Exploring the Exposome

A Focus on Totality of Exposures Could Mean New Opportunities for Industrial Hygienists

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Despite decades of research, the etiology of many diseases remains largely unknown. Evidence indicates that the origins of certain chronic diseases have both genetic and environmental components.[1] Studies have suggested linkages between depression and heart disease, inadequate vitamin D and risk of stroke and heart disease, and a variety of occupational exposures and associated health outcomes. Also, the rates of certain diseases among immigrants change to match those of the population where they move, which suggests an environmental component of disease.[1] To better define the study of this environmental component, a new term, "exposome," has arisen in the scientific literature.[2]

The Exposome Defined

Success in mapping the human genome has generated considerable scientific interest in the complementary concept of the exposome—the totality of exposures over a lifetime that predispose and predict health effects in an individual. The exposome describes response to any and all insults from conception—injuries, irritations, stressors and traumas, including those from occupational and environmental sources. These include lifestyle and diet, which are likely (in combination with the genome) to have a significant role in the etiology of disease (see Figure 1). Thus, research on the exposome may help understand the multitude of interactions leading to disease (see Figure 2).

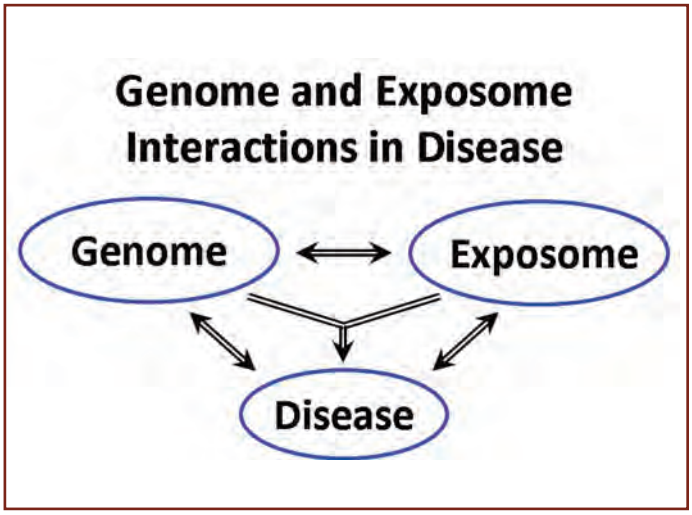
Clearly, the exposome is a compelling topic for those whose objective is to prevent illnesses caused or exacerbated by workplace exposure, and it has the potential to be a major focus of research.

Exposome Studies

While exposure assessment, existing biomarkers and epidemiologic approaches inform the study of the exposome, these traditional approaches are not sufficient. Exposure assessment related to the exposome will require other biologically based technologies that can offer fingerprints or signatures of exposures across a broad spectrum of insults and stimuli.

Promising areas of study may involve the advancing "omic" technologies ("technomics"), such as epigenomics, proteomics, metabolomics, and adductomics. The suffix "omic" is derived from genomics and often indicates a focus on complex, large-scale systems rather than individual biological structures. (Proteomics, for example, is the study of a large collection of proteins in a cell or tissue.) One of the hallmarks of the technomics is the need for high-throughput analysis—that is, simultaneous measurement of thousands of data points considering protein expression levels and complete pathways.

Figure 1. Conceptual view of how complex interactions among the genome, the exposome, and disease may determine our state of health.



NIOSH exposomic studies include conducting proteomic investigations that employ a matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI- TOFMS) to evaluate toluene diisocyanate binding to proteins as a way to identify exposed workers. NIOSH is also conducting metabolomic studies to identify predictors of occupational exposure to phthalates by evaluating changes in metabolite levels. A question yet to be answered is whether these technomics can be developed to the point where they can be useful in evaluating the exposome.[2]

Exposome Challenges

Developing reliable measures for life-course exposures is challenging. Further, the exposome, expressed at the individual level, is highly variable and dynamic. Once a disease has been diagnosed, the environmental or occupational factors that lead to the disease may no longer be present, and, therefore, no longer measurable. However, as Parmigiani et al recently decribed, the accumulation of mutations in carcinogenesis provides clues to etiology and has utility for early detection.[3]

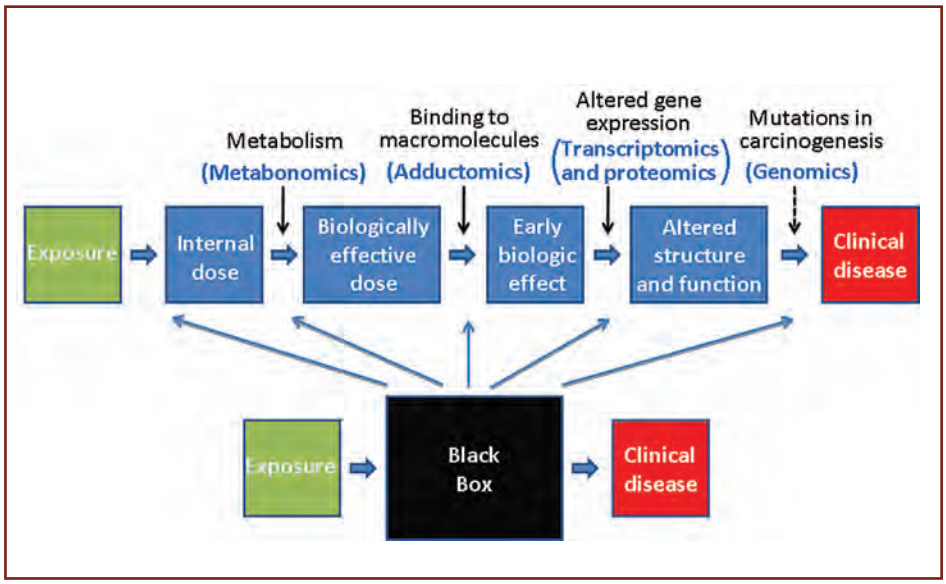
Consequently, a major challenge will be to develop legacy biomarkers, using approaches such as technomics, that can be measured and correlated with an individual's health and can provide fingerprints or signatures over a broad spectrum of exposures and stimuli. Because technomics often involve processing large amounts of data, standardized approaches to collection and storage of data (as well as improved analytic tools) will be needed.

Implications for Industrial Hygienists

Some resources about the exposome are already available. Earlier in 2010, a U.S. National Academy of Sciences workshop examined the concept of the exposome and its significance to the etiology of human diseases. Presenters discussed the promise of the "omic" technologies, environmental exposures and the etiology of cancer, scientific challenges to the exposome approach, and many other related topics. Workshop presentations and audio recordings are available at http://dels-old.nas.edu/envirohealth/exposome.shtml. Also, episode 12 of the AIHA radio show "Safe & Sound" features a discussion of the exposome with Paul Middendorf and Gayle DeBord of NIOSH. A lunch-and-learn session on the exposome is also planned for Monday, Oct. 11, at PCIH 2010 in Fort Worth, Texas.

As technologies develop to permit a better understanding of the exposome, industrial hygienists may find increasing intersections and research opportunities with molecular biologists, geneticists, and professionals in other disciplines. In particular, industrial hygienists can help advance the understanding of genetic-exposure-disease relationships by fully characterizing and documenting occupational exposures and by including technomics in medical surveillance of occupational workforces. The concept of the exposome will likely impact and inform the practice of industrial hygiene for years to come.

Figure 2. Research into the exposome and application of the "technomics" may help decipher the multitude of interactions that lead to disease. (The dotted line in this illustration of carcinogenesis indicates that genomics may play a role in many processes and that mutations may only represent a portion of the events or activities leading to cancer.)



The findings and conclusions in this report are those of the authors and do not necessarily represent the views of NIOSH.

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Resources

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