Rachel's Environment & Health News
#498 - Dangers of Chemical Combinations
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The chemical industry received some extraordinarily bad news last week. SCIENCE magazine published a new study showing that some COMBINATIONS of hormone-disrupting chemicals are much more powerful than any of the individual chemicals by themselves.[1] SCIENCE magazine is the conservative voice of mainstream science in the U.S. Until last week SCIENCE had largely ignored the possibility that industrial chemicals may be interfering with hormones in wildlife and humans.

The new study shows that combinations of two or three common pesticides, at low levels that might be found in the environment, are up to 1600 times as powerful as any of the individual pesticides by themselves. The study showed that one chemical, chlordane, which has no ability to disrupt hormones by itself, nevertheless greatly magnifies the ability of other chemicals to disrupt hormones. If these findings are confirmed by follow-up studies, it could profoundly affect the way chemicals are viewed, tested for toxicity, and regulated because combinations of chemicals will have to be considered. The environmental protection apparatus of the U.S. and, indeed, the world, is presently based on studies of individual chemicals acting alone.

Hormones are natural chemicals that act as messengers, traveling through the blood stream, regulating various bodily processes, coordinating the body's activities to maintain health. Hormones are particularly important during growth and development of an egg, an embryo, a fetus, a baby. About 100 different hormones have now been identified, and they control growth, development and behavior in all vertebrates (fish, birds, reptiles, amphibians, and mammals), including humans.[2] (See REHW #263, #264.)

Since 1991, studies have shown that at least 50 synthetic (human-created) industrial chemicals can interfere with hormones and disrupt normal growth and development in birds, fish, mammals, reptiles, amphibians, and humans.[3] The results of such interference can include changes in sexual preference and behavior; small penises; diminished sperm count; various cancers; nervous system disorders; birth defects; and damage to the immune system, among other effects. Many of the 50 hormone-disrupting chemicals are commonly found in detergents, plastics, and pesticides. In response to these studies, the chemical industry has asserted that low-level environmental exposures are not powerful enough to affect humans.[4] The new study published this week in SCIENCE shows that the chemical industry's position is not likely to hold up under scrutiny.

The editors of SCIENCE evidently considered the new study so important that they simultaneously published two articles commenting on the findings.[5,6] (Furthermore, in the same issue, they published a flattering review of the recent book on hormone-disrupting chemicals, OUR STOLEN FUTURE.[7])

Even the editors of the NEW YORK TIMES considered the new study important enough to report on it in a straightforward manner.[8] In March and April the TIMES had published a series of biased and inaccurate articles by Gina Kolata, who said the theory that industrial chemicals might interfere with hormones had been "refuted by careful studies," none of which she cited or described. (See REHW #486 and #492.) When scientists wrote letters to the editor, seeking to restore balance after Ms. Kolata's reporting, the TIMES refused to publish any of their letters. One group of scientists finally grew so frustrated that they took the highly unusual step of purchasing ad space in the TIMES to complain about Ms. Kolata's inaccuracies and bias.[9]

The idea that common industrial chemicals may be interfering with the hormones of wildlife and humans, has far-reaching implications. If it is true, it means that the chemical industry as we know it is a threat to all life on earth. How can we learn whether this is true?

Chemicals with vastly different molecular struc-tures have proven to be hormone disrupters.[10] This means that a chemical's ability to disrupt hormones cannot be discovered simply by examining a diagram of the molecule. In other words, the study of so-called structure/function relationships is not helpful in the case of hormone-disrupters. Therefore thousands of chemicals will need to be tested individually for their ability to disrupt hormones. A thorough battery of tests has not yet been devised, and there are now 70,000 chemicals currently in commercial use, with about 1000 new ones added each year. The prospect of testing the toxicity of this number of chemicals, even one at a time, is daunting. No one knows where the resources would come from to conduct such a large number of tests. The new study in SCIENCE makes the enormous problem of individually testing 70,000 chemicals seem small by comparison. If scientists have to study COMBINATIONS of chemicals, their job is vastly increased.[11] For example, to test just the commonest 1000 toxic chemicals in unique combinations of 3 would require at least 166 million different experiments (and this disregards the need to study varying doses).[12] Even if each experiment took just one hour to complete and 100 laboratories worked round the clock seven days a week, testing all possible unique 3-way combinations of 1000 chemicals would still take over 180 years to complete.

This is not the first evidence that some combinations of chemicals are more powerful than any of their individual chemicals. Earlier this year researchers at the Duke University Medical Center published a study of three chemicals to which U.S. soldiers were exposed during the Gulf War. None of the three chemicals, by itself, caused nerve damage in laboratory animals, but TOGETHER the three chemicals showed powerful nerve-damaging effects --effects so strong that the researchers concluded that they may have found the cause of "Gulf War Syndrome," which plagues at least 30,000 U.S. veterans of that war.[13]

Even earlier, studies had shown that exposure to radiation enhances the toxicity of certain chemicals,[14] and that tobacco smoke and asbestos enhance each other's toxicity.[15] However, the U.S. never tests chemical combinations to assess chemical dangers. For example, the National Research Council (NRC) recently studied the problem of doing "risk assessments" for combinations of chemicals. The NRC concluded that simply adding up the individual toxicities was the way to handle combinations. NRC said this approach would underestimate the toxicity of combinations of chemicals no more than 10-fold.[16]

The new study published in SCIENCE throws the NRC's conclusion into a cocked hat. Combinations of two and three pesticides turn out to be anywhere from 160 to 1600 times as powerful as any of the individual pesticides. Risk assessments that assume chemical combinations are only 10 times as powerful as the individual chemicals may underestimate the dangers 100-fold or more.

Most importantly, one chemical (chlordane) by itself showed no hormone- disrupting effects, yet it magnified the hormone-disrupting power of other chemicals when combined with them. This means that we must identify, and protect ourselves against, even very weak hormone- disrupting chemicals because they may not be so weak when combined with other common chemicals. It is hard to imagine a practical, manageable testing program that can sort through these problems and produce reliable, comprehensive results in less than a century. By that time, if damage is being done now, as many scientists believe is the case, it will be far too late.

The solution to this huge, complex problem? Theo Colborn and Pete Myers suggested some beginning steps in their recent book, OUR STOLEN FUTURE (see REHW #486, #487, #490):

** Greatly reduce the number of chemicals on the market. (pg. 226)

** Reduce the number of chemicals used in a given product; make products simpler. (pg. 226)

** Make and market only chemicals that can be readily detected at relevant levels in the real world with current technology. (pg. 226)

** Do not produce a chemical unless its degradation in the environment is well understood. (pg. 227)

** Curtail the introduction of thousands of new synthetic chemicals each year. (pg. 247)

** Reduce the use of pesticides as much as possible. (pg. 247) Pesticides should be used only in genuine emergencies. (pg. 217)

** Shift the burden of proof onto manufacturers... To a disturbing degree, the current system assumes that chemicals are innocent until proven guilty. This is wrong. The burden of proof should work the opposite way, because the current approach, a presumption of innocence, has time and again made people sick and damaged ecosystems. (pg. 219)

** The tool of risk assessment is now used to keep questionable compounds on the market until they are proven guilty. It should be redefined as a means of keeping untested chemicals off the market and eliminating the most worrisome in an orderly, timely fashion. (pg. 219)

** Science alone does not always have the answer.... The time has come to pause and finally ask the ethical questions that have been overlooked in the headlong rush of the 20th century. Is it right to change Earth's atmosphere? Is it right to alter the chemical environment in the womb for every unborn child? (pg. 247)

** Now that we know better, we must have the courage to be cautious, for the stakes are very high. (pg. 249)

--Peter Montague (National Writers Union, UAW Local 1981/AFL-CIO)

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[1] Steven F. Arnold and others, "Synergistic Activation of Estrogen Receptor with Combinations of Environmental Chemicals," SCIENCE Vol. 272 (June 7, 1996), pgs. 1489-1492.

[2] Anthony W. Norman and Gerald Litwack, HORMONES (San Diego, Ca.: Academic Press, 1987). See Appendix A.

[3] Theo Colborn, Frederick S. vom Saal, and Ana M. Soto, "Developmental Effects of Endocrine-Disrupting Chemicals in Wildlife and Humans," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 101, No. 5 (October, 1993), pgs. 378-384.

[4] Stephen H. Safe, "Environmental and Dietary Estrogens and Human Health: Is There a Problem?" ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 103, No. 4 (April, 1995), pgs. 346-351.

[5] Jocelyn Kaiser, "New Yeast Study Finds Strength in Numbers," SCIENCE Vol. 272 (June 7, 1996), pg. 1418.

[6] S. Stoney Simons, Jr., "Environmental Estrogens: Can Two 'Alrights' Make a Wrong?" SCIENCE Vol. 272 (June 7, 1996), pg. 1451.

[7] Anne N. Hirschfield and others, "Problems Beyond Pesticides [review of OUR STOLEN FUTURE]," SCIENCE Vol. 272 (June 7, 1996), pgs. 1444- 1445.

[8] Warren E. Leary, "Test Developed to Weigh Impact of Hormone-Like Pollutants," NEW YORK TIMES June 7, 1996, pg. A15.

[9] "When It Comes to Chemicals, Is Only Good News Fit to Print? [advertisement]" NEW YORK TIMES May 29, 1996, pg. A19.

[10] John A. McLachlan, "Functional Toxicology: A New Approach to Detect Biologically Active Xenobiotics," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 101, No. 5 (October, 1993), pgs. 386-387.

[11] Leslie Lang, "Strange Brew: Assessing Risk of Chemical Mixtures," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 103, No. 2 (February, 1995), pgs. 142-145

[12] The formula for calculating how many different subcollections of size k can be formed from a collection of n different chemicals is (n!)/((k!)*((n-k)!)) where n! means n factorial and * means "multiplied by". In the case under discussion, k is 3 and n is 1000. See, for example, Michael Orkin and Richard Drogin, VITAL STATISTICS (New York: McGraw-Hill, 1975), pg. 285.

[13] Mohamed B. Abou-Donia and others, "Neurotoxicity Resulting From Coexposure to Pyridostigmine Bromide, DEET and Permethrin: Implications of Gulf War Chemical Exposures," JOURNAL OF TOXICOLOGY AND ENVIRONMENTAL HEALTH Vol. 48 (1996), pgs. 35-56. For popular accounts of this study, see Elizabeth Pennisi, "Chemicals Behind Gulf War Syndrome?" SCIENCE Vol. 272 (April 26, 1996), pgs. 479-480, and Philip J. Hilts, "Chemical Mix May Be Cause of Illnesses in Gulf War," NEW YORK TIMES April 17, 1996, pg. A17.

[14] J.G. Sharp and D.A. Crouse, "Apparent Synergism between Radiation and the Carcinogen 1,2-Dimethylhydrazine in the Induction of Colonic Tumors in Rats," RADIATION RESEARCH Vol. 117 (1989), pgs. 304-317. And see Frank E. Lundin, Jr., and others, RADON DAUGHTER EXPOSURE AND RESPIRATORY CANCER; QUANTITATIVE AND TEMPORAL ASPECTS (Springfield, Va.: National Technical Information Service, 1971).

[15] Agency for Toxic Substances and Disease Registry, TOXICOLOGICAL PROFILE FOR ASBESTOS (UPDATE) (Atlanta, Ga.: Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health & Human Services [1600 Clifton Rd. -Mail Stop E-29, Atlanta, GA 30333; phone (404) 639-0730], August, 1995), pg. 75.

[16] SCIENCE AND JUDGMENT IN RISK ASSESSMENT (Washington, D.C.: National Academy Press, 1994). See Chapter 11.

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