The Winners of the Blue Planet Prize

2000

2000

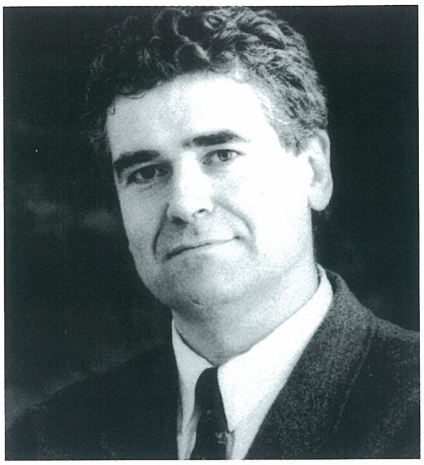
Blue Planet Prize

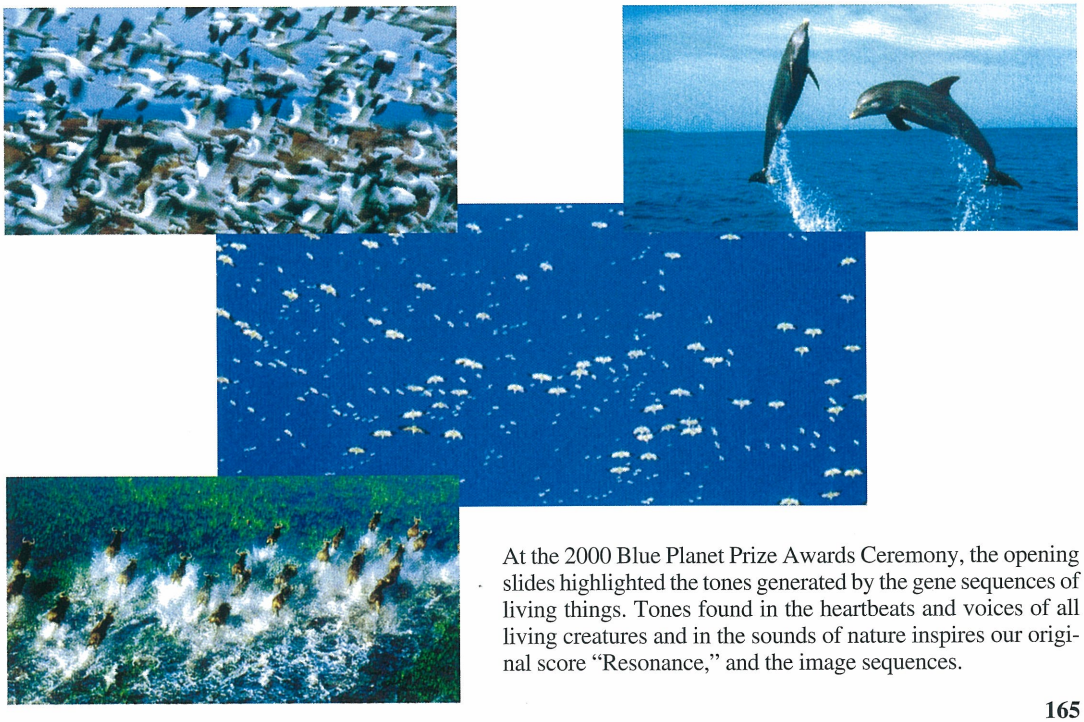
Dr. Theo Colborn (U.S.A.)

Senior Scientist and Director, Wildlife and Contaminants Program, World Wildlife Fund

Dr. Karl-Henrik Robèrt (Sweden)

Chairman of The Natural Step (NGO)





At the 2000 Blue Planet Prize Awards Ceremony, the opening slides highlighted the tones generated by the gene sequences of living things. Tones found in the heartbeats and voices of all living creatures and in the sounds of nature inspires our original score "Resonance," and the image sequences.

His Imperial Highness Prince Akishino congratulates the laureates.

Hiromichi Seya, chairman of the Foundation, delivers the opening address.

The prizewinners receive their trophies and certificates of merit from Chairman Seya.
Upper: Dr. Theo Colborn
Lower: Dr. Karl-Henrik Robèrt

Thomas S. Foley, Ambassador of the United States to Japan (left), and Krister Kumlin, Ambassador of Sweden to Japan (right), congratulate the laureates.

Prior to the awards ceremony, the award recipients meet the press. From right: Dr. Robèrt; Dr. Colborn; Chairman Seya; and Kimihiko Sato, senior executive director of the Foundation.

The Blue Planet Prize Commemorative Lectures.

Profile

Dr. Theo Colborn

Senior Scientist and Director, Wildlife and Contaminants Program, World Wildlife Fund

Education and Academic and Professional Activities

1927	Born in March in the United States.
1947	B.Sc., Pharmacy, Rutgers University.
1981	M.Sc., Fresh Water Ecology, Western State College of Colorado.
1985	Ph.D., Zoology, University of Wisconsin-Madison.
1985-1987	Congressional Fellow, Office of Technology Assessment.
1988-1993	Researcher, World Wildlife Fund.
1990	Fellowship, W. Alton Jones Foundation.
1991	National Water Alliance Award.
1993	Pew Scholars Award.
1993—	Senior Scientist and Director, Wildlife and Contaminants Program, World Wildlife Fund.
1994	National Conservation Achievement Award.
1997	United Nations Environment Programme, Women Leadership in the Environmental Award.
1997	State of the World Forum, Mikhail Gorbachev "Change Makers Award."
1999	Norwegian International "Rachel Carson Prize."

Dr. Colborn investigated declining populations and abnormalities in development, reproduction, behavior and immune systems and other phenomena that had caused concern about wildlife in North America's Great Lakes area in relation to cancer-causing agents. However, she was unable to find a correlation between these data and cancer. At that point, she hypothesized that these phenomena might be related to the disruption of endocrine systems by synthetic chemicals. As she continued to analyze mountains of studies, she confirmed this hypothesis, revealing that certain chemicals being released into the environment were being concentrated via the food chain and disrupting the endocrine systems of wildlife and humans.

In 1991, she invited 21 expert researchers from various disciplines to a conference in Wisconsin State in the United States to scientifically examine the effects of endocrine disruptors on the reproductive, developmental and physiological functions of wildlife and humans. The "Wingspread Consensus Statement" announced by the conference participants advised that the endocrine disruptor chemicals that threatened wildlife were endangering the future survival of humankind, and they informed the world that this was a problem that had to be dealt with expeditiously.

In 1996, Dr. Colborn aroused the world's attention with the publication of *Our Stolen Future* a book she co-authored. It explains in simple terms how persistent synthetic chemicals

are collected in the body, how they cause abnormalities by disrupting the functions of the endocrine system and how they adversely affect the next generation.

Through the submission of her information on these problems, Dr. Colborn prompted the United Nations, the OECD countries, the North American and European countries and Japan to undertake full-fledged studies, research and countermeasures to deal with the problem.

Essay

Say 'No' to Toxic Hitch-hikers

Dr. Theo Colborn

June 2001

Scientists, industrialists and governments are seemingly locked in a perpetual battle over the issue of climate change. As the parties come closer to agreement on the need to address the problem, cost-benefit analyses will drive political decisions on how and what should be done next. It is time that a new set of benefits that have heretofore received little attention should be included in the strategies for reversing the warming trend. Global climate change has clearly been identified as the result of atmospheric accumulation of greenhouse gases that include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6) and a number of the ozone-depleting chlorofluorocarbons. The largest source of these gases that trap and hold heat in the earth's atmosphere is combustion. Combustion of fossil fuels also produces dangerous compounds that pose a threat to our children before they are born, and to their children and grandchildren. These compounds include some well-publicized, persistent, organochlorine chemicals such as dioxins, also called TCDDs, furans, hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs) and trace metals like mercury and cadmium. The amounts of these toxic hitch-hikers might seem insignificant compared to the tons of greenhouse gases that are released. But their impact on human and wildlife health and the global economy is significant. Unfortunately, their toxicity is so great that only the newest, most sensitive instrumentation can measure the concentrations at which they can injure living organisms. Their invisibility, similar to the nature of their toxicity, is so insidious that when environmentalists and climatologists began to focus on the problem of global warming, their role was not yet understood.

Dioxins, furans, HCB and PCBs are associated with serious widespread human and wildlife health problems. Human prenatal exposure to PCBs, dioxins and mercury has been significantly correlated with impaired intelligence, behavior, immune competency, reproductive success and metabolism. Wildlife exposure to these same chemicals, especially in aquatic systems where the chemicals readily biomagnify in the food web, has led to severe reproductive problems in a number of species with occasional regional extirpation of some populations. The economic benefits from lowering emissions of these compounds could be astronomical. Reductions would improve the quality of life and assure the integrity and perpetuation of all species, including humans.

The Great Lakes basin of the United States and Canada offers an example of the dam-

age these toxic substances can cause. In the late 1890s and early 1900s, the chlor-alkali industry started to produce free chlorine (a chemical that has improved the general health of the world) at a number of locations on the shores of the Great Lakes. Industrialists had no idea that they were inadvertently producing dioxin and causing widespread contamination. By the 1930s and 1940s, top predator fishes, herring and lake trout, began to disappear in the Great Lakes,resulting in the declines of several huge commercial fisheries. It took until the 1990s for scientists at the University of Wisconsin, Madison, to discover that very low concentrations of dioxins in lake trout eggs injure embryos so that they are unable to reach maturity. About the same time, EPA scientists doing core drills in Lakes Michigan and Ontario discovered that dioxin concentrations in the lakes were high enough in the 1930s and 1940s to prevent these top predator fish in the lakes from reproducing. This raises questions about whether the loss of some of the major ocean fisheries in the world might not have been in part the result of the global dispersal of dioxins, furans, PCBs and similar organochlorine chemicals. Black-footed albatrosses that feed only on the surface of the North Pacific Ocean and nest on Midway Island are already carrying elevated levels of furans, dioxins and PCBs near or above concentrations at which aquatic birds are being affected in the more highly contaminated areas of the Great Lakes.

It has taken the regulatory community years to reach the conclusion that dioxin is a human carcinogen. Reducing cancer associated with exposure from stack emissions is a hidden benefit. But cancer is only one of the many impacts these chemicals can have on animals and humans. The greenhouse gases' co-contaminants are also endocrine disruptors, chemicals that look like or interfere with the hormones that control the development of an individual from conception to birth. Their effects are insidious and can undermine an individual's ability to reach his or her fullest potential. Biologists have learned how devastating impacts like this can be on a population from their experience working in the field with wildlife. They warn that endocrine disruptors can lead to the loss of wildlife populations without society knowing what is happening. They also agree that endocrine disruptors can change the character of human societies. These chemicals can interfere with the developing brain and nervous system, and humankind, again, could miss what is happening. As a matter of fact, cancer is essentially a rare event compared with the impact of these chemicals on populations of wildlife and humans. Cancer has never led to the extirpation of a wildlife population, but prenatal damage as a result of exposure to PCBs, dioxins and furans has caused populations of fish and birds to decline dramatically or disappear.

Among humans, for those individuals who survive birth, insidious health effects such as susceptibility to disease, autoimmune problems, learning problems, early or delayed puberty, abnormal urogenital development, reduced sperm count and fertility problems may not be terminal or lethal, but certainly impair quality of life. And their social costs can be significant.

For example, prenatal exposure to background or ambient levels of PCBs can interfere with the development of the brain. This is reflected in reduced Intelligence Quotient (IQ) scores and disturbing behavioral changes. Children exposed prenatally are hyper-reactive, cry a lot, are fearful and do not settle down well; they do not habituate well to strange or

unpleasant surroundings. They have difficulty reading and processing information, and can be as much as two years behind in school by the time they reach the 6th grade. Their odds of becoming law-abiding, tax-paying adults are reduced as a result of their prenatal exposure to PCBs, dioxins and furans. Their lifetime earning ability is jeopardized.

PCBs and HCB were not considered harmful when they were first produced on a large scale. And dioxins, furans and mercury, as by-products of combustion, were never intentionally produced or released. The impact of these chemicals on behavior and function is not easily identifiable at the individual level. It has taken expensive, long-term epidemiological studies, some as long as a generation (20 years or more), to determine the damage from exposure to these greenhouse gas hitch-hikers in humans. It is clear what society has to gain by removing them from the environment. And as analytical chemical protocols improve, more hitch-hikers may be discovered spewing into the air along with the greenhouse gases that have been overlooked thus far. There could be a lot more to gain than meets the eye. It is time to tally up the benefits and take action.

Lecture

Inner Space Research: Assuring the Integrity of Future Generations

Dr. Theo Colborn

I want to thank the Asahi Glass Foundation for providing me the opportunity to come to Japan to speak to you. It is with great humility that I stand here, because the research behind my message was not done by me, but by vast numbers of scientists around the world. It is the cumulative result of their research that the Blue Planet Prize is recognizing. I only come to this podium with my interpretation of their story.

I am going to share with you some of their remarkable findings that have led to concern on the part of many scientific and public health professionals about the manner in which governments have managed the man-made chemicals that you encounter in your daily lives. Second, I am going to provide several examples of what has prompted this concern. Some of you may feel a little uncomfortable with what I am going to say. That is because I am going to describe some disturbing health problems that are not generally discussed in front of large audiences—a fact that may be contributing to the health authorities' difficulty in dealing with the problem—because not enough people are aware of the problems. And, I will close with some options for addressing the problem—for it is not just governments and corporations that need to address this problem. There are things that we can do as individuals as well.

Inner Space

Today, I want to take you on a journey into space. Not to outer space to explore the surface of Mars, but to inner space where every one of you has been already. To the womb—where, from the moment your father's sperm entered your mother's egg, until you were born, you spent approximately 266 days.

In the inner space of your mother's womb, with unbelievable precision, your cells replicated, moved about, and formed buds that grew into limbs and brains and sensory and reproductive organs, contributing to the most miraculous phenomenon on Earth. You. From the moment of your conception, your development was orchestrated solely by chemical messengers called hormones. Constantly shifting blends of hormones told your cells when to divide and where to move as your endocrine system supervised your construction. Only within the past decade have scientists been able to measure the infinitesimally small concentrations of hormones that engineered you. From recent laboratory studies we now know that your developing systems were so fine-tuned that they depended on shifts in hormones in concentrations as little as a tenth of a trillionth of a gram when you were in your mother's womb environment. That is as inconspicuous as one second in 3,169 centuries.

The technology that provided these insights on inner space is dragging years behind the

outer-space and cyber-space technology that have contributed to the 500 or more chemicals that every one of you is carrying in your body today—chemicals that no one was exposed to before the 1920s. There is now undeniable evidence that a pregnant woman shares some of these chemicals with her baby in her womb—and at even higher concentrations with her baby when she breast feeds—chemicals capable of interfering with the natural hormones that tell the baby how to develop. Some chemicals can interfere not only with the actual physical structure of the systems, but with the imprinting of these systems as well—such as improperly programming the brain so that an individual does not respond to the hormone messengers that ordinarily would control how he or she functions later in life.

Without realizing that man-made chemicals could pierce the placental and brain barriers and interfere with fetal development, we have in the 20th century released large volumes of chemicals into commerce and the environment that can mimic or interfere with natural hormones. They are often found at 100- to a 1,000-times higher concentrations in human tissue than the natural hormones themselves—in wildlife tissue, even higher. Although they may be weaker than the natural hormones, at concentrations that high, they can out-compete or perturb natural hormone signals in numerous ways.

These chemicals do not damage chromosomes and thus have eluded us. Much of traditional toxicology is directed at detecting damage to chromosomes. Instead, these chemicals interfere with the ability of genes to modulate the production and action of signaling chemicals such as hormones—so that the genes cannot express what they have evolved to do. In so doing, unfortunately, there are infinite ways that disrupted gene expression can interfere with the development and function of an individual. In terms of quality of life, the costs can be high.

Exposure

You, your children and your grandchildren are all exposed to these kinds of chemicals. You are not exposed to one chemical at a time, but to a complex mixture of chemicals that changes hour by hour, depending on where you are and the environment you are in. You cannot escape exposure in your homes, offices, schools, hotels, meeting rooms, gymnasiums, automobiles, airplanes and the outdoors.

Many of these chemicals build up in the body and remain in human tissue from one generation to the next. Others do not build up in tissue, but are constantly present in your daily lives. They are in the common, everyday products people have become dependent upon, such as plastic products, including toys, food containers, medical equipment, automobiles, TVs, cell phones and computers. They are used to line food and drink cans, and to make compact discs, sporting equipment, high-impact parts for vehicles and vast amounts of construction material.

They range from industrial chemicals, to pesticides, to perfumes and cosmetics. They are found in fast foods, deep ocean fish and even the most rigid, organic, vegetarian diet.

Let me reinforce what I have said so far: wildlife tissue from the Arctic to the Antarctic contains chemicals that can undermine the development of the brain, and intelligence and behavior, and the endocrine, immune, and reproductive systems—vital systems that assure the perpetuity of species.

A growing collection of wildlife, human and laboratory studies reveals that some of

these chemicals can affect our children's ability to learn, to socially integrate, to fend off disease and to reproduce. Unfortunately, invisible, delayed effects such as these are difficult to link with exposure to a specific chemical—especially when the target animal is the offspring, not the initially exposed individual—and the effects are manifested in the next generation.

A group of international experts unanimously agreed that chemicals of this nature can change the *character* of human societies or destabilize wildlife populations without society realizing what is happening. The group called for using precaution—to reduce exposure and to practice prevention—rather than continuing to try to develop cures for conditions that cannot be repaired.

Neurodevelopmental Impairment

The concept of endocrine disruption emerged from a 1988 analysis of the health status of wildlife around the North American Great Lakes, the largest body of fresh water in the world. Where the adult animals, if present, looked fine—but their offspring, if they had any, rarely survived to adulthood—and if they did survive to adulthood, they rarely could reproduce.

In response to concerns like these about the health of wildlife that consumed fish from the Great Lakes, a human epidemiological study was started in 1979, comparing children born of women who ate Great Lakes fish and those who did not eat the fish. The results of that early study combined with a series of newer studies contributed in part to the issuing of the consensus statement I just mentioned. The first study commenced 20 years ago; others have followed.

These studies have confirmed that prenatal exposure to a group of widely dispersed, persistent industrial chemicals, such as PCBs, dioxins and similar chlorinated compounds, can undermine neuromuscular and neurological development that trained technicians can measure at birth in humans. The infants' parents or family physician would not be able to detect these problems.

PCBs are oily, very stable, and thus persistent liquids that were used as fire retardants in transformers, capacitors, and other electrical and construction products. They were produced under the name Kanechlor in Japan. Their production was banned in Japan in 1972, seven years before they were banned in the U.S. where they are still widely used in closed systems at low concentrations. They will be in the environment for hundreds of years.

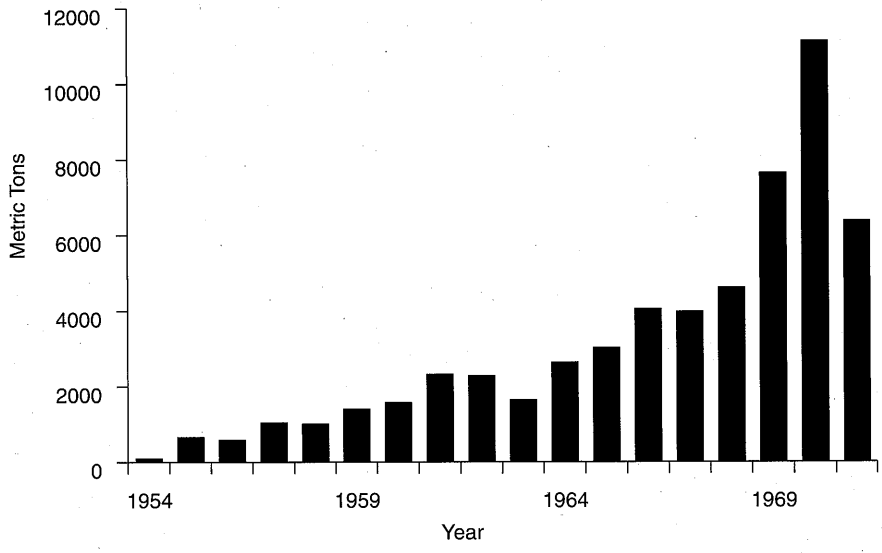


Figure 1. Annual Kanechlor production in Japan from 1954–1971. (Source: Loganathan et al. Environmental Pollution, 1993)

Two Great Lakes studies confirm that as the prenatally-exposed children mature, they exhibit short-term memory problems and are difficult to calm down in unpleasant situations. In the earliest study, the more highly exposed children's average reduction in IQ was 6 points at age 11, with some of the children more than two years behind in reading and school performance.

Table 1. Lake Michigan Findings

	At Birth:
Mothers' Fish Consumption **Fein, et al., 1984**	**Poorer neuromuscular maturity** **Higher PCB cord serum levels**
Higher PCB Cord Serum Levels	**At Age 4:**
Jacobson and Jacobson, 1993	**Poorer short-term memory** **Lower cognitive processing speed** **Auditory verbal deficit** **Quantitative memory deficit** **Lower visual discrimination memory**
	At Age 11:
Jacobson and Jacobson, 1996	**6.2-point deficit in IQ** **6 to 12 months behind in word and reading comprehension**

Another independent study using only healthy mothers and infants 12 years later followed the protocols in the first study, but also utilized more psychological tests. These children also had the same memory problems and difficulty with processing information relative to the concentrations of PCBs they were exposed to in the womb.

Using a new psychological test to determine temperament, the second team also found that the affected children cried more, laughed less, expressed more fear and did not habituate well to changes in their environment.

There was a marked increase in the mothers' PCB blood levels if they ate Great Lakes fish prior to their pregnancy and throughout their pregnancy compared with those mothers who stopped eating GL fish when they found out they were pregnant. There was an even greater reduction in the mother's blood PCBs if they stopped eating GL fish in 1984 when the first fish advisories were released. Even with convincing research results such as this, there are those in governing positions who do not want to release fish advisories because they might discourage tourism. They argue that it will have a negative impact on the recreation industry around the Lakes.

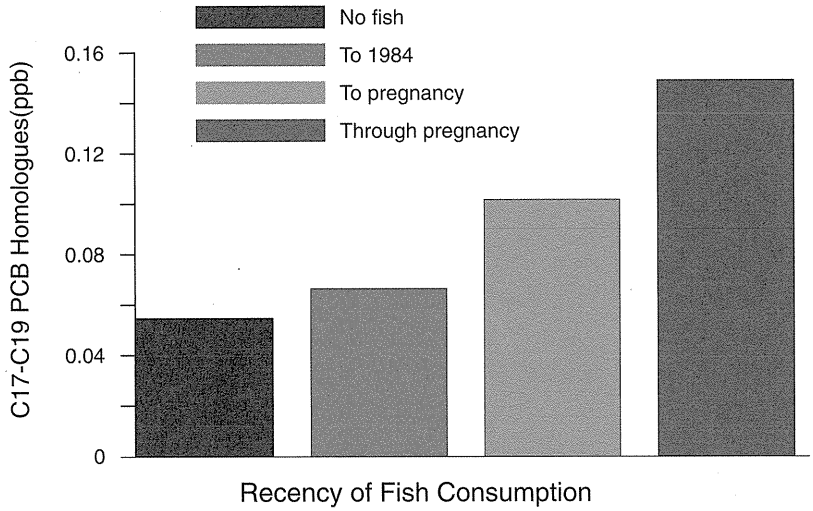


Figure 2. C17-C19 PCB congeners in controls, women who stopped consuming fish in 1984, women who stopped consuming fish upon learning of their pregnancy, and women who ate fish throughout their pregnancy. (Source: Stewart et al. Environmental Research, 1999)

Note the relationship between the PCB concentrations in the mothers during gestation and their children's ability to habituate to changes in their environment. Their habituation scores decreased in a dose-response manner as the mothers' blood levels of the more persistent highly chlorinated PCBs increased.

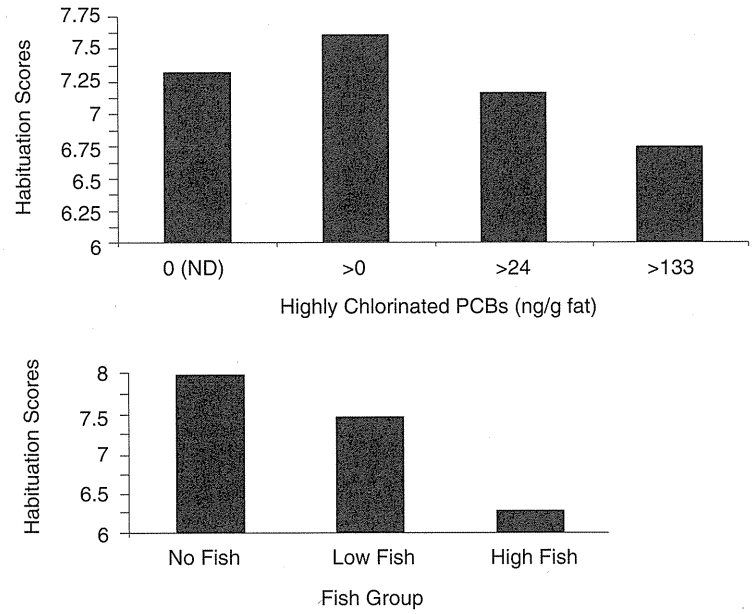


Figure 3. Habituation (48 hrs. postnatal). (Source: Stewart et al., 1999. Neurotoxicology and Teratology)

The average PCB level in all of us in this room today is undoubtedly within the range at which the affected children in the studies were exposed prenatally. Fish are not the only source of PCBs. Society is going to have to decide if it wants to gamble with exposure odds like this—and risk the loss of our best and brightest—our future scientists, educators and world leaders. It will also have to decide whether it wants to reduce the odds that children will end up in special education classes and under the surveillance of social service agencies.

An entirely different study that also looked at healthy mothers and infants from both the urban and suburban Netherlands did not include the extensive psychological testing used in the Great Lakes study, but it did detect neuromuscular delays, measured as hypotonia and abnormal reflex responses, which is similar to the results in the other mother-infant studies. In this study, the mothers were not selected because they were fish eaters.

Table 2. Netherlands Studies

n=418*	hypotonia	43% muscle tone ↓	22% reflex ↓
n=207**	CD4 T-cell receptors (birth) ↑	CD4 and CD8 T-cells (18 mos.) ↑	Monocytes and granulocytes ↓
n=105***	free thyroxine and total thyroxine ↓		

*Sauer *et al.* 1995 **Weisglas-Kuperus *et al.* 1995 ***Koopman-Esseboom *et al.* 1994

The researchers also found an association with increased levels of PCBs and dioxin in the mothers' blood during gestation, with increased changes in the children's immune systems and reduced thyroid hormone levels.

It has been known for over a century that thyroid hormones are critical for proper brain development and intelligence. Scientists have discovered innumerable ways in which PCBs disturb the thyroid system. In one series of laboratory studies, it was demonstrated that prenatal exposure to PCBs causes loss of motor coordination and loss of hearing for low and intermediate frequency sounds in rat pups. Loss of auditory discrimination such as this has been linked to difficulty with phonics, reading, learning and ultimately intellectual development. Like the laboratory rats, the children in the PCB studies I mentioned earlier had difficulty with what psychologists call audio-visual discrimination—which they will tell you could have led to the children's reading and scholastic problems.

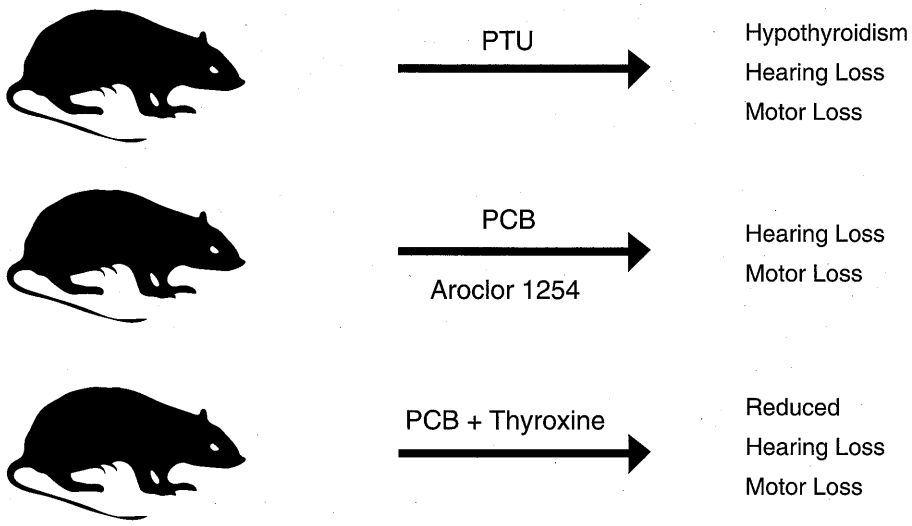


Figure 4. U.S. Environmental Protection Agency Studies. (Sources: Goldey et al., 1995; Herr et al., 1996; Goldey and Crofton, 1998)

A medical doctor and thyroid specialist on my team recently published a literature review on the effects of environmental chemicals on the thyroid system. We were surprised at the length of her list of environmental chemicals that affect the thyroid. Although this information is published in prestigious scientific journals, governments do not regulate chemicals based on what is found in the literature. Because of the increasing number of new chemicals introduced into commerce each year, governments are forced to depend on the information industry provides them about the safety of their products. To date, industry has no standardized protocols to test chemicals for these effects.

Population-Level Impairment

The second set of studies that I want to tell you about also comes from the Great Lakes region. In this study, researchers administered cutting-edge, low-doses of dioxin to rats and fish.

They found that the very low doses, orders of magnitude lower than anyone had ever used before, could have significant effects on male sexual development in rats—and survival of hatching embryos in fish. This data has never gotten the recognition it deserves by fisheries managers or risk assessors. The battle over the safety of dioxin continues to focus on its carcinogenic effects. Beware, because cancer in the case of dioxin is like a red herring, detracting attention from what could be, its far more prevalent, insidious, developmental effects.

Based on this data, later in 1995, organochlorine analyses of core drills of Lake Michigan sediments revealed that there was sufficient dioxin in the Great Lakes as early as the 1940s to prevent lake trout and other top predator species in Lake Michigan from maturing. Further testing of core drills in Lake Ontario provided the same evidence. Historically, these findings coincide with the first large-scale production of free chlorine using the chlor-alkali process along the shores of the lakes. The fish disappeared from the Lakes about the same time

as giant industrial and pharmaceutical industries adopted catalytic chlorine chemistry technology. The dioxin-exposed fish eggs hatched, but they suffered from edema and hemorrhages and did not survive through swim up.

Today, Canada and the U.S. combined, spend approximately $50 million a year raising and stocking the lakes with top predator fish because most populations of top predator fish are still having trouble reproducing there. Fisheries managers still insist that over-fishing, habitat destruction, and the lamprey eel caused the crash of the top predator fish in the Lakes in the 1950s. Managers are reluctant to get involved with the issues of contamination and their effects on the development and reproductive success of fishes. This holds true with managers not only of freshwater species but marine species as well.

Seventy percent of the world's commercial marine fish stocks are threatened with extinction. No one can deny that over-exploitation of the fisheries resource is a serious problem, but with the evidence available today, it is time to add contaminants considerations to the management of all free-ranging species.

We must take precautionary steps to reduce the release of dioxin and other persistent organic chemicals, called POPs, that eventually move to the seas and oceans and to the animals that live there.

Let me recapitulate for a minute: there is clear evidence that, in less than a century, humankind has changed the chemistry of the Earth with compounds that were considered safe because they did not cause cancer or other very obvious toxic effects. And over the past decade, we have begun to recognize the fact that indeed, some of these chemicals do enter the womb environment and cause irreversible changes—changes that are invisible and sometimes not expressed until an individual reaches adulthood—but changes that ultimately undermine the individual's potential in endless ways. Many of the chemicals of concern are either residuals from past use, or current-use pesticides and industrial chemicals upon which we have been told repeatedly that our survival and economy are based. Yet it appears that some of these products may be costing a lot more than their market price when their generational effects are taken into consideration.

Individual-Level Impairment

I want to tell you about one more condition that *is* visible at birth as the result of something that goes wrong during sexual differentiation in the womb during a limited period of time. The condition is called hypospadias, one of the most common birth defects in the U.S. today, although it is not talked about much. Hypospadias is a condition where the urethra does not open at the end of the male external organ. In mild cases, the opening is near the head or the end of the organ. In the more severe cases, the opening is located anywhere along the shaft or even in the scrotum. Hypospadias has only one treatment. Surgery. The closer the urethral opening is to the body, the more difficult the surgery. The difficult cases cannot always be corrected. Embryologists know that this abnormality starts somewhere between day 56 and 84 in the womb—when the urethra and male organ begin to lengthen and enlarge together.

A very special male steroid hormone is required for this remarkable process to take place, and scientists have now discovered a number of chemicals in various ways can interfere

with the production and activity of this hormone.

Hypospadias doubled between 1970 and 1993 in the U.S. and now occurs in approximately 1 in 125 boys. The more severe cases appear to be increasing more rapidly. Boys born with hypospadias have a significantly greater risk in adulthood of developing testicular cancer and reproductive problems. It behooves us to try to understand what a condition like this can do to the quality of life of these young men as they mature.

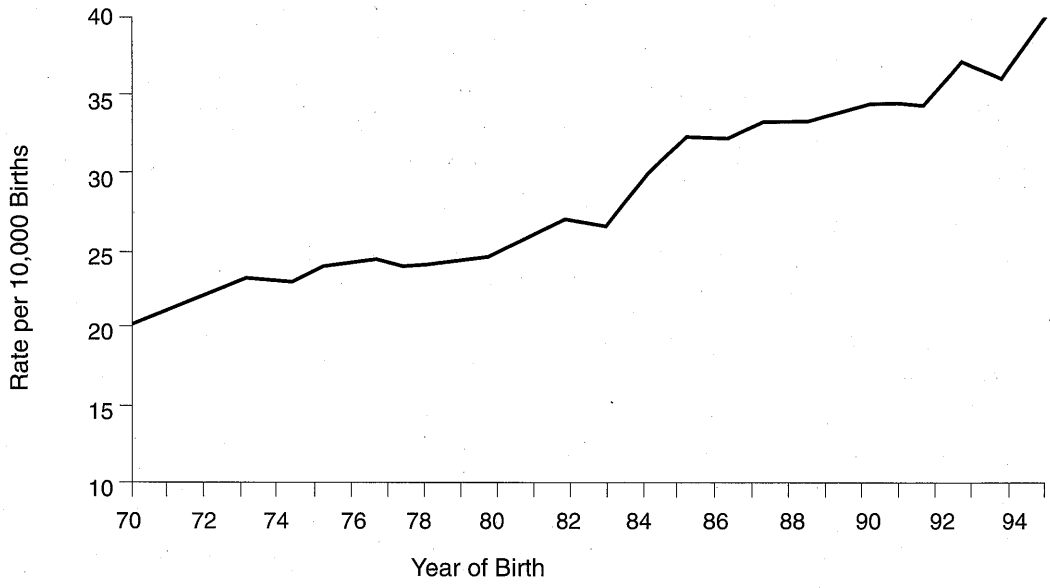


Figure 5. Hypospadias rates: 1970–1993. (Source: Paulozzi et al., 1997)

Just think about this—if wildlife biologists had not discovered that a large number of alligators from Florida's Lake Apopka had small phalluses, or external male organs, and were barely capable of reproducing, scientists would probably never have discovered that there are chemicals in the environment that can interfere with male hormones, the testosterones. No one knew that there were any environmental anti-testosterones until six years ago.

When the wildlife biologists showed some alert Environmental Protection Agency (EPA) toxicologists pictures of their alligators' unusual external male organs, the EPA men asked immediately what the alligators could be exposed to. The biologists thought that perhaps DDE, the breakdown product of DDT, might be involved. Much to everyone's surprise, it was. Not only do the male offspring of rats fed DDE suffer from hypospadias, they also suffer from undescended testicles and other disturbing developmental problems. I will make a bet with anyone in this room that at least 95% of you will have measurable DDE in your bodies. To be sure, the women who have breastfed several babies will have the lowest DDE concentrations because they will have unknowingly released an appreciable part of their body burden into

their babies while nursing. This is something that women should not have to accept or worry about.

Thanks to some forlorn alligators in Florida's swamps, we now know that some pesticides used on fruits and vegetables, some plastic components and DDE could cause hypospadias in humans if the timing of exposure is correct. Amazingly, DDE is one-tenth as potent as flutamide, a drug used to chemically castrate men with prostate cancer. This is the son of a DDE-fed rat. This is the son of a fungicide-fed rat. The fungicide is vinclozolin.

Let me repeat here, that there are no standardized protocols to screen and test chemicals for hypospadias or any of their other hormone-disrupting effects, including intellectual and behavioral impairment that I mentioned earlier. Consequently, there is no way governments and corporations can assure that any product in use today is safe—not until these tests become available.

Developing the tests is going to require an international effort because so many chemicals are now an integral part of the global economy and commerce. And persistent chemicals like PCBs and DDT flow on air and water and ocean currents as well as in commerce, and are accumulating in animal and human tissue thousands of miles from where they were used.

Entering the Inner-Space Age

In 1996, it looked like the U.S. was going to take the lead on this issue. The U.S. Congress wrote into the reauthorization of both the Safe Drinking Water Act and the Food Quality Protection Act—the U.S. pesticide law—that EPA must come up with a set of protocols to test chemicals for their endocrine disrupting effects and get a program in place by 2000. There was great expectation at that time that the U.S. government would take the lead and establish such a set of tests that could be used globally. Unfortunately, here we are almost through the year 2000 and not one test has been standardized or validated yet. It is very apparent that if we wait for the U.S. government or any other government to move on this, we will continue to use our children as substitute laboratory subjects—and wildlife species will continue to slowly disappear.

Are we going to wait until every child is affected? Are we going to continue to gamble that our sons will *not* be hypospadiacs?

The individual costs and *societal* costs are just too high not to change the system. We must move from complacency and from assuming that governments will provide protection from chemicals of this nature. We must act as soon as possible. Manufacturers of products that enter our homes want a set of tests to assure that their products are not posing risks to us and future generations.

It is obvious. We need a new inner space effort that is funded as generously as previous outer space efforts. It must be an international, independent research effort that moves ahead rapidly to undo what has evolved as the result of the chemical technology that grew out of World War II. Governments, by nature, will not move forward fast enough. Consequently, industry is going to have to take the lead and come forth with the money. With sufficient funding and shared goals, industry could give the world, in a very short time, the rudimentary screens and assays for detecting chemicals that are endocrine disruptors. As the new inner

space program probes deeper into the mysteries of development, more and better assays will be proposed. In light of what already has been discovered in the past 10 years and the complexity of the endocrine system, it is apparent that the commitment to this research must be long term.

There is no doubt in my mind that industry can do this. We just saw what industry can do if it wants to. In less than three years, it spent billions of dollars preventing a Y2K crisis, and at the same time it helped the economy. The effort I am calling for would require far less of industry's time and investment. It would also create jobs, and it would assure a healthier, more productive society. I envision a three-branched infrastructure, with industry on one branch providing the money. The second branch would handle the money and provide a buffer between industry and the third branch, comprised of scientific experts.

The process of framing the research, conducting the research, evaluating the results and sharing the information with the public must be beyond reproach. The credibility of the effort will hinge on keeping industry and government and other funders from influencing how the research is designed and the results reported.

This is important because the public has lost faith in industry's research when it comes to health issues. Many business people agree that even if industry were to do good science, the public would not believe it. It is to industry's advantage to have the research done independently. In no way should the shame of "cigarette science" taint this effort.

I have learned from previous speaking engagements that many of you are wondering how you can become involved at the personal level. How you can you protect yourselves and your families?

First of all, you can become more knowledgeable about the products you bring into your home. Ask for more information on the labels of the products you purchase. Call and write manufacturers and tell them you want assurance that there are no endocrine disruptors in their products. Tell them to support the international research effort.

Seek safe alternatives for the pesticides you use in your homes, gardens and lawns. Purchase organically grown food whenever you can. In so doing, you not only reduce your exposure but that of thousands of farm workers. And by reducing the use of pesticides in the fields, you are also protecting the beneficial attributes of natural systems that are essential for sustained agriculture.

Never heat something in plastic in your microwave even if the container says "microwave safe." That statement is based on whether the chemicals that leak from plastic containers cause cancer, not whether they have endocrine system effects. Wash children's hands frequently.

At the community level, get involved in neighborhood groups to discourage the use of pesticides in your area, and urge your schools to join a nationwide campaign to remove pesticides from schools and playgrounds and gymnasiums. On a broader scale, perhaps through a breast cancer or prostate cancer action group, insist that they support research that is based on prevention not just treating symptoms, because, as I mentioned with hypospadias, there is growing evidence that prenatal exposure to endocrine disruptors can lead to sex-organ cancers later in life. Few research dollars are directed toward the impact of prenatal exposure to syn-

thetic chemicals on cancer incidence. Yet, a great deal of evidence has accumulated over the past 10 years suggesting that this could be a factor in secondary sex-organ cancers.

At the international level, Japan has a critical role to play in the international treaty negotiations on Persistent Organic Pollutants (POPs), which will reach closure in December. You need to urge your government to support elimination of the 12 targeted POPs, to incorporate precaution as a guiding principle of the treaty, and commit sufficient technical and financial assistance to ensure that all nations can participate effectively in the new treaty's implementation.

In addition, the Blue Planet Prize grew out of activity from the 1992 Earth Summit in Rio. Endocrine disruption was not on that agenda. It is imperative that Endocrine Disruption gets on the Agenda of the 2002 Earth Summit—the Rio +10 high-level conference. I hope I can encourage every one of you here today to make this one of your near-term goals.

In light of the momentum already generated by the amazing discoveries that have surfaced through endocrine disruption research over the past decade, I have great hope that inner space research will go beyond learning more about signaling chemicals, embryonic and fetal development, establishing screens and assays to detect endocrine disruption, and come closer to assuring a cleaner womb environment for future generations.

And as we move into the inner-space age, we will also probe more deeply into the humanity in each one of us so that society gets its priorities straight and begins to think in terms of future generations, not just in terms of the bottom line, the Gross National Product, or the outcome of the next election. For it is going to take a major societal change in order to place the value of quality of life before the Gross National Product, and it would be much better if this change took place voluntarily rather than necessarily.

In closing, for our children's sake, let us make the new millennium the Inner Space Age.

Thank you.

Major Publications
Dr. Theo Colborn

Articles

Colborn, T. "Aquatic Insects as Measures of Trace Element Presence: Cadmium and Molybdenum." Master's Thesis, Western State College of Colorado, 1981.

—. "Aquatic Insects as Measures of Trace Element Presence in Water: Cadmium and Molybdenum." *Aquatic Toxicology and Hazard Assessment.* Ed. J.B. Pearson, R.B. Foster and W.E. Bishop. ASTM: STP 766 (1982), 316–325.

—. "Measurements of Low Levels of Molybdenum in the Environment Using Aquatic Insects." *Bulletin of Environmental Contamination and Toxicology*, 29 (1982), 422–428.

—. "The Use of the Stonefly, *Pteronarcys Californica* Newport, as a Measure of Bioavailable Cadmium in a High-Altitude River System, Gunnison County, Colorado." Ph.D. Thesis, University of Wisconsin, Department of Zoology. 1985.

—. "The Use of the Stonefly, *Pteronarcys Californica* Newport, as a Measure of Biologically Available Cadmium in a High Altitude River System, Colorado, USA." *Water Quality Bulletin*, World Health Organization, 11 (3) (1986), 141–147.

—. "*Pteronarcys Californica* Newport: Mortality and Cadmium Accumulation at Three Stations on the Gunnison River, Gunnison County, Colorado." In *Heavy Metals in the Environment.* Ed. S.E. Lindberg and T.C. Hutchinson. 2 (1987).

Blackwelder, B., T. Colborn and B. Harding. "Alternatives to Traditional Water Management in the United States." *AMBIO*, 16 (1) (1987), 32–37.

Barnard, W., T. Colborn, P. Johnson and D. Pauli. "Using Desalination Technologies for Water Treatment." Congress of the United States, Office of Technology Assessment, 1988.

Colborn, T. "The Great Lakes Toxics Working Paper." Environmental Interpretation Division, Environment Canada, 1988.

—. "The Use of Toxicity Equivalency as a Complement to Biomonitoring and Wildlife Research in the Great Lakes." Report to Environmental Results Branch, Office of Policy, Management, Planning and Evaluation, U.S. Environmental Policy Agency, 1988.

—. "Background Paper—An Overview of Toxic Substances and Their Effects in the Great Lakes Basin Ecosystem." Report to Health Effects Committee, Science Advisory Board, International Joint Commission, 1989.

Colborn, T., J. Chudnoff, R.M. Friedman, K. Harrison, J.B. Milford, R.D. Rapoport and N.B. Szabo, ed. "Catching Our Breath: Next Steps for Reducing Urban Ozone." Congress of the United States, Office of Technology Assessment, 1989, 238.

Colborn, T. "The Impacts of Great Lakes Toxic Chemicals on Human Health." A Working Paper Report to the Environmental Health Directorate, Canada, 1989.

—. "The High Price of Progress." Rev. of *High Tech Holocaust.* Ed. J. Bellini. *Chemical and Engineering News*, 67 (44) (1989), 65–68.

—. "Innovative Approaches for Evaluating Human Health in the Great Lakes Basin Using Wildlife Toxicology and Ecology." *Report to the Health Effects Committee of the Science Advisory Board*, International Joint Commission, 1990.

Colborn, T. and R.A. Liroff. "Toxics in the Great Lakes." *EPA J.*, 16 (6) (1990), 5–8.

Colborn, T. "The Wildlife Connection: Wetlands and Toxicology." *National Wetlands Newsletter*, 12 (5) (1990), 17–18.

Colborn, T., A. Davidson, S.N. Green, R.A. Hodge, C.L. Jackson and R.A. Liroff, ed. "Great Lakes: Great Legacy?" *The Conservation Foundation and The Institute for Research on Public Policy*, Washington, D.C.: 1990.

Colborn, T. and J.P. Myers. "Blundering Questions, Weak Answers Lead to Poor Pesticide Policies and Rebuttal: Immense Unknowns Characterize the Assessment of Pesticide Risks." News Forum, *Chemical and Engineering News* (1991), 40–43.

Colborn, T., A. Duda and M. Gilbertson. "IJC Fosters Use of Forensic Approach to Identify Ecosystem Effects of Persistent Toxic Substances." *Focus on International Joint Commission Activities*, 16 (2) (1991), 7–10.

Colborn, T. "Environmental Degradation and Health Care Costs." Rev. of *Health and the Global Environment*. Ed. Ross Hume Hall. *Chemical and Engineering News*, 69 (50) (1991), 25–26.

—. "Global implications of Great Lakes Wildlife Research." *J. International Environmental Affairs*, 3 (1) (1991), 3–25.

—. "Epidemiology of Great Lakes Bald Eagles." *J. Toxicology and Environmental Health*, 33 (1991), 395–453.

—. "Nontraditional Evaluation of Risk from Fish Contaminants." In *Proceedings of a Symposium on Issues in Seafood Safety*. Ed. F. Ahmed. Institute of Medicine, National Academy of Sciences, 1991, 95–122.

Clement, C. and T. Colborn, ed. "Chemically-Induced Alterations in Sexual and Functional Development: The Wildlife/Human Connection." 403. Princeton, NJ: Princeton Scientific Publishing, 1992.

Colborn, T., co-author. "Health Effects Section" of the *EPA Great Waters Report to Congress*, authorized under the Clean Air Act Amendments of 1990. 1992.

Colborn, T., A. Soto and F. vom Saal. "Developmental Effects of Endocrine-Disrupting Chemicals in Wildlife and Humans." *Environmental Health Perspectives*, 101 (5) (1993), 378–384.

Colborn, T. "Chlorine: Dispelling Seeds of Doubt and Disaster." Ed. W. Reilly. *Environment Strategy America* (1994/5), 60–61.

—. "The Wildlife/Human Connection: Modernizing Risk Decisions." *Environmental Health Perspectives*, 102 (12) (1994), 55–59.

Colborn T., M. Gilbertson and R.M. Rolland, ed. "Wildlife Development, Environmentally Induced Alterations in Development: A Focus on Wildlife." *Environmental Health Perspectives Supplement*, 103 (4) (1995).

Colborn, T. "Pesticides—How Research Has Succeeded and Failed in Transforming Policy: Endocrinological Effects in Wildlife." *Environmental Health Perspectives Supplement*, 103 (6) (1995), 81–85.

—. "Environmental Estrogens: Health Implications for Humans and Wildlife." *Environmental Health Perspectives Supplement*, 103 (7) (1995), 135–136.

Colborn, T. and M.J. Smolen. "An Epidemiological Analysis of Persistent Organochlorine Contaminants in Cetaceans." *Rev. of Environmental Contamination and Toxicology*, 146 (1996), 91–172.

Colborn, T. "The Great Lakes: A Model for Global Concern." In *Interconnections between Human and Ecosystem Health*. Ed. R.T. Di Guillo & E. Monosson. London: Chapman & Hall Publishers, 1996, 86–102.

Colborn, T., D. Dumanoski and J.P. Myers. "Our Stolen Future." N.Y.: *Dutton* (1996), 306.

Colborn, T. "From Silent Spring (1962) to Wingspread (1991)." *Comments on Toxicology*, 4 (4-5) (1996), 319–328.

Colborn, T. and P.L. de Fur. "Endocrine Disruptors: Opening Pandora's Box." *SETAC News*, 16 (4) (1996), 10–11.

Auman, H.J., T. Colborn, L. Froese Kenneth, et al. "PCBS, DDE, and TCDD-EQ in Two Species of Albatross on Sand Island, Midway Atoll, North Pacific Ocean." *Environmental Toxicology and Chemistry*, 16 (3) (1996), 498–504.

Jones, P.D., D.J. Hannah, S.J. Buckland, T. Colborn, et al. "Persistent Synthetic Chlorinated

Hydrocarbons in Albatross Tissue Samples from Midway Atoll." *Environmental Toxicology and Chemistry*, 15 (10) (1996), 1793–1800.

Colborn, T. and M.J. Smolen. "Endocrine Disruption: Hidden Threats to Wildlife." *Endangered Species Update*, 14 (9-10) (1997), 6–10.

Colborn, T. "Screening and Testing Chemicals for Prenatal Exposures and Effects." *The Risk Advisory (December)*, American Chemical Society. Washington, D.C.: 1997.

Auman, H.J., J.P. Ludwig, J.P. Giesy and T. Colborn. "Plastic Ingestion by Laysan Albatross Chicks on Sand Island, Midway Atoll, in 1994 and 1995." *Albatross Biology and Conservation*. Ed. G. Robinson & R. Gales. Surrey Beatty & Sons, Chipping Norton, 1997, 239–244

Ludwig, J.P., T. Colborn, et al. "The Roles of Organochlorine Contaminants and Fisheries Bycatch in Recent Population Changes of Black-footed and Laysan Albatrosses in the North Pacific Ocean." *Albatross Biology and Conservation*. Ed. G. Robinson & R. Gales. Surrey Beatty & Sons, Chipping Norton, 1997, 225–38.

Colborn, T. "Building Scientific Consensus on Endocrine Disruptors." *Environmental Toxicology and Chemistry*, 17 (1) (1998), 1–2.

Colborn, T., F.S. vom Saal and P. Short, ed. "Environmental Endocrine-Disrupting Chemicals: Neural, Endocrine, and Behavior Effects." *J. Toxicology & Industrial Health*, 14 (1-2) (1998), 365.

Colborn, T., M.J. Smolen and R. Rolland. "Environmental Neurotoxic Effects: The Search for New Protocols in Functional Teratology." *J. Toxicology & Industrial Health*, 14 (1-2) (1998), 9–24.

Ankley, G., T. Colborn, E. Mihaich, R. Stahl, D. Tillitt, et al. "Overview of a Workshop on Screening Methods for Dectecting Potential (Anti-) Estrogenic/Androgenic Chemicals in Wildlife." *Environmental Toxicology & Chemistry*, 7 (1) (1998), 68–87.

Colborn, T. "Endocrine Disruption from Environmental Toxicants." In *Environmental and Occupational Medicine*, 3rd Edition. Ed. W.N. Rom. Philadelphia: Lippincott-Raven Publishers, 1998, 807–815.

Short, P. and T. Colborn. "Pesticide Use in the US and Policy Implications: A Focus on Herbicides." *Toxicology and Industrial Health*, 15 (1) (1999), 240–275.

Colborn, T., P. Short and M. Gilbertson, ed. "Health Effects of Contemporary-Use Pesticides: The Wildlife/Human Connection." Special edition of *Toxicology and Industrial Health*, 15 (1-2) (1999), 275.

Devito, M., L. Biegel, A. Brouwer, S. Brown, F. Brucker-Davis, A. Cheek, Oliver Cheek, R. Christensen, T. Colborn, et al. "Screening Methods for Thyroid Hormone Disruptors." *Environmental Health Perspectives*, 107 (5) (1999), 401–415.

Fournier, M., V. Degas, T. Colborn, F.O. Omara, F. Denizeaui, E.F. Potworsk and P. Brousseau. "Immunosuppression in Mice Fed on Diets Containing Beluga Whale Blubber from the St. Lawrence Estuary and Arctic Populations." *Toxicology Letters* (2000), 112–113; 311–317.

Colborn, T. and K. Thayer. "Aquatic Ecosystems: Harbingers of Endocrine Disruption." *Ecological Applications*, 10 (4) (2000), 949–957.

Colborn, T. "Peace." In *Architects of Peace*. Ed. M. Collopy and J. Gardner. Novato, CA: New World Library, 2000.

Brucker-Davis, F., K. Thayer and T. Colborn. "Significant Effects of Mild Endogenous Hormonal Changes in Humans." *Environmental Health Perspectives*, 109 (1) (2001), 21–26.

Colborn, T. "Endocrine Disruption: Interface between Wildlife and Humans." *Conservation Medicine*, 2001. (In press)

Colborn, T. and M.J. Smolen. "Cetaceans and Contaminants." In *Toxicology of Marine Mammals: Target Organ Toxicology Series*. G. Bossert, J. Vos, M. Fournier. Ed. Taylor and Francis. UK: 2001. (In press)

Baskin, L.S., K. Himes and T. Colborn. "Hypospadias and Endocrine Disruption: Is There a Connection?" *Environmental Health Perspectives*, 2001. (In press)