In this series, we have been reviewing studies published during the past two years in ENVIRONMENTAL HEALTH PERSPECTIVES, a peer-reviewed journal published by the U.S. National Institutes of Health. Our purpose has been to discover whether mainstream scientists believe that industrial chemicals, released into the environment, can interfere with the hormones of wildlife and humans, leading to widepsread harm. It is abundantly clear that they do. To keep abreast of the torrent of new studies of hormone disruption appearing in dozens of journals, check in regularly at http://www.ourstolenfuture.org.

Now the question becomes, "What does all this information about hormone disruption mean?" One person eminently qualified to comment on that question is Dr. J.P. Myers, a zoologist and co-author (with Theo Colborn and Dianne Dumanoski) of OUR STOLEN FUTURE, the book that pushed "hormone disruption" to the top of the international environment-and-health agenda. The following essay first appeared in the February, 2002, issue of OUR PLANET, the journal of environmental sustainability published by the United Nations Environment Program. See http://www.ourplanet.com. We added the footnotes.

Disrupting Life's Messages

by John Peterson Myers*

A revolution in scientific understanding of the impacts of contamination on health is under way. As it unfolds, it is likely dramatically to alter our understanding of the consequences of pollutants for human well-being, and to require fundamental changes in how chemicals are regulated. The revolution arises from scientific discoveries which establish that many chemicals both from the natural world and synthesized in laboratories interfere with the natural chemical messaging systems that direct the biological development of plants and animals, including humans.

Virtually all biological development is under the control of various chemical messaging systems that convey instructions from the genes to their targets, thereby directing development. Hormones, neurotransmitters and growth factors, among others, are key elements of these message systems. Their successful transmission of genetic instructions is vital to normal healthy development, as they control almost if not every aspect of the process from what sex a baby will become to how many fingers it will have, to whether its brain is capable of intelligent reasoning or whether its immune system will be able to resist disease.

Science has now established that a wide array of chemicals can disrupt these genetically based messages without damaging the genes themselves. Much attention has focused on disruption of hormonal signalling, which has become known as endocrine disruption.

The roots of research in this arena go back to the 1930s, but it has burgeoned in the last ten years because of very significant investments of funds by European, Japanese and North American governments. New results are published virtually every week.

These new findings are rich in detail, fascinating in what they reveal about biological mechanisms, and sometimes breathtaking in their implications.

For example, a study published in July 2001 by the United States Centers for Disease Control reported a strong relationship between DDT contamination in mothers and the likelihood of pre-term birth of their infants.[1] Using biological samples stored since the 1960s, the authors report that their findings indicate that the United States experienced an epidemic of pre-term birth during the hey-day of DDT use, and that this persistent pollutant may have caused up to 15 per cent of infant mortality in America during that period.

Several important broad trends in the pattern of research findings can be identified from the thousands of studies on endocrine disruption published since the early 1990s.

First, the research confirms that contamination by hormonally active compounds is globally ubiquitous. No one is unexposed, even in the womb. The same is true for most, if not all living organisms, especially those higher in ecological food chains and thus consuming foods in which the contaminants have become concentrated by bioaccumulation. Contamination is partly so widespread because of the global redistribution of pollutants transported through air and water. The inadvertent but pervasive inclusion of hormonally active compounds in consumer products such as many cosmetics and plastics also contributes.

Empirical confirmation

Second, effects of exposure can be observed at levels dramatically lower than those thought relevant to health a decade ago. Scientists are measuring the endocrine-disruption impacts of contaminants like arsenic, dioxin and bisphenol A (a basic component of polycarbonate plastic) in the low parts-per-billion. This was unmeasurable two decades ago (scientific instruments simply were not that accurate) and highly controversial until recent review and empirical confirmation.

Third, the findings indicate that virtually all chemical messaging systems are vulnerable, in principle, to message disruption. Work in this area focused for decades on interference with oestrogen. As the focus has expanded to other hormones, one or more disrupting contaminants have been discovered for every system studied carefully, including the thyroid system (crucial for brain development), the retinoid system (involved in very basic control of development), and the glucocorticoids (important for metabolism and tumour suppression, among other things). In the summer of 2001, new results reinforced this trend dramatically, with a report that the ecological symbiosis between leguminaceous plants like beans and the bacteria responsible for nitrogen fixation is vulnerable to disruption by contaminants.[2] This symbiosis, mediated by chemical communication between the plant and the bacteria, is a vital component of the global nitrogen cycle.

Fourth, the health effects of concern have expanded dramatically beyond those of the traditional focus for toxicology. Laboratory studies unequivocally demonstrate effects on disease resistance, cognitive function and fertility resulting from low-level exposures.

These findings should be of deep concern to people, organizations and agencies focused on human economic development and equity. It is clear, for example, that background levels of contamination can make children less resistant to infectious agents. Further research in this area may force a radical reassessment of the toll of contamination, as this implies that many deaths and diseases would have been avoided had contaminants not reduced resistance.

Similarly, the research suggests that widespread exposure to neurologically active contaminants as might occur, for example, in agricultural areas in the developing world with intensive pesticide use may lead to community-wide erosion of cognitive abilities. In a world in which information is a key economic currency, this contamination burden could consign those affected to the economic margins forever.
\tab\b Conceptual shifts

These emerging trends are forcing toxicologists toward several conceptual shifts that will lead to fundamental changes in the ways that chemicals are managed. The most important of these involves a change in the way that toxicologists think about what is relevant to human health.

Traditional toxicology focuses on damage, such as cell death, mutations, cancer or genotoxicity. Message disruption can cause these, but the effects may also be of a very different, but equally important, nature. Most challenging to traditional toxicology, message disruption does not work by overwhelming the body's (or the cell's) defences. It works by hijacking the developmental process, adding to or subtracting from the body's own control mechanisms at remarkably low levels of exposure. By subtly (or blatantly) altering the path of development, message disruption leads the victim to a different future. The difference may be small, as in the loss of a few IQ points, or it may be large, as in a completely dysfunctional immune system.

Toxicology has focused traditionally on the impact of high levels of exposure on small numbers of people. This new approach requires considering widespread, low-level exposures experienced by many people -- exposure levels that many had come to write-off as "background" and, by implication, irrelevant.

Taken together, these new scientific findings add to growing pressure to change the basic rules of chemical regulation. Once again, we have been blind-sided. Our ability to synthesize chemicals got far ahead of our scientific understanding of their impacts.

Traditional risk assessment allowed them to be commercialized and distributed, causing pervasive contamination. Risk assessment's partner in developing protective standards, epidemiology, by definition works only after an epidemic. Even then, its tools are remarkably insensitive in studies of the effects of endocrine disruption, and strongly biased toward negative results even when there are real effects.

The answer, still imperfect, lies in implementing precautionary measures that impose far more stringent requirements on old and new products alike. As the Swedish

Chemicals Policy Committee has recognized, certain attributes should be knock-out criteria.[3] Persistent bioaccumulative compounds, for example should be eliminated from use even without demonstrating toxicological risk. Endocrine-disrupting materials should be removed from consumer products and their environmental release should be phased out. More generally, the demonstration of potentially harmful biological impacts in laboratory studies should reverse the burden of proof in developing regulations from one in which harm must be demonstrated before a product is withdrawn, to an approach where safety is ensured beyond reasonable doubt before widespread deployment is allowed. These steps will help ensure that the benefits we all enjoy from modern chemistry do not come back to haunt us.

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[1] M.P. Longnecker, M.A. Klebanoff, H. Zhou, J.W. Brock, "Association between maternal serum concentration of the DDT metabolite DDE and preterm and small-for-gestational-age babies at birth, " THE LANCET Vol. 358 (2001), pgs. 110-114.

[2] J.E. Fox, M. Starcevic, K.Y. Kow, M.E. Burow and J.A. McLachlan, "Nitrogen fixation: Endocrine disrupters and flavonoid signalling," NATURE Vol. 413 (2001), pgs. 128-129.

[3] Swedish chemicals policy recommendations were reported in Lotta Fredholm, "Chemical Testing: Sweden to Get Tough on Lingering Compounds," SCIENCE Vol. 290, No. 5497 (Dec. 1, 2000), pgs. 1663-1666.