Human Biomonitoring of Environmental Chemicals

Measuring chemicals in human tissues is the "gold standard" for assessing people's exposure to pollution

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What chemicals in your daily routine should you be most concerned about? The volatile organic compounds from your carpet? The exhaust fumes on the road to work? The pesticide residues in the apple in your lunch? Most of us are exposed to low levels of thousands of toxic chemicals every day. How can a person—or a nation—decide which substances should be controlled most rigorously?

One strategy is to go after the largest sources of pollution. This approach certainly makes sense when those pollutants have obvious and widespread consequences, such as warming the globe, causing algal blooms, eroding the ozone layer or killing off wildlife. But for protecting human health, this strategy does not serve so well, because the link between a given compound and its biological effects can be difficult to gauge. For epidemiologists to correlate environmental pollutants with health problems, they need to know who has been exposed and at what level.

This knowledge is exceptionally difficult to gain when there is a lag between exposure and the manifestation of illness. In such cases, the data are seldom—if ever—sufficient to determine the precise agent, the details of contact and the full extent of the affected population. Complicating matters, the scientific understanding of the mechanisms of exposure, such as how various compounds are carried through the air and changed along the way, is often incomplete. As a result, epidemiologists often find it difficult to establish cause-and-effect relationships for environmentally induced sicknesses. Without reliable information some pollutants may be unfairly blamed, whereas others exert their dire effects without challenge. Fortunately, there is hope: a method of accurately measuring not only contact with, but also absorption of toxic chemicals from, the environment—human biomonitoring.

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Is It in Me?

Each person's risk of developing an environmentally related disease, such as cancer, results from a unique combination of exposure, genes, age, sex, nutrition and lifestyle. Science doesn't fully understand how these variables interact, but exposure is clearly a key factor. Thus, a fundamental goal of environmental health policy is to prevent (or at least reduce) people taking in chemicals that lead to any of the five *D*s—discomfort, dysfunction, disability, disease or death.

Exposure to an environmental chemical is minimally defined as contact with the skin, mouth or nostrils—a meaning that includes breathing, eating and drinking. For the purposes of assessing risk, the most important attributes of exposure are magnitude (what is the concentration?), duration (how long does contact last?), frequency (how often do exposures occur?) and timing (at what age do exposures occur?). The calculation of actual exposure also requires complex detective work to discover all kinds of details, including the chemical identity (for example, the pesticide chlorpyrifos), source (nearby agricultural use), medium of transport (groundwater) and route (drinking contaminated well water). Scientists must consider this information on exposure against the background of people's activity patterns, eating and drinking habits, and lifestyle, and they must also evaluate the influence of other chemicals in the air, water, beverages, food, dust and soil. Overall, this is a daunting challenge.

Historically, those scientists who undertook such a complex task have relied on indirect methods: questionnaires, diaries, interviews, centralized monitoring of community air or water, and a record of broad activity patterns among the population. But the results were often disappointing. Although these circumstantial approaches have the advantages of practicality and frugality, they can also introduce substantial uncertainty into resulting exposure estimates. This shortcoming multiplies the potential for a fundamental error—classifying a person as "not exposed" when he or she has been or vice versa.

A second approach, the direct measurement of an individual's environment, is sometimes a possibility—for example, a person might carry a portable monitor to record contact with airborne chemicals. Although this technique offers an unequivocal record of chemical contact, it is technologically infeasible or prohibitively expensive to measure most pollutants this way. Also, although such monitors document exposure, they tell nothing about the person's uptake of these airborne chemicals—how much truly gets into his or her body, which is, of course, the most relevant