications suggesting that human sexual development, function and behavior may be altered by exposure to organic materials in addition to PCBs and PBBs. Dichlorodiphenyldichloroethylene, *p*, *p'*-DDE (the metabolite of DDT) is known to affect reproduction in birds (Carson & Darling, 1962). Now there is evidence that it can affect sexual maturation in humans. Several studies report that boys' and girls' sexual maturation is altered in relation to indicators of exposure to DDT or its metabolite (Den Hond et al., 2002; Pflieger-Bruss et al., 2004; Mol et al., 2002); (Cao et al., 2008; Denham et al., 2005; Gladen et al., 2000; Su et al., 2012; Ouyang et al., 2005; Ozen et al., 2012; Vasiliu et al., 2004).

Phthalates are used in plastics to soften their structure and improve flexibility and human exposure is common. In one study, exposure to phthalates was associated with the newborn's ano-genital distance corrected for body weight. Ano-genital distance is often used in rodent studies of sexual dimorphism and is sexually dimorphic in humans (Sharpe, 2001). Shorter ano-genital distance is characteristic of females. In boys with higher levels of phthalates, their ano-genital distance was decreased (more feminine) compared to boys who were less exposed (Swan et al., 2005).

These are but a few examples of the kinds of effects that some researchers are finding and have been reviewed elsewhere (Schell, 2010; Hatch et al., 2012)

Pollutants: Conclusion

Pollutants exist in myriad forms and may produce a bewildering variety of effects. Many operate through altering the endocrine system. These are the so-called endocrine disruptors. Because they operate by altering the endocrine system, there are multiple effects including alterations of reproduction, immune function, growth, maturation, and the development of the central nervous system.

The Role of Culture

For many years modern social philosophers and anthropologists envisioned culture as the primary means of human adaptation to the environment. The position taken in this essay is fundamentally different. This position is based on a clear causal chain. Human biology is changed by pollution, and much pollution is caused by human activity and human activity is directed by culture. Thus, culture itself is the stressor of modern life. Unquestionably humans adapt to many environmental challenges through culture, but culture also creates the forces that challenge us biologically and change us.

Conclusion

The expression 'Man makes himself' is most dramatically expressed in the effects of pollution on human biology and health. But pollution is just one aspect of urbanization and

there are many other aspects to consider such as infectious disease transmission, energy balance (nutrition and energy expenditure) and social hierarchies that focus risks to health, to happiness on the poor while sparing the wealthy of those same risks. Urbanization has been the predominant social change for the past 10,000 years of human existence and this essay has argued that it has changed who we are from our cells to our society.

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