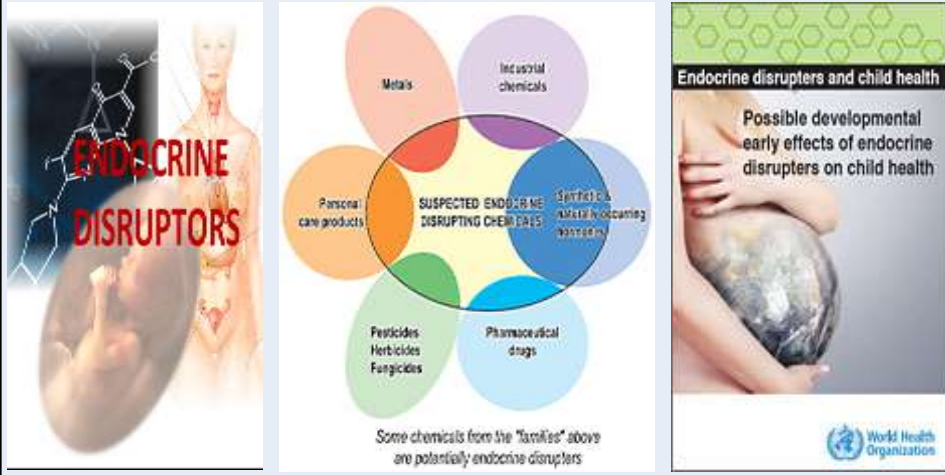


Endocrine Disrupting Contaminants (EDCs)

= man-made chemicals that alter function of the endocrine system and often the reproductive system.



1

Reading Assignments:

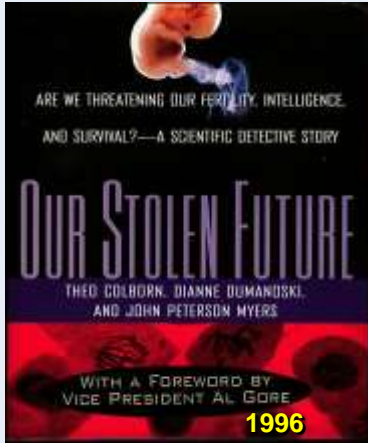
1. [Altered Sex Ratios in Children Exposed to Environmental Contaminants](#)
2. [Gender Bending In Utero \(review\)](#)
3. [Boys Won't Be Boys \(review\)](#)

Added 4/9/24

Recent resource, IF you're interested in knowing about [contaminants in your tap water where you live](#):

2

A large number of man-made chemicals that have been released into the environment, as well as a few natural ones, have the potential to disrupt the endocrine system of animals, including humans.



<http://www.ourstolenfuture.org/>



Hormonally Active Agents in the Environment

Committee on Hormonally Active Agents in the Environment
Board on Environmental Studies and Toxicology
Commission on Life Sciences
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C.

1999

<http://www.nap.edu/books/0309064198/html>

3

Lethal impacts vs Sub-lethal Impacts of EDCs

Lethal Impacts

> Toxic, kills directly

Sub-Lethal Impacts:

> Doesn't kill directly

> Can affect development

> capacity to accumulate in tissues
"Biological magnification" = _____

concentration of a contaminant
builds up (↑) in food chains
to high levels in top consumers

****Magnification increases as you go up a food chain.**

> Many contaminants fat-soluble (build up in fat stores)

> Can disturb reproductive functions.

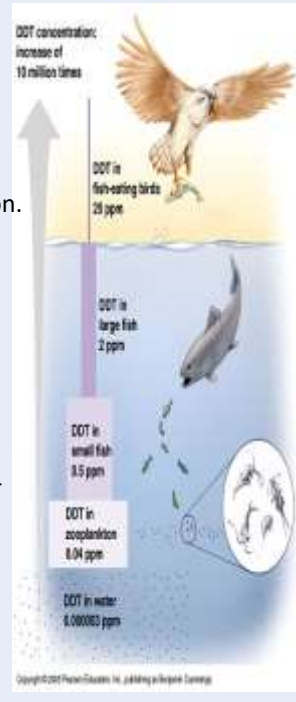


4

Example of Biological Magnification

DDT = dichlorodiphenyltrichloroethane

- > In water at 0.000003 ppm (parts per million) – very low!
- > DDT filtered by & concentrated to 0.04 ppm in zooplankton.
[That's 13,000 times the original dose in water!]
- > Zooplankton eaten by small fish - DDT in fish at 0.5 ppm.
[That's 12.5 times the dose in zooplankton.]
- > Large fish eat small fish, DDT accumulates to 2 ppm.
[That's 4 times the dose in small fish.]
- > Osprey or Eagle (top predator) eats fish, accumulates DDT to 25 ppm. [That's 12.5 times the dose in large fish]



5

Well Known EDCs <http://www.ourstolenfuture.org/basics/chemlist.htm>

Pesticides:

1. DDT - **estrogenic**

Herbicides:

2. Atrazine - **estrogenic**

Organohalogenes

3. PCBs – **anti-estrogen**

“Other”

4. Phthalates - **estrogenic**
5. Bisphenol-A (BPA) - **estrogenic**
6. Pulp mill effluent - **androgenic**

Less Known (Recent) but More Common EDC

7. Nitrate – **anti-estrogen, anti-androgen**

6

1. DDT = = dichlorodiphenyltrichloroethane



7

1. DDT = = dichlorodiphenyltrichloroethane

Rachel Carson published "Silent Spring" in 1962.


> Environmentalist that reported evidence that use of pesticides like DDT was harming wildlife – especially evident in birds.

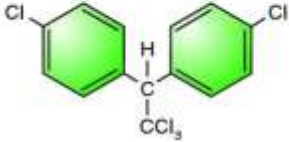
> Silent Spring title represented the silence of birds, that were dying from bioaccumulation of pesticides.

> DDT shown to thin eggs of eagles & ospreys & kill embryos, almost causing populations to crash in 1963 – almost 20 yrs after DDT introduced and used.



8





DDT (dichlorodiphenyltrichloroethane)

- Persists in environment
- High solubility in lipids
- Found in high concentrations at higher trophic levels

9

1. DDT = = dichlorodiphenyltrichloroethane

Rachel Carson published "Silent Spring" in 1962.

> Environmentalist that reported evidence that use of pesticides like DDT was harming wildlife – especially evident in birds.

> Silent Spring title represented the silence of birds, that were dying from bioaccumulation of pesticides.

> DDT shown to thin eggs of eagles & ospreys & kill embryos, almost causing populations to crash in 1963 – almost 20 yrs after DDT introduced and used.

> Was a warning cry (canary in the coal mine) for possible risks of pesticides to humans.


> Her book played large role in DDT being banned 1972 in USA.

BUT it's persistent in soil & river sediment & has half life of 70 YEARS!



10

1. DDT = = dichlorodiphenyltrichloroethane




1980 - large pesticide spill from Tower Chemical Company leads to formation of a **Superfund site** in Lake Apopka, Florida (3rd largest lake in state)

"Superfund Site" = program established to address abandoned hazardous waste sites.

LAKE	CITY	ACREAGE
Apopka	30,000	61,000
Griffin	30,000	61,000
Woodruff	30,000	61,000
Jessup	30,000	61,000
Monroe	30,000	61,000
Orange	30,000	61,000
Wetland	30,000	61,000
Wetland	30,000	61,000

11

1. DDT = = dichlorodiphenyltrichloroethane



1980 - large pesticide spill from Tower Chemical Company leads to formation of a **Superfund site** in Lake Apopka, Florida (3rd largest lake in state)

"Superfund Site" = program established to address abandoned hazardous waste sites.

Louis Guillette (Ph.D.) at University of Florida (UF) captured & released alligators, collected eggs in contaminated Lake Apopka versus clean lakes looking at:

1. egg mortality
2. penis morphology
3. reproductive hormones

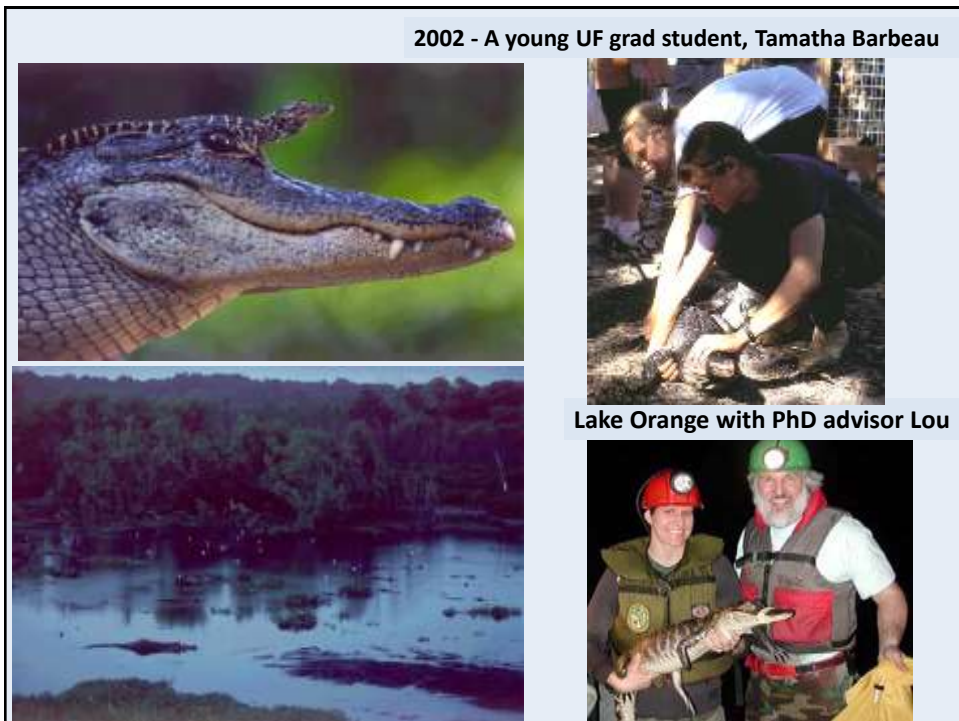
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Wetland	30,000	61,000

12



**Lou Guillette - 2000,
Lake Apopka**

13



2002 - A young UF grad student, Tamatha Barbeau

Lake Orange with PhD advisor Lou

14

1. DDT = = dichlorodiphenyltrichloroethane

1. Alligator Egg Mortality Studies



Results:

"Contaminated" Lake Apopka = 70-90% Egg mortality
 "Clean" Lake Woodruff = 10% Egg mortality.

15

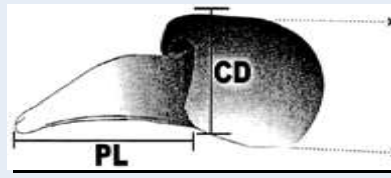
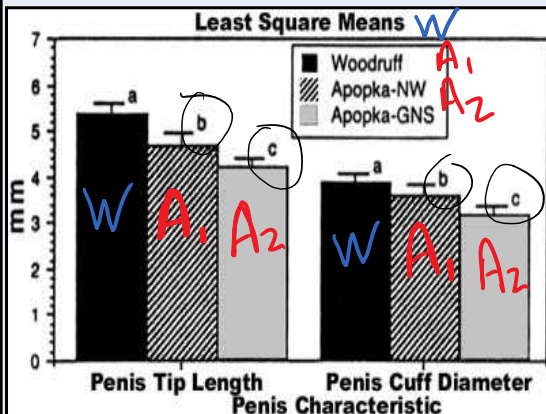
1. DDT = = dichlorodiphenyltrichloroethane

2. Alligator Penis Development - dependent on testosterone and DHT just like for humans. DHT = dihydrotestosterone

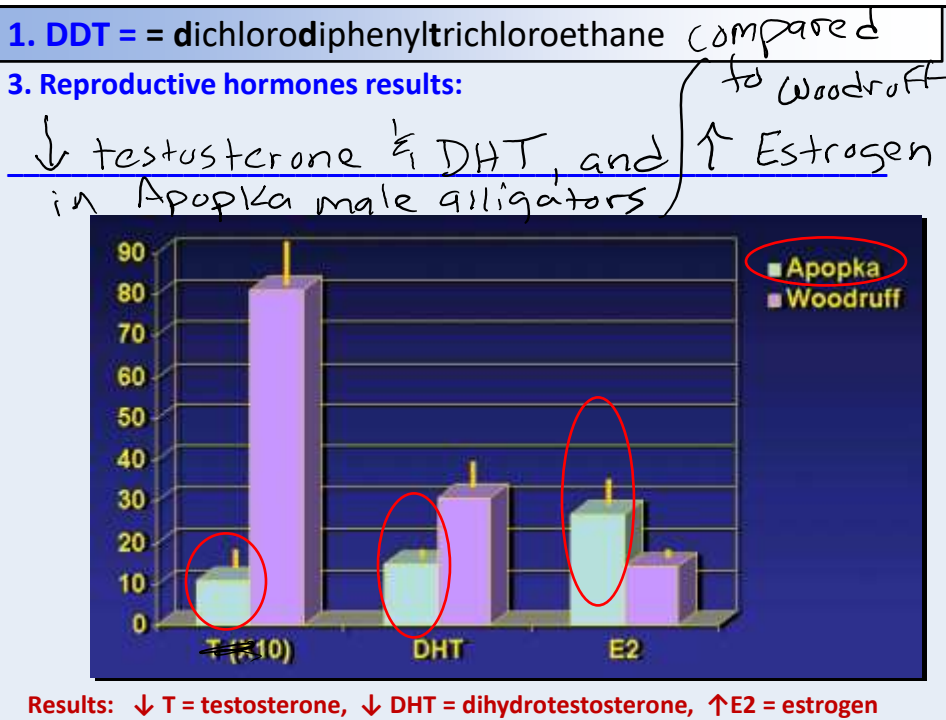
Results:

> Penis size in Apopka alligators
was 50% smaller compared


to woodruff alligators.



16



17



St. Louis, Michigan

- > Velsicol Chemical Corp manufactured pesticides (like DDT) up until 1963.
- > Made DDT & PBB (polybrominated biphenyls)
- > In 1973 Velsicol responsible for PBB contamination of cattle feed - killed thousands of cattle & 500 farms quarantined, & had human exposure. Company closed in 1982.
- > EPA took control of site in 1982 – 3.5 square mile (54 acres) area of town around plant now has **3 Superfund Sites**.
- > Residents for years repeatedly reported dead songbirds in town.
- > Recently (2014), birds examined had **lethal levels of DDT** in brains (from eating worms in contaminated soil from DDT banned 42 years ago!).

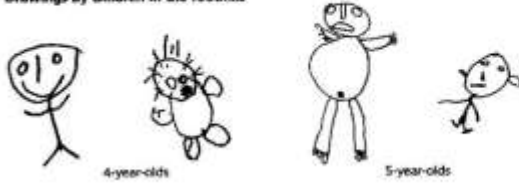
<http://www.environmentalhealthnews.org/ehs/news/2014/jul/dead-robins>

18

Pesticide (DDT) exposure in Yaqui children in Northwestern Mexico
(Elizabeth Guillette, 1998) – decreased cognitive & motor abilities.

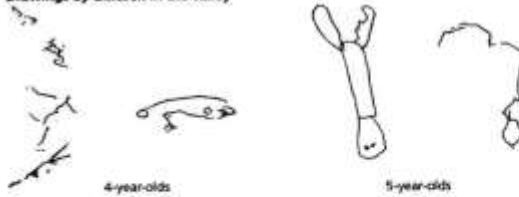
Human Neurological Effects

Drawings by children in the foothills



Area of No Pesticide Use

Drawings by children in the valley



Area of Pesticide Use

Elizabeth Guillette's study in Mexico's Yaqui Valley offers a startling example of apparent neurological effects of pesticide poisoning. Young children from foothills areas where pesticides were not commonly used drew recognizable figures of people. Children the same age from valley areas where pesticides were used heavily in industrialized agriculture could draw only scribbles when asked to draw people. Adapted from Elizabeth A. Guillette, et al., *Environmental Health Perspectives*, 1998.

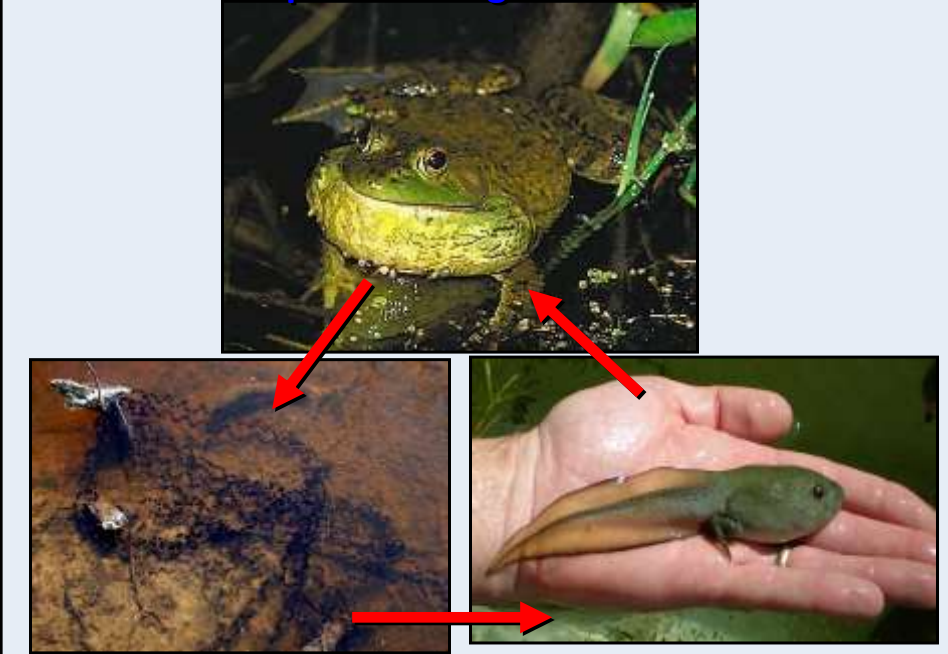
19

Endocrine Disruptors in Frogs?



20

Endocrine Disruptors in Frogs?



21

Endocrine Disruptors in Frogs?

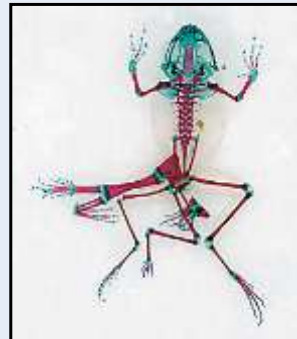


Henderson, Minnesota – 1995

Students on field trip seined local farm ponds.
Found 50% of Leopard frogs collected were deformed:

- > multiple and missing legs
- > eyes in wrong place).

(normal rates deformity frog populations 0-2%)



22

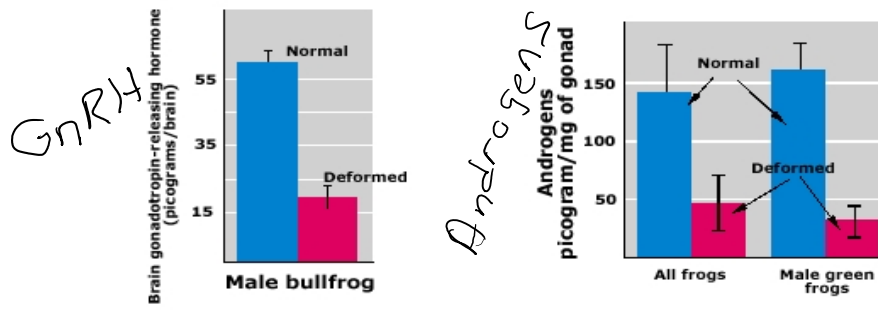
Endocrine Disruptors in Frogs?

Sower et al., 2000 EHP V 108 (No. 11)- Measured hormones in deformed Bullfrogs.

Results:

Deformed frogs had 3x lower levels of GnRH and lower testosterone than normal frogs.

The results are clear-cut: deformed frogs have lower concentrations of gonadotropin-release hormones in the brain, and both male and female gonads of deformed animals produce reduced androgens

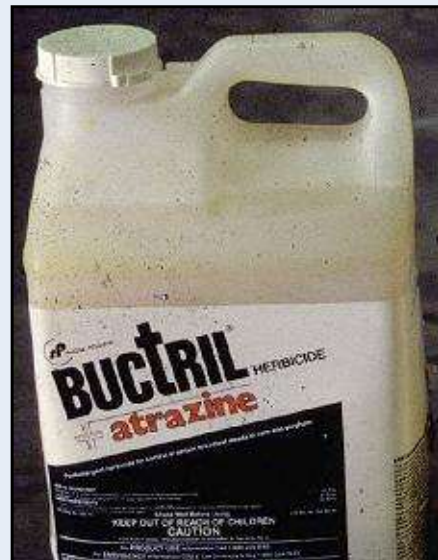


23

2. Atrazine = most widely used herbicide in agriculture in USA.

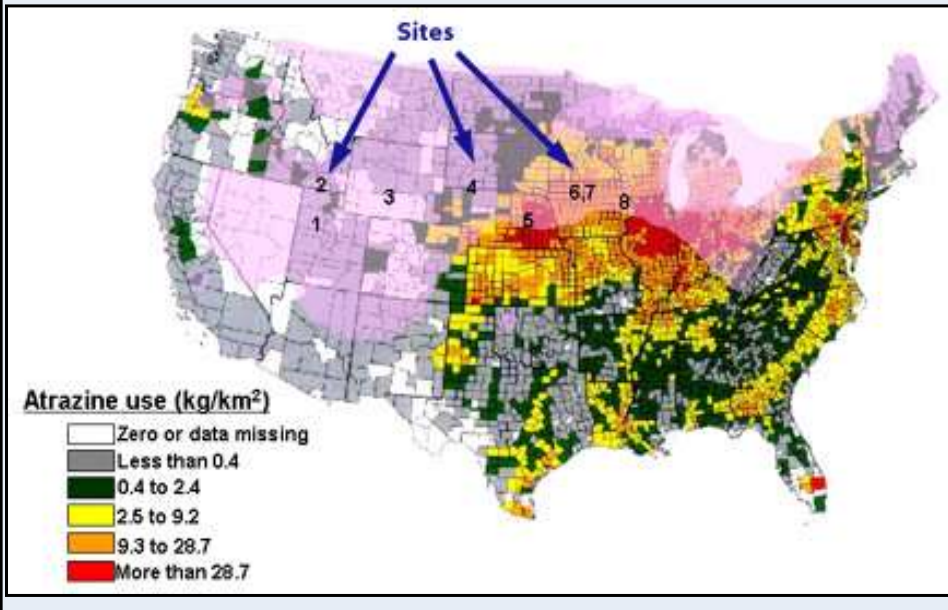
> 60 million tons/year used in USA

> EPA limit for drinking water 3ppb
(parts per billion)



24

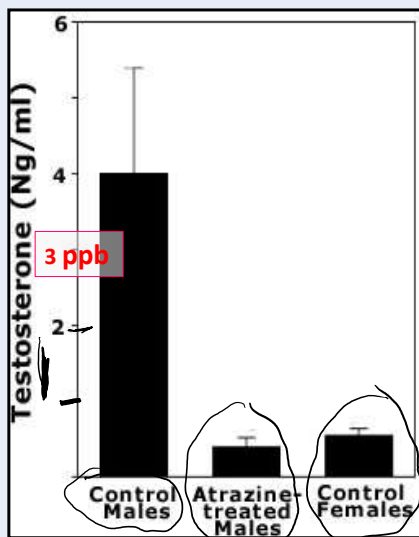
2. Atrazine = most widely used pesticide in agriculture in USA.



25

2. Atrazine and Frogs

Research by Tyrone Hayes (Berkley Univ.) - exposure of male frogs to Atrazine at low doses. (1 ppb = 1 Ng/ml)



Results:

Male frogs exposed to atrazine (at levels lower than EPA limit) had ↓ testosterone



↓ testosterone

26

3. PCB= polychlorinated biphenyl in flame retardants, lubricating oils, hydraulic fluids, capacitors, sealants, adhesives, & plasticizer in paints.

- > Banned In USA in 1977
- > Fat-soluble (biological magnification)
- > Interferes with sex steroid production (anti-estrogenic)

http://en.m.wikipedia.org/wiki/Polychlorinated_biphenyl#United_States

27

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History of PCBs in South Carolina:

1955-1977 Sangamo Weston Plant (Pickens, SC) dumped 200 tons of PCB wastewater into Twelve Mile Creek.

1990 EPA declared 228 acres around that site a **Superfund site**.

2009. State Environmental regulators noted fish species in Lake Wateree contained very high levels of PCB - so bad posted lake advisory that fish not safe to eat.

2013 – High levels PCBs found in wastewater sludge in South Carolina. Criminal investigation underway.

2014 City of Charlotte discovered high PCB's entering its sewage waste water treatment plants.

http://en.m.wikipedia.org/wiki/Polychlorinated_biphenyl#United_States

28

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[Recent News in NC](#)

PCBs found in North Carolina State University in 2024 (Click [HERE](#))

http://en.m.wikipedia.org/wiki/Polychlorinated_biphenyl#United_States

29

4. Phthalates (used in making plastics)

See Reading: "Gender Bending in Utero"

- > **Phthalates** used to make soaps, makeup, plastics (other everyday items) can disrupt the development of male baby reproductive organs in utero.
- > ~95% of Americans have detectable phthalates in urine.
- > Shown to be estrogenic (feminizes male fetuses in utero - intersex).



23 month old Puerto Rican with premature breasts (**thelarche**)

30

4. Phthalates (used in making plastics)

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> ~95% of Americans have detectable phthalates in urine.

> Shown to be estrogenic (feminizes male fetuses in utero - intersex).

> Researchers found women with high phthalate metabolites in their urine were more likely to give birth to baby boys with undescended testicles (Cryptorchid), or small testicles, and small penises (micropenis).

And girls with premature breast development, known as thelarche



23 month old Puerto Rican with premature breasts (**thelarche**)

31

4. Phthalates (used in making plastics)

Short List of Products Containing Phthalates:

Baby toys (plastic)	Mobile phones
Backpacks	Moisturizers
Beach balls	Nail polish
Bubble bath	Paint
Cleaning agents	Perfume
Coatings for tablets	Plastic raincoats
Computers	Portable music players
Deodorant	PVC flooring
Disinfectant	Shampoo
DVD players	Shaving foam
Electrical cables	Shower curtains
Garden hoses	Soap Sunscreens
Hair gels and mousse	Toothbrushes
Hairspray	Trainers
Ink	Vinyl blinds
Insect repellent	Wallpaper (PVC)
IV fluid bags	Washing-up liquid
Lipstick	Wellington boots

Japan, Austria, Greece, Norway, Sweden, Finland, Germany have banned PVC toys w/phthalates for children < 3yrs.

Not banned in USA.

32

5. Bisphenol-A (BPA) = also used in making plastics.

- > Found in soda bottles, plastic utensils, Tupperware.
- > Estrogenic by activating estrogen receptors on tissue.
- > **In-utero effects in lab animals:**
 - Alters development of genitals (intersex)
 - Reverses sex differentiation of brain
 - Damages eggs (chromosomes)
- > **Adult effects in lab animals:**
 - Decreases maternal behavior
 - Predisposes breast cells to cancer
 - Predisposes prostate cells to cancer



33

5. Bisphenol-A (BPA) = also used in making plastics.

Dose ($\mu\text{g}/\text{kg}/\text{day}$)	Effects (measured in studies of laboratory animals)	Study Year [20]
0.025	Permanent changes to genital tract	2005
0.025	Changes in breast tissue that predispose cells to hormones and carcinogens	2005
1.5	Low levels of human exposure from diet	2003
2	30% increase in prostate weight	1997
2.4	Signs of early puberty	2002
2.4	Decline in testicular testosterone	2004
2.5	Breast cells predisposed to cancer	2006
10	Prostate cells more sensitive to hormones and cancer	2006
10	Insulin resistance	2006
10	Decreased maternal behavior	2002
13	High levels of human exposure from diet	2003
20	Damage to eggs and chromosomes	2003
25	Health Canada provisional human exposure limit	1999
30	Hyperactivity	2004
30	Reversal of normal sex difference in brain structure	2001
50	U.S. human exposure limit	1998

34

5. Bisphenol-A (BPA) = also used in making plastics.



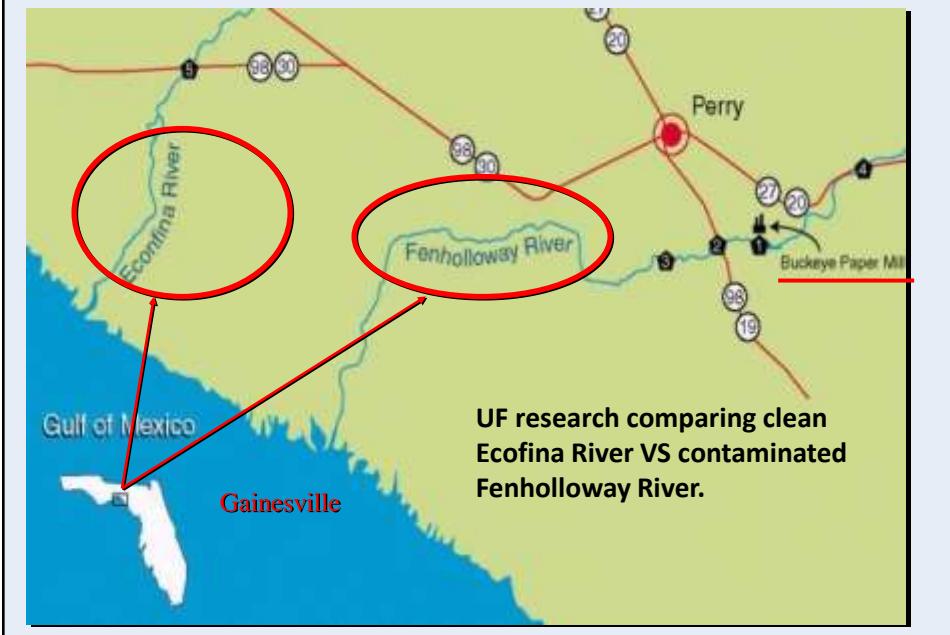
35

6. Pulp Mill Effluent = runoff from pulp mill processing.

- > Rivers & streams downstream of pulp mills contaminated.
- > Aquatic wildlife impacted.
- > Androgenic (mimics male testosterone).
- > Masculinizes female fish.

36

6. Pulp Mill Effluent = runoff from pulp mill processing.



37

6. Pulp Mill Effluent = runoff from pulp mill processing.

- > Seined clean Ecofina and contaminated Fenholloway rivers to collect Mosquitofish
- > Examined fish for abnormal reproductive growth.

Results:

Contaminated

Fenholloway
mosquitofish
had ↑ #
of masculinized
females
(intersex)



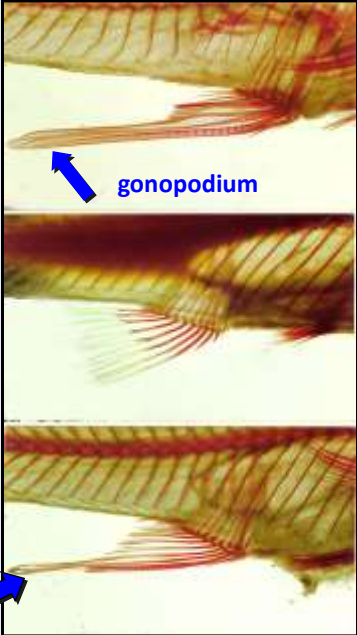
38

Results:

Normal Male Mosquitofish
- has "gonopodium" – an androgen dependent structure.

Normal Female Mosquitofish
- no gonopodium.

Abnormal Female Mosquitofish (intersexed).
- has gonopodium (intersexed).



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8. Nitrate as an EDC

Urban Sources:

- > Fertilizer runoff from lawns, & golf courses
- > Leakage of sewage & industrial wastes

Agricultural Sources:

- > ~83 million tons nitrogen / year!
- > Animal wastes





<http://www.ourstolenfuture.org/Commentary/News/2003/2003-0404-EST-nitrateedc.htm>

40

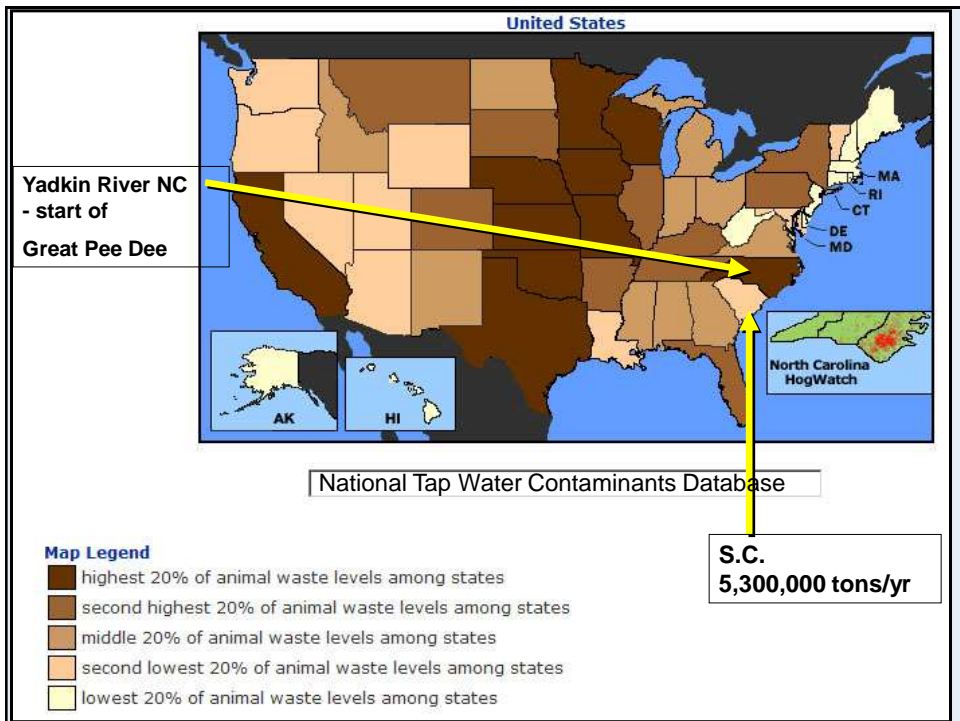
8. Nitrate as an EDC

Open manure pit – length football field, 2 stories high !



10 acre Hog Lagoon

41



42


8. Nitrate as an EDC

"Only two substances for which standards have been set pose an immediate threat to health whenever they are exceeded: bacteria and nitrate."

US EPA Office of Water (WH-550) "Is Your Drinking Water Safe?" EPA 570 9-91-005, 1991.

EPA limits for nitrate in drinking water = < 10 mg/L

43



<http://www.ewg.org/tapwater/contaminants/>

avg = 2.6 - 6.0 ppm

Source: National Tap Water Quality Database: SC State Contaminant Report (<http://www.ewg.org/tapwater/staterports/staterport.php?state=SC>)

- 2,416,677** People drinking water contaminated with Nitrate in South Carolina
- 465** Communities served water contaminated with Nitrate in South Carolina
- 1,358** People drinking water contaminated with Nitrate over health based limits in South Carolina
- 4** Communities served water with Nitrate above health based limits in South Carolina

Table. The most polluted communities in South Carolina

1,358 Americans in 4 South Carolina communities were served tap water contaminated with Nitrate above health based limits between 1998 and 2003

Ranked by highest average Nitrate level

Rank	System	Population Served	Positive test results of total reported tests	Average Level (Range)
1	Oakbrook Landing SC	53	2 of 2	3.98 ppm (0.08 to 11.9 ppm)
2	Bunnamers's Hts Matthews, SC	67	11 of 11	4.33 ppm (2.5 to 14.4 ppm)
3	City Mobile Court Milledale, SC	115	3 of 5	3.32 ppm (0 to 12 ppm)
4	Town of Lamar Water Lamar, SC	1,092	1 of 6	2.67 ppm (0 to 14 ppm)

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8. Nitrate as an EDC

EDC Effects Of Nitrate:

- hemoglobin carries O₂
doesn't release O₂ at tissues
- > **Humans** – methemoglobinemia & lymphatic cancer, bladder cancer
 - > **Rodents** – ↓ testosterone in gonads
 - > **Bulls** – ↓ testosterone in gonads, abnormal sperm
 - > **Alligators** – ↑ testosterone
 - > **Fish** – ↓ testosterone
 - > **Frog tadpoles (juveniles)** – ↓ growth and ↑ limb abnormalities at 2-500 mg/L
 - > **Frogs** – ↓ testosterone & estrogen***

↓ Testosterone = anti-androgenic
↓ estrogen = anti-estrogen

Panesar & Chan, 2000

Zrally et al., 1997

Guillette et al. 2000

Folmar et al., 1996

Xu and Oldham, 1997

Ward et al. (1991)

[Barbeau and Guillette, 2007 *** \(full article PDF\)](#)

45



46

EDC Effects Of Nitrate on Frogs:

> Continuous nitrate exposure of adult female frogs to low nitrate levels in water for 1 week.



> Examined ovaries and oviducts for abnormalities, and testosterone and estrogen production.

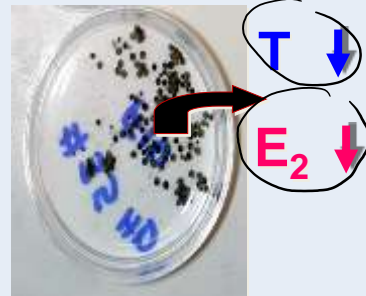
Results:

Frogs had ↓ testosterone

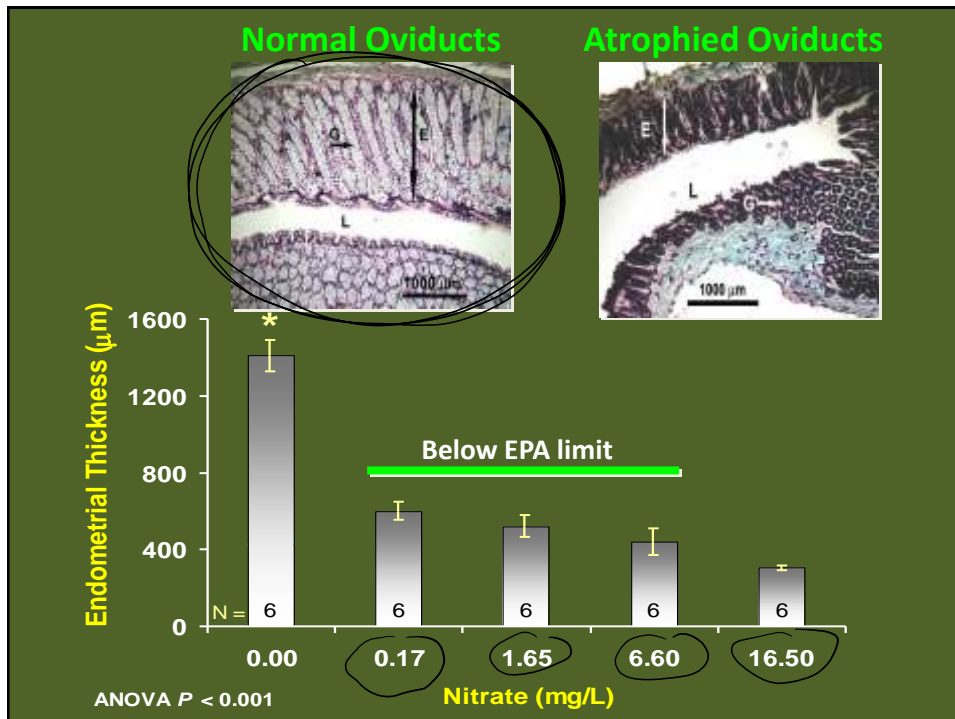
↓ estrogen

in eggs

(from ovary)



47



48

"The universe is full of magical things
waiting for our wits to grow sharper."

- *from a Fortune Cookie*

49

What To Do About Our Poo (Nitrate)?

- "leakage of animal wastes in waterways (i.e. hog lagoons, cattle lots, dairy farms, or even human sewage spills).



Breeched hog lagoon



Flooded hog lagoon

50

What To Do About Our Poo (Nitrate)?

- Anammox bacteria being researched in hog waste lagoons as bioremediation for nitrate-contaminated water at Florence USDA Agricultural Research Center.
www.ars.usda.gov/is/pr/2005/050722.htm
- Reverse osmosis water filtration can remove nitrate from drinking water.



51

What To Do About Our Poo (Nitrate)?

Use of **Fe-TAML** – an enzyme that breaks down estrogen, pesticides, and other contaminants in water. Research being done at Florence, USDA ARS.

USDA United States Department Of Agriculture
Agricultural Research Service

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News & Events

"Green" Catalyst Takes on Hormones in Wastewater

By Jan Ruppel
June 29, 2006

Hydrogen peroxide is best known for its bubbly cleansing of minor cuts and scrapes. But combining it with an enzyme-like catalyst called Fe-TAML also produces reactions that break down dyes, pesticides and other wayward chemicals that have become environmental pollutants.

Now, the dynamic duo's powers of degradation may include neutralizing hormones in municipal and agricultural wastewater, an Agricultural Research Service (ARS) scientist reports today.

Speaking at an American Chemical Society meeting in Washington, D.C., ARS animal physiologist Nancy Shoppell discussed the results of a laboratory study in which she combined Fe-TAML with hydrogen peroxide to break down estradiol, a natural form of the female hormone estrogen, and ethinylestradiol, a synthetic version used in contraceptives. Fe-TAML is short for iron tetra-amido macrocyclic ligand.

Image courtesy: Carnegie Mellon University.

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52

Review – added 4/9

EDCs – endocrine disruption contaminants

Lethal vs Sublethal effects of contaminants (defined)

Biological magnification

Deformed frogs had decreased GnRH and testosterone than normal frogs (study by Sower)

1. **DDT (insecticide)– estrogenic.** What did it do to eggs of predatory birds (eagles, ospreys)?
 > study by Guillette on alligators in contaminated lake Apopka vs clean lake Woodruff
 (egg mortality, penis size, and reproductive hormones)
2. **Atrazine (herbicide) – estrogenic** in frogs (study by Hayes)
3. **PCBs (industrial contaminant) - anti-estrogen**
 > high levels found in NC State University building & increased cancer rates
4. **Phthalates (found in plastics) – estrogenic**
 > study of women with high phthalates in urine had:
 - male babies with increased rates of cryptorchidism & micropenis
 - girl babies that had premature breast development (thelarche)

53

Review

5. **BPA (found in plastics) – estrogenic**

6. **Pulp mill effluent – androgenic**

> female mosquitofish in contaminated Fenholloway river masculinized with gonopodium compared to clean Ecofina river.

7. **Nitrate** (found in fertilizer and sewage waste)

> effects in humans, rodents, bulls, & fish (anti-androgenic)

> in alligators – androgenic

> frogs (Barbeau) – anti-estrogenic & anti-androgenic, and oviduct atrophy

Research by scientists at Florence SC USDA Agricultural Research Station

> bacterial remediation of nitrate contaminants by Anammox bacteria

> **Fe-TAMIL** – an enzyme that breaks down estrogen, pesticides, and other contaminants in water.

54