ANCIENT BODIES, MODERN LIVES

HOW EVOLUTION HAS SHAPED WOMEN'S HEALTH

WENDA TREVATHAN

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Writing a book like this requires a number of key ingredients. One is the body of sophisticated and exciting research on reproductive biology and health from which I have drawn extensively. A quick glance at the list of references cited provides a good compilation of the work that I believe has the most to offer as we try to understand challenges to women's health that we are facing and will continue to face as global resources constrict, population expands, and more and more people strive for the lifestyles of the "health-rich" nations. I want to particularly call attention to some of the scholars whose work I cite frequently and in almost every chapter. They include Virginia Vitzthum, Carol Worthman, Jim McKenna, Gillian Bentley, Barry Bogin, Jim Chisholm, Kathryn Dettwyler, Boyd Eaton, Peter Ellison, Paul Ewald, Dean Falk, Tuck Finch, Helen Fisher, Helen Ball, Kristen Hawkes, Sarah Hrdy, Chris Kuzawa, Jane Lancaster, Lynette Leidy Sievert, Thom McDade, Randy Nesse, Catherine Panter-Brick, Tessa Pollard, Karen Rosenberg, Dan Sellen, Meredith Small, Stephen Stearns, Beverly Strassman, David Tracer, Pat Whitten, and Andrea Wiley. In addition to this being a group of exceptional scholars, I am immensely pleased to say that they are my friends. And as most authors have said, the good stuff in this book is theirs; the mistakes in interpreting their work are mine.

Another important requirement for writing a book is time. Ask any academic (perhaps any professional from any field) what commodity they desire the most and virtually all will answer "time." The information was there in the publications of my colleagues, the ideas were in my head, the benefits of what I wanted to say seemed clear, and the potential audience appeared receptive. What I didn't have was the time to write it all down. For that, I thank the School for Advanced Research (SAR) in Santa Fe, New Mexico. When I received their invitation to spend nine months as a resident scholar on their beautiful campus, I knew that I finally had the opportunity to complete a book that had been spinning around in my mind and in my classrooms for a decade or more. The peace and quiet, the intellectual stimulation from fellow resident scholars and staff, and the beauty of northern New Mexico came together to create the perfect opportunity for reading, writing, and reflection. It is difficult to find the words to express my appreciation to SAR and all who support it for my time there.

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Introduction: What Does Evolution Have to Do with Women's Health?

We may live in both the best of times and the worst of times, although I'm sure that Charles Dickens would beg to differ. For those of us who have the fortune to live in health-rich nations like the United States, Canada, Japan, and those of Western Europe, we enjoy a level of health that was unimaginable when Dickens was writing. "Seventy is the new fifty" and not only are we living longer, we are doing so in a state of fairly good health. But for people in health-poor nations, the scenes that Dickens described of London and Paris in the 18th century would be all too familiar. Globalization, which seems to improve standards of living for some people, has had profoundly negative effects in many parts of the world. Political and social scientists tackle some of the big issues that arise from increasing health and economic inequality, and even in the health-rich nations we know we can do better to improve overall health and quality of life.

Scientists who study *evolutionary medicine* attempt to determine, by better understanding evolutionary processes, how some of the health problems we face today arose. This approach will not solve all of our entrenched and deep-rooted health challenges, but it does offer a new, more holistic way of viewing individual and population health from both research and practice standpoints. In this book I hope to describe this approach with regard to the health of women.

One common refrain of evolutionary medicine is that our biological selves are not well matched with our contemporary lives, and the result of this "discordance" is poor health, especially with regard to chronic and degenerative diseases and disorders such as type 2 diabetes, cardiovascular disease, cancers, and hypertension.[1] If we could return to the lifestyles of the Stone Age, the argument runs, we would quickly become healthier. Certainly there are practices from earlier times that would probably improve our health, most notably dietary and exercise modifications, but with more than 6 billion people on the planet, the reality of "returning" to prehistoric ways of living is out of reach for the vast majority of us. Furthermore, one of the most obvious mismatches between our evolved bodies and today's environments results from newly created biochemicals that are in our foods, water, clothing, furniture, and the air we breathe and for which our bodies have not evolved adaptations.[2] There is not much of an evolutionary take on this except to state the obvious (that is, all of these chemicals are products of modern technology), and there is little chance that we will be able to return to the Stone Age as regards several decades of "better living through chemistry."

In my mind, the best that evolutionary medicine can offer is new ways of thinking about old diseases and disorders, particularly those for which medical research has been unable to find a cure or other highly successful treatments. Evolutionary medicine offers a broader and more inclusive approach to medicine and health and urges us to ask new questions about both the immediate and developmental causes and explanations of poor health. Most medical research is highly specialized and focuses on fairly narrow windows into diseases and disorders. This is understandable and necessary because of the continuing expansion of knowledge about disease processes at the molecular, cellular, and organ system levels. Social and behavioral scientists urge concern for behavior, psychology, and the sociopolitical environments when considering not only causes of diseases but treatments as well. Evolutionary medicine steps back further and takes into consideration the entire species and its evolutionary history.

So what does evolution have to do with women's health?

Plain and simple, evolution is about reproduction. And since so much of what women are biologically is about reproduction, almost every book dealing with biology and evolution and women will focus on reproduction—this one is no exception. Whether we reproduce or not, our evolutionary history and our current biology were shaped by natural selection operating to increase reproductive success. This means that almost anything we have to say about women's health from an evolutionary perspective will involve reproduction in one way or another. On the other hand, reproduction and virtually every other aspect of human life take place in dense social and cultural contexts that also shape and define them. For example, *menarche* is not just the first instance of menstruation; in most cultures of the world, it comes with new social roles and status for girls who from that point on may be eligible for marriage, be required to adopt new clothing or hair styles, or be seen as women rather than girls. If we talk only about the biological aspects of menarche, we will lose track of what it means to be human. This is no less true for other aspects of reproduction and women's biology.

As noted, one of the common approaches of evolutionary medicine argues that contemporary health problems to some extent result from a mismatch between our evolved bodies and our present lifestyles (culture).[3] What is usually meant by "evolved bodies" is the physical human form that resulted from millions of years of evolutionary processes at work on our ancestors from the origin of the primate order (approximately 60 million years ago) to the origin of food production (agriculture) approximately 10,000 years ago. This is not to imply that evolutionary processes stopped 10,000 years ago, but it does highlight the extraordinarily short time during which the pace of cultural evolution has far outstripped the pace of biological evolution. In this view, 10,000 years ago, a mere blip in the time span of evolution, marked the beginning of a veritable explosion of culture and technology.

For most of the span of human existence, individuals were born into and lived their lives in pretty much the same environment. Furthermore, they experienced life in environments not very different from those of their recent ancestors. Thus, it was not necessary for them to respond to significant environmental changes within one or several lifetimes. Today, however, with mass migrations, major environmental challenges, and unavoidable sociopolitical changes occurring within single lifetimes, many humans are stressed to their limits (and often beyond) to adapt physically, emotionally, and materially, and to do so in ways that often result in considerable challenges to health, especially reproductive health. Not only are we facing a "third epidemiological transition" with the reemergence of infectious disease[4] but we are also facing an epidemiological *collision* as the health challenges of the past (high infant mortality, malnutrition, infectious disease) meet those of the present (obesity, cardiovascular diseases, cancer) in ways that will severely test our abilities to respond.

In fact, even though our ancestors may not have had to face major environmental changes in their lifetimes, natural selection has favored in the human species a level of adaptability (also known as *plasticity*) that is unusual in the mammalian world. For example, although we are *omnivores* (that is, we can eat all kinds of things and lack a specialized digestive system), we can also adapt to diets very high in animal foods (such as a traditional Arctic Inuit diet) or become exclusively vegetarian, depending on habitat and habits. Of course, there are limits to our adaptability as would be quickly seen for someone whose chosen or imposed diet excluded essential nutrients like ascorbic acid (vitamin C) or vitamin B-12. Perhaps few aspects of human life have changed as much as diet, and few aspects have as great an impact on health as diet. And as we will see, reproduction has a lot to do with food.

Throughout this book I will talk about "our ancestors" or "ancestral humans." As noted earlier, the context of human lives changed considerably with the beginnings of food production (agriculture and animal domestication) less than 10,000 years ago. Human reproductive biology was shaped during the long period from the origin of the human lineage about 5 to 7 million years ago until the present, but almost all the time during which natural selection operated on reproduction occurred before the advent of agriculture. This period is often referred to as the environment of evolutionary adaptation or EEA, and when we discuss the concept of mismatched bodies and lives, we usually mean the body that was shaped during that period. When I discuss ancestral humans in this book I usually refer to those who lived in that bulk of evolutionary history. Unfortunately, most reproductive variables and behaviors do not leave their marks in the fossil record, so I and others working in the area of evolutionary medicine must rely on studies of living nonhuman primates and human populations who lead existences that we think resemble somewhat those of our ancestors.

For example, studies of our closest living relatives—chimpanzees, gorillas, and orangutans—reveal that females in captivity reach puberty earlier, give birth first at younger ages, and have lower birth intervals than those in the wild.[5] In most cases, captive great apes have more reliable and more abundant food and they are less active, mirroring in some ways the changes that occurred when humans began producing their own food and living in settled communities. (Perhaps it can be said that captive apes and food-producing humans have become "domesticated," and that they experienced changes in reproductive biology similar to those experienced by other domesticated animals.) Thus, to the extent that there are similarities in the reproductive physiology of apes and humans, comparative research on wild and captive populations can provide insights into ancestral human biology and behavior and the changes that occurred with domestication.

Of course, chimpanzees and gorillas are not ancestral humans. Neither are the foraging populations of Africa and South America that have often been used as "proxies" for our ancestors because their ways of living are presumably somewhat like those of our ancestors, at least in comparison to the lives of 21st-century men and women in industrialized nations. But these are only rough proxies and much of the discussion of "ancestral bodies" must remain at the level of conjecture, albeit conjecture based on pretty good reasoning.

Often when one uses the term *conjecture* to refer to an idea, it has a derogatory connotation that suggests that the idea is just somebody's wild, unfounded notion. For those of us who provide evolutionary explanations, however, it is an admission that we can never know for certain that we are right, we can never "prove" anything about human thought and behavior that occurred far in the past. (Actually, proof is never a goal of science; support or refutation of a hypothesis is the most one can strive for because the scientific method requires that every explanation be open to rejection with new data or new interpretations of existing data.) But that does not mean that we are not good scientists. As with any scientific explanation, we put forth a possible scenario and it stands or falls based on how well it explains what it proposes to explain. New fossil evidence, new observations about nonhuman primates, new data based on comparative DNA analysis, even new "wild ideas" can alter or outright reject any scenario. This is how science works and how knowledge proceeds, including aspects of science that explore ancestral biology and behaviors.

As I describe some of the proposals about ancestral humans throughout the book, I often present the ones that make the most sense to me or seem to have more "explanatory power." In some cases I provide several alternative views, but in others, one explanation may seem so strong to me that I focus almost exclusively on that one. Readers should keep in mind, however, that there are almost always several ways of viewing a given phenomenon and if I were to write a second edition of this book in a few years, chances are good that some of the explanations would need to be altered significantly because of new information.

Evolutionary Medicine

Defined simply, evolutionary or Darwinian medicine is the application of principles of evolutionary theory to human health and disease (and, we hope, to medical practice and research). Although most recent discussions of the field trace its origin to works in the 1990s by evolutionary biologists Randy Nesse and George Williams,[6] the usefulness of an evolutionary lens for viewing human health has been recognized for at least a hundred years.[7] Unfortunately, that does not mean that an evolutionary perspective is currently being embraced by medical practice, which would be a key measure of its usefulness.[8] Nesse and Stephen Stearns, another evolutionary biologist,[9] cite a number of reasons that evolutionary theory is not incorporated into medical research and practice, including the scarcity of evolutionary biologists on medical school faculties, the very little exposure that medical students get to evolutionary thinking, and the fact that many medical students (in the United States, at least) do not accept evolution as the basis of biological sciences. Given the complexity and burden of the current medical curriculum, it is unlikely that courses in evolutionary medicine will be added any time soon. This is unfortunate, because it actually might lighten their burden if students were armed with understanding of theories rather than the endless details that are deemed necessary to pass medical boards. As Nesse and Stearns note, evolutionary biology "can help make medical education more coherent by giving students a framework for organizing the required 10,000 facts."[10]

Another point at which medicine and evolutionary biology are sometimes at odds is in their views of the body. A common metaphor found in medicine is that the body is a machine designed for certain functions and when things go wrong, it can be treated in much the same way that an auto mechanic treats a poorly functioning car. Add a little oil here, tighten the belts, clean the carburetor, replace the spark plugs, adjust the tire pressure, or remove the possum from the engine compartment. The machine was designed by an engineer using blueprints that can be consulted when making the repairs. The human body, however, is a bundle of "compromises shaped by natural selection in small increments to maximize reproduction, not health."[11] This leaves us vulnerable to lots of diseases and disorders, but it also makes us amazingly resilient. Nesse and Stearns suggest that if medicine would give up the idea that the body is a machine, physicians would find it easier to place the discipline on firmer biological foundations. Evolutionary medicine attempts to move medical research and practice in that direction.[12]

For example, an evolutionary view of infectious disease can add a great deal to our understanding of newly emerging diseases and may enable epidemiologists to predict where an outbreak will occur and how it will progress.[13] The evolutionary view warns us that trying to treat bacterial infections with ever more powerful antibiotics will ultimately backfire as the bacteria evolve resistance to our medical interventions. It may also help us deal with major health crises of our time such as the human immunodeficiency virus (HIV) by figuring out a way for evolution to work *for* us in directing the course of microbial evolution from greater to less virulence, rather than the usual arms race we employ that results in greater and greater virulence.[14] We may be able to develop successful vaccines against a number of diseases if we have a clear picture of how they have evolved. Because both clinical medicine and evolutionary medicine have as their goals the control of diseases and the minimization of misery, the evolutionary perspective has hope of slowly becoming part of research and practice. The money, time, and cost of mistakes makes attempting to completely eradicate a disease a poor use of resources and one that will likely fail. Leading pathogens to a state of benign coexistence through evolutionary mechanisms would be a better use of resources and intellectual talents and would promise much greater success. This means we would have a nice barnyard of domesticated critters rather than a forest of dangerous ones with the potential to kill.

As in many other modern health movements, consumers are often the engine that drives change by requesting that their physicians consider, for example, gender, inequality, or lifestyles in their treatments and health recommendations. Feminist writing and persuasion introduced into medicine new ways of viewing childbirth, reproductive technologies, human subjects in medical research, and reproductive cancers.[15] The language used in medical discourse has undergone change (perhaps not enough) in the past few decades because of feminist critiques.[16] Anthropology has attempted to make medicine aware of the great amount of variability that exists in the human species, including variability in "normal health."[17] Perhaps among the readers of this book will be health consumers who make possible an expansion of the medical view to include evolutionary as well as sociocultural factors in treatments and recommendations. As noted, scholars writing in the field have so far had limited success with facilitating acceptance of evolutionary principles in medicine.

Evolutionary Theory

A number of fundamental concepts from evolutionary theory underlie much of the work in the field of evolutionary medicine and are discussed throughout this book. I assume that most readers have a general understanding of how the evolutionary process works: natural selection operates on traits, behaviors, and characteristics that promote health, survival, and, most important, reproductive success, in a given environmental context—and against those that compromise health and reproductive success. In order for any characteristic to have an evolutionary basis, it must have some underlying genetic basis, it must vary, and it must be heritable. This last requirement is where reproduction comes in. The only thing that "counts" as far as the process of evolution is concerned is whether or not a trait is passed on to succeeding generations, and the only measure of evolutionary success is reproductive success (also known as *fitness*). For instance, if a woman has a genotype that results in sterility, she will not pass that trait along to her direct descendents (because she will not have any), so the trait will not evolve. In the language of evolution, the trait has a negative effect on fitness and will not persist. On the other hand, a trait that enhances reproductive success will have a positive effect on fitness and will be passed down through generations. But, as we will see, whether a trait is positive or negative for reproductive success depends almost entirely on context.

Evolution has often been described as a “selfish” process. According to this view, individuals (actually, individual genes) will do almost anything to get their genes into the next generation. The result is intense competition between individuals to get ahead in the evolutionary race. The individual whose genes are represented in the greatest numbers several generations down the line is, at least for a time, the “winner.” To get those genes into succeeding generations, individuals have *reproductive strategies* to find the best mate (known as *mating effort*), provide the best care of offspring (*parental effort*), and help others with shared genes do the same (*kin selection* or *inclusive fitness*). The strategies lead to allocation of time, energy, and other resources toward the goal of increased reproductive success. Many of the terms used to describe behaviors related to reproduction are not ideal (like *selfish, competition, strategy, goal, allocation*) because they imply conscious intent, but the behaviors and traits are simply the results of whatever characteristics lead to greater numbers of surviving genes in subsequent generations.

Another somewhat misunderstood concept that plays an important role in evolution and in the topics covered in this book is that of *parent-infant conflict*. Most of us have intimate experience of this conflict in the colloquial sense if we were ever teenagers or had teenage children. But when it is used in an evolutionary sense this concept refers to the fact that the interests of two individuals are never the same, and when the needs of one compromise the health or reproductive success of the other, conflict in one form or another often results. Consider, for example, that a mother (who is related to her offspring by about 50 percent of her genes) will do everything she can (theoretically) to enhance the survival of a given child as long as it does not interfere with the survival of other young she has or can potentially have. The child is related to himself by 100 percent of his genes, so he, in turn, will do everything he can to survive, even if it compromises the health of his mother or current and future siblings. As we will see in later chapters, this comes into play in pregnancy and during breastfeeding when the needs of the developing fetus or nursing infant and of the mother are not always the same. The infant may try to prolong the free ride and nurse as long as he can, but the mother needs to terminate breastfeeding in order to reproduce again and to preserve her own energy reserves.

Proximate and Ultimate Causation

When we examine a characteristic that influences health, survival, and reproduction, it is important to consider that “causes” can be both *proximate* and *ultimate*. The proximate cause is usually the immediate one and the one that a clinician might write on the medical chart. The proximate cause is what is most commonly treated by drugs, surgery, or other medical procedures. A frequently cited example is that of a fever in response to an infectious agent. The cause of the fever is a virus or bacterium and a treatment would involve seeking something to wipe out the cause or reduce the symptoms. But an evolutionary, or ultimate, perspective argues that a fever is one of the best tools the body has to fight off infection, a tool that has evolved as part of a complex immune system that enhanced survival and reproductive success in the past.[18] In fact, it may be one of the few tools at our disposal for dealing with viruses, which do not respond to antibiotics. In the language of evolutionary medicine, a fever is a defense rather than a defect.[19] Of course, like any defense mechanism, it can get out of control and become a problem that needs medical intervention. Certainly a fever of 105°F in a 3-year-old child would not be considered a healthy response to an infection and would require treatment to bring it down.

Another example comes from considering why a person develops sickle cell anemia. The proximate focus may be on the genetic anomaly that caused the anemia: people with two alleles[20] for sickle cell (hemoglobin S rather than the "normal" hemoglobin A that most people have) usually develop a severe form of anemia that most commonly resulted in death or severely compromised health before age 20 in the past, as it often does today in the absence of medical intervention. When a person seeks medical help for anemia, most clinicians seek the proximate cause or the specific mechanism that caused the disorder in the individual and this is the focus of treatment.

On the other hand, concern for the ultimate explanation for the high prevalence of the sickle cell allele would lead to assessing why the alleles are distributed in such a way that they reach high frequencies among those living in or descended from people in Africa and the Mediterranean. What selective value does the sickling allele have in these regions that would explain the high frequencies? Anthropologist Frank Livingstone,[21] who can be considered one of the first scholars of evolutionary medicine (although it was not called that at the time he was writing), noted that the geographic distribution of the sickle cell allele coincides with the distribution of malaria. His conclusion was that those who had a single allele for sickle cell (referred to as "sickle cell trait") were less likely to develop or die from malaria than those who had two copies of the allele for "normal" hemoglobin A. Thus, those who were heterozygous for hemoglobin S had greater reproductive success in malarial areas, and the allele is maintained in high frequencies even today. This hypothesis, that sickle cell trait is protective against malaria, has been tested and confirmed, and although knowing this has not necessarily been useful in treating sickle cell anemia, it has led to greater understanding of the "adaptive significance" of the allele and its pattern of distribution.

Another way of thinking about proximate and ultimate causation is to consider that proximate causes are things that happen to an individual in a lifetime, whereas ultimate causes affect populations and species over much longer spans of time, thousands rather than dozens of years. This is a key to knowing why clinical medicine has been slow to embrace evolutionary medicine—clinicians who focus on the ultimate or evolutionary explanation (who "practice" evolutionary medicine) probably will not have as much impact on their clients' health and well-being as those who focus on and treat the proximate causes.

Evolutionary biologist Paul Ewald has expressed concern that when evolutionary medicine tries to develop ultimate or evolutionary explanations for diseases and disorders based on well-established proximate medical explanations, the wrong explanation may result if the proximate medical causes are themselves wrong.[22] The risk of not being right about evolutionary explanations increases when infectious causes are not considered, and Ewald has been critical of much of evolutionary medicine for ignoring them. For example, when the assumed cause of peptic ulcers was stress interacting with a particular genotype, an evolutionary explanation based on that assumption would have been wrong once it was determined that ulcers had infectious origins.

If our focus on "causes" of cancers is restricted to mismatches between evolved biology and 21st-century lives, we may ignore evidence that infectious agents play roles. Ewald argues that evolutionary medicine approaches to every disease and disorder should consider all three categories of explanation: genetic, infectious, and environmental/lifestyle.[23] This is particularly important in investigations of causes when treatment and prevention are the goals of research. Clearly, treating a disease that is presumed to be caused solely by genes but is, in fact, infectious in origin, will result in failure or incomplete healing if the infectious agent is not considered. Telling people to relax and remove stress from their lives did not really cure them of ulcers caused by a bacterium (although it was probably helpful for their overall health). On the other hand, we know that tuberculosis is cause by a bacterium, but how it is manifested and how it is treated depend a great deal on both genes and environment (such as diet and hygiene). If it turns out that some severe cases of morning sickness (see Chapter 4) are caused by pathogens, making a case that the nausea is adaptive because it "protects the embryo" may not only backfire but could also result in the death of the mother and her fetus from severe dehydration. In this case, the watchful waiting recommended by evolutionary medicine would be the wrong prescription. If evolutionary medicine is to have any impact at all, it must live up to its claim of taking a holistic and deep-time view of human health.

The Concept of "Normal"

Those who view human health and development through the lens of evolutionary medicine take as their beginning assumption the idea that humans are highly diverse with a biology that unfolds in a context rather than in predictable, unvarying ways. Modern medicine tends to think in terms of "normal" and averages, with the model for normal usually being well-nourished people in health-rich populations. Clinicians tend to treat the deviations from normal, but what is normal for women growing up in relative affluence may be very different for