City of Lawrence
Sustainability Advisory Board (SAB)
June 13, 2007 (5:30 PM) Meeting Minutes

MEMBERS PRESENT:	Chris Cobb, John Craft, Dickie Heckler, Sarah Hill-Nelson, Daniel Poull, Laura Routh, Cindy Strecker, Marie Stockett
MEMBERS ABSENT:	Brent Swain
STAFF PRESENT:	Tammy Bennett, Michelle Crank, Kathy Richardson
GUESTS PRESENT:	Amy Albright, Kevin Kennedy
PUBLIC PRESENT:	Kevin Doyle, Matt Lehrman

ANNOUNCEMENTS

Daniel Poull stated that Jae Chang has resigned from the Board.

☐ **Action:** Kathy Richardson will inform City Manager's office of current SAB board opening.

APPROVAL OF MEETING MINUTES

Motion and second to approve the April 11th and May 9th minutes (Heckler/Routh).
Vote: Motion was passed unanimously.

Presentation by Amy Albright on Pesticide use at Prairie Park Nature Center

Amy Albright informed SAB that the City of Lawrence Prairie Park Nature Center, a location highly trafficked by children, has its gardens routinely sprayed with pesticides as part of its Parks & Recreation maintenance. Amy Albright stated that not only would she like to see this area turned into a pesticide free zone but also thinks it would be a great location for sustainable gardening education programs (handout provided; see attachments). Amy has received verbal support from the Prairie Park Nature Center staff. Kevin Kennedy from Children's Mercy Hospital handed out information regarding how pesticides affect children (see attachments). Both Amy and Kevin asked for SAB's support.

There was discussion on wanting to suggest renaming Prairie Park Nature Center to Prairie Park Preserve and Nature Center. Tammy Bennett indicated that would be a discussion for the Parks and Recreation Advisory Board to have.

Motion and second to support Prairie Park Nature Center as a pesticide free zone and support sustainable gardening education programs to be taught through the Nature Center (Hill-Nelson/Craft).
Vote: Motion was passed unanimously.

☐ **Action:** SAB will write a letter to the Parks & Recreation Advisory Board and copy City Commission and Amy Albright. Laura Routh will draft the body of the letter and Marie Stockett will edit the text within 2 weeks. Letter will be e-mailed out to SAB for review and comments should be sent to Daniel Poull.

(Approved on 7/11/07)

Discussion on Home Energy Conservation Fair

Kathy Richardson informed SAB that WRR cannot organize/coordinate the Home Energy Conservation Fair (HECF) this year without assistance. WRR is down 2 full-time employees and all other employees are new in their assigned jobs. This past week Kathy asked Tammy Bennett to request a part time intern position whose focus would be to help coordinate the HECF. WRR will be on board with HECF if the City Manager approves this internship.

Motion and second to support the Home Energy Conservation Fair efforts if the WRR internship is funded by City of Lawrence (Craft/Routh).
Vote: Motion was passed unanimously.

If the internship is approved, Richardson stated that a HECF Committee will need to be formed ASAP. The Committee would meet once a month until October. The following SAB members signed up for the HECF Committee: Chris Cobb, Dickie Heckler, Sarah Hill-Nelson, Daniel Poull, and Laura Routh. Richardson will keep SAB members informed on meeting dates.

Richardson also requested that HECF be put on the monthly SAB agenda until October.

Richardson and various SAB members stated that Michelle Crank has done an excellent job coordinating the HECF in past years. Although Michelle's new job responsibilities do not allow her to participate at the same level as previous years, Michelle will be a key component to the success of this year's HECF.

Discussion on Standing Committees

Daniel Poull stated that he prefers not to have standing committees. Instead he would support forming ad hoc committees as necessary.

Motion and second to form ad hoc committees when necessary (Heckler/Cobb).
Vote: Motion was passed unanimously.

Discuss inviting Dennis Murphey, Chief Environmental Officer for Kansas City, MO to future meeting

Daniel Poull suggested inviting Dennis Murphey to give a presentation to SAB members and other interested parties during a special announced meeting and not during a scheduled SAB meeting.

☐ **Action:** Daniel Poull will invite Dennis Murphey and coordinate a date and time.

☐ **Action:** Once a date and time has been established Tammy Bennett will reserve a room for this presentation.

Discuss impact of Kevin's Dismissal

Tammy Bennett and Dena Mezger are now jointly assigned to chair the Energy Management Committee which is composed of City employees in various departments. Tammy Bennett drafted an Energy Report which the Committee reviewed during today's meeting. This Energy Report will be sent up to City Manager's office for inclusion at next City Commission meeting's regular agenda.

☐ **Action:** Kathy Richardson will send out Energy Report to SAB via e-mail.

Tammy also informed SAB that city staff, two SAB members and two Sierra Club members participated in a Local Government Climate Change Initiatives Wed Cast on June 12, 2007. Dennis Murphey gave a great PowerPoint presentation as part of this Web Cast.

Waste Reduction and Recycling Report – Staff

Printed copy of the monthly updates provided to SAB.

☐ **Action:** Kathy Richardson will e-mail SAB the new WRR staff flow chart.

Laura Routh asked if there was an update on the waste characterization study which Bob Yoos mentioned at the last SAB meeting he would be working on.

☐ **Action:** Kathy Richardson will have Bob's update on the waste characterization study by next board meeting.

Miscellaneous and Guest Comments

Daniel Poull proposed to start inviting City Commissioners to the SAB meetings. He would like to invite Sue Hack first, then Mike Dever, next Rob Chestnut and so on.

Agenda items:

- Next meeting: July 11, 2007
  - LEED certification and City facilities, Dave Wagner, Director of Utilities, discussion of status of LEED certification for both the Water Reclamation Facility and the existing Wastewater Treatment Plant
  - Home Energy Conservation Fair
  - Update on Waste Characterization from Bob Yoos

- Future meetings
  - Green Campaign (Marie Stockett)
  - Downtown Recycling

Meeting adjourned 7:00 p.m.

Attachments:

- Sustainable Gardening Education Programs by Amy Albright
- Chemicals combine in our bodies, but are rarely tested that way. Why?
- How are Children Different from Adults?
- Waste Reduction and Recycling Division report

City of Lawrence

Waste Reduction & Recycling Division - Update for May 2007

WASTE REDUCTION AND RECYCLING DIVISION UPDATE

On May 14th, Michelle Crank began her new role as WRR Field Supervisor. Her new responsibilities include overseeing the Fibers Program. Michelle supervises crews engaged in the collection routes for baling operations; and assumes program management responsibilities including program design, siting of containers, troubleshooting, data collection from route operators, quality control for collected materials, identification of new markets, and determining how to best maximize revenues from materials collected.

On May 24th, the City's Stormwater Division and WRRD constructed a Rain Garden at the SWAN building located at 320 NE Industrial Lane, Lawrence. Rain gardens are gardens planted in low spots using native plants, designed to catch rainwater from downspouts, sidewalks, driveways, or parking lots. Rain gardens soak up rain where it falls, reduce rainwater runoff, reduce erosion and remove pollutants, and create attractive landscaping.

HOUSEHOLD HAZARDOUS WASTE (HHW) PROGRAM REPORT

Month	HHW Drop-Offs	Battery Bags in Mail	Appt No Show	Home-bound	Saturday Collection	Abandoned Waste	Orphan Waste	SQG Inventory	SQG Drop-off	Product Reuse Appt
January	119	7	12	0	0	2	0	2	2	18
February	76	5	10	1	0	1	0	8	6	8
March	177	3	6	0	0	2	0	5	4	20
April	201	4	13	1	12	5	0	10	9	39
May	**290**	**5**	**11**	**1**	**33**	**6**	**0**	**11**	**9**	**55**
June										
July										
August										
September										
October										
November										
December										
TOTAL	**863**	**24**	**52**	**3**	**45**	**16**	**0**	**36**	**30**	**140**

(Approved on 7/11/07)

FIBERS REPORT

OLD CORRUGATED CONTAINERS (OCC)

Cardboard	Tons	Revenue
Current YTD	435.04	**$48,433.64**
Prior YTD	400.16	$27,671.70

Avg. Price/ton thru May 2007: $111.33 Avg. Price/ton thru May 2006: $ 69.15

OLD NEWSPAPERS (ONP)

Newspaper	Tons	Revenue
Current YTD	411.02	**$38,784.00**
Prior YTD	385.66	$29,659.35

Avg. Price/ton thru May 2007: $94.36 Avg. Price/ton thru May 2006: $ 76.91

OFFICE WASTE PAPER (SOP)

Sorted Office Paper	Tons	Revenue
Current YTD	none	**$** n/a
Prior YTD	10.08	$ 609.84

Avg. Price/ton thru May 2007: $n/a Avg. Price/ton thru May 2006: $ 60.50 (we are holding for full load)

OLD MAGAZINES (OMG)

Magazines	Tons	Revenue
Current YTD	**.63**	**$40.63**
Prior YTD	0	$0

Avg. Price/ton thru May 2007: $ Avg. Price/ton thru May2006: $

MIXED WASTE PAPER (MIX)

Mixed Paper	Tons	Revenue
Current YTD	none	**$** N/A
Prior YTD	N/A	$ N/A

Avg. Price/ton thru May 2007: $n/a Avg. Price/ton thru May 2006: $ N/A (we are holding for full load)

TOTAL	**YTD TONS**	**REVENUE**
	846.68	**$87,258.27**
Prior YTD	795.90	$57,940.89

YARD TRIMMINGS COLLECTION & COMPOST PROGRAM REPORT

	January	February	March	April	May	June
Total Tons collected curbside	21.45	NA	1114.98	1413.36	2545.08	617.60
Commercial YW received	2.00	1.80	29.00	132.10	50.61	data forthcoming
Other YW received	0.00	0.00	0.00	0.00	0.00	0.00
Total tons this month	23.45	1.80	1143.98	1545.46	2595.69	617.60
Average Preferred Container Compliance	100%	NA	98%	99%	99%	99%

(Approved on 7/11/07)

Sustainable Gardening Education Programs

Prairie Park Nature Center
written by Amy Albright
Vinland Valley Nursery

Why does our community need this?	Lawrence should be a model of what a green city's leading role can be in this global movement!
Public Health and safety	
Education in Wildlife Conservation	
Education in Conservation of Resources	

Why Prairie Park Nature Center?	This city park is a natural choice for this programming.
The nature center already promotes education and awareness of wildlife and natural systems.	
The nature center already has garden beds in place that can easily be transformed into educational plantings.	
Using safe chemicals and organic gardening practices in this park will strengthen the natural systems being showcased.	
Children using the gardens in the park while studying wildlife and nature will never be exposed to potentially dangerous chemicals.	
Classes at the nature center can be tailored to provide hands-on gardening education that can also benefit the upkeep of the gardens at no cost to the city!	
Federally protected public education animals housed at this park have special needs, and can be endangered by conventional gardening materials and chemicals.	

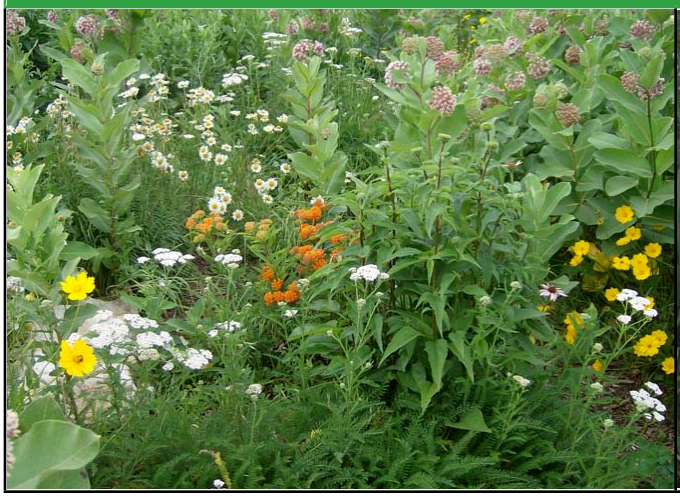
Sustainable Gardening Education Programs

Prairie Park Nature Center
written by Amy Albright
Vinland Valley Nursery

How can PPNC expand it's role in this area?	**Staff and volunteers can create interesting and practical programs.**
Lawrence has a huge range of available individuals and local business people who can be invited to develop programs.	 
Offer seasonal, hands-on classes	
Create hand-outs and web resource, promote green education in nature center newsletter	

What do we need to get it done?	
Designate PPNC a safe chemical park	Freedom to run PPNC as green as practically possible.
Allow PPNC staff to direct all plantings around the nature center	Volunteers!

Prairie Park Nature Center is already a superior park with creative, progressive programming. By increasing the scope of the park's educational focus, it has the potential to be a truly cutting edge city park that would make even the largest conservation education-minded American city green with envy!

Prairie Park Nature Center
written by Amy Albright
Vinland Valley Nursery

Sustainable Gardening Education Programs at the Prairie Park Nature Center

Why does our community need this?

Lawrence City Commissioner and former mayor Boog Highberger was quoted recently about his wish to see Lawrence become a green city. While part of making the city green is setting up city systems and departments to use green technologies to lesson their impact, and creating legislation to reward private citizens and businesses for using green practices, it is also necessary to provide education and to promote awareness to the public at large.

The landscape around this city park is a major part of the nature center's purpose for existing! Because these gardens are not meant to display formal garden styles like those at the train depot or South Park gazebo, but rather to demonstrate sustainable, wildlife friendly, natural environments, turf and other traditional landscape design and material is not aesthetically or practically appropriate to this park.

• **Public health and safety** are historically a natural place for cities to take a leadership role. The pesticide-free parks program has been a tremendous start for the city, and taking it to an educational level is the next logical step towards explaining the "whys and hows" of the program to the public, and showing citizens how to use what the city has done in their own landscapes.

• **Wildlife conservation** is a major part of the green movement, and gardens are the average citizen's first but sometimes least obvious place to take part. By educating the public on such topics as safe chemical use, plants and their individual benefits to certain species, and where plants and animals fit into natural systems in the residential garden, we're engaging people in the daily act of preserving natural systems in their own backyards!

• **Conservation of resources** is another major part of the green movement, and gardens that create safe habitat don't necessarily follow good resource conservation practices. Good gardeners reduce their use of water through such tricks as planting xeriscape plants, watering at the correct time of day and for the right length of time, and using rain barrels and other reclamation techniques. They also protect the water supply by not using chemicals that can run off into streams and lakes, contaminating water for wildlife and humans alike. Buying locally grown plants uses less fuel for transportation. It also increases the likelihood of plant material growing successfully in our area, which in turn lessens the temptation to use damaging chemicals and excessive water.

Prairie Park Nature Center
written by Amy Albright
Vinland Valley Nursery

Why Prairie Park Nature Center?

• The nature center already promotes education and awareness of wildlife and natural systems. This park is the natural place to undertake this type of programming. Unreleasable wild animals are on display for visitors, and they make an impact that words alone simply cannot make. The same can be said for demonstration gardens being an invaluable tool for informing the public about safe gardening practices and how their choices impact the larger ecosystem, including the animals on display at the center.

• The nature center already has garden beds in place that can easily be transformed into educational plantings. With the direction of park staff, gardens can be created to demonstrate such topics as green home landscaping plants and practices, butterfly gardens, bird and mammal friendly gardens, and historic prairie plants. With the addition of informational signage, park beds can be easily be further developed into interpretive gardens.

• Using safe chemicals and organic gardening practices in this park will strengthen the natural systems being showcased. Butterfly milkweed that has been sprayed with chemicals isn't a healthy diet for monarch caterpillars used in the classroom where young children learn about butterfly life cycles. Bird watching classes will have greater success spotting birds when plants that attract and feed the birds are planted around the nature center. The examples are endless …

• Children using the gardens in the park while studying wildlife and nature will never be exposed to potentially dangerous chemicals. Classes at the nature center are "hands-on", and re-entry time on various chemicals being used in the park is difficult if not impossible to coordinate with landscape crews and nature center staff. It is unacceptable for children to be allowed into areas where they will come into contact with landscape chemicals.

• Classes at the nature center can be tailored to provide hands-on gardening education for children and adults that can also benefit the upkeep of the gardens! Expanding class offerings at the nature center and inviting more instructors will broaden the interest and use in the park. Partnerships with area high school biology instructors might be developed to offer field experience in parks systems by allowing students to assist in the creation of garden beds, interpretive signage and class development.

• Federally protected public education animals housed at this park have special needs, and can be endangered by conventional gardening materials and chemicals. For example, raptors can contract pneumonia from wood chip mulch, therefore landscaping outside wildlife pens cannot contain traditional mulch but must instead be underplanted with groundcover as a living mulch or rock. Another example is the new Mary's Lake subdivision with development of 39 new homes. The potential for dangerous contamination from traditional lawn fertilizers, herbicides, pesticides and pre-emergents to fish and other wildlife in the lake is high. This is a clear example of the difference the city, through nature center staff and volunteers, could make by educating new homeowners in this subdivision about green gardening practices to make them good stewards of Mary's Lake.

How can PPNC expand its role in this area?

Lawrence has a huge range of individuals and local business people who can be invited to help develop programs. Following is just a quick start:

- Amy Albright/Doug Davison — Vinland Valley Nursery (safe chemicals, organic gardening, native plants)
- Kevin Kennedy — Environmental Health Specialist and Program Manager for Children's Mercy Hospital's Environmental Health Program
- Sarah Hill-Nelson — Bowersock Dam, Bonneville-Zephyr Energy (renewable energy)
- Kenton Knowles — Global Homes (green building)
- Margarete Johnson, Chip Taylor — Monarch Watch (creating butterfly gardens, registering sites)
- Ron Swall — Brookside Landscaping, biology teacher, Free State High School
- Julie Vernon — Lawrence Sustainability Network (local resources/experts on a range of topics)
- Chris Hamill — landscape designer
- Paul Hotvedt — Director, Blue Heron Typesetting; member of Committee on Imagina tion&Place, Lawrence Arts Center; gardener
- Brendan Lynch — web design, creation of no-cost educational resource for homeowners looking for green gardening solutions

Offer seasonal, hands-on classes for children and adults

Create hand outs and web resource, promote green education and green gardening in nature center newsletters

What do we need to get it done?

Designation as a safe chemical/organic garden park — gardens are wildlife centered by design.

Allow PPNC staff to direct all plantings around the nature center structure, trails and parking area island.

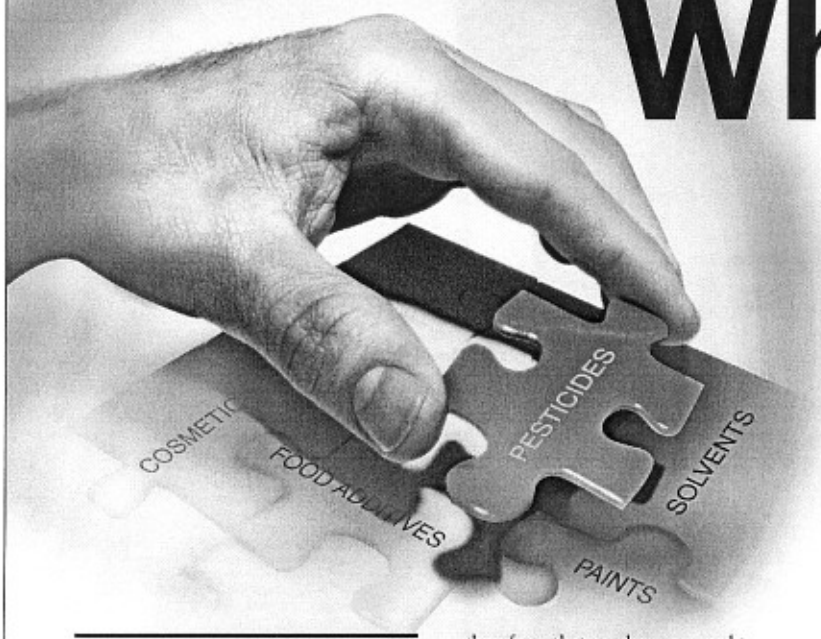
Freedom to run the nature center as greenly as possible!

Volunteers! A periodic call for volunteer gardeners can be implemented to keep gardens in top shape, in addition to those members of the community listed above.

Prairie Park Nature Center is already a superior park with creative, progressive programming. By increasing the scope of the park's educational focus, it has the potential to be a truly cutting edge city park that would make even the largest conservation education-minded American city green with envy!

Chemicals combine in our bodies, but are rarely tested that way.

Why?



Multiple exposures pose unknown risks.

A good pharmacist will alert you that a newly-prescribed medicine may adversely interact with some other medicine you're already taking. That is, two medications that are individually benign can cause problems in combination. Careful studies have been undertaken to identify those drug interactions.

But when it comes to toxic chemicals in everyday products, there is surprisingly little information available about how they behave in combination. How, for example, are our bodies affected when the chemicals in paint thinners interact with those in dark hair dyes, or when we are exposed to one pesticide on a fruit, and another from our neighbor's lawn?

What We Know

Here is an analogy: Compared with non-smokers, cigarette smokers have ten times the risk of contracting lung cancer. We also know that workers exposed to asbestos have five times the lung cancer risk compared with those never exposed. You might think, therefore, that smokers exposed to asbestos would have 15 times the risk of getting lung cancer. In fact, they face 55 times the risk. A powerful interaction.

We know that the tissue of nearly every human on earth contains detectable levels of a range of chemicals called persistent organic pollutants or POPs. We find POPs in pesticides, industrial chemicals, indeed in a broad range of products introduced over the past sixty years. We know that occupational exposure to PCBs, dioxin, and other POPs has been linked to several cancers and to a broad range of reproductive problems, including birth defects in offspring. Clinical and epidemiological studies suggest that non-occupational exposures to POPs at much lower levels may also cause significant harm, especially to developing fetal organs. And the little we know of exposure to a multiplicity of these chemicals should cause concern.

Dutch scientists have documented that when PCBs, at a non-toxic level, are mixed with dioxin, at a level that produced only minor liver damage, the combination produced 400 times the damage of the dioxin alone.

A study at Tufts University tested the effects of 10 pesticides which mimicked estrogen in the body. At low levels, none of the pesticides alone had an effect on human tissue. But in various combinations, there was a strong estrogen-mimicking effect ... even at low levels.

In a study at the University of Wisconsin, mice showed no effect when exposed to atrazine or aldicarb, two pesticides commonly found in drinking water in the Midwest. When mice were exposed to both chemicals, as humans often are, the combination produced immune system impairment.

What We Can Do

Parents should limit their children's exposure to pesticides, both in and outside the home. Organically produced foods should be purchased whenever possible. The use of paints, solvents, and cleaning products containing toxic and volatile chemicals should be limited. There are more suggestions on our website.

But we must do more. Of the thousands of synthetic chemicals on the market, relatively few have been tested for safety. And even fewer have been tested in combination with other chemicals. For our health, for our children's health, such testing should be in place for all chemicals.

A summary of the supporting scientific evidence, and a list of scientific endorsers, can be found at www.childenvironment.org.

Center for Children's Health and the Environment

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Box 1043, One Gustave Levy Place, New York, NY 10029 • **www.childenvironment.org**

How Are Children Different from Adults?

Cynthia F. Bearer

Division of Neonatology, Department of Pediatrics, Rainbow Babies and Children's Hospital, Cleveland, Ohio

Abstract

Several factors alter an individual's risk for an environmentally related illness. A major determinant is the age of the individual. The toxicodynamic processes that determine exposure, absorption, metabolism, excretion, and tissue vulnerability are all age related. This paper discusses each of these processes and their variability with age, and illustrates these points with examples of environmentally related disease cases. -- **Environ Health Perspect** 103(Suppl 6):7-12 (1995)

Key words: developmental stages, environmentally related diseases, developmental toxicology, routes of exposure, exposure, absorption, metabolism, excretion, preconception

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This paper was presented at the Symposium on Preventing Child Exposures to Environmental Hazards: Research and Policy Issues held 18-19 March 1994 in Washington, DC.

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Introduction

Several factors alter an individual's risk for an environmentally related illness. These include genetic background, nutrition, age, lifestyle, etc. These categories are not mutually exclusive but are influenced by each other. This article will focus on age as a susceptibility factor and specifically on how the toxicokinetic parameters of exposure, absorption, metabolism, distribution, and target organ susceptibility change during development (*1*).

Exposure

Exposure to an environmental agent is the first step in the sequence of environmentally related health effects. Exposures differ with developmental stage because the environments of children are different than those of adults.

When considering exposures, one must look at the exposures of an individual over the course of a day. In general it is true that people may move through several environments during a day, to doing errands, going home, going to sleep. This is also true for infants and children, going to school, going to day care, going to play. What is needed is a sum total of all the exposures and some idea of the maximum exposure. But we are usually not able to put monitors on people and measure them. Usually, our estimates of exposure are from retrospective estimates. This is true not only for adults, but for children as well. Although the total exposure in a day may be the same, the pattern of exposure may have totally different health effects. For example, nitrates in well water may cause methemoglobinemia. However, if they are ingested at a rate where the methemoglobin reductase can continue to keep the iron in hemoglobin in the reduced state, no health effect will occur. But if the dose exceeds the capacity of methemoglobin reductase, then methemoglobinemia will result (*2*). This is one mechanism that results in a threshold effect.

Exposures that have profound health effects on an individual may occur at periods of time that frequently are not considered, such as an exposure that may occur to the mother before the conception of that individual which may have a profound effect on that individual. For example, women who conceived after eating cooking oil contaminated with polychlorinated biphenyls (PCBs) gave birth to infants with yusho (*3*). The mechanism responsible is felt to be storage of PCBs in adipose tissue during exposure, which are then mobilized during pregnancy (*4,5*). Another example is that of a woman who was inadequately treated for plumbism in childhood and who gave birth to an infant with congenital lead poisoning (*6*). Storage of the lead in bone with mobilization during pregnancy is the most logical explanation for this result (*7*).

Another example of an exposure prior to conception, which may result in effects on the individual, is a preconception exposure that directly affects the ovum or sperm. The ovum, formed within the fetus of the future mother, is dependent on the exposures of both the grandmother and the mother. The ovum, therefore, is a stage of development that sums all the exposures of the other stages of development. Studies have measured xenobiotics in follicular fluid, showing the potential for exposure (*8*). Sperm, in contrast, are created only a few hours to days prior to conception. Thus, the exposures to the sperm are dependent on paternal exposure in the periconception period.

In most instances, exposures to the fetus are dependent on the exposures to the mother. However, premature infants delivered after 24 weeks have very different exposures in the newborn intensive care unit (NICU), such as to noise, light, compressed gases, intravenous solutions, and benzyl alcohol (*9*). Not only is the NICU a unique environment, but these infants remain in the same environment often for months.

Exposures of newborns, infants, toddlers, school-age children, and adolescents can be discussed with reference to changes in physical location, breathing zones, oxygen consumption, food consumption, types of foods consumed, and normal behavioral development.

Physical Location

The physical location of children changes with development. The newborn is usually near the mother or held by the mother, so exposures will be like those experienced by the mother. The newborn frequently spends more time in a single environment for prolonged periods of time, i.e., a crib, rather than several different environments. Infants and toddlers are frequently placed on the floor or carpet, or on grass. Therefore, they have much more exposure to chemicals associated with these surfaces, such as formaldehyde and volatile organic chemicals from synthetic carpet (*10*) and pesticide residues from flea bombs (*11*).

Preambulatory children also may experience sustained exposure to noxious agents because they cannot remove themselves from their environment. An example is the infant who is badly sunburned due to the inability to protect himself/herself. It has been shown that the risk of skin cancer is most closely related to the amount of sun damage the skin sustains during the first 18 years of life (*12*).

School-age children spend a significant period of time at school, a very different physical environment than the house. Schools are frequently built on relatively undesirable land for economic reasons. These sites are frequently near highways (auto emissions and lead), under power lines (electromagnetic fields), or on old industrial sites (benzene, arsenic). Until relatively recently schools made frequent use of asbestos as a building material (*13*).

Adolescents not only have a new school environment, but begin to self-determine physical environments, often misjudging or ignoring the risks to themselves (*14*). In addition, many adolescents have part-time jobs that place them in physical environments which may be hazardous due to occupational exposures (*15*).

Breathing Zones

The breathing zone for an adult is typically 4 to 6 ft above the floor. However, for a child, it is closer to the floor and dependent on the height and mobility of the child. It is within these lower breathing zones that heavier chemicals such as mercury and large respirable particulates settle out (*16*) and radon accumulates (*17*). This is one factor that may have accounted for the case of acrodynia in Michigan from latex house paint (*18*).

Oxygen Consumption

Because of their larger surface-to-volume ratio, the metabolic rate of children is higher, and hence their oxygen consumption is greater. Therefore, their exposure to any air pollutant is greater. For example, if radon is present at 2 pCi/l, an adult with an average O_2 consumption rate of 3.5 ml/kg body weight/min will receive an exposure of 48 pCi/kg in 24 hr. In contrast, a 6-month-old child with an average O_2 consumption rate of 7 ml/kg body weight/min will receive an exposure of 96 pCi/kg in 24 hr, which is twice as much (*19*).

Quantity and Quality of Food Consumed

Just as O_2 requirement is higher for children as a function of their surface-to-volume ratio, so is caloric requirement. Not only do children maintain homeostasis, they also grow. Therefore, the amount of food they consume per kg/body weight is higher than that of the adult (*20*). Consider the amount of water consumed by an infant who receives formula reconstituted in boiled tap water. Average consumption is 6 oz/kg. (In comparison, for the average male adult, this is equivalent to drinking 35 cans of soda pop a day.) Blood lead levels greater than 10 µg/dl have been found in infants with exposure to tap water in formula (*6*). It has also been shown that the types of food they consume differ from those of adults (*21*). The diets of many newborns are limited to breast milk. Breast milk has been documented to contain many environmental pollutants including lead, PCBs, and dioxins (*22-24*). Children's diets contain more milk products and more fruit and vegetables. When the level of exposure of children to Alar was calculated using a child's daily consumption of apples and apple products, an unacceptable level of risk for cancer was found (*25*).

Normal Behavioral Development

The normal behavioral development of a child will also influence his environmental exposures. A preambulatory infant will not be able to remove himself/herself from a noxious environment as mentioned earlier. Normal children pass through a developmental stage of intense oral exploratory behavior. Most objects grasped will be placed in the mouth. This behavior is one common etiology of lead poisoning in environments with high levels of lead dust (*26*). It also places the child at risk in environments that have not taken the oral orientation of children into account. One example is arsenic- and creosote-treated wood in playgrounds. Children will frequently place their mouths on these materials in the course of normal play (*27*). The ability to walk often places the child in unusual situations for play, such as used drums, mud puddles, or empty lots, environments where adults spend little time and which have the potential for dangerous exposures. As children become adolescents, they gain more and more freedom from parental authority. However, they are at a stage of development in which physical strength and stamina are at a peak, yet they are continuing to acquire abstract thinking (*28*). Therefore, they do not consider cause and effect, particularly delayed effects, in the same way adults do. They often place themselves in situations with greater risk due to this lack of perception. An example is the increased incidence of farm injuries involving adolescents as compared to adults (*29*).

Absorption

Absorption generally occurs by four major pathways: transplacental, percutaneous, respiratory tract, and gastrointestinal tract. Each of these portals of entry is dependent on the developmental stage of the child.

Transplacental

During the fetal stage, a major pathway of absorption is the placenta. Until the late 1950s, the placenta was thought to protect the fetus from any maternal exposure. However, the experience with thalidomide drastically changed this paradigm (*30*). It is now known that several classes of compounds readily cross the placenta. Compounds of low molecular weight cross the placenta readily. Carbon monoxide is a good example of this type of chemical. Because carbon monoxide has a higher affinity for fetal compared to adult hemoglobin, the concentration of carboxyhemoglobin is higher in the fetus than in the mother (*31*). Lipophilic compounds such as polycyclic aromatic hydrocarbons and ethanol also readily gain access to the fetal circulation. PCBs have been measured in equal concentration in fetal and maternal blood (*32*). Fetal and maternal blood levels of ethanol are equal in pregnant ewes (*33*). The fetal liver does not express alcohol dehydrogenase until near term (*34*). Therefore, the majority of ethanol diffuses back across the placenta and is metabolized by the mother. There are also specific transport mechanisms in the placenta that actively transport specific nutrients. Calcium is such a nutrient; a 100 to 140 mg/kg/day accretion is required by the fetus in the third trimester (*35*). Lead is transported via the calcium transporter. Fetal blood lead concentration is equivalent to maternal blood lead concentration (*36*).

Percutaneous

Transdermal pathways of absorption are particularly important for lipophilic compounds. The skin undergoes enormous changes with each developmental stage, which alters the properties of absorption.

The skin of a fetus is unkeratinized (37) and is thus without one of the major barriers of the skin. Although xenobiotics have been described in amniotic fluid (*38*), the transdermal absorption of these compounds has not been studied. Keratinization occurs over the initial 3 to 5 days following birth and is independent of gestational age. Therefore, the skin of a newborn remains a particularly absorptive surface. Several epidemics have been described involving percutaneous absorption of xenobiotics, including hypothyroidism from iodine in betadine scrub solutions (*39*), neurotoxicity from hexachlorophene baths (*40*), and hyperbilirubinemia from a phenolic disinfectant (*41*). An additional factor in the absorption of these chemicals transdermally is the larger surface-to-volume ratio of newborns compared to older children and adults.

Respiratory Tract

During prenatal life, the fetus makes breathing motions. Although the net flux of fluid is from the lungs out of the trachea into the amniotic fluid, some xenobiotics in amniotic fluid may be in contact with the respiratory epithelium. Studies on this pathway are limited. It has been noted that maternal smoking during pregnancy is associated with significant reductions in forced expiratory flow rates (*42*).

The surface absorptive properties of the lung probably do not change during development. However, from birth to adolescence, the lung continues to develop alveoli (*43*). A consequence of this development is an increasing surface absorptive area in the lung.

Gastrointestinal Tract

The gastrointestinal (GI) tract undergoes numerous changes during development. The fetus actively swallows amniotic fluid (*44*). Xenobiotics are known to be present in amniotic fluid, but prenatal absorption from the GI tract has not been investigated.

Following delivery, the gastric pH is relatively high and does not achieve adult levels of acidity until several months of age (*45*). The difference in pH will markedly affect xenobiotic absorption from the stomach, as it will change the ionization status of these chemicals (*46*). In addition, under low levels of acidity, bacterial overgrowth in the small bowel and stomach may result. The absorption of nitrites formed by bacteria from ingestion of

formula reconstituted with well water with nitrate contamination resulted in several cases of methemoglobinemia in Iowa (*47*).

The small bowel is felt to express specific transport mechanisms in the newborn. In the newborn mouse and rat, maternal IgM and IgG present in colostrum are specifically transported across the small bowel and into the blood. Whether these mechanisms are present in humans has not been proved (*48*). The bowel also responds to increased nutritional needs by increasing absorption of the particular nutrient. For example, growing children require more calcium than adults for continued bone growth. Thus, they absorb more calcium from intraluminal contents than adults. However, they also absorb more lead from the GI tract than adults because of this enhanced absorption. It is estimated that an adult will absorb 10% of ingested lead, whereas a 1- to 2-year-old child will absorb 50% of ingested lead (*49*).

Distribution

The tissue distribution of chemicals varies with developmental stage of the child. For example, many drugs in the newborn have higher apparent volumes of distribution (*50*). In animal models, it has been shown that lead is retained to a larger degree in the infant animal brain than in the adult (*51*). Lead also accumulates more rapidly in children's bones, doubling between infancy and the late teen years (*52*).

Metabolism

Metabolism of chemicals may result in their activation or deactivation. These enzymes involved in the biotransformation of chemicals can be categorized into two groups, Phase I and Phase II enzymes. Phase I enzymes promote formation of a conjugable group, and phase II enzymes catalyze the conjugation of a more polar compound to the conjugable group such that the resulting conjugate is more polar and therefore more easily excreted. Not only does developmental stage determine the activity of these metabolic pathways, but also the genetic polymorphisms of each locus determine the activity of each component enzyme. The family of glutathione *S*-transferases, phase II enzymes, illustrates both of these points. The glutathione *S*-transferases (GST) are a large and complex family of enzymes which share the catalytic activity of glutathione conjugation to a second substrate with a conjugable group (*53*). They can be separated into four families of enzymes: α, μ, ¼, and microsomal. The μ family is lacking in 50% of individuals (*54*). Smokers with lung cancer have a higher incidence of lacking the μ glutathione transferases (*55*). Thus, these individuals have a genetic susceptibility to carcinogenesis from cigarette smoke. The expression of the families of GST show a marked tissue specificity. GST ¼ is only found in placenta (*56,57*); the Yc isozyme of GST α is not expressed in brain, but the Yb_3 isozyme of GST μ is only expressed in brain (*58,59*). Developmental regulation is evident in that 50% of GST activity in fetal liver is GST ¼, which is not expressed in adult liver (*60*).

Developmental regulation is more complex in the P450 cytochrome family. [Nebert and Gonzales (*61*) present a complete review.] Clinically this is important for the pediatrician to know in order to prescribe medications accurately. Theophylline is metabolized by the P450 cytochrome system. Initially, during the newborn period, the half-life of theophylline is prolonged, requiring dosing twice a day. However, P450 cytochrome expression increases over the first few months of life, decreasing drug half-life and necessitating more frequent dosing. If one examines urinary metabolites of theophylline during this period, one sees a difference in the pattern of metabolites denoting complex developmental stages in the expression and activity of the P450 cytochromes (*61*). The half-life of theophylline is again prolonged during adolescence, possibly as a consequence of competition with steroid hormones (*62*). Dosing interval must again be prolonged to avoid toxicity.

Another clinical example of developmental changes in metabolism is the case of acetaminophen. In the adult, as well as the pregnant adult, high levels of acetaminophen may cause fatal hepatotoxicity. However, infants delivered to mothers with high acetaminophen levels will also have elevated acetaminophen levels in blood, but will not sustain liver damage. It is thought that the lack of the fetus's ability to metabolize the acetaminophen protects the fetus from end-organ damage (*63,64*).

From these two examples, one can conclude that biotransformation of xenobiotics is developmentally regulated and may either protect or harm the individual.

Excretion

Kidney function is also developmentally regulated. At birth, glomerular filtration rate is a fraction of normal adult values. It gradually increases to adult values by approximately 1 year of age. The ability to concentrate urine is also developmentally regulated, the newborn being relatively poor at concentrating urine. By 16 months of age, renal function has reached adult capabilities (*65*).

Target Organ Susceptibility

Children are also different than adults because their organs are undergoing growth and differentiation. Both of these processes may be affected by xenobiotics. The result of exposure to xenobiotics may be different in children than adults, both in the degree of severity of effect and also in the nature of the effect. Since children's bodies are growing and developing, these processes may be disrupted as a result of environmental exposures, leading to different outcomes. Examples of such outcomes are prenatal and postnatal growth retardation, diminished IQ, precocious puberty, microcephaly, and diminished lung volume.

Growth occurs by three mechanisms: auxelic, where growth occurs by cells becoming larger; multiplicative, where growth occurs by cells dividing; and accretionary, where ground substance and nonliving structural components accumulate (*66*). Multiplicative growth is felt to be complete at 6 months of gestation for those tissues not undergoing continual turnover such as epithelial cells. All subsequent growth is accretionary or auxelic. Cells undergo two further processes to become the adult organism, differentiation and migration. Differentiation is the process by which cells take on their particular chemical operations and lose the ability to divide. These events may be triggered by hormone-receptor interactions. Some environmental agents may mimic hormones and alter the differentiation of some tissues. Chlorinated insecticides are an example of this mechanism. Recent studies have shown effects on the reproductive system from exposure to chlordecone (*67*).

Cell migration is necessary for certain cells to reach their destination for function. Neurons, for example, originate in the germinal matrix, then migrate out along radial glia to a predestined location in one of the many layers of the brain (*68*). Xenobiotics may have a profound effect on this process, as shown in children with fetal alcohol syndrome. Prenatal exposure to ethanol may result in interruption in this process severe enough to cause lissencephaly (*69*).

Examples of organs that have a prolonged period of postnatal development are the brain and the lungs. Myelination of the brain is not complete until adolescence (*70*). Alveolarization is not complete until adolescence (*43*). This protracted period of growth and development increases the vulnerability of these organs. For example, intracranial tumors are frequently treated by radiation therapy in adults, with uncomfortable but reversible side effects (*71*). However, in infants, radiation therapy is avoided because of the profound and permanent effects on the developing central nervous system.

Another example of the unique vulnerability of children is the neurotoxic effects of lead. The current blood lead concentration of concern for children is 10 µg/dl (*72*). This level is based on studies by numerous investigators (*73*) that show that children with blood lead concentrations greater than 10 µg/dl have measurable decreases in intelligence quotient. The occupational limit for adults is 60 µg/dl, at which no encephalopathy is noted, but may impair kidney function, fertility, and peripheral nerves (*49*).

That the developing lung may also be compromised by exposure to environmental agents is illustrated by studies of the effects of environmental tobacco smoke on children. It has been shown that the FEV1's of children exposed to environmental tobacco smoke (ETS) are measurably slower than children with no exposure (*74*).

Tissues undergoing proliferation and terminal differentiation are particularly susceptible to carcinogenesis (*75*). This increased susceptibility is due to the shortened time period for DNA repair and the multiple changes that are

occurring within the DNA, such as interaction with growth factors, the switching on of genes as well as the switching off of genes. All are likely sites for interaction with chemicals that will interrupt the sequence of events. A clinical example is the epidemic of scrotal cancer among the pubertal chimney sweeps of Victorian England (*76*). Chimney sweeps were usually adolescents with developing secondary sexual characteristics. Occupational exposure to carcinogens such as soot was common, but the site of the tumor is uncommon outside this situation. Thus, it can be hypothesized that the scrotum, while undergoing terminal differentiation, had increased susceptibility to the carcinogen.

Summary

This presentation has attempted to outline the reasons why children cannot be considered little adults in the area of environmental medicine. Their exposures are different, their pathways of absorption are different, their tissue distribution is different, their ability to biotransform and eliminate chemicals is different, and their bodies respond differently to environmental chemicals and radiation. Each of these differences is dependent on the developmental stage of the child--all children are not the same! Each of these differences must be taken into account when considering the health impacts of a particular exposure on the population. Our database is still incomplete as regards pediatric environmental medicine.

What can the practitioner do? The roles of educator, investigator, and advocate are extremely important when assessing children for their environmental health. Prevention is the most important intervention in this field. Parents, children, teachers, community leaders, and policy makers need to be educated about the unique vulnerability of children to environmental pollution. Most environmentally caused diseases have been diagnosed by an alert clinician. Publication of case studies has allowed further description of environmentally mediated diseases. Finally, clinicians must be advocates for their patients. Most regulatory policies do not take the unique vulnerability of children into account when setting limits. A clinician must understand the basis for this unique vulnerability and all the factors that influence it to be an effective advocate.

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