

Dioxins

Dioxins are mainly byproducts of industrial practices. They are produced through a variety of incineration processes, including improper municipal waste incineration and burning of trash, and can be released into the air during natural processes, such as forest fires and volcanoes. Almost every living creature has been exposed to dioxins or dioxin-like compounds (DLCs).

Strict regulatory controls on major industrial sources of dioxin have reduced emissions into the air by 90 percent, compared to levels in 1987.¹

Today people are exposed to dioxins primarily by eating food, in particular animal products, contaminated by these chemicals. Dioxins are absorbed and stored in fat tissue and, therefore, accumulate in the food chain. More than 90 percent of human exposure is through food.²

The National Institute of Environmental Health Sciences (NIEHS) funds research to understand how dioxins affect health and cause disease. The goal is to reduce exposure to dioxins and develop treatments for dioxin-related diseases. Intense work carried out by government agencies, in cooperation with industry, has drastically reduced industrial dioxin emissions in the U.S.

Before safeguards and regulations were introduced, dioxin releases were a major problem in the United States. The U.S. Environmental Protection Agency (EPA) worked with industry to ban products containing dioxin and to curb dioxin emissions. In 1979, the EPA banned the manufacture of products containing polychlorinated biphenyls, or PCBs, some of which are included under the term dioxin.

Reducing Dioxin Exposure



Consumers should eat a balanced diet and follow the 2010 Dietary Guidelines for Americans.³ Each food group provides important nutrients needed for health.

The following steps can reduce the potential for exposure to dioxin:

- Remove skin from fish and chicken
- Select cuts of meat that are naturally lean, or trim visible fat
- When catching your own fish, check local fishing advisories, as there may be consumption limits for particular kinds of fish, in particular bodies of water where local contamination has occurred
- Use fat-free or low-fat milk and use butter in moderation



However, dioxins break down very slowly and emissions released long ago remain in the environment. Some dioxins endure a long time, are extremely resistant to environmental degradation, and therefore are classified as persistent organic pollutants (POPs). Dioxin contamination is an increasing problem in some developing countries, particularly with uncontrolled burning, and dismantling and recycling of electronic products, such as computers.

Health Effects

The dioxin TCDD, or 2,3,7,8-tetrachlorodibenzo-p-dioxin, is a known cancer-causing agent,⁴ and other DLCs are known to cause cancer in laboratory animals. Additionally, dioxin exposure has been linked to a number of other diseases, including type 2 diabetes, ischemic heart disease, and an acne-like skin disease called chloracne, a hallmark of dioxin exposure.



Former Ukrainian President Viktor Yushchenko was intentionally poisoned with dioxin, resulting in facial scarring.

Dioxins can cause developmental problems in children, lead to reproductive and infertility problems in adults, result in miscarriages, damage the immune system, and interfere with hormones.

Exposure to dioxins has widespread effects in nearly every vertebrate species, at nearly every stage of development, including in the womb.

The Science of Dioxins



Dioxins are a family of compounds that share distinct chemical structures and characteristics. Numerous dioxin-like compounds have been identified that are considered to have significant toxicity and can cause disease. The singular term dioxin refers to the most toxic compound, TCDD.

NIEHS researchers continue to explore the detailed chemical pathway through which dioxin damages the body, but scientists are now confident that the first step takes place when dioxin binds to an intracellular protein known as the aryl hydrocarbon receptor (AhR). When that happens, the AhR can alter the expression, or function, of certain genes. The resulting cellular imbalance leads to a disruption in normal cell function and ultimately adverse health effects.

In addition to TCDD, many other chemicals bind to AhR. About 400 compounds in the environment act on the body through the AhR receptor. Public health officials around the world are concerned about the combined effects of multiple chemicals that activate the AhR, and are developing health standards that take into account the fact that people are exposed to mixtures of DLCs, not just one at a time.

The National Toxicology Program (NTP), an interagency program headquartered at NIEHS, has conducted a series of studies in which rodents were exposed to either a single DLC or mixtures of DLCs for up to two years. Analysis of data confirmed that mixtures of DLCs are additive, meaning their effects on health increase in proportion to the toxicity of each DLC in the mixture.^{5,6}

More About NIEHS Research

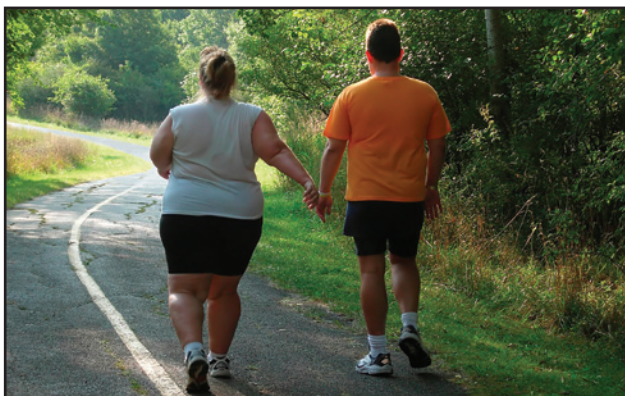
In addition to research being conducted in NIEHS laboratories, NIEHS awards grants to other



scientists who are studying a wide array of dioxin-related health issues. NIEHS, along with the NTP, also organizes and participates in workshops that bring together researchers from around the globe. Together, they multiply their efforts by sharing findings and mapping out new directions for research.

Scientists funded by NIEHS are working on dioxin-related issues from multiple perspectives, including gene interactions and the dioxin receptor. They are also researching the mechanisms through which dioxin functions in various diseases, and are studying populations exposed to high levels of dioxins through accidental releases.

- An NIEHS research team is determining if dioxins alter the way the blood-brain barrier handles therapeutic drugs and, if so, how. The study showed that dioxins appear to reduce the ability of drugs to enter the central nervous system, making it difficult to treat disease.⁷
- Researchers at NIEHS also are studying prenatal and early-life dioxin exposure and links to adult obesity and diabetes.^{8,9}
- Studies have also shown that AhR binds not only to DNA, but also to other proteins. Using that knowledge, NIEHS-funded researchers at the Pennsylvania State University made AhR ligands that bind to other proteins without binding to DNA. This breakthrough led the team to research the possibility of using AhR as a therapeutic target. Already, the researchers have made compounds that show anti-inflammatory activity through AhR.¹⁰



- An NIEHS-funded team at the University of Cincinnati is studying the effects of DLCs on different types of heart cells. In the future, this method could be used to study many different environmental agents and their effect on various organs, genes, and tissues.¹¹
- The Seveso Women's Health Study, underway since 1996, continues to yield troves of information about TCDD exposure and its effects on human health and reproductive issues. Residents of the Italian town were exposed to record amounts of dioxin after an explosion at a chemical plant nearby. Nearly 1,000 women with different levels of exposure, and with exposures at different ages, are participating in studies examining a wide range of issues, from the incidence of breast cancer to tooth defects in their offspring.

Dioxins' Impact

The public health threats posed by dioxins were highlighted dramatically in the public consciousness in the late 1970s and early 1980s. Newspapers and television broadcasts were full of stories about ailing veterans who had been exposed to dioxins through Agent Orange, an herbicide and defoliant used in the Vietnam War.

Concerns about Agent Orange and other DLCs continue today. Research supported by NIEHS and many others, examining the link between dioxin and serious illnesses, has helped lead the U. S. Department of Veteran Affairs (VA) to recognize certain cancers and other health problems as presumptive diseases associated with exposure to Agent Orange or other herbicides during military service. Presumptive diseases are certain diseases that the VA assumes can be related to a Veteran's qualifying military service.¹²

Dioxins were also brought to light in 1982, when the town of Times Beach, Mo., was declared off-limits, because of dioxin contamination.

This incident in Missouri, as well as others, helped spark passage of legislation that created Superfund, the environmental program established to address abandoned hazardous waste sites.¹³



Dioxin emissions have been reduced 90 percent since 1987.

In addition to funding work in labs across the nation, NIEHS administers the Superfund Research Program (SRP). SRP involves a network of university grants that are designed to seek solutions to the complex health and environmental issues associated with the nation's hazardous waste sites.

The research conducted by the SRP is a coordinated effort with the EPA, the federal entity charged with cleaning up the worst hazardous waste sites in the country, including those contaminated with dioxins.

Today, the hazards posed by dioxins have faded from public view. And, in fact, the extent

of the hazard has diminished in the U.S., as environmental controls significantly reduced the introduction of new industrial sources of dioxin.

However, the problem has not vanished, and the scientific community has continued its work to reduce exposures and treat diseases that arise from them.



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- ¹ EPA (Environmental Protection Agency). 2012. Dioxin Science Assessment Consumer Fact Sheet. Available: http://www.epa.gov/dioxin/pdfs/EPA_Dioxin-Factsheet-2012.pdf [Accessed 04 June 2012].
- ² WHO (World Health Organization) 2010. Dioxins and their effects on human health (Fact Sheet No. 225). Available: <http://www.who.int/mediacentre/factsheets/fs225/en/> [Accessed 14 June 2012].
- ³ USDA (U.S. Department of Agriculture). 2010. Dietary Guidelines for Americans, 2010. Available: <http://www.cnpp.usda.gov/dgas2010-policydocument.htm> [Accessed 19 June 2010].
- ⁴ NIH (National Institutes of Health). 2001. Press Release: TCDD – Dioxin — Is Listed as ‘Known Human Carcinogen’ in Federal Government’s “Ninth Report on Carcinogens.” Available: <http://www.nih.gov/news/pr/jan2001/niehs-19.htm> [Accessed 04 June 2012]. 1
- ⁵ NTP (National Toxicology Program). 2006. Long-Term Study Reports and Abstracts: TR-520, TR-521, TR-525, TR-526. Available: <http://ntp.niehs.nih.gov/?objectid=D16D6C59-F1F6-975E-7D23D1519B8CD7A5> [Accessed 14 June 2012].
- ⁶ Walker NJ, Crockett PW, Nyska A, Brix AE, Jokinen MP, Sells DM, Hailey JR, Easterling M, Haseman JK, Yin M, Wyde ME, Bucher JR, Portier CJ. 2005. Dose-additive carcinogenicity of a defined mixture of “dioxin-like compounds”. *Environ Health Perspect* 113(1):43-8. 1
- ⁷ Wang X, Hawkins BT, Miller DS. 2011. Aryl hydrocarbon receptor-mediated up-regulation of ATP-driven xenobiotic efflux transporters at the blood-brain barrier. *FASEB J* 25(2):644-652.
- ⁸ Thayer KA, Heindel JJ, Bucher JR, Gallo MA. 2012. Role of environmental chemicals in diabetes and obesity: a national toxicology program workshop review. *Environ Health Perspect* 120(6):779-789. 1
- ⁹ La Merrill M, Birnbaum LS. 2011. Childhood obesity and environmental chemicals. *Mt Sinai J Med* 78(1):22-48.
- ¹⁰ Perdew, GH. 2008. Ah receptor binding to its cognate response element is required for dioxin-mediated toxicity. *Toxicol Sci* 106 (2): 301-303.
- ¹¹ Puga A. 2011. Perspectives on the potential involvement of the AH receptor-dioxin axis in cardiovascular disease. *Toxicol Sci* 120(2): 256-261.
- ¹² VA (U.S. Department of Veteran’s Affairs). 2012. Veterans’ Diseases Associated with Agent Orange Available: <http://www.publichealth.va.gov/exposures/agentorange/diseases.asp> [Accessed 18 June 2012].
- ¹³ EPA (U.S. Environmental Protection Agency). 2012. Superfund: Basic Information. Available: <http://www.epa.gov/superfund/about.htm> [Accessed 04 June 2012].