Do Pesticides Affect Learning and Behavior?

The neuro-endocrine-immune connection

By Warren Porter, Ph.D.

Children are our future and the people we have to protect. I have serious concerns about children exposed to low level pesticide mixtures from lawns and in the food, water, and air that passes through their bodies. Children do not have defensive enzymes at levels present in sexually mature adults. In this presentation, I will explore the neurological, endocrine, immune and developmental effects of such exposures.

Herbicides inaccurately touted as safe

In 1945, a National Geographic photographer took a picture of a child walking through DDT that was being sprayed from a truck at New York's Jones Beach State Park. The side of the truck said, "DDT. Powerful Insecticide. Harmless To Humans."

Since that time, herbicides like RoundUp (glyphosate) have been touted for their safety. Yet, they are capable of modifying the most fundamental biological processes. For example, many people report experiencing severe digestive problems related to overexposure to RoundUp. In fact, Finnish researchers showed that RoundUp's active ingredient, glyphostate, decreases the defenses of enzymes of the liver and intestines.[1] RoundUp, as a mixture of all its ingredients, has been shown to shut down a powerful antioxidant in the liver that detoxifies harmful compounds so they can be excreted through bile. A paper published in August 2000 shows that RoundUp alters gene expression and inhibits necessary steroid production by disrupting a particular protein expression. In 2002, a paper shows that RoundUp can also affect early cell division processes in embryos.

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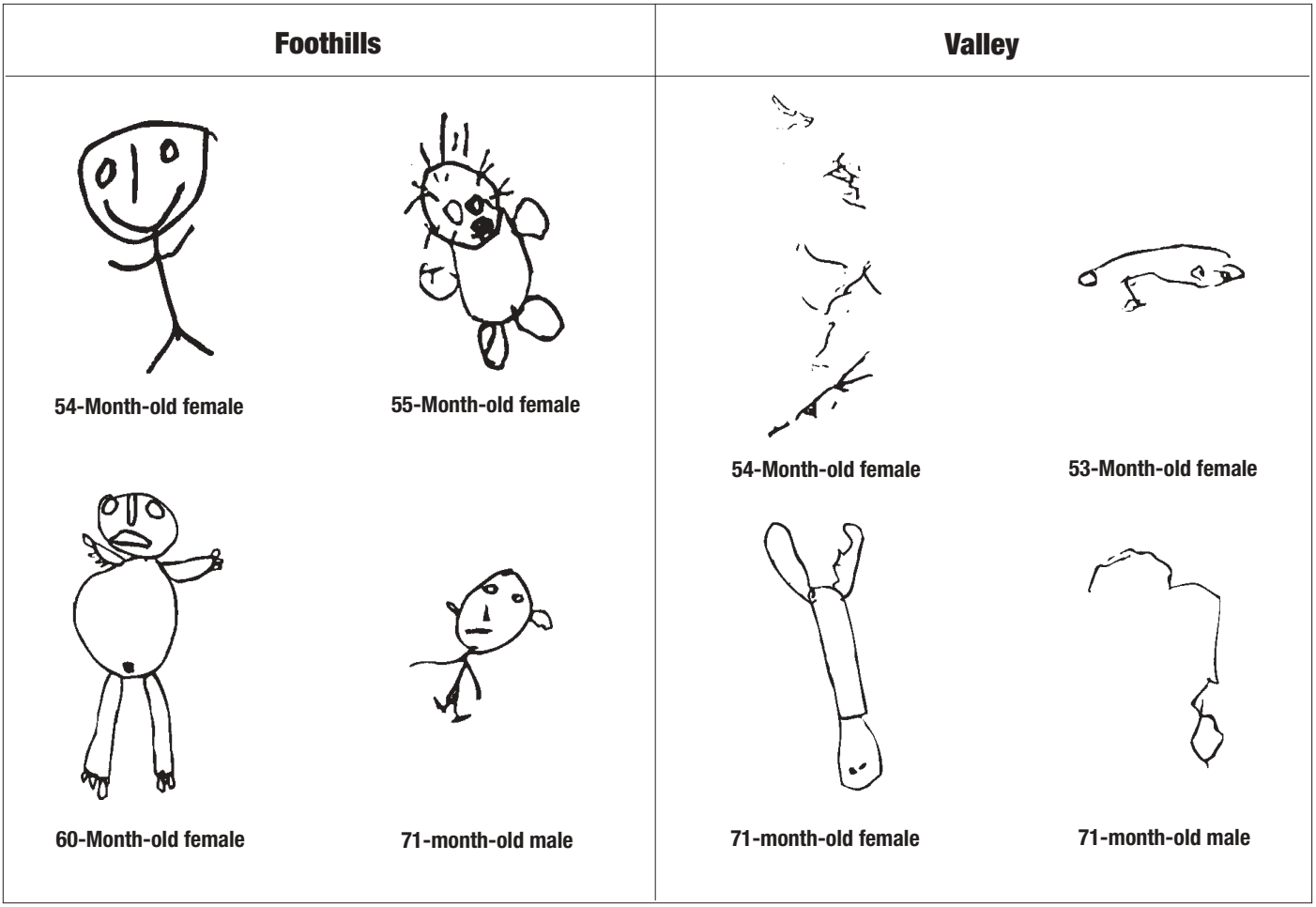
This article contains excerpts from a talk that Dr. Porter gave to the Nutrition for Optimal Health Association on February 4, 2004.

The increase in children with disabilities is alarming

I really got into the issue of children's pesticide exposure after reading an article in 1997 that looked at student disabilities in the Madison Metropolitan School District (WI), based on the U.S. Department of Education Federal Child Count Data from 1990-1995.[2] The data showed that the number of children in Madison that were emotionally disturbed increased 87%, children with learning disabilities increased 70%, and children with birth defects increased 83% in that five-year period. This is a serious epidemic and yet no one really knows exactly how or why this is happening. It's not unique; not to Madison, the state of Wisconsin, Chicago, New York, Philadelphia, Iran or Australia. It seems to be a global phenomenon and the question is why and how is this happening and what can we do about it.

Neurological processes and functions are tied to the hormone and immune systems and thus impact developmental processes.[3] When we think about learning we also have to think about how the immune system is working what the hormones in the body are doing, and how might all this be impacting the developmental processes. Organ system processes as well as the central nervous, endocrine, and immune systems talk to each other all the time by many different chemical mechanisms and support individual level functions of reproduction, growth and behaviors. Studies show that pesticides can function as nerve poisons and as pseudo hormones, modify hormone levels, and/or impact immune system function. Therefore, the hypothesis is that if one of these is impacted then because of the interconnection in the communications among them, it is likely that all other systems will be affected. Because organ system functions affect the intake of food, energy and mass, the fundamental foundation on which this whole super structure rests may be eroding in very subtle ways.

Perhaps the most telling experiment in effect is the work of Elizabeth Guillette, Ph.D. in her study on the children in the



Representative drawings of children exposed to pesticides (valley) and those that were not (foothills). (Adapted from Elizabeth Guillette, 1998, Environmental Health Perspectives.*)*

Yaqui Valley in Sonora, Mexico. Dr. Guillette compared preschool-aged children living in the foothills where pesticides use was avoided with children living in the valley where agricultural pesticides were frequently used. Although Dr. Guillette and her colleagues found no differences in growth patterns, the exposed children demonstrated decreases in stamina, gross and fine eye-hand coordination, 30-minute memory and in the ability to draw a person. It is those drawings that are the most telling of all and show the most striking differences between the exposed and unexposed children. The children from the foothills drew figures of humans with features that are characteristic of four and five year olds, whereas the children from the valley lacked the ability to draw humans with any such detail.[4]

EPA lacks sufficient data on safety

Surfactants, organic soaps and "re-worked" chemicals in herbicide mixtures together with active ingredients create the cocktails that are sold but unregulated. EPA registration is based on tests of the pure agent chemicals. Yet, it is the mixes with all the surfactants and all the other ingredients present in them that are sold. These are very different products from what is registered. When a pesticide is registered, the following six items are *not* included in the toxicology data submitted to EPA.

Dosing deficient. Pulse doses at low concentrations are not considered.

Routes restricted. Single exposure routes are used in registering a pesticide. However, oral, cutaneous and respiratory routes are very significant ways for these chemicals to get right at the brain.

Endpoints excessive. Cancer and mutations are used. Yet, even though the *Food Quality Protection Act* mandates testing for immune, endocrine and nervous system and developmental function defects from pesticide exposure, it has not been enforced.

Additives absent. Manufacturing contaminants, toxic waste contaminants deliberately added ("reworking") and inert ingredients are missing from the laboratory testing that is done for a pesticides' registration.

Mixtures missing. There is little or no testing for commonly occurring mixtures.

Stresses squelched. Nutrition, disease, and climate stress are not considered.

Weeding Out Hazardous Pesticides

As spring approaches and pesky weeds begin appearing on lawns and landscapes, be sure to implement a prevention-oriented weed management program. *For more information, contact Beyond Pesticides or see www.beyondpesticides.org.*

Prevention

The first step is to prevent weed infestations by maintaining a healthy lawn.

- **Develop healthy soil**. Using a soil probe, cut or dig a small hole about 10" deep and with one side that is straight and smooth. The lawn should have between 5"-6" of topsoil, which is the darkest soil layer. If needed, add topdressings of organic matter.
- **Plant well-adapted, pest-resistant grass varieties**. Find out which grass is most suitable to your climate from your local cooperative extension. A mix of two or more grass varieties is preferable. Over seeding can also reduce weed problems in some cases.
- **Aerate the lawn regularly**. Aerating loosens the soil, allowing air, water, and nutrients to reach the grass roots. Most lawns should be aerated twice a year.
- **De-thatch.** Thatch is a dense layer of grass stems and roots on the surface of the soil. When it becomes thick, roots will grow within the layer of thatch instead of establishing themselves deeply in the soil, which can lead to insect and disease problems, and increase susceptibility to cold, heat and drought. Thatch is reduced by aeration, topdressing with organic matter, or by vertical mowing.
- **Maintain proper pH.** Test the soil and adjust the pH if necessary. Low pH means high acid content – add lime to lower the acidity to 6.7-7 for most grass varieties. High pH means high alkaline – add sulfur to lower the pH, taking care not to add too much and burn the lawn.
- **Fertilize** the lawn at least once a year, preferably in the fall, using a slow-release, urea based product. Fertilizer should not be water-soluble.
- **Water properly**. Too much or too little water can induce pest outbreaks. Enough water should be used each time to wet the soil to the depth of the grass root zone. Soil should be allowed to become nearly dry between watering. Avoid frequent, shallow watering, which promote shallow root systems and reduce the ability of the lawn to resist stress.
- **Mow** correctly and frequently to ensure that weeds are unable to build energy reserves and become well established. Use sharp blades set as high as possible to minimize adverse effects. Never cut off more than 30-40% of the grass blades in a single mowing. Rotate mowing patterns to reduce lawn compaction. Leave a light layer of grass clippings on the grass, as they can provide up to half the lawn's nitrogen requirement.

Least-toxic control strategies

When weeds appear, you don't have to resort to toxic chemicals to get rid of them.

- If you feel that an herbicide is necessary, **corn gluten meal** is an excellent pre-emergent. Because of its high nitrogen content, it can be applied to turf grass as a fertilizer and top dressing, and it suppresses growth of annual weeds such as crabgrass.
- **Fatty acid soaps**, which rapidly biodegrade in soil, provide a least-toxic post-emergent weed control option. Over use of soaps, like chemical pesticides, can lead to pest resistance. Carefully read the label of fatty-acid soap pesticide products to identify the active ingredient and make sure that they do not also contain toxic pesticides or synergists. A fatty-acid soap product called Sharpshooter™ is an effective broad-spectrum herbicide.
- **Vinegar** in at least a 20% solution can be used to spot treat weeds.

Beware of genetically engineered (GE) turfgrass seed varieties, such as RoundUp Ready bentgrass that is currently being developed by Scotts and Monsanto. Many agree that GE turfgrass will lead to an increase in the use of toxic pesticides.

Pulse doses – small exposures, big problems

Enzymes in the liver detoxify the human body of fat-soluble molecules that are most dangerous. It takes anywhere between a half a day to five days to defend against a chemical exposure, which in many cases is not quick enough in protecting the body from defending itself. The trouble is, these liver enzymes, which we do not want too high or too low, not only help detoxify the body, but they also carefully regulate the level of reproductive hormones in the human body. There is now some evidence that is beginning to accumulate that suggests that very short-term pulses concerning key hormones related to thyroid hormones may in fact be behind a large number of pesticide poisoning symptoms.

For example, a pregnant woman standing by a window at springtime inhales pesticides or it lands on her skin, it will get in her blood. Because pesticides contain surfactants and organic soaps that allow them access to the brain, she will get a sudden pulse of a thyroid hormone response either up or down and that thyroid hormone crosses the placenta. All of a sudden the thyroid hormone level changes and the fetus' brain changes the way it is forming. A baby's brain forms in a two-day window. According to animal studies, if the mother's thyroid is either too high or too low when the brain is forming, it will cause the spinal cord to form inappropriately. A year or so later the child is having trouble learning. Yet, there is no trace of a pesticide.

Pesticides get into the human body and make their way to the brain easily because of the way they are formulated to get into plants and insects.

Herbicides and birth defects

The owner of a lawn company once said that the diluted pesticide sprays they use on yards is perfectly safe. Yet, Vincent Garry, M.D., one of the top epidemiologist in the country at the University of Minnesota Laboratory of Environmental Medicine and Pathology, did a long-term study, a retrospective study, which was based on the assumption that if pesticides are safe and applied according to label instructions, then we should be able to look at the children of the pesticide applicators and compare them to the children of general population and there should be no difference. Dr. Garry's study looked at 210,723 live births in Minnesota from 1989 to 1992, a very large sample size, and found three things:

1) Pesticide applicators' children had significantly higher birth defect rates;

2) Birth defect rates were significantly higher in the western agriculture region of the state; and,

3) A significant majority of children with birth defects were born nine months after spring, suggesting that whatever was causing the birth defects was happening at a very early stage in fetal development.[5]

Poisoning similarities of plants, insects and humans

Pesticides get into the human body and make their way to the brain easily because of the way they are formulated to get into plants and insects. Two routes of entry exist. One way is through the waxy skin, the cuticle of the plant or insect. Lipids and organic soaps, surfactants, dissolve wax and are therefore added to pesticides in order to get rapid penetration through the waxy surface of the insect or plant. Unfortunately, human skin is also a waxy surface and pesticides have the same affect on humans.

The other primary route of entry is through plants and insects' breathing pores, which have a hemispheric film of water that acts as a physical barrier. But surfactants are designed to weaken that watery film and make for rapid penetration. Unfortunately, there are tiny cavities on the surface of human lungs, which are also lined by a thin film of water with surface tension that acts as a barrier. Therefore, pesticides act in a similar way in getting into human lungs quickly.

Both of these routes of entry, absorption and inhalation, allow for immediate access to the blood stream. These fat-soluble substances cross the blood brain barrier, because the barrier does not protect against anything that is fat-soluble. So in effect, you are giving these very reactive chemicals access to the command and control center of the body.

Herbicide mixtures and the thyroid connection

The thyroid hormone that controls brain, sexual development, irritability, steroid hormone and immune interactions, is consistently modulated in adult and fetal exposures to all the herbicide mixtures we have tested.

Tests of carbamate insecticides and triazine herbicides mixtures show a: (i) reduction in spatial discrimination, (ii) decrease in speed of learning, (iii) reduction in exploratory behavior, (iv) change in aggression intensity and frequency, (v) change and reduction in memory and motor coordination in the brain, (vi) change in food absorption, (vii) change in thyroid hormone, (viii) change in growth hormone, (ix) reduction in antibodies formation capability, (x) reduction in the host defense mechanisms of the white blood cells in the immune system, (xi) reduction in the ability to gobble up foreign microorganisms and (xii) change in DNA synthesis of genetic materials and RNA synthesis in a cell culture.[6]

Low level exposure to herbicides

The mixture studies have consistently shown neurological, endocrine and immune effects at low doses, most of which were environmentally relevant. Some colleagues and I developed a study looking at an herbicide mixture of 2,4-D, mecoprop, dicamba and its effect on fetal exposures, starting with a concentration that EPA said would have an effect, diluted down to a level to be considered "safe," to then even lower concentrations. We specifically wanted to see what the effect was in the ability to bring young successfully to birth and wean; and how an herbicide induced abortion of fetuses. The results, published in November 2002, showed that this common lawn pesticide mixture is capable of inducing abortions and resorptions of fetuses at very low parts per billion concentrations. The greatest effect was at the lowest dose.[7]

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It is important to point out that these hormonal results are not unique. It is seen in the inverse dose response of the immune system that we published in 1987, where we looked at aldicarb.[8] And in 2000, a study found that chlorpyrifos' greatest impact was at the intermediate doses or really the lowest dose and that the female rats are much more affected, whereas the males tend to be relatively unaffected, thus showing a differential sexual dependent response in terms of learning abilities.[9]

Seasonal effects on immune function

There are seasonal effects on the immune system function due to herbicide exposure as well, which are also not considered in EPA's testing requirements for pesticide registration. For instance, we have found that herbicide exposure in the spring has an increased effect on males, exposure in the fall has an increased effect on males and females, and in the winter there is no effect at all. Not only season, but season plus sex is involved in terms of immune function. For example, we found that immune function changes occurred in males in the spring, and females were significantly different in the fall. In looking at blood level thyroid hormone levels, we found significant differences in the males in the fall and in the winter.

Dr. Porter received his Ph.D. in physiological ecology from the University of California, Los Angeles and has been a professor of zoology and environmental toxicology at the University of Wisconsin, Madison since 1986. Dr. Porter and his colleagues have found that even minute levels of pesticides can harm the immune, reproductive, endocrine and nervous systems of animals. For more information about Dr. Porter's work, see www.wisc.edu/zoology or contact him at Department of Zoology, University of Wisconsin, 250 N. Mills Street, Madison WI 53706, 608-262-1719 or wporter@mhub.zoology.wisc.edu.

Endnotes

1 Hietanen, E., et al. 1983. "Effects of phenoxy herbicides and glyphosate on the hepatic and intestinal biotransformation activities in the rat." *Acta Pharma et Toxicol* 53:103-112.
2 *Wisconsin State Journal*. February 10, 1997. Page A1.
3 Porter, W.P., et al. 1999. "Endocrine, immune and behavioral effects of aldicarb (carbamate), atrazine (triazine) and nitrate (fertilizer) mixtures at groundwater concentrations." *Toxicology and Industrial Health* 15(1-2): 133-150.
4 Guillette, E., et al. 1998. "An anthropological approach to the evaluation of preschool children exposed to pesticides in Mexico." *Environmental Health Perspectives* 106(6): 347-353.
5 Garry, V., et al. 1996. "Pesticide appliers, biocides, and birth defects in rural Minnesota." *Environmental Health Perspectives* 104(4):394-399.
6 Porter, W., et al. 1999.
7 Cavieres, M., et al. 2002. "Developmental toxicity of a commercial herbicide mixture in mice: I. Effects on embryo implantation and litter size." *Environmental Health Perspectives* 110:1081-1085.
8 1987. *Archives of Environmental Contamination and Toxicology* 16:433-439.
9 Levin, E., et al. 2002. "Prenatal chlorpyrifos exposure in rats causes persistent behavioral alterations."*Neurotoxicology and Teratology* (24)6: 733-741.