Metabolic Challenges of the Modern World:
Evolution and Human Nutritional Health.

William R. Leonard
Department of Anthropology
Northwestern University

Over the last 25 years, evolutionary approaches to study of human health and nutrition have received ever-greater attention among researchers in number of fields, including anthropology, nutritional science, and exercise science. We now understand that many of the key features that distinguish humans from other primates (e.g., our bipedal form of locomotion, and large brain sizes) have important implications for our distinctive nutritional needs. In addition, an evolutionary perspective is also useful for understanding the origins of and potential solutions to the growing problems of obesity and associated metabolic disorders.

In a very real sense, the story of human evolution is one of food, energy, and nutrition. A hallmark of human evolution has been our ability to increase the *efficiency* with which we extract food from our environments. Throughout most of our past, human lifestyles were characterized by high levels of physical activity and frequent periods of marginal or negative energy balance. These conditions selected for improvements in the energetic efficiency of human foraging strategies. Today, human populations of the industrialized world live in *obesogenic* environments with low levels of energy expenditure and abundant food supplies contributing to strongly positive energy balances and growing rates of obesity and chronic, metabolic disorders.

When we look at the evolutionary history of the hominid lineage, it appears that many of the key distinguishing features of human nutritional ecology arise with the emergence and early evolution of the genus *Homo*. This phase of human evolution was associated with major changes in brain size, body size, diet composition and foraging behavior --- that have had profound influences on shaping the nutritional and energy demands of the human species. The changes that occurred at this stage of human evolution appear to have established two of the prime drivers of human energy and nutritional needs that persist through time: (1) the need for a high quality (energy and nutrient dense) diet to fuel high energy costs of our large brains, and (2) in turn, to acquire that nutritional dense diet, the development of foraging strategies that required movement over wide areas, promoting large activity budgets.

Comparative Nutrition & Metabolism in Humans and other Primates.

Human nutritional needs are strongly shaped by extraordinary metabolic costs of our large brains. Per unit weight, the energy demands of the brain are *16 times greater than those of muscle tissue*. Yet, despite the fact that humans have much larger brains per body weight than other primates or terrestrial mammals, the total energy (caloric) demands for the human body are no more than for any other mammal of the same size. The implication of this paradox is that humans allocate a much larger share of our daily energy budget for brain metabolism than other species. Adult humans expend about 20-25% of resting metabolic rate (RMR) on brain metabolism, as compared to ~8-10% in other primate species, and 3-5% for non-primate mammals.

To support the high energy cost of our large brains, humans consume diets that are more dense in energy and nutrients than other primates of our size. Compared to other large apes, humans (both subsistence-level and industrialized populations) derive a much greater share of their diet from energy-rich fat. In contrast, apes consume diets that are composed largely of low quality plant foods, high in structural carbohydrates. Across all primate species, larger brains require higher quality diets. Humans fall at the positive extremes for both parameters, having the largest relative brain size and the highest quality diet.

To acquire energy-rich diets, traditional human foragers move farther and are more active than other ape species. Human foragers have much larger daily ranges (i.e., miles moved/day) and home ranges (i.e., total territory needs) than other primate species. In addition, recent studies also show that humans have higher activity and energy expenditure levels than chimps or orangs.

Thus, from a comparative perspective, the two of the key distinguishing features of human nutritional biology are (1) a high quality, energetically dense diet to support our large brains, and (2) a foraging strategy that necessitated large ranges and high activity budgets. The first evidence of these trends in the human evolution appear with the emergence of the genus *Homo,* and continue to shape our nutritional requirements today.

Obesity, Diet and Activity in the Modern World.

Since the emergence of the genus *Homo* and the initial spread of hominids out of Africa, humans have successfully colonized almost every major ecosystem on the planet. Our ancestors' ability to exploit diverse environments and colonize the globe was largely dependent on developing strategies for increasing the energy returns from subsistence activities, and raising the nutritional quality of staple food items.

Over our evolutionary history, we have been quite successful in developing strategies for meeting our nutritional needs; however, when we look at our modern industrialized societies, it appears that our nutritional strategies have become *too* successful. That is, we have become so efficient in obtaining energy with minimal time and effort that we have created ever-larger positive energy balances.

Comparative data on body size and composition from around the world highlight the fact that rates of overweight, obesity and other metabolic health problems (e.g. diabetes, high blood pressure) are much higher in industrialized world populations than they are in traditional, subsistence-level populations (foragers, farmers, herders). In addition, over the last 50 years, rates of obesity in the US have more than doubled in women and tripled in men. It is widely assumed that both of these phenomena are almost entirely due to much greater food energy intakes. However, the available evidence indicates that changes in activity patterns and energy expenditure are equally or more important than dietary changes in explaining both the US and global increases in obesity rates.

Studies of activity and metabolism in industrialized populations and 'traditional' subsistence populations suggest that levels of daily energy expenditure were much higher in the past. Compared to modern, industrialized societies, daily energy expenditure levels for a subsistence lifestyle are 400-450 kcal/day higher in men and 200-250 kcal/day higher in women (after adjusting for body weight). While these are substantial differences in energy demands, it is also clear that subsistence-level societies achieve these robust levels of daily energy expenditure through sustained *modest* increases in metabolic intensity over large portions of the day, rather than very high intensity work outputs in short bouts. This observation has direct implications for our urban societies because it supports a "slow and steady" approach to promoting healthier lifestyles with greater activity. That is, you don't have to be exercising at near maximal capacity to gain the benefits of greater daily activity. Indeed, current recommendations on daily activity have the potential to raise daily expenditure values surprisingly close to those of subsistence-world populations.

Relevance of Evolutionary Approaches to Human Nutritional Health

Overall, an evolutionary perspective provides important insights into the origin and nature of human chronic health problems. It also provides a framework for both evaluating the ways in which our distinctive energy and nutritional demands are "at odds" with dimensions of our modern world, and formulating changes that specifically address those 'imbalances'.

Our disproportionately large brain necessitates that the quality and nutritional density of our foods be higher than those of our primate kin. Throughout most of our evolutionary history, the acquisition of our high quality diets required substantial expenditure of energy and movement over large areas. Over time, our species has become ever more efficient at extracting energy and nutrients from our environments. In this context, the problems of "over-nutrition" currently seen this country and around world are deeply rooted in trends from our evolutionary past. They are problems that require attention to both the intake and expenditure sides of the energy balance equation.