In the Beni region—the lowlands—of Bolivia, the Tsimane people still live by traditional means, employing hunting, fishing, and modest horticultural gardens to obtain their food. A rare example of a traditional subsistence population, they have lean bodies that endure high rates of disease, tough workloads, and little modern medical care. Because of these factors, Hillard Kaplan, SFI External Faculty member and professor of anthropology at the University of New Mexico, believes the Tsimane will provide a window into understanding the process of aging. For three years, Kaplan has been researching this population alongside Michael Gurven of the University of California at Santa Barbara and graduate student Jeff Winking, University of New Mexico.

Most of what we know about the aging process comes from studying modern populations. However, such studies provide an incomplete picture because they leave out a vast majority of humans’ evolutionary history. By studying a traditional society, a group about which very little is known in regards to aging and the epidemiology of disease, Kaplan hopes to contribute to a debate on the human life span that ultimately seeks to answer the questions: what causes humans to age and die and how long can people live?

It is almost certain that at least some of the processes leading to aging among traditional subsistence peoples differ from those afflicting people in modern developed nations. In developed nations, humans experience very different diets, activity regimes, and physical assaults on their bodies.
Modern hunter-gatherers are not living replicas of our stone age past, having been affected by global socioeconomic and epidemiological forces. Nevertheless, studying them can provide an important, if imperfect, lens on the life histories of our ancestors and the conditions that shaped the biology of human development and aging. Such research is urgent, because global change is proceeding rapidly, and virtually all human populations will soon be incorporated into global economic and health systems.

The next decade will probably be the last during which such research will be possible. Although the Tsimane were exposed to Jesuit missionaries in the late 17th century, they were never successfully settled into missions and remain relatively unacculturated. The Tsimane are thus an ideal population for a study of the aging process among traditional forager-horticulturalists.

By linking medical information with more traditional studies of cultural norms, diet, hygiene, work effort, activity, mobility, housing, and social networks, Kaplan and his research team hope to gain a more complete cultural epidemiological understanding of health and disease among the Tsimane. A long-term goal of the research is to explain the age profile of human mortality and the rate at which humans develop and age in terms of economic productivity, muscular strength, endurance, body composition, disease resistance, and cognitive function.

Caring Parents

Also working with Kaplan on this SFI project are economist Arthur Robson of Simon Fraser University and Ronald Lee, director of the Center on the Economics and Demography of Aging at University of California, Berkeley. Both Robson and Lee have independently proposed new theories of aging with a common point of departure: classical biological theories of aging are inadequate for species such as humans, which engage in extensive and prolonged parental care.

According to the new theories, resource transfers from parent to offspring are critical to understanding the role of natural selection in determining mortality rates. One goal of the project is to further develop these theories and to work through the shared and unshared features of the two approaches.

The starting point for the new theories on the human life course is the observation that successful reproduction is not mainly a matter of producing offspring, but rather is a matter of acquiring food and allocating it to offspring so as to maximize the number of surviving, sexually mature adults. This perspective places the acquisition and distribution of food at the center of reproductive fitness, rather than fertility. Humans have long childhoods, compared to other species, and may be dependent on parents for as long as two decades. From an evolutionary point of view, it makes no sense for people to be able to reproduce up until their mid-40s if they cannot survive long enough for their children to become self-sufficient. Natural selection seems to have favored long childhoods in humans, and previous theories of aging didn’t take this into account.

A second component of the Santa Fe Institute project is to organize a theoretical working group of biologists, demographers, economists, and anthropologists to exchange ideas and promote further development in the theory of the life course. The third component is to assemble another working group of empirical scientists interested in aging research in both developed and less developed contexts, with the goal of stimulating more comparative research.

In addition to informal working group meetings, two workshops will be organized, one focusing on theoretical results and the other on empirical applications.

How We Grow Old—Contrasting Views

Life expectancy in developed countries has increased dramatically in the past 100 years. Medical advances have led to a reduction of infant and childhood mortality rates and helped people live longer. These increases have reopened the debate on the potential length of the human life span, but there are differing views on how aging occurs.

According to one view, the human lifespan is like a ticking clock (time bomb?) with an upper limit of about 85 to 86 years. Improved medical care and public health have allowed people to live longer and caused the distribution of deaths to become increasingly compressed in the upper-age range. This ticking clock view, characterized as the gerontological view, treats the various outcomes of aging as resulting from...
a single, unitary process, resulting in programmed death.

But, according to an alternative view, there is no set upper limit to the human lifespan, and improvements in medical treatment and living conditions will continue to produce increases in longevity. This view, called the epidemiological view, treats aging as resulting from a competing set of risks due to independent or quasi-independent processes. According to this view, there is no ticking time bomb that results in death, and as advances in medical care succeed in preventing or curing diseases, the causes of aging and death can individually be eliminated.

**Genetic Factors Matter**

Although there have been dramatic gains in the survival rates of older people in the United States over the last several decades, the potential for improvements remains an open question, because our knowledge about the interaction of biology, behavior, and environmental conditions in determining the aging process is still limited. There is, however, growing evidence that the aging process is strongly influenced by biological control mechanisms, and that genetic variation among humans and nonhumans is associated with differences in rates of aging. This means that between species, and within the human species, there are genetic differences that code for different rates of aging: genes regulate cellular processes that lead to different rates of cellular, and ultimately whole-organism aging. But the interrelation between genes, genetic expression, and the environment is not completely understood. Progress in mapping the human genome is likely to lead to major advances in our understanding of the genetic substrate governing the aging process.

There is also strong evidence, however, that genetic control mechanisms do not necessarily lead to a fixed pattern of aging. For example, environmental factors, such as restricted dietary intake in many mammals, is associated with a series of physiological adjustments, including lower growth rates, delayed age at first reproduction, and shortened life span. Human life histories show evidence of systematic variation in response to environmental variation. These outcomes appear to be the result of the interaction between changes in environmental conditions and genes affecting human physiology and behavior.

**Diet and Inflammation Count Too**

Standard epidemiological theory suggests that chronic diseases, such as heart disease and cancer, have increased in relative frequency, due to reductions in mortality resulting from infectious disease. Fewer people die from infectious disease, so the relative rate of chronic disease such as heart disease and cancer has increased. Changes in diet and exercise in developed societies may also play a role. Yet it also has been argued that aging and the onset of chronic disease may be accelerated in response to poorer nutrition and increased disease loads.

Two University of Southern California researchers who have been collaborating with the team recently proposed that major decreases in mortality at the older ages are due to a reduction in the level of inflammation experienced over a lifetime. The human body’s reaction to bacteria, viruses, and parasites is to engulf the agent, causing inflammation. These researchers believe that chronic exposure to such physical assaults has negative secondary effects and may cause the body to age more rapidly. Defense and repair is costly to the body. With the introduction of antibiotics and public water systems, exposure to foreign agents, and hence, the body’s inflammation, has decreased.

Kaplan’s research project is collecting data on diet, weight and growth, biomarkers of inflammatory processes, viral, bacterial, and parasitic infection rates, and aging among the Tsimane to help evaluate the different theories of aging that have been proposed. In addi-
tion to these scientific goals, Kaplan’s research is contributing to student training and the participation of traditionally under-represented groups in research. Both Bolivian and U.S. graduate and undergraduate students have participated in data collection and will continue to do so in the future. The research also involves the community members themselves in data collection, and trains Tsimane in primary health care.

Most of the theories of aging have been based on analyses of historical populations in societies with a central government, such as historical Europe. By working with the Tsimane, Kaplan and his team will be able to, in a sense, travel back in time and thereby bring new insight to the future.

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