

The What, Where, How, When, and Why of Endocrine Disrupting Chemicals (EDCs)

Edward F. Orlando
Florida Atlantic University

1980s Great Lakes Study

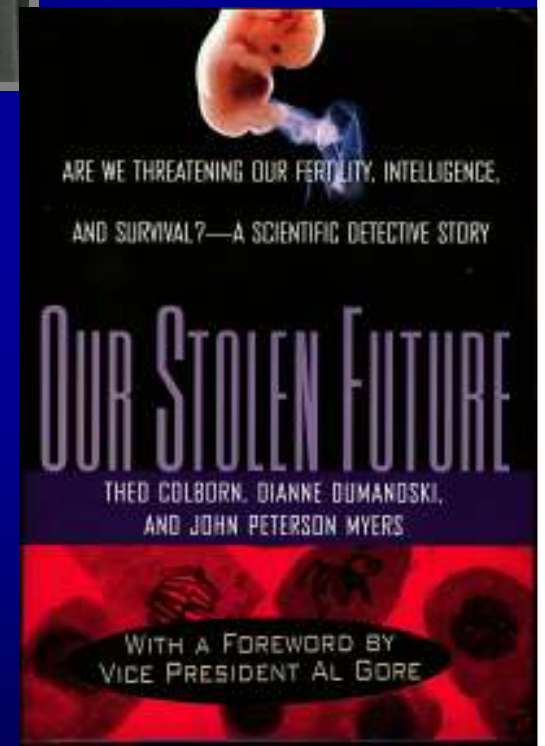
1991 Wingspread I

. . . experts in anthropology, ecology, endocrinology, histopathology, immunology, medicine, law, psychiatry, reproductive physiology, toxicology, wildlife management, tumor biology, and zoology.

1992 Chemically-Induced Alterations in Sexual and Functional Development: The Human - Wildlife Connection



Theo Colborn



1996

Wingspread I Consensus Statement

We are certain of the following:

“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”

Although EDC research has become widely known since the early 1990s . . .

the disruption of the endocrine system is

not novel,

Estrogenic properties of DDT since 1950

not just another negative human activity,

Plant and fungal estrogens

Products of combustion

and can be deliberate.

Birth control and hormone replacement therapy

1958 Dr. Roy Hertz described a “steroid cycle” that anticipated what we today call the endocrine disruptor hypothesis.

His concern was with the use of the potent estrogen DES in cattle and chickens and the potential for human exposure. Early reports of breast development in exposed children supported his contention. He also warned of excreted hormones in land-applied manure and the potential for groundwater contamination.

“I think that we are now actually setting up a steroid cycle in our environment, and we have to give very serious consideration to its implications for our subsequent development and growth and possibly reproductive function”

Government Response

John McLachlan and Ken Korach NIEHS

1979 Estrogens in the Environment I

1985 Estrogens in the Environment II

1994 Estrogens in the Environment III

Focus on human health

Robert Kavlock and Gary Ankley

1995 and 1996 EPA held two international meetings about EDCs to assess what was known and to identify research needs.

Focus includes human and wildlife

Government Response (cont.)

US Congress mandates EDC research (1996)

1996 Safe Water Drinking Act amendment

1996 Food Quality Protection Act

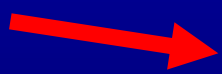
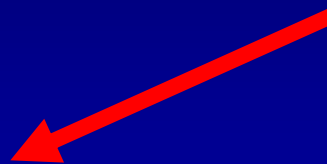
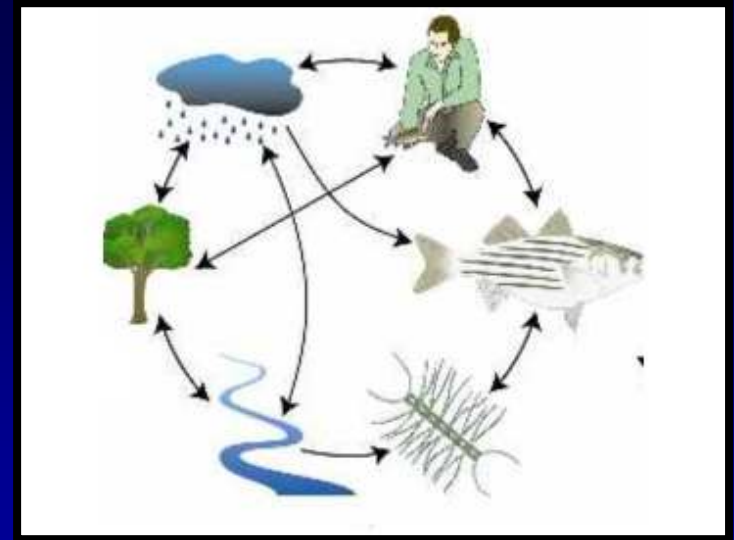
USEPA is charged with assessing and testing water and food for estrogen and other hormonal activity of more than 70,000 compounds.

Endocrine Disruptor Screening Program

1998 EDSTAC recommendations

US, EU, Japan, and other OECD members cooperating to safeguard human and environmental health.

Healthy Aquatic Ecosystems



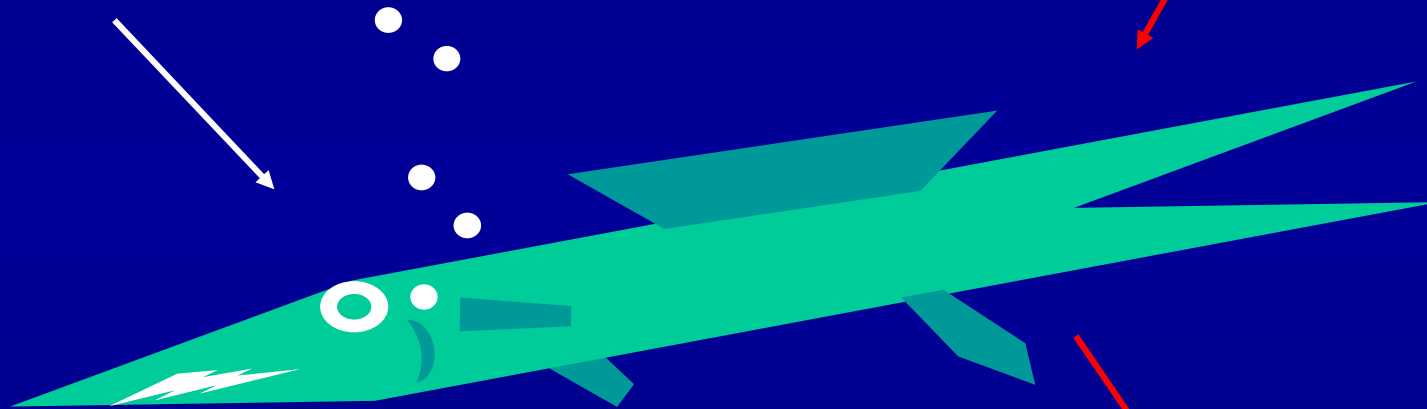
Watersheds



Nutrient Runoff

Physicochemical
Behavior / pheromones

Endocrine disrupting
chemicals (EDCs)



Normal reproduction

Altered development
and reproduction

What are EDCs?

“ . . . an exogenous chemical substance or mixture that alters the structure or function(s) of the endocrine system and causes adverse effects at the level of the organism, its progeny, populations, or subpopulations of organisms. . . . ”

(EDSTAC 1998)

A chemical or mixture of chemicals, which come from outside of an organism, that changes how the endocrine system normally works and so negatively affects that organism, its offspring, and other members of the population.

What is the Endocrine System?

Essentially a communication network that consists of hormones, the glands that produce them, and receptors.

The production and secretion of hormones is regulated mostly by the brain and pituitary gland.

The endocrine system regulates behavior, development, growth, reproduction, and homeostasis.

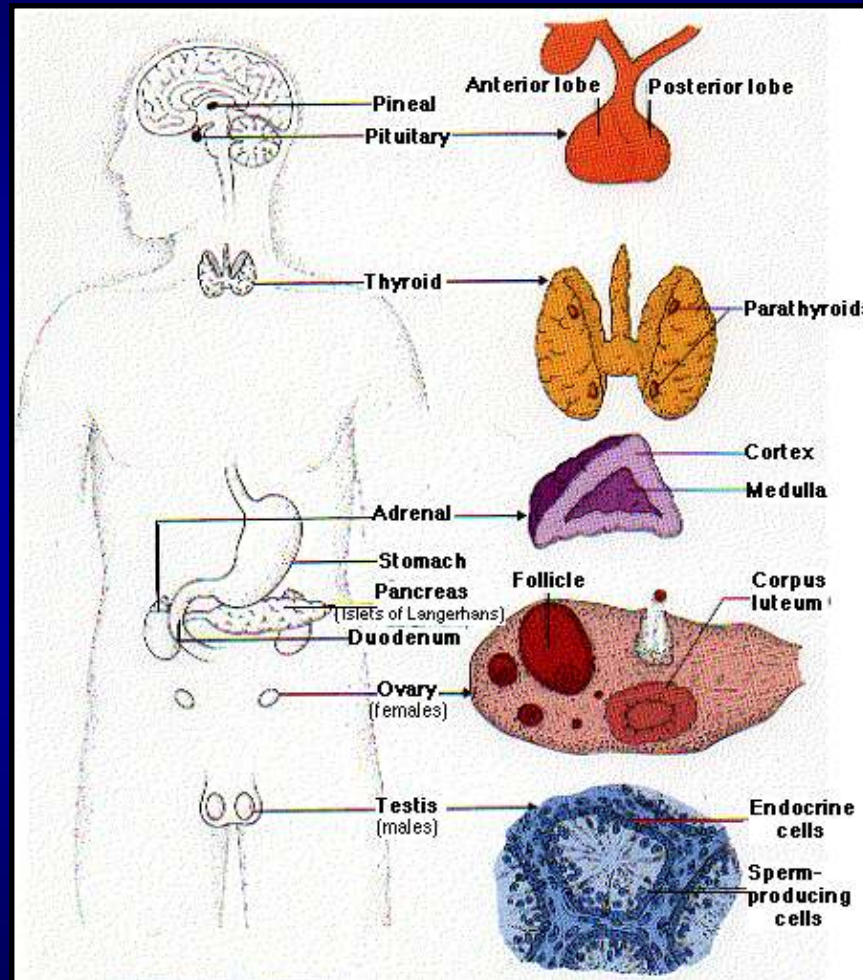
So, normal endocrine system function is IMPORTANT!

Human Endocrinology

H-P-T axis

Thyroid hormones

T₄ and T₃

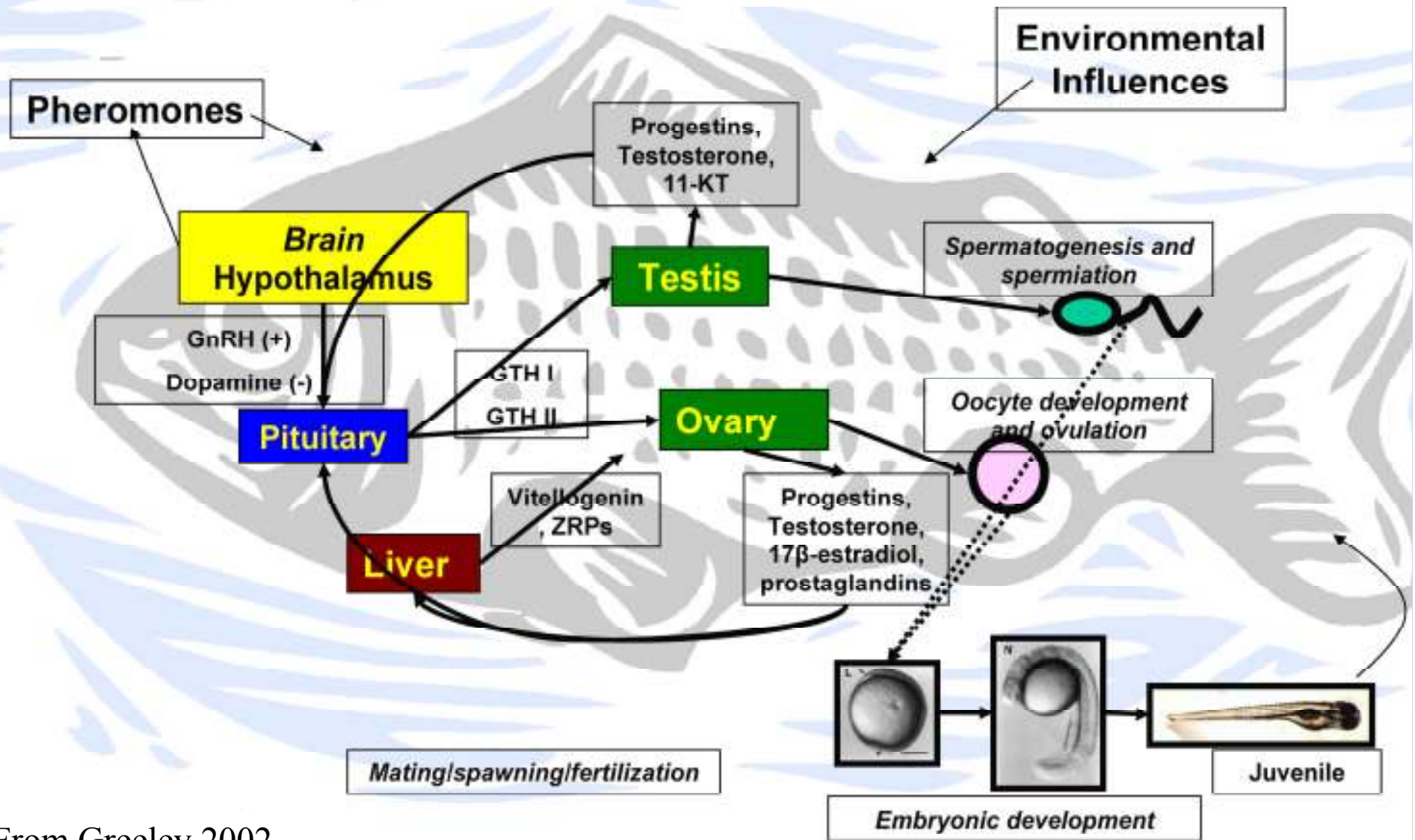


H-P-G axis

Reproductive hormones

Progesterone
Testosterone
Estradiol

Overview of Fish Reproduction

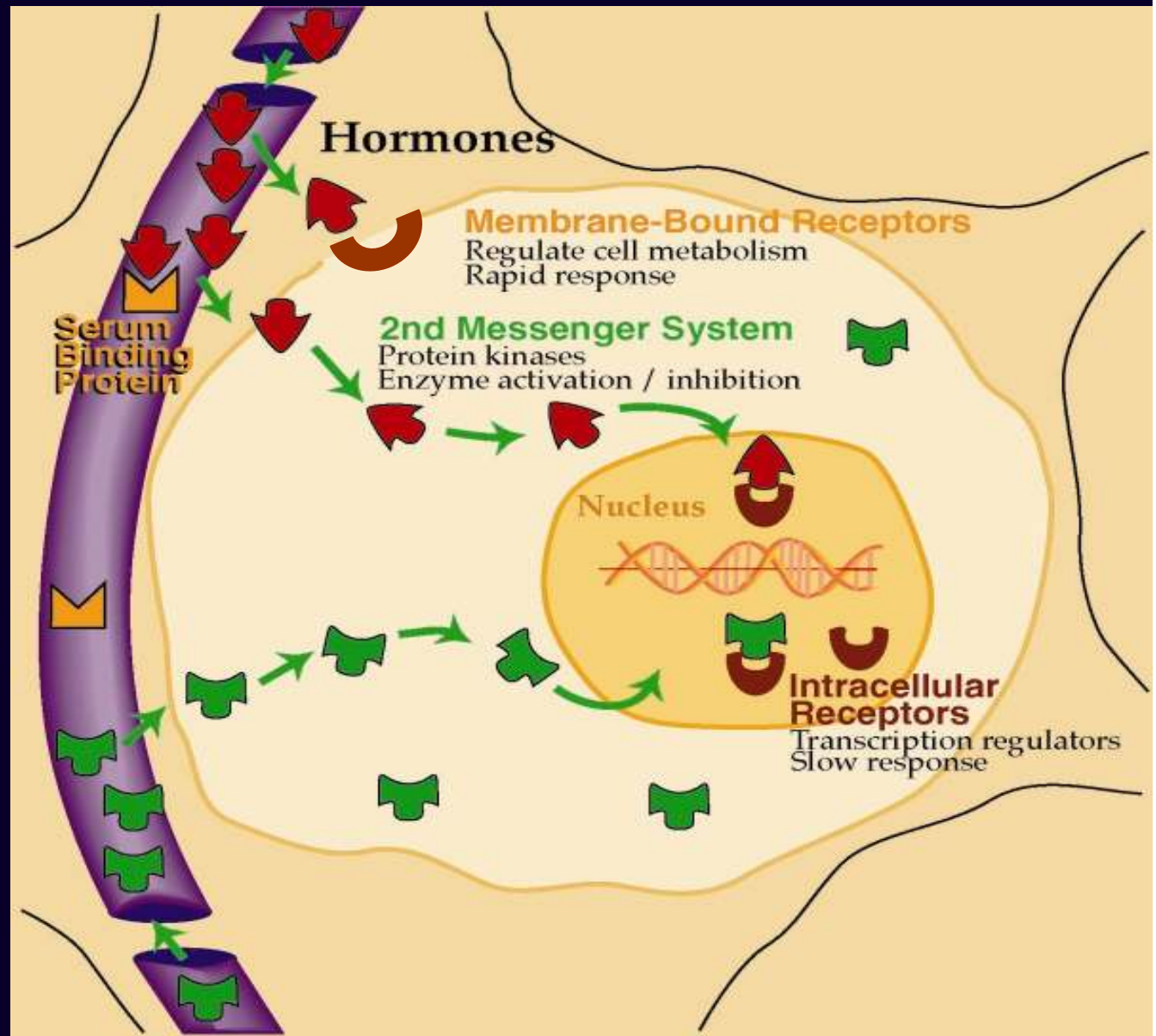


From Greeley 2002

Hormones and Receptors

EDCs as mimics

EDCs as antagonists



Some EDCs and Mechanisms of Action

- **Estrogenic**

fungal and plant estrogens, pharmaceuticals, pesticides, plasticizers, detergent components

- **Androgenic**

anabolic steroids, paper mill effluent

- **Anti-androgenic**

fungicides, pesticides, and plasticizers

- **Thyroid hormone disrupters**

PCBs, flame retardants, and rocket fuel component

Not only do EDCs act as mimics or antagonists . . .

Nonreceptor mediated actions of EDCs

1. Affect synthesis or degradation of hormones
2. Epigenetic effects: heritable changes in gene expression

Given the cross-talk among the nervous, endocrine, and immune systems, EDCs probably have broader effects

Altered Development and Reproduction



Sex Reversal - Imposex - Female Phallus Development, Abnormal Steroidogenesis & Spermatogenesis, and Behavior



Sex Reversal - Ovotestis - Hermaphrodites



Sex Reversal - Abnormal Penis Development, Steroidogenesis & Gene Expression Patterns



Abnormal Gonadal Differentiation and Altered Reproductive Behavior and Neurotransmitters



Abnormal Genital Development, Steroidogenesis & Gene expression

Possible role of EDCs in Human Pathologies

DES daughters - estrogen

Prenatal exposure to DES associated with vaginal adenocarcinoma, altered ovarian development

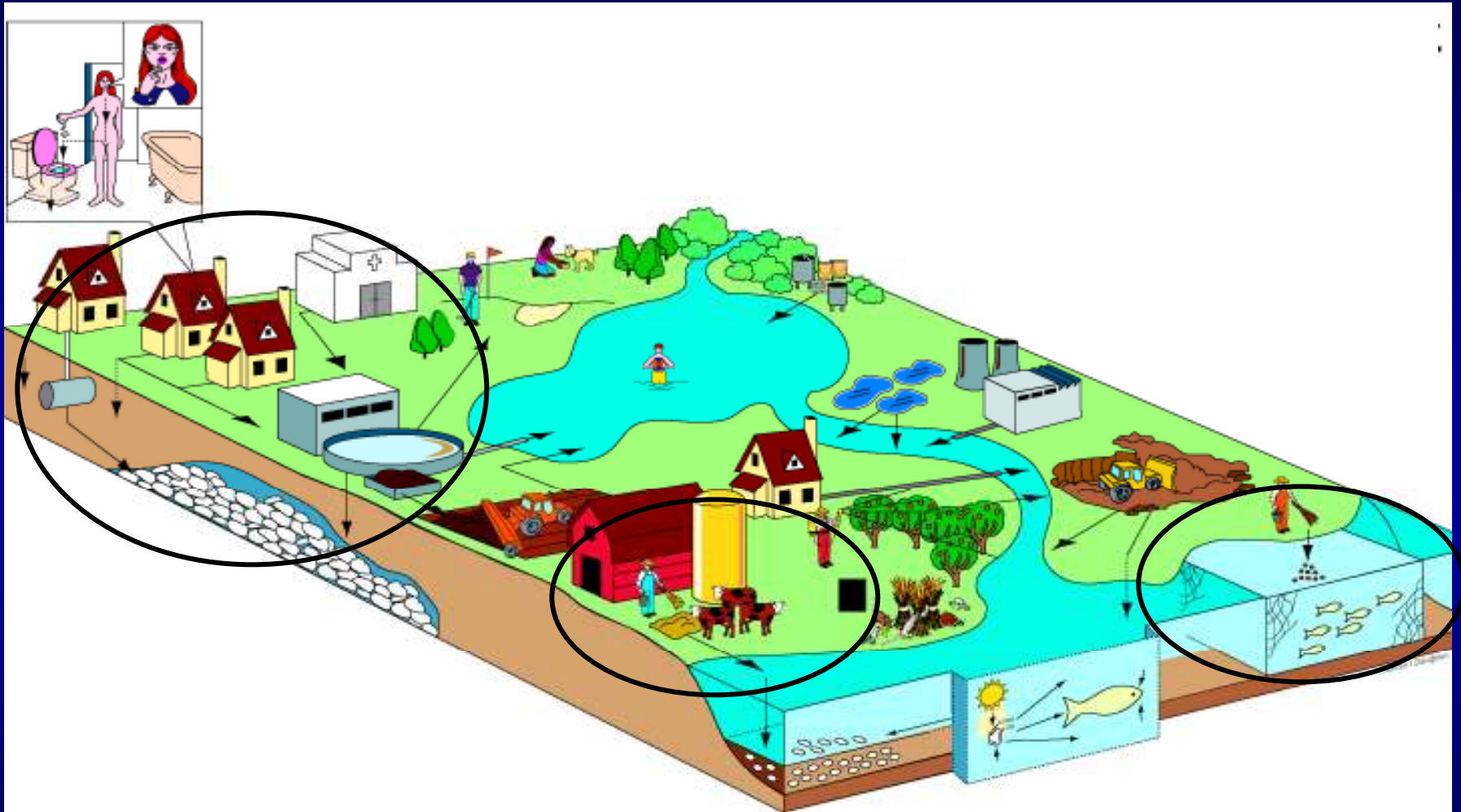
Testicular dysgenesis syndrome – anti-androgens

Prenatal exposure to certain phthalates and other anti-androgens associated with cryptorchidism, hypospadias, impaired spermatogenesis, and decreased anogenital distance

Thyroid mediated alterations in neural function - thyroid disruptors

Prenatal exposure to certain PCBs, PBDEs, and to perchlorate is associated with altered IQ, behavior, ear development and hearing, and neuromuscular development.





Concentrated Animal Feeding Operations (CAFOs)

What is a CAFO?

An animal feeding operation (AFO) is a lot or facility (not including aquaculture) where:

1. livestock is stabled or confined for a total of 45 days or more per year *and*
2. crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season

A CAFO is an AFO . . .

Definitions of Large, Medium, and Small CAFOs

A **Large CAFO** confines at least the number of animals described in the table.

A **Medium CAFO** falls within the size range in the table below and either:

- a manmade ditch or pipe that carries manure or wastewater to surface water *or*
- the animals come into contact with surface water

A **Small CAFO** confines fewer than the number of animals listed in the table **and** has been designated as a CAFO by the permitting authority as a significant contributor of pollutants.

Animal Sector

Size Thresholds (# of animals)

	<u>Large</u>	<u>Medium</u>	<u>Small</u>
beef cattle	1,000 or more	300 - 999	< 300
dairy cows	700	200 - 699	< 200
Laying hens & broilers w/ liquid manure handling system	30,000	9K – 29.9K	< 9,000
Laying hen w/ other than liquid manure handling system	82,000	25K – 81.9K	< 25,000



Human waste production at 150 million tons is processed in STPs before effluent is released.

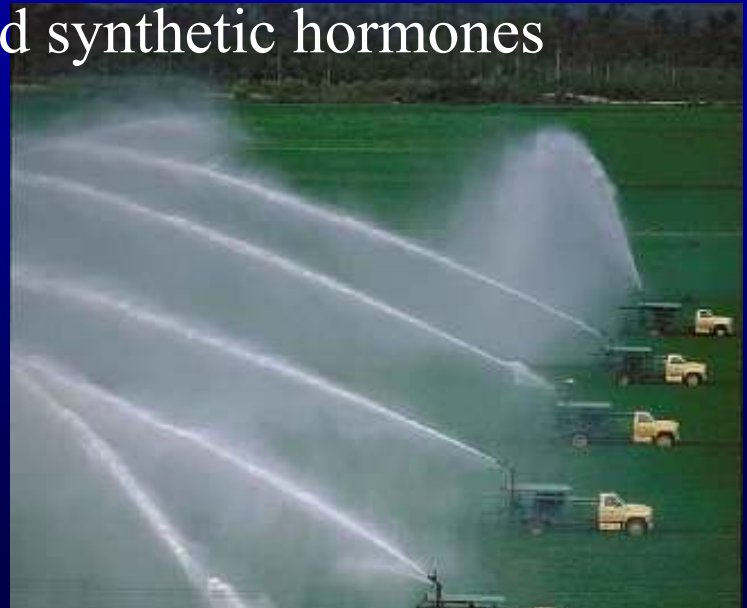
Agricultural animal waste at 500 million tons.

Past livestock practices are rapidly changing as evidenced by growth of CAFOs.



Environmental Challenges of CAFOs

- Concentration of livestock
- Manure applied to land (dry litter)
- Waste stored in ponds (wet litter)
 - Solids settle and applied
 - Liquid evaporates or is sprayed
- Point source of nutrients, natural and synthetic hormones





What do we know about fate and potential effects of natural hormones from agricultural animal waste?

- Natural hormones are present in dairy cow wash water (Kolodziej 2004)
- Water samples collected downstream of farms where poultry litter was applied contained natural hormones (Shore 2004)
- Groundwater adjacent to field amended with poultry litter contained natural estrogens (Finlay-Moore 2000)
- Lab studies suggest rapid degradation of natural estrogens in soils; whereas field studies show they are mobile and persistent enough to reach ground water (Hanselman 2003)

What do we know about fate and effects of hormones from human waste?

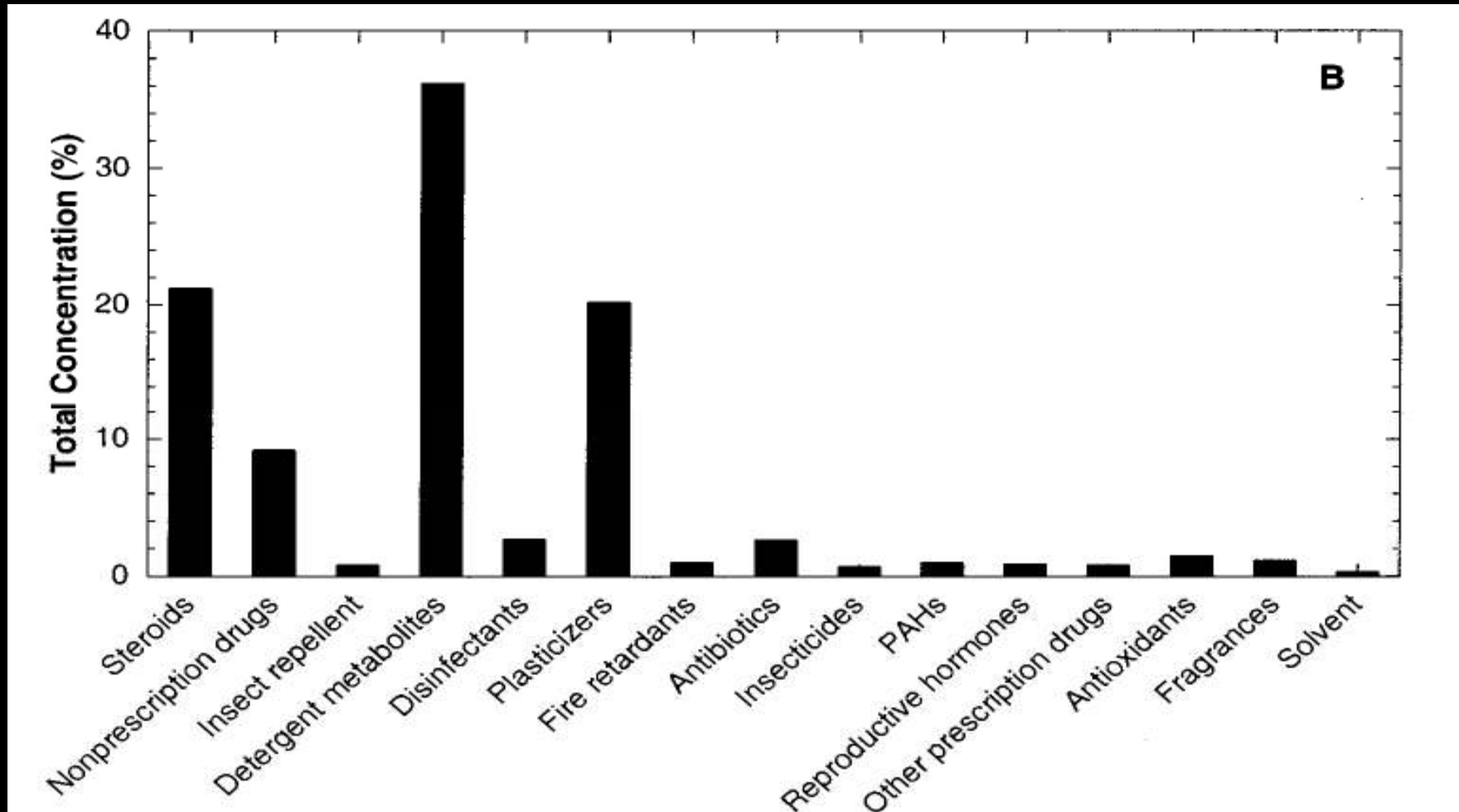
STPE is a complex mixture of EDCs

- **naturally occurring hormones (e.g., progesterone, testosterone, and estradiol)**
- **synthetic hormones (birth control estrogen - EE₂)**
- **neuroactive pharmaceuticals (antidepressant, - anxiety, ADHD medications)**
- **surfactants, plasticizers, and antimicrobials**

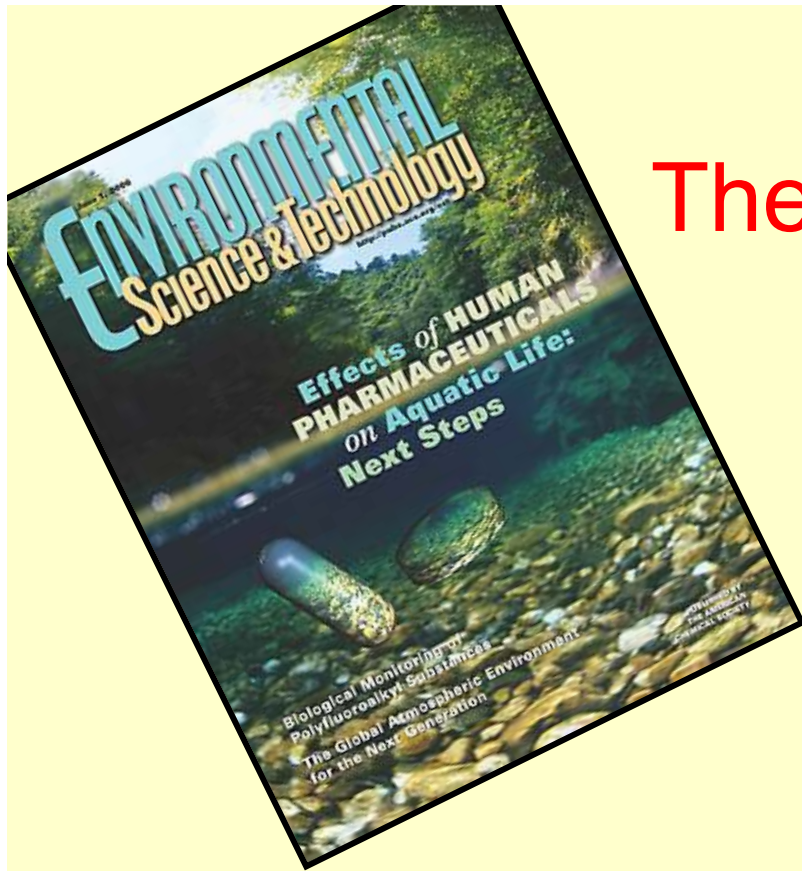
Current treatment removes more lipid soluble EDCs

- **These partition to biosolids**
- **Effluent still contains bioactive [hormones]**

Pharmaceuticals, Hormones, and Organic Waste Contaminants in U.S. Streams (USGS)



Kolpin et al., Environ Sci Technol (2002)



The Next Step?

Current STP technology

Natural and synthetic hormones

Neuroactive pharmaceuticals

~ 25% of US households have residential septic system



EPA is currently supporting research whose goals are to characterize the impact of natural and synthetic steroid hormones in animal waste from CAFOs on the environment.

Information Sources

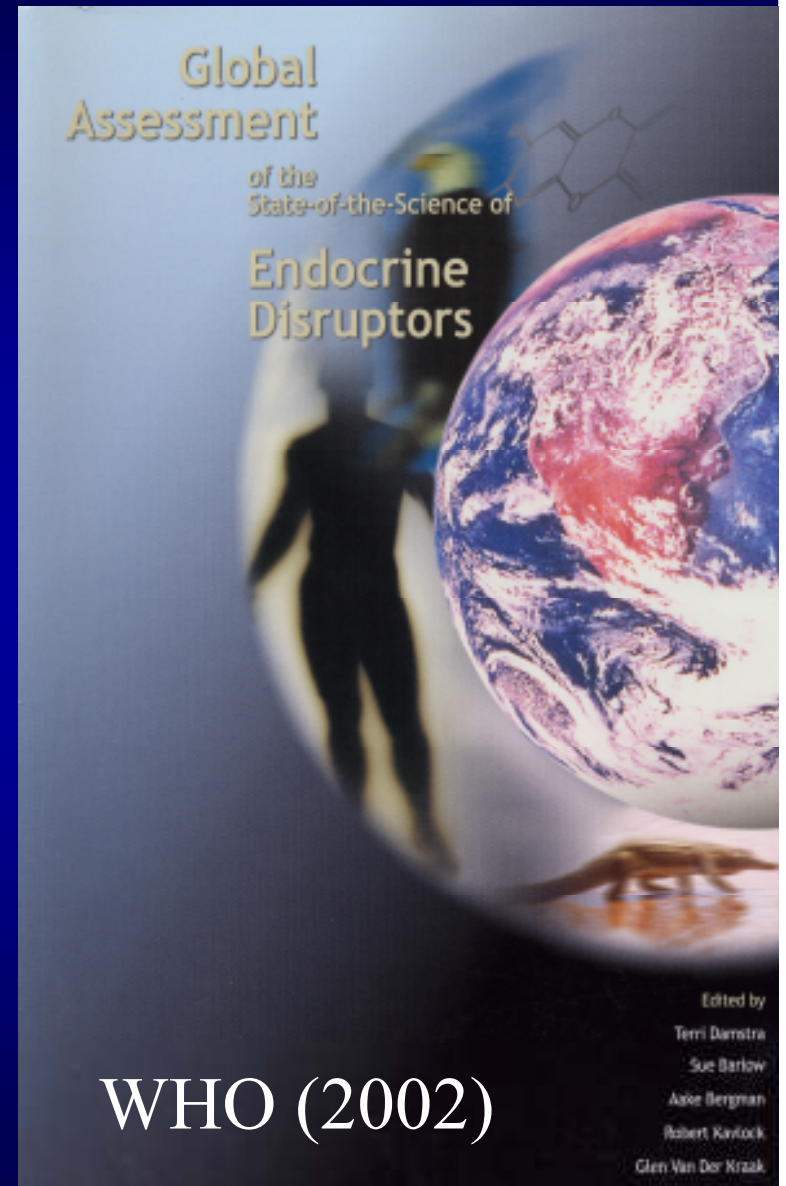
USEPA <http://www.epa.gov>

**Organization for Economic
Cooperation and
Development**

<http://www.oecd.org>

Our Stolen Future

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



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