After three years of study, U.S. Environmental Protection Agency [EPA] is about to publish a 9-volume draft "scientific reassessment" of dioxin and other dioxin-like chemicals, including dibenzofurans and some PCBs [polychlorinated biphenyls]. PCBs are industrial poisons now banned in the U.S. because of widespread environmental damage. Dioxins and furans are highly toxic byproducts of certain industrial operations including incineration, tire burning, combustion of coal and oil, manufacture of paper and some pesticides, metal smelting, and perhaps diesel engine exhausts [pgs. 6-9]. There are probably other sources as well. Dioxins and furans are created when chlorine combines with other chemicals at high temperatures.

A copy of EPA's summary volume (Chapter 9) was leaked to the press in mid-May. We obtained a copy and reported some of its findings and conclusions last week, focusing on the cancer hazard. This week, we bring you more, stressing non-cancer effects. [Page numbers inside square brackets refer to EPA's draft of Chapter 9, dated May 2, 1994.]

According to EPA, nature produces only small amounts of dioxin. The vast majority of dioxin is created by human economic activities. Since about 1920, industrial emissions, and inattention to the potent toxic effects of dioxin-like chemicals, have allowed the environment to become widely contaminated with significant quantities of dioxins, furans and PCBs. As a result, all Americans eat and breathe small but important amounts of dioxin every day.

Human exposure to dioxin begins early in life. A human fetus lives in the womb enclosed inside a fluid-filled sac called the placenta, which provides a barrier to many poisons that the mother might ingest. Unlike many other poisons, dioxin crosses the placenta and begins affecting the fetus [pg. 23]. The human body retains dioxin, so a "body burden" begins accumulating in each of us during our early months in the womb. [1]

In humans and other species, it is the growing embryo or fetus that is most sensitive to the toxic effects of dioxin-like chemicals. EPA: "A general finding in fish, bird, and mammalian species is that the embryo or fetus is more sensitive to TCDD-induced mortality than the adult. [TCDD is a shorthand name for dioxin.] Thus the timing of TCDD exposure during the life history of an animal can greatly influence its susceptibility to overt dioxin toxicity." [pg. 36]

Growth occurs in two ways: cells multiply, and cells of one type turn into cells of another type (a process called differentiation). Thus some cells become eyes and other cells become fingers by differentiation. Dioxin-like chemicals can disrupt both cell multiplication and cell differentiation.

"Of particular interest to the risk assessment process is the fact that a wide variety of developmental events, crossing three vertebrate classes and several species within each class, can be perturbed, suggesting that dioxin has the potential to disrupt a large number of critical developmental events at specific developmental stages. Not only can these changes lead to increases in embryo/fetal mortality, but they can disrupt organ system structure and irreversibly impair organ function." [pgs. 34-35]. In other words, damage that occurs in the womb can last a lifetime.

After a baby (or animal) is born, rapid growth continues, so sensitivity to the toxic effects of dioxin continues as well. Human infants who breast feed get a particularly high dose of dioxins. EPA's report calculates that an infant who breast feeds for a year will receive 4% to 12% of his or her full lifetime dose of dioxin during that one year [pgs. 15, 21]. (Despite the presence of dioxin-like chemicals in human milk, breast feeding is still the best way to nourish an infant; all of the alternatives are worse.) [2]

Although dioxin can presumably interfere with every bodily system in the growing infant, there is evidence that the developing immune system is one of the most sensitive to disruption by low-level exposure to dioxin-like chemicals. EPA says, "Furthermore, since TCDD [dioxin] alters the normal differentiation of immune system cells, the human embryo may be very susceptible to long-term impairment of immune function from in utero [in the womb] effects of TCDD on developing immune tissue." [pg. 39]

EPA points out that, "Impairment of the immune system can be considered an adverse outcome in its own right, being responsible for induced pathologies." [pg. 51] And: "Concern over the potential toxic effects of chemicals on the immune system arises from the critical role that the immune system plays in maintaining health. It is well recognized that suppressed immunological function can result in increased incidence and severity of infectious diseases as well as some types of cancer. Conversely, the inappropriate enhancement of immune function or the generation of misdirected immune responses can precipitate or exacerbate the development of allergic and autoimmune diseases." [pg. 37] In other words, there are two ways your immune system can malfunction: it can be depressed and fail to protect you against bacteria, parasites, viruses and cancer. Or it can become too active and start to attack you; this creates autoimmune diseases like asthma, diabetes, and lupus.

EPA clearly considers these immune system hazards important; the report spends considerable time discussing them: "Animal host resistance models that mimic human disease are available and have been used to assess the effect of TCDD on altered host resistance [to disease]. Results from host resistance studies provide evidence that exposure to TCDD results in increased susceptibility to bacterial, viral, parasitic, and neoplastic [cancer] disease. These effects are observed at relatively low doses and likely result from TCDD-induced suppression of immunological function." [pg. 38]

The immune system is as complex as the brain and central nervous system. [3] Scientists speak of two basic parts of the immune system: those that work via cells (called "cell-mediated") and those that work in the blood stream without entering cells (called "humoral").

EPA: "Both cell-mediated and humoral immune responses are suppressed following TCDD exposure, suggesting that there are multiple cellular targets within the immune system that are altered by TCDD. Evidence also suggests that the immune system is indirectly targeted by TCDD-induced changes in nonlymphoid tissues." [pg. 38]

EPA goes on: "One potentially important indirect mechanism is via effects on the endocrine system. Several endocrine hormones have been shown to regulate immune responses, including glucocorticoids, sex steroids, thyroxine, growth hormone, and prolactin. Importantly, TCDD and other related compounds have been shown to alter the activity of all of these hormones." [pg. 38]

The EPA's draft report speaks of "a window of sensitivity of biological processes." [pg. 48] In other words, there are certain times during the life of an animal (or human) when it is more sensitive to dioxin's effects than at other times. The perinatal period (shortly before or shortly after birth) is one such "window of sensitivity." But there are evidently other such "windows." EPA suggests that any time the immune system begins to respond to a challenge, disruption by dioxin can have far-reaching effects: "It is important to consider, however, that if an acute exposure to TCDD even temporarily raises the TCDD body burden at the time when an immune response is initiated, there may be a risk of adverse impacts even though the total body burden may indicate a relatively low average TCDD level." [pgs. 38-39] Thus even a short-term exposure to dioxin at the wrong time might cause disease in a person by suppressing the immune system, even though the person's average lifetime body burden of dioxin may not be greatly increased.

Dioxin may also cause inheritable genetic changes: "While dioxin and related compounds are not generally considered to be 'genotoxic' in traditional terms, both empirical data and the results
of modeling efforts suggest that they may be functioning indirectly to produce irreversible genetic changes in exposed cells.” [pg. 33]

EPA's draft report emphasizes that most people get their daily dose of dioxin from their food (about 90% from meat, fish and dairy products) [pg. 12]. However, people who live near sources of dioxin emissions (listed in our first paragraph, above), should consider that inhalation may be an important hazard for them. EPA says, "The use of incineration as a means of solid and hazardous waste management results in the emission of contaminated particles that may contain TCDD and related compounds into the environment. Thus, exposure to TCDD and related compounds may result from inhalation of contaminated fly ash, dust and soil. Systemic effects occur in animals after pulmonary exposure to TCDD, suggesting that transpulmonary [lung] absorption of 2,3,7,8-TCDD does occur. Further results suggest that the transpulmonary absorption of 2,3,7,8-TCDD and 2,3,7,8-TBDD was similar to that observed following oral exposure.... these data provide support for the inference that efficient absorption will occur when particles containing dioxin and related compounds are inhaled by humans.” [pgs. 17-18]

How much dioxin is "safe"? EPA: "The USEPA has frequently defined a reference dose (RfD) for toxic chemicals to represent a scientific estimate of the dose below which no appreciable risk of non-cancer effects is likely to occur following chronic exposures. In the case of dioxin and related compounds, calculation of an RfD based on human and animal data and including standard uncertainty factors to account for species differences and sensitive subpopulations would result in a reference intake levels on the order of 10-100 times below the current estimates of daily intake in the general population.” [pg. 51]

How much dioxin is "safe"? EPA's answers: For cancer hazards? Three hundred to 600 times less than we all now take in every day. (See RHWN #390.) For non-cancer hazards? Ten to 100 times less than we all now take in every day.

EPA's "dioxin reassessment" raises one key public policy question: How much additional dioxin is acceptable in the environment? To us, the answer seems clear: zero. To protect public health, no new sources can be allowed, and present sources must be sharply reduced.

--Peter Montague

[1] The "half-life" of dioxins in humans is somewhere between 5.8 years and 7 years [pgs. 13, 20]. (The half-life is the time it takes for half of today's dioxin intake to be excreted.) Therefore, dioxin builds up in our bodies as we age.
