

**Chapter 1 : Polychlorinated Biphenyls (PCBs), Organochlorine Pesticides, and Neurodevelopment**

*A polychlorinated biphenyl (PCB) is an organic chlorine compound with the formula  $C_{12}H_{10-x}Cl_x$ . Polychlorinated biphenyls were once widely deployed as dielectric and coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids.*

They have been shown to cause cancer in animals as well as a number of serious non-cancer health effects in animals, including: Studies in humans support evidence for potential carcinogenic and non-carcinogenic effects of PCBs. The different health effects of PCBs may be interrelated. Alterations in one system may have significant implications for the other systems of the body. The potential health effects of PCB exposure are discussed in greater detail below. Cancer Did you know? EPA uses an approach that permits evaluation of the complete carcinogenicity database and allows the results of individual studies to be viewed in the context of all of the other available studies. Studies in animals provide conclusive evidence that PCBs cause cancer. Studies in humans raise further concerns regarding the potential carcinogenicity of PCBs. Taken together, the data strongly suggest that PCBs are probable human carcinogens. PCBs are one of the most widely studied environmental contaminants. Many studies in animals and human populations have been performed to assess the potential carcinogenicity of PCBs. At that time, data was limited to Aroclor The reassessment was peer reviewed by 15 experts on PCBs, including scientists from government, academia and industry. EPA uses an approach that permits evaluation of the complete carcinogenicity database, and allows the results of individual studies to be viewed in the context of all of the other available studies. The cancer reassessment determined that PCBs are probable human carcinogens, based on the following information: EPA reviewed all of the available literature on the carcinogenicity of PCBs in animals as an important first step in the cancer reassessment, which presented clear evidence that PCBs causes cancer in animals. An industry scientist commented that "all significant studies have been reviewed and are fairly represented in the document". An industry-sponsored peer-reviewed rat study, characterized as the "gold standard study" by one peer reviewer, demonstrated that every commercial PCB mixture tested caused cancer. The reassessment provided EPA with sufficient information to develop a range of potency estimates for different PCB mixtures, based on the incidence of liver cancer and in consideration of the mobility of PCBs in the environment. The reassessment resulted in a slightly decreased cancer potency estimate for Aroclor relative to the estimate due to the use of additional dose-response information for PCB mixtures and refinements in risk assessment techniques e. The reassessment concluded that the types of PCBs likely to be bioaccumulated in fish and bound to sediments are the most carcinogenic PCB mixtures. In addition to the animal studies, a number of epidemiological studies of workers exposed to PCBs have been performed. Results of human studies raise concerns for the potential carcinogenicity of PCBs. Studies of PCB workers found increases in rare liver cancers and malignant melanoma. The presence of cancer in the same target organ liver following exposures to PCBs both in animals and in humans and the finding of liver cancers and malignant melanomas across multiple human studies adds weight to the conclusion that PCBs are probable human carcinogens. Some of the studies in humans have not demonstrated an association between exposures to PCBs and disease. However, epidemiological studies share common methodological limitations that can affect their ability to discern important health effects or define them as statistically significant even when they are present. Often, the number of individuals in a study is too small for an effect to be revealed, or there are difficulties in determining actual exposure levels, or there are multiple confounding factors factors that tend to co-occur with PCB exposure, including smoking, drinking of alcohol, and exposure to other chemicals in the workplace. Epidemiological studies may not be able to detect small increases in cancer over background unless the cancer rate following contaminant exposure is very high or the exposure produces a very unusual type of cancer. However, studies that do not demonstrate an association between exposure to PCBs and disease should not be characterized as negative studies. These studies are most appropriately viewed as inconclusive. Limited studies that produce inconclusive findings for cancer in humans do not mean that PCBs are safe. It is very important to note that the composition of PCB mixtures changes following their release into the environment. The types of PCBs that tend to bioaccumulate

in fish and other animals and bind to sediments happen to be the most carcinogenic components of PCB mixtures. As a result, people who ingest PCB-contaminated fish or other animal products and contact PCB-contaminated sediment may be exposed to PCB mixtures that are even more toxic than the PCB mixtures contacted by workers and released into the environment. Non-Cancer Effects EPA evaluates all of the available data in determining the potential noncarcinogenic toxicity of environmental contaminants, including PCBs. Based on extensive studies conducted using environmentally relevant doses, EPA found clear evidence that PCBs have significant toxic effects in animals, including non-human primates. As a result, it is not surprising that PCBs can exert a multitude of serious adverse health effects. Immune Effects Did you know? It is one of the most common human viruses and is found all over the world. EBV spreads most commonly through bodily fluids, primarily saliva. Centers for Disease Control The immune system is critical for fighting infections, and diseases of the immune system have very serious potential implications for the health of humans and animals. The immune effects of PCB exposure have been studied in Rhesus monkeys and other animals. It is important to note that the immune systems of Rhesus monkeys and humans are very similar. Studies in monkeys and other animals have revealed a number of serious effects on the immune system following exposures to PCBs: This is a standard laboratory test that determines the ability of an animal to mount a primary antibody response and develop protective immunity Decreased resistance to Epstein-Barr virus and other infections in PCB-exposed animals Individuals with diseases of the immune system may be more susceptible to pneumonia and viral infections. The animal studies were not able to identify a level of PCB exposure that did not cause effects on the immune system. In humans, a recent study found that individuals infected with Epstein-Barr virus had a greater association of increased exposures to PCBs. It also increased the risk of non-Hodgkins lymphoma more than for those who had no Epstein-Barr infection. This finding is consistent with increases in infection with Epstein Barr virus in animals exposed to PCBs. Immune effects were also noted in humans who experienced exposure to rice oil contaminated with PCBs, dibenzofurans and dioxins. Taken together, the studies in animals and humans suggest that PCBs may have serious potential effects on the immune systems of exposed individuals. Reproductive Effects Reproductive effects of PCBs have been studied in a variety of animal species, including Rhesus monkeys, rats, mice and mink. Rhesus monkeys are generally regarded as the best laboratory species for predicting adverse reproductive effects in humans. Potentially serious effects on the reproductive system were seen in monkeys and a number of other animal species following exposures to PCB mixtures. Most significantly, PCB exposures were found to reduce the birth weight, conception rates and live birth rates of monkeys and other species; and PCB exposure reduced sperm counts in rats. Effects in monkeys were long lasting and were observed long after the dosing with PCBs occurred. Studies of reproductive effects have also been carried out in human populations exposed to PCBs. Children born to women who worked with PCBs in factories showed decreased birth weight and a significant decrease in gestational age with increasing exposures to PCBs. Studies in fishing populations believed to have high exposures to PCBs also suggest similar decreases. This same effect was seen in multiple species of animals exposed to PCBs, and suggests that reproductive effects may be important in humans following exposures to PCBs. Neurological Effects Proper development of the nervous system is critical for early learning and can have potentially significant implications for the health of individuals throughout their lives. Effects of PCBs on nervous system development have been studied in monkeys and a variety of other animal species. Newborn monkeys exposed to PCBs showed persistent and significant deficits in neurological development, including visual recognition, short-term memory and learning. Some of these studies were conducted using the types of PCBs most commonly found in human breast milk. Studies in humans have suggested effects similar to those observed in monkeys exposed to PCBs, including learning deficits and changes in activity associated with exposures to PCBs. The similarity in effects observed in humans and animals provide additional support for the potential neurobehavioral effects of PCBs. Endocrine Effects There has been significant discussion and research on the effects of environmental contaminants on the endocrine system "endocrine disruption". While the significance of endocrine disruption as a widespread issue in humans and animals is a subject of ongoing study, PCBs have been demonstrated to exert effects on thyroid hormone levels in animals and humans. Thyroid hormone levels are critical for normal

growth and development, and alterations in thyroid hormone levels may have significant implications. It has been shown that PCBs decrease thyroid hormone levels in rodents. Research has also shown that these decreases result in developmental deficits in rodents, including deficits in hearing. PCB exposures have been associated with changes in thyroid hormone levels in infants in studies conducted in the Netherlands and Japan. Additional research will be required to determine the significance of these effects in the human population. A variety of other non-cancer effects of PCBs have been reported, including the following: Each IRIS assessment can cover a chemical, a group of related chemicals, or a complex mixture.

**Chapter 2 : Learn about Polychlorinated Biphenyls (PCBs) | Polychlorinated Biphenyls (PCBs) | US EPA**

*Polychlorinated biphenyls (PCBs) are a mixture of individual chemicals which are no longer produced in the United States, but are still found in the environment. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children.*

This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. Polychlorinated biphenyls are mixtures of up to individual chlorinated compounds known as congeners. There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U. The manufacture of PCBs was stopped in the U. Products made before that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils. PCBs entered the air, water, and soil during their manufacture, use, and disposal; from accidental spills and leaks during their transport; and from leaks or fires in products containing PCBs. PCBs can still be released to the environment from hazardous waste sites; illegal or improper disposal of industrial wastes and consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes in incinerators. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, a small amount of PCBs may remain dissolved, but most stick to organic particles and bottom sediments. PCBs also bind strongly to soil. PCBs are taken up by small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water. Using old fluorescent lighting fixtures and electrical devices and appliances, such as television sets and refrigerators, that were made 30 or more years ago. These items may leak small amounts of PCBs into the air when they get hot during operation, and could be a source of skin exposure. The main dietary sources of PCBs are fish especially sportfish caught in contaminated lakes or rivers, meat, and dairy products. Breathing air near hazardous waste sites and drinking contaminated well water. In the workplace during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights, and other old electrical devices; and disposal of PCB materials. The most commonly observed health effects in people exposed to large amounts of PCBs are skin conditions such as acne and rashes. Studies in exposed workers have shown changes in blood and urine that may indicate liver damage. PCB exposures in the general population are not likely to result in skin and liver effects. Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs. Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects. Few studies of workers indicate that PCBs were associated with certain kinds of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate food containing high levels of PCBs for two years developed liver cancer. Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. Babies born to women who ate PCB-contaminated fish also showed abnormal responses in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in

children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects caused by exposure to PCBs or of health effects of PCBs in older children. The most likely way infants will be exposed to PCBs is from breast milk. You and your children may be exposed to PCBs by eating fish or wildlife caught from contaminated locations. Certain states, Native American tribes, and U. Children should be told not play with old appliances, electrical equipment, or transformers, since they may contain PCBs. Children should be discouraged from playing in the dirt near hazardous waste sites and in areas where there was a transformer fire. Children should also be discouraged from eating dirt and putting dirty hands, toys or other objects in their mouths, and should wash hands frequently. If you are exposed to PCBs in the workplace it is possible to carry them home on your clothes, body, or tools. If this is the case, you should shower and change clothing before leaving work, and your work clothes should be kept separate from other clothes and laundered separately. Tests exist to measure levels of PCBs in your blood, body fat, and breast milk, but these are not routinely conducted. Most people normally have low levels of PCBs in their body because nearly everyone has been environmentally exposed to PCBs. The tests can show if your PCB levels are elevated, which would indicate past exposure to above-normal levels of PCBs, but cannot determine when or how long you were exposed or whether you will develop health effects. The EPA has set a limit of 0. Discharges, spills or accidental releases of 1 pound or more of PCBs into the environment must be reported to the EPA. The Food and Drug Administration FDA requires that infant foods, eggs, milk and other dairy products, fish and shellfish, poultry and red meat contain no more than 0. Many states have established fish and wildlife consumption advisories for PCBs. If you have questions or concerns, please contact your community or state health or environmental quality department or: For more information, contact:

**Chapter 3 : pcbs | PCB Testing**

*Fact Sheet 12 What Are The Human Health Effects Of PCBs? Polychlorinated biphenyls are a group of different chemicals which share a common structure but vary in the number of attached chlorine atoms.*

Needs references[ edit ] Many statements in this article need references. I will try to provide them as I have time, but any help is appreciated. Indeed, they are when they escape into the environment, but initially they were a rather powerful enabling technology in electrical power generation, were they not? Excellent chemicals for what they were originally used for. No one saw the long term health effects. GE was present at the meeting, since it was a kind of electrical industry powwow. The Drinker Study indicated that there was liver necrosis in workers exposed to the substance. So from right at the beginning of commercial production, there was the long term health issue. This is from my article in Sierra magazine Public Health Service, and state health officials from Massachusetts and Connecticut. But that was easily said but not so easily done. Brown stressed the "necessity of not creating mob hysteria on the part of workmen in the plants" where chemical-safety inspections were being made. Problems with PCBs and naphthalenes, he predicted, "may continue, probably will continue for years. A study of PCB-oil mixtures manufactured by Westinghouse and GE demonstrated that liver damage could be caused by skin contact alone, and called for the "greatest personal hygiene" in minimizing exposure. In further research for Monsanto, Drinker warned that adequate ventilation was necessary when handling the chemicals. Is there some way some of this information can be included in the history section without copyright issues? Parts of it also appear opinionated, and the section as a whole is uncited thus rendering it worthless to someone like me doing research. Internal leaked documents released ex post facto show that Monsanto Chemical Company knew increasingly more about the harmful effects of PCBs to humans and the environment through the s. Please correct me if i am wrong. Many sources are available. I chose one on an EWG website that documents the issue extensively. Washington Post had relevant articles, if more reference is needed. I opened a thread at RSN here. Would you be able to suggest a reliable source, Jytdog? This topic has also been covered by the Washington Post, though i find those news stories to be missing recently from the web, strangely. Would that be acceptable to you? Common Dreams has a story here that is the same article that was published on the Washington Post, as it says in the byline of "Published on Tuesday, January 01, by the Washington Post". The author of the article is Michael Grunwald. It is in the newspaper, archived, somewhere. LexisNexis has old newspaper articles and your local library probably has a subscription to it. Thanks for the advice. Indeed, i found it there: A01, words, Michael Grunwald, Washington Post Staff Writer I do see the full text of the original Washington Post story by Grunwald, words long, and it does support the sentence i originally used the website you objected to, to support. Work dating back to Anderson et al, Environ. Work has been done to sensitize PCBs to solar wavelengths Manzano et al, Chemosphere, , 57, , but if this takes place at all in the atmosphere, it would be negligible compared to the OH radical pathway. They can be found here [http:](http://) I suggest reverting it back to include your addition unless they can provide a good reason for removing it. So I reverted it too. The cite for this statement is Lauby-Secretan et al I propose that the sentence simply be deleted. If you claim that it is fact since PCBs are on a government list as a carcinogen, please research saccharine and see how it was on a government list at one time also. Clearly the article needs more information on the controversy and cited sources, though. PCB are comprhensively studied carcinogens, and the references provided by abover poster are a GE funded epidimeological syudy, and a New York Times review article of said study. Below please find several recent references from the scientific literature detailed toxicity and mechanism for PCB. Cancer initiation by PCBs. Differential disrupting effects of polychlorinated biphenyl isomers on homeostasis of thyroid hormone and retinoid in mice. Organohalogen Compounds , 63 Mechanisms of hepatic tumor promotion by polychlorinated biphenyl mixtures. Dean, Charles Edward, Jr. I agree that the NPOV tag should be removed. It looks like the POV tag may have been erroneously restored in anti-vandal effort. It can be put back in with a source. Superm - Talk There is a reference on the dioxin page to Olestra therapy, which I will copy over. I went through a fast search in PubMed and there is only one paper on Olestra having effects after Arochlor

poisoning. Treatment with a dietary fat substitute decreased Arochlor contamination in an obese diabetic male. Olestra increases faecal excretion of 2,3,7,8-tetrachlorodibenzo-p-dioxin. Olestra has also been used in a clinical setting for TCDD exposure: Severe 2,3,7,8-tetrachlorodibenzo-p-dioxin TCDD intoxication: All dioxins, by virtue of their structure, are planar due to the dual oxygen linkage between the chlorinated rings. PCBs have a single linkage and therefore the rings may be able to rotate outside of a coplanar configuration. This is mostly dependent on the positions of the substituent chlorines. For example, the rings will be forced out of a coplanar configuration if there are multiple ortho chlorines. This leads to a wide variation in biological effects between various PCB congeners. The ortho substituted PCBs are quite non-coplanar, and thus have different toxicokinetics. However, they may have similar hydrophobicities, which I think is probably the relevant parameter in regards to solubility in olestra. I have edited that passage accordingly. If Congress banned their domestic production, how can "some uses continue"? Are the chemicals imported? Inquiring minds would like to know. While I was at it, I removed the word dielectric from its use in transformers, as the chemical is used there as an insulator dielectrics are for capacitors. In other words, how can you use something without also producing it? The ban did not require electrical utilities, for example, to remove 10 year old transformers with a useful life of 50 years from power poles. Many older transformers and other large electrical components that contained PCBs that were manufactured when it was still legal remain in use. I would like to correct it from " The sentence which dil quotes in defense of his point of view, "From their use was banned in "open" or "dissipative" sources Can anyone contribute a source here? Featured Article Status[ edit ] Where are we at now and what needs to be done to make this a featured article? Not enough to make a difference. However, healthy nursing mothers in Japan have 0. It is mentioned in the article that some PCBs exhibit dioxin-like toxicity, this ranges from 10x to ,x less potent than 2,3,7,8-TCDD, the prototypical dioxin, and many PCBs show no dioxin-like activity. Therefore it would be very possible to have a large amount of PCBs in terms of concentration, but still a relatively small amount of "dioxin" using the TEF system, I think perhaps this article should be linked much more closely with "Dioxin" as many cases listed as PCB contamination, such as Ireland , are in fact more widely considered as Dioxin contamination incidents. A little joined up thinking on both areas may be useful to clarify and prevent duplication of information. Robert Brown reminded chemists in that Arochlors were "objectionably toxic. Thus the maximum permissible concentration for an 8-hr. They also produce a "serious and disfiguring dermatitis". Does anyone know where to place the second quotation mark? Alternatively, there may be an extra mark the one in the middle that needs to be removed. I do not have access to the referenced book Brown, , so it would be helpful if someone who does could resolve this discrepancy. A list of reactions that the material does not undergo is potentially useful but only for reactions that might reasonably be applicable one can always long list things that do not happen! It might be useful to layout the chemical processes by which PCBs are prepared and their main reactions nucleophilic substitution, probably. I am not sure of the point here, especially for the languages that do not use our alphabet. The names for English-speaking countries should possibly be a serial list vs column. Also are these redirects? There is significant redundancy here as well. According to the regulators, is there only one PCB classification? Readers would probably be interested in knowing where this material is still being used and made. Thank you for your time and i hope u will help us to make our community cleaner. While it rambles, there is but one word to which i can assign no sensible meaning -- Ah, and in fact, it is perhaps a ref to " kidney [damage] "!

Chapter 4 : Polychlorinated biphenyl - Wikipedia

*The biodegradation of polychlorinated biphenyls (PCBs) relies on the ability of aerobic microorganisms such as Burkholderia xenovorans sp. LB to tolerate two potential modes of toxicity presented by PCB degradation: passive toxicity, as hydrophobic PCBs potentially disrupt membrane and protein function, and degradation-dependent toxicity from intermediates of incomplete degradation.*

Polychlorinated biphenyls PCBs are a family of chemicals with varying numbers of chlorine atoms attached in varying positions to two connected benzene rings Figure 1. Commercial PCB products are always mixtures of PCBs and are usually contaminated with small amounts of polychlorinated dibenzofurans furans or polychlorinated dibenzodioxins dioxins. Contamination by furans is a concern because their toxicity is generally much greater than that of PCBs. Integrating a Missing Element into Medical Education. The National Academies Press. PCBs have also been used in inks and carbonless paper. They evaporate slowly at room temperature; however, their volatility increases dramatically with small increases in temperature. Overheated equipment that contains PCBs can vaporize significant quantities of these compounds, causing an inhalation hazard, especially in areas where ventilation is poor. Today PCBs are found mainly in transformers and capacitors manufactured before the U. Many of these old transformers and capacitors are still contained in industrial equipment such as welding equipment , medical equipment such as X-ray machines , and household appliances such as refrigerators. Ballasts of fluorescent light fixtures may contain PCBs. During normal lighting operation, the PCBs are entirely enclosed; however, when the capacitor wears out, it may burn or break and leak PCBs. PCBs can be released into the general environment from poorly maintained toxic waste sites; by illegal or improper dumping of PCB wastes, such as transformer fluids; through leaks or fugitive emissions from electrical transformers containing PCBs; and by disposal of PCB-containing consumer products in municipal landfills. The chemical stability of these synthetic compounds accounts for their persistence in the environment. Another important reason for their persistence is their resistance to biodegradation. Low levels of PCBs can be found throughout the world. PCBs in water or on soil surfaces evaporate and return to earth by rainfall or settling of dust particles. Because PCBs strongly adsorb to soil particles, significant leaching from soil and translocation to plants do not occur. Department of Health and Human Services. Page Share Cite Suggested Citation: Food can be a major source of PCB exposure, usually from fish and animal fat. PCBs are lipophilic; they preferentially separate from water and adsorb to sediment. Bottom feeders and other aquatic organisms then ingest and accumulate PCBs, resulting in bioconcentration upward in the food chain. Composite analysis of commercial whole fish collected from Lake Ontario in found PCB levels of 0. The toxicity of PCBs was dramatically illustrated in when over people in Japan were poisoned by cooking oil contaminated with PCBs from a heat transfer unit. The contaminating oil likely contained furans and dioxins, compounds generally more toxic than PCBs themselves. The discharge has also resulted in a gummy residue on tools and other surfaces. He mentions he sometimes feels dizzy and nauseated after working in the basement all day. Is there an association between the clinical findings and this additional information?

**Chapter 5 : Questions & Answers - PCBs | Region 9: Toxics | US EPA**

*Polychlorinated biphenyls, or PCBs, are a group of man-made compounds that generally occur as complex mixtures. PCBs are very persistent, lasting for decades in the environment. Like other persistent, bioaccumulative, and toxic chemicals, PCBs move easily between air, water, and land and are found throughout Washington.*

These were sold under trade names followed by a four-digit number. In general, the first two digits refer to the product series as designated by Monsanto e. It is a myth that the first two digits referred to the number of carbon atoms; the number of carbon atoms do not change in PCBs. Different Aroclors were used at different times and for different applications. In electrical equipment manufacturing in the US, Aroclor and Aroclor were the main mixtures used before ; Aroclor was the main mixture used in the s and s until it was phased out in and replaced by Aroclor The United States was the single largest producer with over , tonnes produced between and The European region follows with nearly , tonnes through It is unlikely that a full inventory of global PCB production will ever be accurately tallied, as there were factories in Poland, East Germany, and Austria that produced unknown amounts of PCBs. In an electric arc, PCBs generate incombustible gases. Use of PCBs is commonly divided into closed and open applications. In contrast, the major open application of PCBs was in carbonless copy "NCR" paper , which even presently results in paper contamination. Environmental transport and transformations[ edit ] PCBs have entered the environment through both use and disposal. The environmental fate of PCBs is complex and global in scale. The immense volume of water in the oceans is still capable of dissolving a significant quantity of PCBs. The atmosphere serves as the primary route for global transport of PCBs, particularly for those congeners with one to four chlorine atoms. For instance, ducks can accumulate PCBs from eating fish and other aquatic life from contaminated rivers, and these can cause harm to human health or even death when eaten. Phase I reactions occur by adding an oxygen to either of the benzene rings by Cytochrome P However, some metabolites of PCBs containing ortho- meta protons have increased steric hindrance from the oxygen, causing increased stability and an increased chance of accumulation. Looking at the PCB metabolism in the liver of four sea turtle species green, olive ridley , loggerhead and hawksbill , green and hawksbill sea turtles have noticeably higher hydroxylation rates of PCB 52 than olive ridley or loggerhead sea turtles. This is because the green and hawksbill sea turtles have higher P 2-like protein expression. This protein adds three hydroxyl groups to PCB 52, making it more polar and water-soluble. P 3-like protein expression that is thought to be linked to PCB 77 metabolism, something that was not measured in this study. The rate of PCB metabolism was temperature dependent in yellow perch *Perca flavescens*. In fall and winter, only 11 out of 72 introduced PCB congeners were excreted and had half-lives of more than 1, days. The main excretion processes were fecal egestion, growth dilution and loss across respiratory surfaces. Since the perch is performing more functions in the warmer months, it naturally has a faster metabolism and has less PCB accumulation. However, multiple cold-water periods mixed with toxic PCBs with coplanar chlorine molecules can be detrimental to perch health. This was looked at in bowhead whales *Balaena mysticetus* for two main reasons: They found that the average PCB concentrations in the blubber were approximately four times higher than the liver; however, this result is most likely age- and sex-dependent. As reproductively active females transferred PCBs and other poisonous substances to the fetus, the PCB concentrations in the blubber were significantly lower than males of the same body length less than 13 meters. The coplanar PCBs, known as nonortho PCBs because they are not substituted at the ring positions ortho to next to the other ring, such as PCBs 77, and , tend to have dioxin -like properties, and generally are among the most toxic congeners. Because PCBs are almost invariably found in complex mixtures, the concept of toxic equivalency factors (TEFs) has been developed to facilitate risk assessment and regulation, where more toxic PCB congeners are assigned higher TEF values on a scale from 0 to 1. Once exposed, some PCBs may change to other chemicals inside the body. Studies in workers exposed to PCBs have shown changes in blood and urine that may indicate liver damage. Stored PCBs in the adipose tissue become mobilized into the blood when individuals begin to crash diet. PCBs, depending on the specific congener, have been shown to both inhibit and imitate estradiol , the main sex hormone in females. Imitation of the estrogen compound can feed

estrogen-dependent breast cancer cells, and possibly cause other cancers, such as uterine or cervical. Inhibition of estradiol can lead to serious developmental problems for both males and females, including sexual, skeletal, and mental development issues. It also resulted in reduced immunity and increased thyroid disorders. In Japan, birds died after eating poultry feed that was contaminated with PCBs. Exposure to PCBs causes hearing loss and symptoms similar to hypothyroidism in rats. EPA, PCBs have been shown to cause cancer in animals and evidence supports a cancer-causing effect in humans. Even units not originally filled with PCB may be contaminated, since PCB and oil mix freely and any given transformer may have been refilled from hoses or tanks also used with PCBs. In the first "PCB-like" chemical was discovered, and was found to be a byproduct of coal tar. Years later in , German chemists synthesized the first PCB in a laboratory. Between then and , large amounts of PCBs were released into the environment, to the extent that there are still measurable amounts of PCBs in feathers of birds currently held in museums. PCBs, originally termed "chlorinated diphenyls", were commercially produced as mixtures of isomers at different degrees of chlorination. The electric industry used PCBs as a non-flammable replacement for mineral oil to cool and insulate industrial transformers and capacitors. PCBs were also commonly used as heat stabilizer in cables and electronic components to enhance the heat and fire resistance of PVC. In a U. Public Health Service official described the wife and child of a worker from the Monsanto Industrial Chemical Company who exhibited blackheads and pustules on their skin. In , a conference about the hazards was organized at Harvard School of Public Health , and a number of publications referring to the toxicity of various chlorinated hydrocarbons were published before Thus the maximum permissible concentration for an 8-hr. They also produce a serious and disfiguring dermatitis ". Kaneka Corporation first produced PCBs, and continued until Despite active research spanning five decades, extensive regulatory actions, and an effective ban on their production since the s, PCBs still persist in the environment and remain a focus of attention. Over 9 million chickens, and 60, pigs were destroyed because of the contamination. The extent of human health effects has been debated, in part because of the use of differing risk assessment methods. One group predicted increased cancer rates, and increased rates of neurological problems in those exposed as neonates. A second study suggested carcinogenic effects were unlikely and that the primary risk would be associated with developmental effects due to exposure in pregnancy and neonates. Research on the adult population of Brescia showed that residents of some urban areas, former workers of the plant, and consumers of contaminated food, have PCB levels in their bodies that are in many cases times higher than reference values in comparable general populations. Contaminated cooking oil sickened more than people. This request for withdrawal of pork products was confirmed in a press release by the Food Safety Authority of Ireland on December 6. The resulting combustion produced a highly toxic mixture of PCBs, dioxins and furans , which was included in the feed produced and subsequently fed to a large number of pigs. When used for frying, it is reported that transformer oil lasts much longer than regular cooking oil. The downside of this misuse of the transformer oil is the threat to the health of the consumers, due to the presence of PCBs. Due to the wastewater and improperly disposed waste products, the area including the Krupa and Lahinja rivers became highly contaminated with PCBs. The pollution was discovered in , when the Krupa river was meant to become a water supply source. The area was sanitized then, but the soil and water are still highly polluted. During this period, waste matter, including PCBs, from the Newport site was dumped at a disused quarry near Groes-faen , west of Cardiff , and Penhros landfill site [91] from where it continues to be released in waste water discharges. Striped dolphins , bottlenose dolphins and killer whales were found to have mean levels that markedly exceeded all known marine mammal PCB toxicity thresholds. Donald Stewart, former Senator from Alabama, first learned of the concerns of hundreds of west Anniston residents after representing a church which had been approached about selling its property by Monsanto. Stewart went on to be the pioneer and lead attorney in the first and majority of cases against Monsanto and focused on residents in the immediate area known to be most polluted. Other attorneys later joined in to file suits for those outside the main immediate area around the plant; one of these was the late Johnnie Cochran. In , the highest pollution levels remained concentrated in Snow and Choccolocco Creeks. They were able to trace the source of the PCBs back to the Outboard Marine Corporation that was producing boat motors next to the harbor. By , the Outboard Marine Corporation was court-ordered to release quantitative data referring to their

PCB waste released. Concerns have been raised regarding the removal of PCBs from the karst.

**Chapter 6 : Polychlorinated Biphenyls Program**

*Because of their insulating and nonflammable properties, PCBs have been used as heat exchange and dielectric fluids in transformers and capacitors, hydraulic and lubricating fluids, diffusion pump oils, plasticizers, extenders for pesticides, and as ingredients of caulking compounds, paints, adhesives, and flame retardants.*

**Abstract Purpose of review** Although environmental levels of polychlorinated biphenyls PCBs and certain organochlorine pesticides – hexachlorobenzene HCB , dichlorodiphenyl trichloroethane DDT and its primary metabolite, dichlorodiphenyl dichloroethene DDE – are generally on the decline, early-life exposures to these prevalent contaminants continue. This review will describe current understanding of the potential neurodevelopmental consequences of low-level exposures to these contaminants. However, despite almost 30 years of research, results of human studies are inconsistent regarding the nature of the observed effects and their persistence over time. Overall, epidemiologic studies support modest associations of primarily prenatal PCB exposures with differences in neuromotor development, decrements in cognition, and behavioral deficits, particularly regarding attention and impulse control. Effective control of exposure is complicated by variable exposure sources and variable contaminant levels in food, particularly fish, for which it is important to balance the risk of contaminants with nutritional benefits. The relation of these organochlorines with premature birth, fetal growth, neonatal behavior, postnatal growth and maturation, and immune function are reviewed elsewhere [ 1 – 5 ]. Studies with published results include birth cohorts in the U. Background PCBs are lipophilic chemicals first produced in and commonly used in electronics manufacture, as vehicles for pesticides, and in building materials. DDE is one of the major degradation products of DDT, a broad-spectrum insecticide widely used in agriculture and residential settings and for mosquito control in malaria-endemic regions. The use of the fungicide HCB was discontinued in the U. Exposures to these organochlorines have declined, but due to bioaccumulation, deposition in land fills and waste sites, resistance to degradation, presence of PCBs in buildings and electronics, and continued use of DDT for malaria control, exposures are expected to continue for several decades [ 6 ]. Non-occupational exposure to organochlorines occurs primarily via diet for PCBs, particularly via contaminated fish, meat, and dairy products [ 7 , 8 ] but also via inhalation and dermal contact with contaminated soils or sediments [ 9 , 10 ]. Caulking materials used in buildings including schools constructed before may lead to high dust and indoor air PCB levels [ 11 ]. The PCB content of fish depends on location, species, and fat content and may be higher among farmed-raised than wild animals because of aquaculture feeding practices [ 12 ]. Recognition of PCBs as human neurodevelopmental toxicants was largely a consequence of two accidental mass poisonings, in Japan in and Taiwan in . Many of those who consumed PCB-contaminated rice oil and their children became ill [ 13 – 17 ]. Taiwanese children exposed prenatally were at increased risk for a syndrome in infancy of intrauterine growth retardation, liver function and ectodermal abnormalities and, in later childhood, lower weight and height, diminished IQ, and behavioral disorders [ 13 , 17 – 21 ]. The contaminated oil contained high levels of polychlorinated dibenzofurans PCDFs , much more potent toxins than PCBs, obscuring the putative causal agent of these outcomes [ 22 ].

**Prospective Studies** Because PCBs and organochlorine pesticides readily cross the placenta and bioconcentrate in breast milk, early-life exposure occurs via maternal-fetal transfer prenatally and via breastfeeding postnatally. North Carolina Birth Cohort women and their infants born – were enrolled in this longitudinal study in Raleigh-Durham, North Carolina [ 23 ]. Prenatal PCB exposure was associated with neuromotor differences up to age 2 years: There were no postnatal PCB exposure effects. Higher prenatal DDE levels were associated with neonatal hyporeflexia [ 24 ]; otherwise, there were no effects of DDE on developmental outcomes. Michigan Birth Cohort pregnant women who consumed moderate amounts of PCB-contaminated Lake Michigan fish and 71 women who did not consume the fish were enrolled in – [ 28 ]. PCB associations with neuromuscular development were not seen in infancy [ 29 , 30 ]. Eleven-year-olds also had prenatal PCB exposure-associated decrements in executive function, focused attention, and word comprehension [ 34 , 35 ]. This is the oldest group in which persistent prenatal PCB effects have been described. This study by Jacobson et al. At both ages 4 and 11 prenatal exposures were

associated with measures of poor attention and impulse control [ 35 , 36 ], though both were generally only seen among children who were not breastfed. Excepting an association of decreased activity at age 4 with concurrent PCB levels, no postnatal PCB exposure effects were seen [ 33 ]. These are North Atlantic Danish islands where the traditional diet includes whale meat and blubber [ 37 ]. Whale meat is high in methylmercury, and blubber is high in PCBs [ 38 ]. Indeed, serum and milk PCB levels were the highest of the studies reviewed [ 39 ]. The first of these cohorts included 1, children born 1987 with neurodevelopmental assessments and prenatal PCB exposure measures for children at age 7 [ 40 , 41 ]. As reviewed elsewhere in this volume see Oken and Bellinger , the predominant findings relate to neurodevelopmental toxicities of methylmercury exposures. For example, higher prenatal PCB exposure measures were associated with poorer performance on the Boston Naming Test verbal ability and longer reaction times on a continuous performance test an indicator of poor attention at age 7 but these associations were no longer significant after adjustment for methylmercury exposure [ 41 ]. Of note, there was evidence of effect modification by joint exposure. Specifically, the association of PCBs with these outcomes was strongest among children with the highest methylmercury exposure, though the interaction was not significant. In neurophysiologic testing at age 7, possible adverse PCB effects on visual evoked potentials VEPs and brain stem auditory evoked potentials BAEPs , reflecting integrity of sensory afferent neural pathways, were also no longer significant after adjustment for methylmercury [ 41 ]. Dutch Birth Cohort breastfed and formula-fed infants born between and in Rotterdam and Groningen were enrolled [ 42 ]. Early-life PCB exposures were not associated with delayed general cognitive development between 3 and 18 months [ 43 ], but cognitive effects were seen at older ages, with poorer overall cognition on the Kaufman Assessment Battery for Children K-ABC and poorer verbal comprehension on the Reynell Developmental Language Scales RDLS at 42 months [ 44 ]. These associations were specific to formula-fed infants and were not found with postnatal or current exposure. In addition, prenatal PCB exposure was correlated with poorer general cognition, memory, and motor skills on the McCarthy at age 6. There was some evidence that postnatal PCB exposures via breastfeeding diminished executive function at age 9. Although this population was born over a decade later, findings paralleled Michigan findings, notable since both cohorts include a large proportion of mothers who consumed contaminated Great Lakes fish. Behavioral assessments demonstrated consistent PCB associations with poor impulse control. In particular, there were associations of prenatal PCB exposures with errors of commission on various continuous performance tasks CPT at ages 4. Prenatal PCB exposure was associated with poor response inhibition at 9. Duesseldorf Germany Birth Cohort In this study mothers from three Duesseldorf hospitals were recruited in 1996 [ 55 ]. In addition, both pre- and postnatal PCB exposure measures were associated with decrements in general cognition on the K-ABC at 42 months [ 56 ]. First, the Cord Blood Monitoring Program, a study of participants which took place from 1996 and a second study of approximately mothers and their infants enrolled between 1996 to assess Inuit infant health and development [ 57 , 58 ]. The traditional Inuit diet includes marine mammals, substantial sources of organochlorines [ 59 ]. Neurophysiologic assessments of 78 of these children at 5 to 6 years demonstrated an association of current blood PCB levels with increased latency and decreased amplitude of Visual Evoked Potentials VEPs , reflecting presumed perturbations in brain visual processing [ 60 ]. Similar associations were seen for current blood HCB levels. Using archived maternal pregnancy serum samples from a random sample of approximately 1, of these children, no discernible adverse cognitive effects of prenatal PCB exposure were found. Spanish Cohorts Organochlorine emissions from a rural electrochemical factory in Flix, Spain produced unusually high ambient air and serum HCB levels [ 63 ]. HCB exposure and child development is being studied among mother-infant pairs recruited between 1996 in Flix and 5 neighboring villages [ 64 ]. A second cohort of children was recruited from pregnant women seeking prenatal care in 1996 in Menorca, Spain, where high concentrations of organochlorines have been reported [ 65 ]. Recent Studies A number of recently initiated birth cohort studies of organochlorines and child development are underway with results limited to infant and early childhood. In a multiethnic cohort of New York City infants born 1996 , maternal pregnancy blood PCB and DDE levels were not associated with abnormal neonatal reflexes or tone [ 68 ]. In assessments of resulting children, higher maternal serum DDE levels in the first trimester of pregnancy were associated

with reduced BSID PDI scores in the first year of life [ 71 ]. However, study findings differ with respect to observed effects and their persistence. There are a number of possible explanations for variable findings. Study populations vary in sociodemographic features that may confound or modify effects. The study populations also differ in both source and rate of exposure, and there is variability in co-occurring exposures that may confound or modify effects. A good example of this is in the Faroe Islands, where despite high PCB and mercury exposures, no strong independent PCB effects have been ascertained [ 37 , 74 , 75 ]. Still, taken in the aggregate, these studies support the conclusions that: Studies have demonstrated associations of prenatal DDE and DDT exposures with decrements in later infant neuromuscular and cognitive development [ 64 , 70 ] and, for DDT, subsequent childhood cognition through age 4 [ 65 , 70 ]. However, conclusive inferences regarding the neurodevelopmental effects of these organochlorine pesticides will not be possible until more epidemiologic data are available. Studies were performed among generally healthy children, with effects measured as continuous outcomes rather than clinically defined abnormalities. It is important not to underestimate the implications for population health of neurobehavioral differences noted with continuous outcomes [ 76 , 77 ]. Small changes in the mean value of health indicators such as IQ can indicate substantial changes in the prevalence of clinically evident cognitive impairment within a population [ 78 ]. Therefore, limiting early-life exposures to these organochlorines is generally desirable. Although contaminated fish is a key source of PCB exposure, in contrast to methylmercury, there are a number of other foods and environmental exposure sources for organochlorines. Because these compounds bioconcentrate in breastmilk, early-life exposures via nursing can be substantial. However, absent acute toxicities in the mother, in essentially all studies, the beneficial effects of breastfeeding consistently outweigh any potential adverse effect associated with milk organochlorine contaminants. Among other dietary exposure sources, PCB levels for example can vary widely even for a single species of fish [ 12 ]. Furthermore, fish sources of organochlorine exposure are often excellent sources of nutrients beneficial to neurodevelopment [ 84 , 85 ]. Where contamination is severe, local advisories exist for sports fishermen see [http:](http://) However, such advisories are not applicable to the majority of consumers, whose fish comes from markets and restaurants. Findings from a number of ongoing studies are not yet available. Therefore, the interpretation of this body of literature may soon change, and updated findings will better elucidate neurodevelopmental risks of PCBs and persistent organochlorine pesticides and inform exposure prevention efforts. Korrick and Sagiv have no conflicts of interest to report. Developmental effects of PCBs in fish eater cohort studies. University Press of Kentucky; Polychlorinated biphenyls PCBs and neurodevelopment in general population samples. Human health effects of polychlorinated biphenyls. Schecter A, Gasiewicz TA, editors. The human health effects of DDT dichlorodiphenyltrichloroethane and PCBS polychlorinated biphenyls and an overview of organochlorines in public health. Annu Rev Public Health. Effects of PCB exposure on neuropsychological function in children. Developmental neurotoxicity of PCBs in humans: Determinants of serum concentrations of organochlorine compounds in Swedish pregnant women: Dietary exposure to polychlorinated biphenyls and dioxins from infancy until adulthood: A comparison between breast-feeding, toddler, and long-term exposure. Concentrations and chiral signatures of polychlorinated biphenyls in outdoor and indoor air and soil in a major U. Loffler G, van Bavel B. Potential pathways and exposure to explain the human body burden of organochlorine compounds: An unrecognized source of PCB contamination in schools and other buildings.

## Chapter 7 : Scientific Facts on PCBs Polychlorinated biphenyls

*Polychlorinated Biphenyl (PCB) Site Revitalization Guidance Under the Toxic Substances Control Act (TSCA) This document was developed as a guide for complying with TSCA regulations for the cleanup and disposal of PCB contamination.*

Click on the image to see a larger version. Selected References These references are in PubMed. This may not be the complete list of references from this article. Classification of polychlorinated biphenyl residues: Quantitative PCB standards for electron capture gas chromatography. Separation of pure polychlorinated biphenyl isomers into two types of inducers on the basis of induction of cytochrome P or P The relationship between polarizability of polychlorinated biphenyls and their induction of mixed function oxidase activity. The structure-activity relationships of halogenated biphenyls as enzyme inducers. Ann N Y Acad Sci. Polychlorinated biphenyls as inducers of hepatic microsomal enzymes: Immunochemical quantitation of cytochrome P isozymes and epoxide hydrolase in liver microsomes from polychlorinated or polybrominated biphenyl-treated rats. A study of structure-activity relationships. PCB congener analysis of water and caddisfly larvae Insecta: Trichoptera in the upper Hudson River by glass capillary chromatography. Bull Environ Contam Toxicol. The effect of structure on the induction of quail hepatic microsomal enzymes. Effects of a polychlorinated biphenyl and a polychlorinated dibenzofuran on molting of the fiddler crab, *Uca pugilator*. The toxicity of polychlorinated polycyclic compounds and related chemicals. Screening of fresh water fish extracts for enzyme-inducing substances by an aryl hydrocarbon hydroxylase induction bioassay technique. J Assoc Off Anal Chem. Metabolism of dichlorobiphenyls by highly purified isozymes of rat liver cytochrome P Bromobenzene metabolism in the rabbit: Conjugation of organic pollutants in aquatic species. Hepatic microsomal epoxidation of bromobenzene to phenols and its toxicological implication. Metabolic activation and detoxification of bromobenzene leading to cytotoxicity. J Pharmacol Exp Ther. Cytochrome P isozymes and monooxygenase activity in aquatic animals. Structure-activity relationships in halogenated biphenyls: PCB isomers and congeners: Highly toxic coplanar PCBs: Aroclor as a 2,3,7,8-tetrachlorodibenzo-p-dioxin antagonist: Aroclor as an antagonist of the teratogenicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin. Polychlorinated biphenyl isomers and congeners as inducers of both 3-methylcholanthrene- and phenobarbitone-type microsomal enzyme activity. Determination of polychlorinated biphenyls in human foodstuffs and tissues:

## Chapter 8 : Polychlorinated biphenyls PCBs | GreenMedInfo | Toxic Ingredient

*PCBs have also been shown to cause a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system and other health effects.*

## Chapter 9 : ATSDR - ToxFAQsâ„¢: Polychlorinated Biphenyls (PCBs)

*What is a PCB transformer? Polychlorinated biphenyls (PCBs) were used in electrical transformers manufactured between and , with the majority being installed in residential and commercial buildings and industrial facilities prior to*