PCB’s

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Environmental Stewardship Concepts

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Effects on Humans

- Cancer
- Altered hormone levels (thyroid, sex)
- Altered condition of skin, liver, pancreas, cardiovascular systems
- Impaired neurological development
- Low birth weight
Effects on Wildlife

- Reproductive impairment in fish, birds, and mammals
- Reproductive failure in mink
- Developmental abnormalities in fish, mammals, and birds
Effects on Humans

- Cancer
- Altered hormone levels (thyroid, sex)
- Altered condition of skin, liver, pancreas, cardiovascular systems
- Impaired neurological development
- Low birth weight
Effects on Experimental Animals

- Reproductive impairment
- Altered hormone levels
- Cancer
- Liver dysfunction
Ecological data performed on...

- Mink
- Bald Eagle
- Snapping Turtles
- Rainbow Trout
- Humans
- Experimental data on 14 other species
PCDD, PCDF, and PCB Molecules:
Important properties of PCBs

- Dissolve in fats and oils, **not** water
- Do not break down easily, persist throughout food chain
- Accumulate in fatty tissues and organic matter
- Slightly volatile - form vapor in summer
- Most exposures are through food, not water
- Toxic at low levels for long periods
How do PCBs Act?

Different ways of affecting living systems:

1. Dioxin-like actions
2. Estrogenic actions
3. Direct actions
4. Neurodevelopment of the brain
Dioxin–like actions

Cell membrane

PCDDs = Dioxins

PCDFs = furans

PCBs

Ah Receptor

Nuclear envelope

Other proteins
Estrogen–like actions

Estrogen

PCB

Estrogen receptor
Effects on Mink

- Reproductive failure
- Wild populations declined or lost
- Fish consumption is key pathway
- Great Lakes
Mink
River Otters
Mink Range
Effects on Bird Species

- Mortality
- Population declines and limitations
- Developmental abnormalities
- Behavioral abnormalities
- Still food contamination
Gulls
Bald Eagle
Effects on Fish

- Developmental abnormalities
- Population declines
- Behavioral problems?
- Mortality
- Migration

Rainbow Trout
Effects on Bivalves

- Clams had reduced levels of Glutathione
  - An antioxidant
- Oxidative stress
- Three types of lesions:
  - Gonadal atrophy, accumulation of Brown cells
  - Generalized edema
  - Necrosis and inflammation of digestive glands and foot processes
- Threat to bivalve reproduction
PCBs in Lake trout in Great Lakes

Figure 8-2  Mean total concentrations of PCBs (reported as mg total PCB/kg, w/w) in whole lake trout from North American Great Lakes, 1972–1990. Reprinted with permission from Michigan Fish Contaminant Monitoring Program 1994 Annual Report.
Blue Sac Disease
Chronological Examination of Human Exposure

- **1929**- PCBs first introduced
- **1938**- First DDT manufactured
- **1939-45 (WWII)**- First widespread human exposure to chemicals
- **1940-50**- First generation exposed postnatally
- **1950-70**- First generation exposed in the womb
- **1970-2000**- First generation exposed in the womb reaches reproductive age
EXPLANATION

Probability of organic contaminants or metals in streambed sediment causing adverse effects on aquatic life — Mercury and lead concentrations were adjusted for particle-size distribution for screening purposes.

- High
- Intermediate
- Low
- Not detected
- Not sampled
- Site location and number

Graphs showing concentrations of various contaminants in streambed sediment:
- Mercury: Sites 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25
- Lead: Sites 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25
- Chlorodane: Sites 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25
- DDT: Sites 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25
- PCBs: Sites 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25

Concentrations in parts per billion for each site.
Fish Tissue and Sediment Levels of PCBs etc.

Median concentrations of total organochlorine pesticides and total PCBs in white sucker tissue and streambedsediment are grouped by the predominant land use in the basin to illustrate the effects of land use.

Sites representing basins with a mixture of agricultural, urban, and industrial land uses had the highest concentrations of total PCBs, total DDT, and total chlordane. PCB concentrations were associated with the highest percentages of urban land use, and DDT and chlordane were associated with the highest percentages of agricultural land use.

(3 large river sites not included)
# Neurotoxicological Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Species</th>
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<tbody>
<tr>
<td>Rogan et al. 1986</td>
<td>Prenatal human</td>
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<tr>
<td>Lilienthal &amp; Winneke 1991</td>
<td>Prenatal Rats</td>
</tr>
<tr>
<td>Tilson et al. 1990</td>
<td>Human model (more sensitive)</td>
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Lake Ontario Findings

“The findings of poorer reflex functioning and greater autonomic immaturity from the high-fish group are consistent with Jacobson’s findings... these babies are more reactive to unpleasant events than non-exposed babies in an additional test.”

-Jacobson 1983-92
Dioxin affects male reproduction

- PCBs and dioxin can act through the same mechanism
- R. Peterson and Co-workers at Univ. Wisconsin (1992, Advan Modern Environ Toxicol.)
- Dosed pregnant rats on day 15 of gestation
- Male offspring- reproductive problems that include structure, function, behavior
Scope of PCB Contamination

- EPA has identified 6,206 waterways impaired by PCBs
- In 2007, PCBs ranked #5 on the CERCLA Priority List of Hazardous Substances (based on frequency of occurrence at NPL sites, toxicity, and potential for human exposure to the substances found at NPL sites)