

## AN ECOLOGICAL VIEW OF HEALTH

| Ted Schettler, MD, MPH |

**W**hen I attended Case-Western Reserve University's medical school in the 1960s, a somewhat revolutionary curriculum was organized by biologic systems and, from the outset, brought us into relationships with local families. We began with cell biology while also joining in the supervised medical care of a family, usually African American, living on Cleveland's east side. Families in the program received their medical care at the university, were willing to participate in the education of physicians in training, and were expecting a baby. We would get to know our family, follow our mothers through pregnancy, make home visits, attend the baby's birth, and join in the care of the family and new child over the next several years. It was my good fortune to have Benjamin Spock as my preceptor. Being in the presence of babies brought him great joy.

We moved through cell biology, tissue biology, organ systems, pathology, pharmacology, history taking, and physical examination. History taking included a social history—questions about marital status, alcohol and tobacco use, occupation, and social circumstances. Although this school emphasized the importance of the social environment, other environmental factors that play a prominent role in health and disease received little attention. I have no recollection of being advised to routinely ask patients about what they ate or what they might be exposed to in their home or workplace. In fact, I have little recollection of any instruction in nutrition at all, except in the care of people with diabetes and hypertension. Once, in a class on obstetrics, the lecturer suggested that we ask a laboring woman whether she was hungry and offer her something to eat. That seemed to me a kind and sensible thing to do. But the next speaker cautioned that this was revolutionary. Conventionally, women in labor were not given anything to eat. It all seemed mysterious to me.

Since those early years, I now better understand the influences of the environment on human health and disease. Despite their second-class status in medical school, the essential roles of the physical, biologic, social, economic, and cultural environments as determinants of health are undeniable. But we need new ways to think about them if we are going to incorporate new insights into medical training and care. Here are some reasons why.

**MODELS**

The dominant models that guide medical care and research in the West presume a world made up of individuals experiencing discreet individual risk or protective factors that combine and interact in complex ways, creating a context for health or disease. The typical biomedical approach to this complexity involves taking it apart into more manageable pieces and dealing with those that we can or that we believe are important and in our sphere of responsibility. Therapeutic interventions are commonly aimed at risk factors most proximate to the health outcome. To a large degree, this approach also thrives in public health.

Clinical medicine tends to emphasize ways to address individual risk factors such as smoking, obesity, elevated cholesterol, high blood pressure, diet, and stress through behavior modification and pharmaceuticals. Epidemiologists attempt to explain the causes and distribution of disease by making mathematical models of individual risk factors linked together and interacting in what are often called causal webs of disease. These multivariate models offer the perfect opportunity for endless discussions about how to rank the risk factors in order of their influence over the health outcome of interest.

To be sure, this approach has been essential to understanding the origins of many diseases. It is directly responsible for many successes in the treatment or prevention of infectious, cardiovascular, and

degenerative diseases, as well as some cancers and birth defects, among others. But despite its utility, these web-like models have important limits.

One limitation is the inevitable uncertainty inherent in multivariate models. When relationships among individual factors are complex, the validity of models becomes increasingly uncertain. Models that attempt to represent the dynamics of a collection of factors in some large population will have trouble accommodating heterogeneity within that same group—heterogeneity that is abundant in biology and nature. Interactions among variables are often poorly understood in smaller subsets of people. Some important variables can only be approximated or are left out entirely. Here's an example.

In developing children, lead exposure, dietary iron deficiency, social deprivation, and stress interact in complex ways to diminish intelligence, memory, learning, and attention and to increase impulsive behavior.<sup>1</sup> Lead alone can cause these effects, and iron deficiency can cause some of them. In combination, lead exposure and dietary iron deficiency become more potent because of interactions between them. Iron deficiency increases lead absorption from the intestine and lead uptake into the developing brain. Now, add stress. In animal tests, lead and stress synergistically interact, with an impact greater than the sum of the two alone.<sup>2</sup> Social deprivation also has adverse impacts on children's neurodevelopment and socially deprived children are more likely to be exposed to lead-based paint in old housing. Moreover, iron deficiency is much more common among children living in poverty.<sup>3</sup>

Commonly used models often do not deal well with multiple risk factors in combination. Some get left out entirely or are given only superficial attention. Interventional studies show that these factors must be addressed collectively to see much improvement in cognition and behavior, but, even then, gains are less than if the

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entire set of circumstances had been avoided from the outset.<sup>4</sup> The brain's vulnerability exceeds its plasticity. However, our medical, social, and political institutions generally deal with these individual factors in relative isolation.

A second problem with the model of a causal web has to do with the origins of the causal web itself. In her paper "Epidemiology and the web of causation: Has anyone seen the spider?", epidemiologist Nancy Krieger claims that the metaphor of a web of causation traps us in a particular way of viewing the world that leaves out important concerns.<sup>5</sup> Why, she asked, were some strands included in the causal web model while others were left out? What might explain the entire web that the mathematical models attempt to describe? Many people, Krieger notes, confuse the causes of cases with the causes of disease patterns. She proposed an eco-social model that could accommodate the influence of numerous environmental influences—physical, biologic, social, cultural, economic—at each level of biological organization—from DNA to the individual to the entire population. Krieger has spent much of her career addressing the influences of gender, race, and income on health outcomes. Her research shows how they shape the strands and structure of causal webs of disease.

Epidemiologists commonly attempt to control for gender, race, and income using multivariate analytic models, but models that represent these variables simply as male-female, black-white, and absolute income fail to recognize an entire cascade of their more nuanced influences on multiple strands of the causal web over lifetimes. Race is more than black or white. Racism, or how a person actually experiences blackness or whiteness, has strong influences on health and may vary dramatically from one place to another.<sup>6</sup> Income is also more than an absolute monetary number. In a given social setting, income inequality, regardless of absolute income level, is also an important determinant of adverse health outcomes.<sup>7</sup> And gender bias in a society influences the life experience of individuals in multiple ways.

Being black and poor will influence what you eat, the composition of the fatty acids that reach the developing brain of your fetus, the extent to which you will

breathe secondhand smoke and other hazardous air pollutants, and your risk of exposure to deteriorating lead-based paint in old housing. The impacts of these experiences are measurable in individuals and populations—at the level of DNA, neurological function, stress hormone levels, blood pressure, job retention, income prospects, and risk of serving time in jail.

At Columbia University, a research team is following a large cohort of mother-infant pairs through pregnancy and infant development. Early data show that maternal exposure to environmental tobacco smoke during pregnancy has a negative impact on the neurological function of their infants.<sup>8</sup> The effect is substantially larger when mothers also experienced even temporary deprivations of food, clothing, or housing during the previous year. The team also detected a level of maternal exposure to chlorpyrifos, an organophosphate pesticide often indiscriminately used for pest control in public housing and agriculture, which impaired neurological development of their infants (during this study, the EPA restricted chlorpyrifos from use in housing, but it continues to be widely used in commercial agriculture where farm workers and farming communities are exposed). This impact was more marked in a subset of the women who were poor. Their chlorpyrifos-exposed infants were more likely to be diagnosed with developmental delays and attention-deficit hyperactivity disorder.

These examples illustrate not only the complex interactions among strands of the causal web of disease or disability but also suggest that the strands and structure of the web are substantially determined by social and economic factors inherent in a larger community. The same analysis could be applied to the ways in which industrial agriculture, political campaign financing, advertising, energy policy, and the quest for perpetual economic growth influence what we eat and what toxic chemicals and how much radiation we are exposed to, each of which is woven into a causal web by the elusive spider.

Adoption of the industrial agricultural system in the United States has transformed diverse rural landscapes and family farms into efficient factories producing corn, soybeans, wheat, hogs, beef, and poultry. Agricultural chemicals that increase risks of birth defects, cancer, learn-

ing disabilities, and infertility in people and wildlife are fully integrated into this system. Pesticides, nitrates, hormones, arsenic, and antibiotic residues contaminate the soil, wetlands, and surface waters. Pesticides drift into homes through open windows and cling to the soles of shoes, contaminating carpets, furniture, house dust, and children's toys. Children and adults breathe the contaminated air and ingest the residues.

Dramatic changes in the nutritional composition of food in the United States over the past 50 years are also tightly linked to this high-input, petroleum-dependent, polluting agricultural system that has devastated rural landscapes, families, and communities. Calorie-dense and nutrient-poor foods contribute to marked increases in obesity, diabetes, cancer, and degenerative diseases.

The context for children's brain development, the food that we eat, and the transformation of rural America is, of course, even larger. Over six billion people inhabit the planet, and midlevel projections anticipate nine billion within 50 years. Humans have altered planetary systems in fundamental ways. Climate, soil, water, and air quality; and fisheries, forests, pollinators, wetlands, coral reefs, and biological diversity are under severe stress. Industrial chemicals contaminate global ecosystems and virtually all developing children and wildlife, with troubling but inadequately understood consequences.

## CHANGING WHAT WE DO

Current trends in medical, public health, and environmental indicators point to a need for change in at least three ways: (1) how we imagine the world, (2) how we study the world, and (3) how we move toward a healthier, more sustainable future.

## HOW WE IMAGINE THE WORLD

In *The Geography of Thought*, Richard Nisbett describes differences in how Asians and Westerners think.<sup>9</sup> Westerners tend to see the world primarily as made up of a collection of discreet objects, whereas Asians tend to see the whole, the context, more than the pieces. Nisbett and his research team repeatedly make this general observation after studying the phenome-

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non through many cleverly designed experiments. Of course, there are gradients within these two views, but the pattern appears robust. It is not difficult to see how the Western worldview influences our science, research, medical practice, and social and political institutions. We have plenty of evidence of the role of a more inclusive concept of “the environment” in health and disease, but we continue to address it as a collection of pieces. An explicit appreciation of the importance of the whole—of the context, the system—is missing from this Western worldview. If we are to address health and environmental trends fundamentally, it seems essential that we adopt a more ecological worldview and more fully integrated models to guide decision making. In important ways, it is the contextual system that spins the causal webs of health or disease.

### HOW WE STUDY THE WORLD

Scientific research is often confined to disciplinary silos, although in recent years, the value of interdisciplinary work has become more apparent. However, much more must be done. Ecology and evolutionary biology should be introduced early into all levels of education. The dialectic relationships among people, wildlife, and the larger environment wherein each changes and is changed by the others must not be ignored. New epidemiologic models and statistical techniques are likely to better address system interactions, feedback loops, and nonlinear system dynamics. Methods used in the ecological and social sciences may have much to offer.

### HOW WE RESPOND

In a 1994 conference on “Visioning a Sustainable World,” the late Donella Meadows, a pioneer in systems science and co-author of *The Limits to Growth*, discarded the talk that she had prepared on complex systems because she realized that there was something to do first. With only a little hesitation, she asked the audience to envision the sustainable world that they would like to live in. What would it look like? Where would they live? Who would be there? What would they eat? Where would they work? How would they move around?

Meadows explained that visions are mutable and idealistic, but they must be responsible and rational. No one has any obligation to know how to get there from the outset. Rather, she said, it is through the sharing and refining of visions that the path toward them reveals itself. For many people, visioning a sustainable future is a sign of hopeless naivety, but the alternative is familiar cynicism.

I am confident that most visions for health and sustainability will require integration of clinical medicine, public environmental health, and ecological economics and not treat them as entirely separate disciplines.<sup>10</sup> Working in disciplinary silos and addressing primarily proximate causes of problems that are an inevitable outcome of systemic failures sustains limited models and encourages responses that no longer serve us well. Various forms of integrative medicine strive to address multiple strands of causal webs simultaneously and collectively to build systemic resilience and foster restoration and well-being. Ecological health practitioners will integrate analyses and interventions across the individual, the community, and the planet. Perhaps even new definitions of “health” will emerge and be widely accepted.

Businesses, healthcare facilities, local and regional governments, farmers, agricultural institutions, religious organizations, and philanthropists could be encouraged through a variety of incentives to expand their concerns to entire ecological systems. New economic analyses that are better indicators of ecological health, rather than simply monetary growth, could be used. As it is, “silos” of specialization encourage a focus on single metrics, with little attention to entire systems in which those factors operate.

How might we address malnutrition, food production systems, soil and water quality, exposure to carcinogens and other toxicants, and poverty collectively? How would this change both the structure and approach of educational, scientific, medical, and civic institutions?

Several weeks ago, I returned to my medical school in Cleveland for the first time since 1969. I was invited to give a lecture on children’s environmental health. The event was sponsored by the Swetland Center for Environmental Health, a new center at the medical

school. In the late 1950s, well before Rachel Carson’s *Silent Spring*, Mary Ann and David Swetland felt that not enough was understood about the unintended health consequences of chemical, agricultural, and industrial products in our environment. Mary Ann Swetland’s estate enabled them to support professorships and, recently, to establish the new academic and clinical center. This, I thought, was a hopeful sign. And it was a wonderful day. But there was also disappointment.

I learned that the medical student family clinic program had ended. Students thought it a waste of time and ultimately prevailed. Missed appointments were a frequent complaint. Yes, that is the world of inner city medicine, where stressors pile up, resources are slim and unreliable, and good intentions get lost in the shuffle.

I also learned that lead levels in children in the largely African-American community next to the university on Cleveland’s east side have fallen in recent years. Yet 12% of children screened still have elevated blood lead levels. And Cleveland has the highest rate of family poverty (31.3%) and child poverty (46.9%) in the nation. Just as in my family from this same neighborhood 30 years ago, many of these kids grow up with a burden of lead, poverty, and malnutrition that makes it difficult for them to learn, remember, and pay attention and reduces their IQ and chances for finishing school, keeping a job, and staying out of jail.

However, a more integrated approach to these problems is in the offing. The Case Healthy Homes and Babies program has received funding from Housing and Urban Development’s Healthy Homes Initiative for assessment and remediation of 150 homes of low-income pregnant women/infants. The Swetland Center is teaming up with the Department of Family Medicine, Environmental Health Watch, a community-based organization, and the Cleveland Housing Network to implement multifaceted, integrated housing and behavioral interventions addressing lead, asthma triggers, pesticides, carbon monoxide, accidental injuries, sleep-related infant deaths, and mold exposures. A challenge comes to mind. Show us how to weave nutritional improvement and poverty reduction into this web. Accomplishing that will provide unique and valuable services for East Cleveland and teach all of us.

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