



Research centre  
for toxic compounds  
in the environment

# Ecotoxicology Part 1 - Introduction

Ludek Blaha + ecotox colleagues

cecoen



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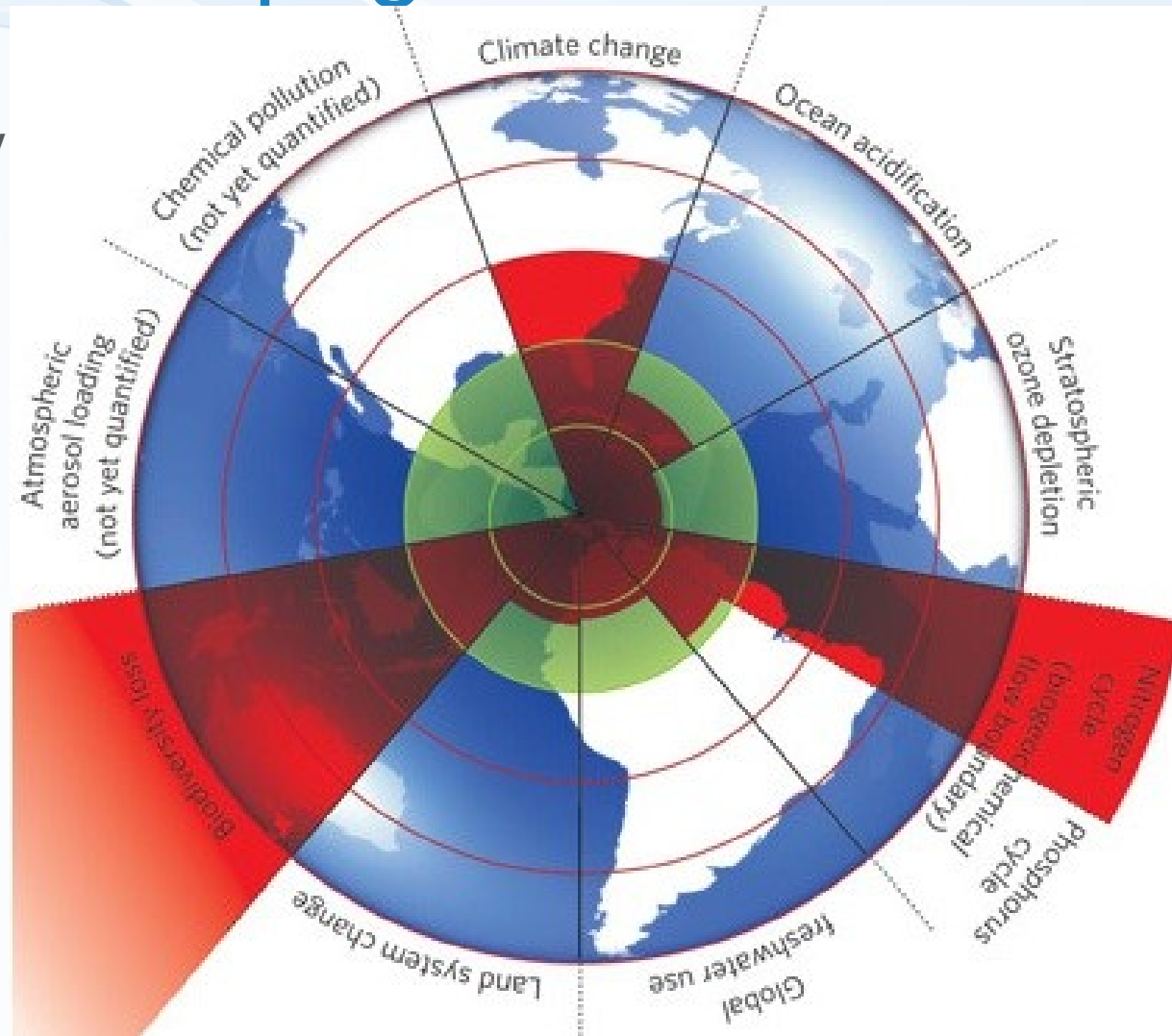
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# Global anthropogenic threats ?

## A safe operating space for humanity & the nine planetary boundaries

Rockstrom et al. 2009  
(*Ecology and Society* 14(2): 32; *Nature* 461, 472-475)



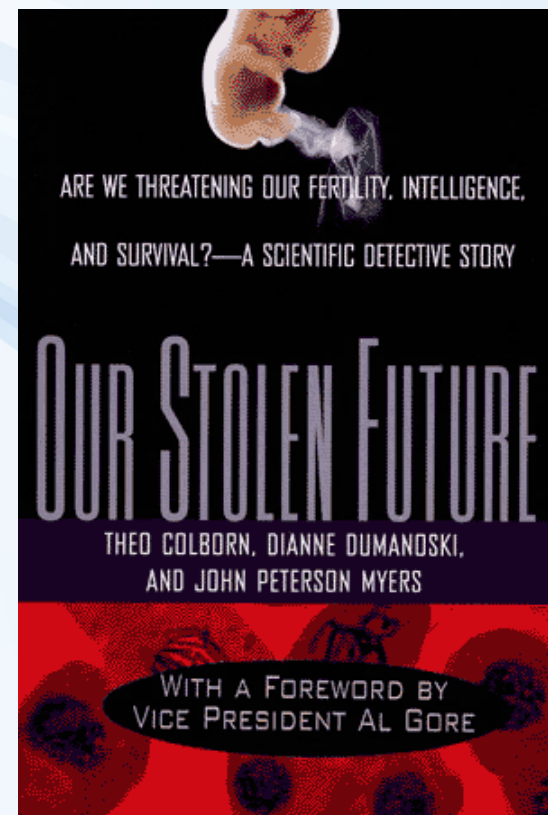
# 1996 - Chemicals in the environment

Do you believe that **chemicals in products** sold to consumers have been proven **safe**?

**Think again**

**most chemicals in modern use have simply not been tested** for their impacts on **human**, even very basic effects.

... what about the effects in nature, then ?



## How we stand 20 years later?

Published online: 21 October 2005; | doi:10.1038/news051017-16

## Pollution makes for more girls

The stress of dirty air skews sex ratios in Sao Paulo.

[Erika Check](#)

Toxic fumes favour the fairer sex, a group of researchers in Brazil has found.



Babies born in highly polluted areas are more likely to be girls.

# theguardian

## World news

# Man-made chemicals blamed as many more girls than boys are born in Arctic

- High levels can change sex of child during pregnancy
- Survey of Greenland and east Russia puts ratio at 2:1

Paul Brown in Nuuk, Greenland

Wednesday 12 September 2007  
03.00 BST



This article is 8 years old

Shares

79



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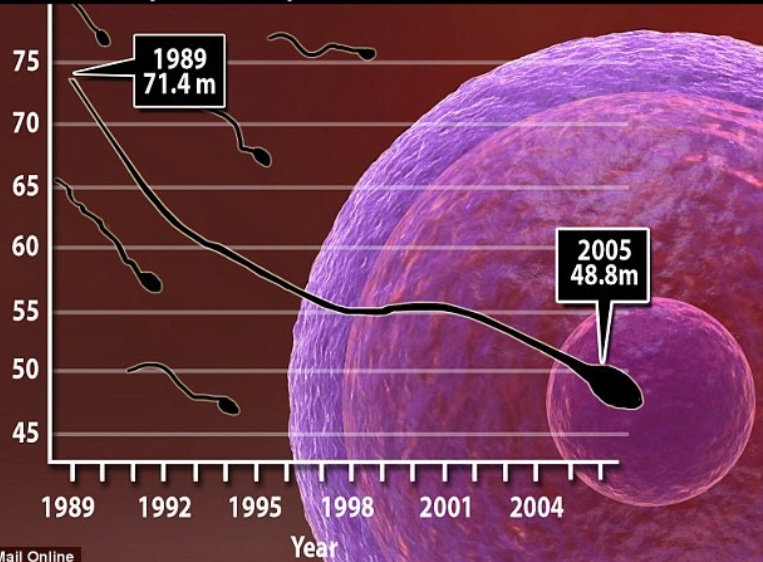


An Inuit child in a traditional parka. Photograph: Joel Sartore/Getty/National Geographic



# Sperm concentration

In millions of spermatazoa per millilitre



© Mail Online

# Global Assessment

of the State-of-the-Science of

# Endocrine Disruptors

WHO/PCS/EDC/02.2



IPCS  
INTERNATIONAL PROGRAMME  
ON CHEMICAL SAFETY

Edited by

Terri Damstra

Sue Barlow

Aake Bergman

Robert Kavlock

Glen Van Der Kraak



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# Environmental pollution

Examples and ecological consequences

# Major anthropogenic threats – example: waters

Direct



Indirect





# Major impacts

- **Loss of biodiversity**







# Major impacts

## Loss of biodiversity



## • Impairment of ecosystem services

### – Unbalanced water cycles

- Water scarcity
- Draughts/floods

### – Impaired water quality

- Drinking waters
- Bathing waters
- Toxicants in food chain

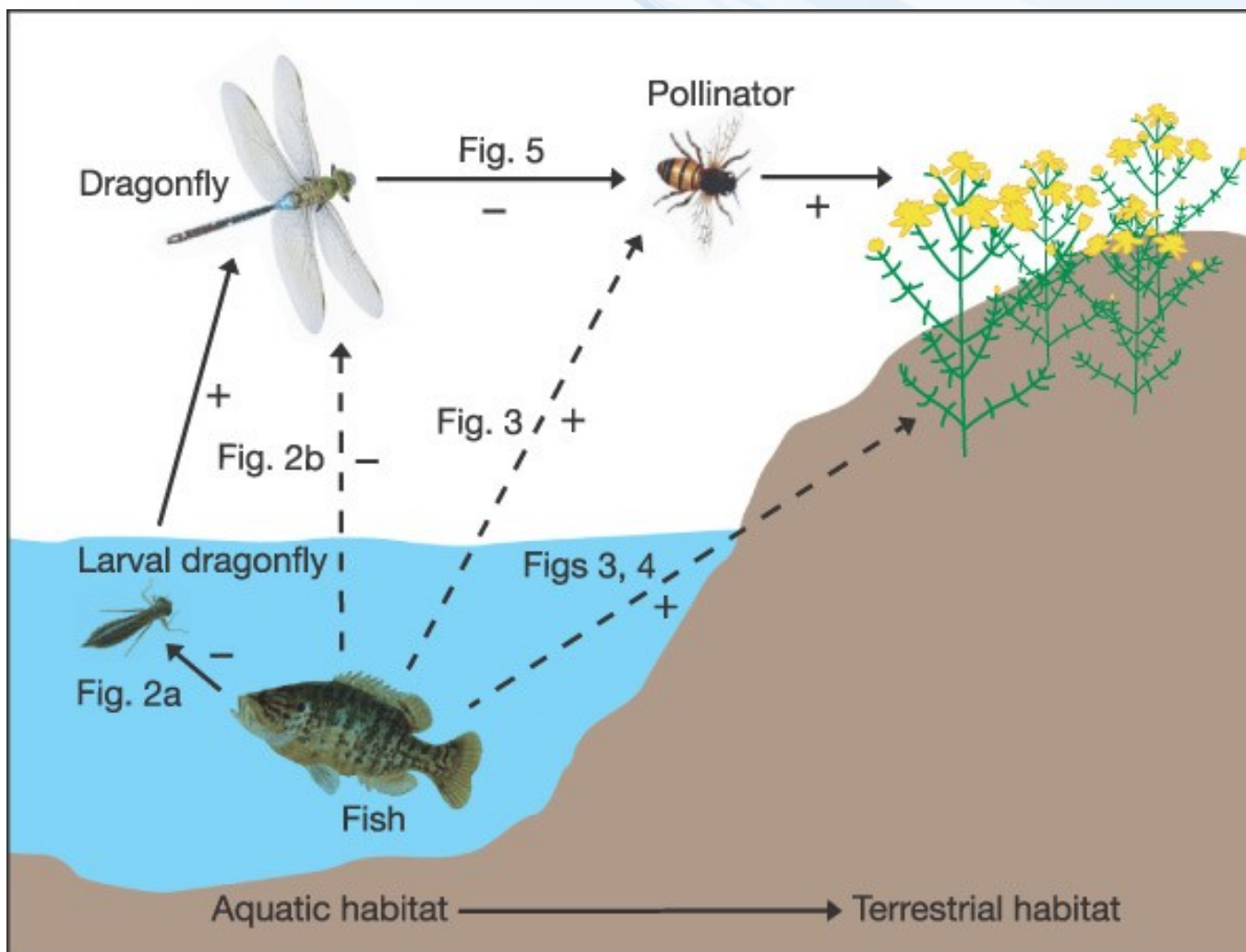
### – Shrinking of food supplies

- Direct → lowering fish amounts
- Indirect → crop yield



# Impacts on fish → decreased crop yields

NATURE (2005) 437: 880



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# Impacts on biota → global effects

## Mixing oceans

→ cooling the atmosphere

[Nature 447, p.522, May 31, 2007]



Marine life supplies up to 50% of the mechanical energy required worldwide to mix waters from the surface to deeper cool layers

[Dewar, Marine Res 64:541 (2006)]

[Katija a Dabiri, Nature 460:624 (2009)]



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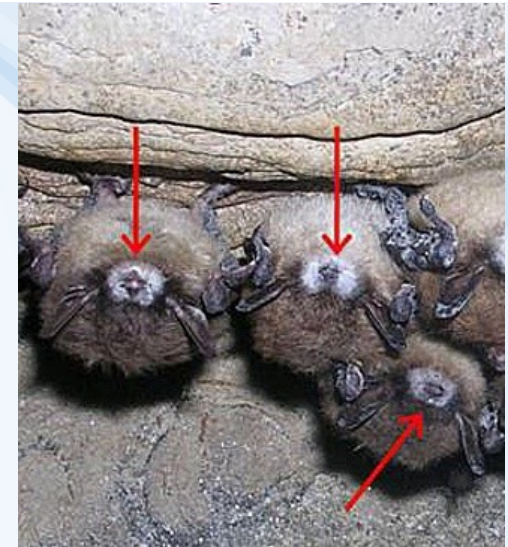
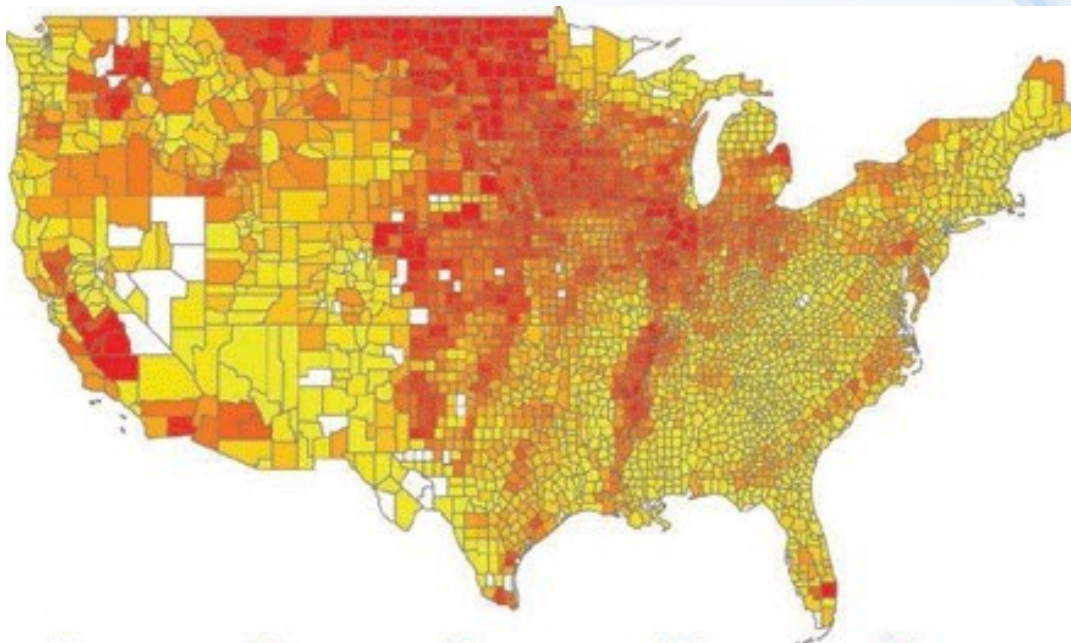


CONSERVATION

# Economic Importance of Bats in Agriculture

Justin G. Boyles,<sup>1\*</sup> Paul M. Cryan,<sup>2</sup> Gary F. McCracken,<sup>3</sup> Thomas H. Kunz<sup>4</sup>

Insectivorous bat populations, adversely impacted by white-nose syndrome and wind turbines, may be worth billions of dollars to North American agriculture.



# Ecotoxicology

assessment of hazards  
and risks of chemicals in  
ecosystems

# Protection of environment / nature

- Is and must be primary aim of **sustainably developing society**
- **why?**

## **How to protect ?**

- Policy
- Legislation
- Research
- Education

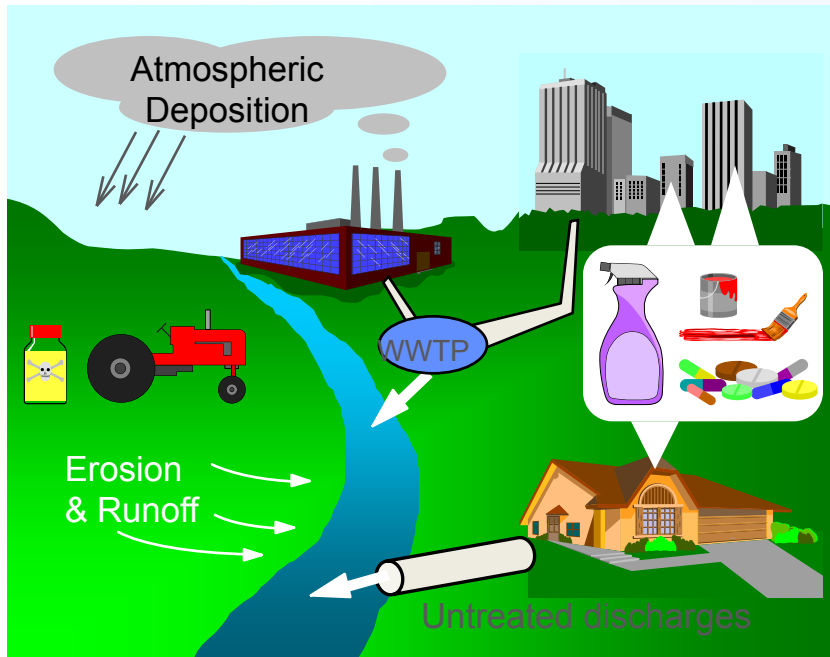


**Ecotoxicology – offers knowledge and tools useful for the effective and reasonable environmental protection (these tools = ecotoxicological bioassays)**

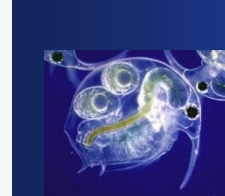


# Cause → Effect (Causality) Dose → Response Risk assessment

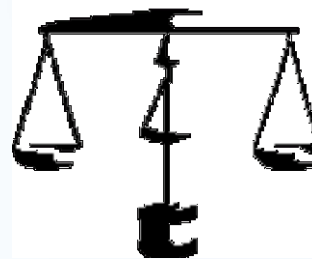
Exposure  
(concentration >> dose)



Effect  
(What exposure causes effects?)



Ecotoxicological bioassays,  
field studies, biomonitoring...





# What is hazardous? What is toxic? How to define toxicity?



# Paracelsus (1493 - 1541)



*'What is there which is not a poison?*

- *All things are poison and nothing without poison.*
- *Solely the dose determines that a thing is not a poison.*

(Eco)toxicology – ultimate goal ?

To identify (or predict)  
**safe vs hazardous** levels



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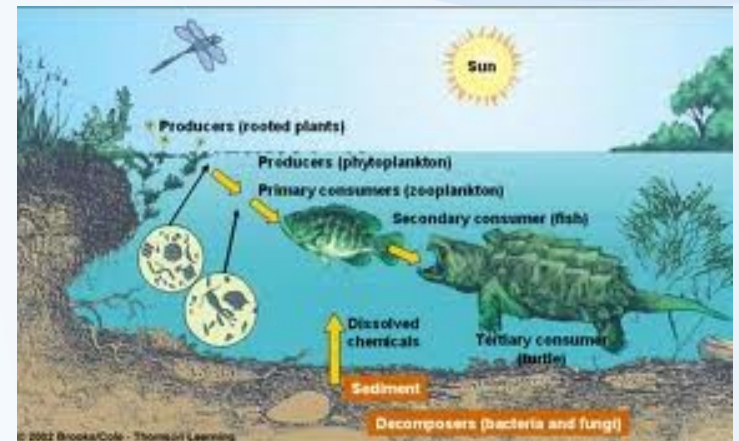
# Assessment of one of the hazards (i.e. toxicity) to different targets

...to...

Humans  
**(TOXICOLOGY)**

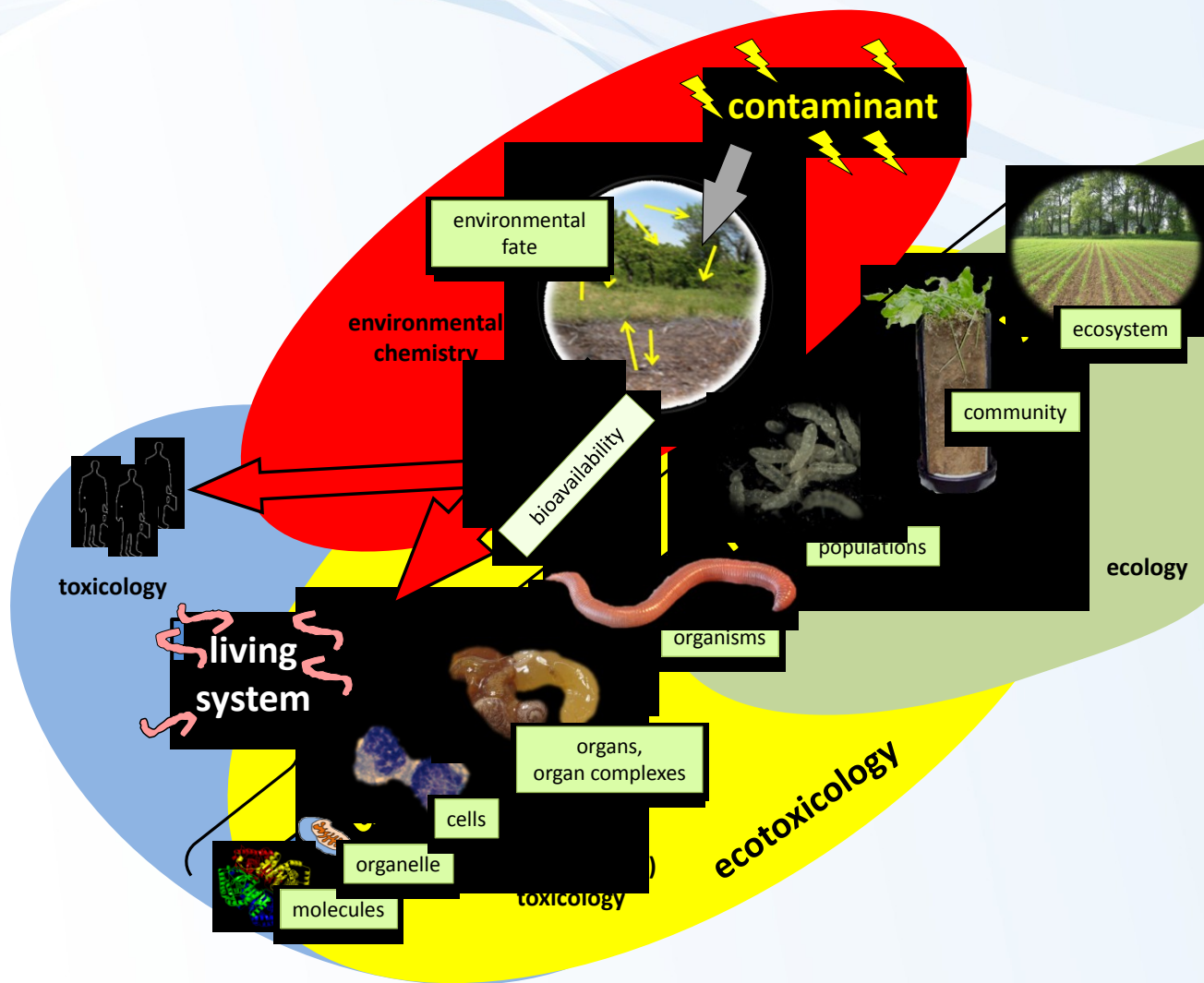


Other organisms  
**(ECOTOXICOLOGY)**





# ECOTOXICOLOGY



# ECOTOXICOLOGY by definition

- **Aim:** to maintain the natural structure and function of ecosystems
- **Definitions:**
  - ecotoxicology is concerned with the **toxic effects** of chemical and physical agents on living organisms, especially on populations and communities within defined ecosystems; **it includes the transfer pathways** and their interactions with the environment
  - science of contaminants in the biosphere and their effect on constituents of the biosphere, including humans' (Newman & Unger, 2002)
  - science that provides critical information on effects of toxic compounds on living organisms which SERVE various practical aims (environmental protection)

**CHEMICAL  
ENTERS THE  
ENVIRONMENT**



**LEVELS, FATE,  
PROCESSES**



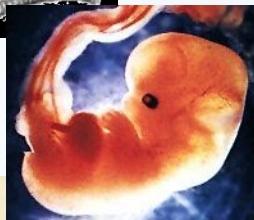
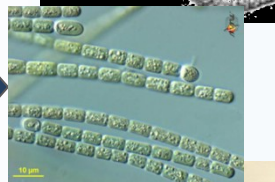
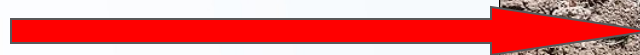
**Bioavailable  
fraction**



**"EXPOSURE"**

acute

chronic



**CHEMICAL  
ENTERS THE  
ORGANISM**

*biomonitoring*



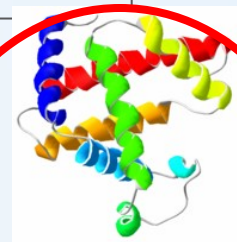
**Toxicokinetics**

*biotransformation  
bioactivation*

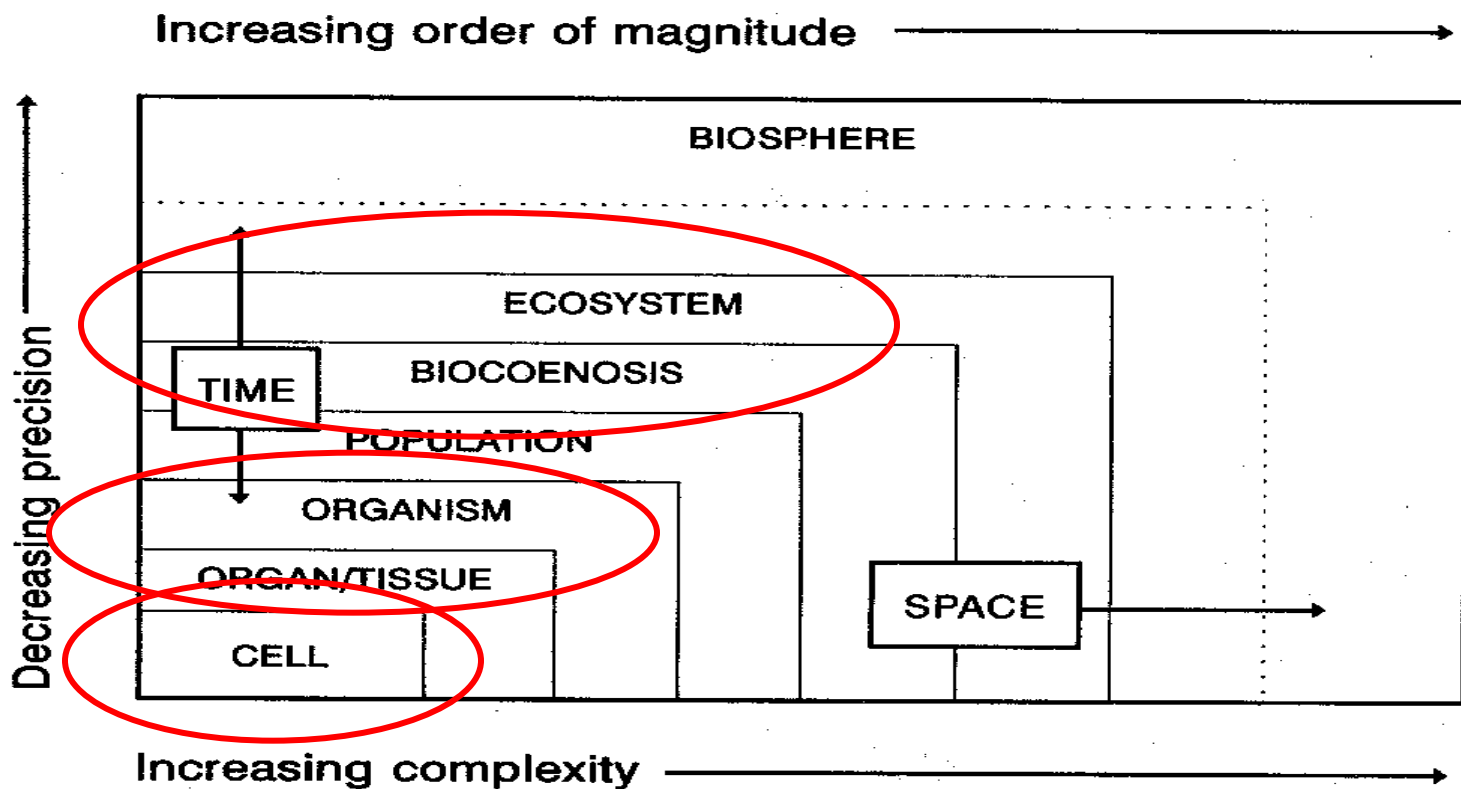
*excretion / sequestration*

**Target site**

**"EFFECT"  
toxicodynamics**



# Ecotoxicology - from molecules to ecosystems ... and backwards

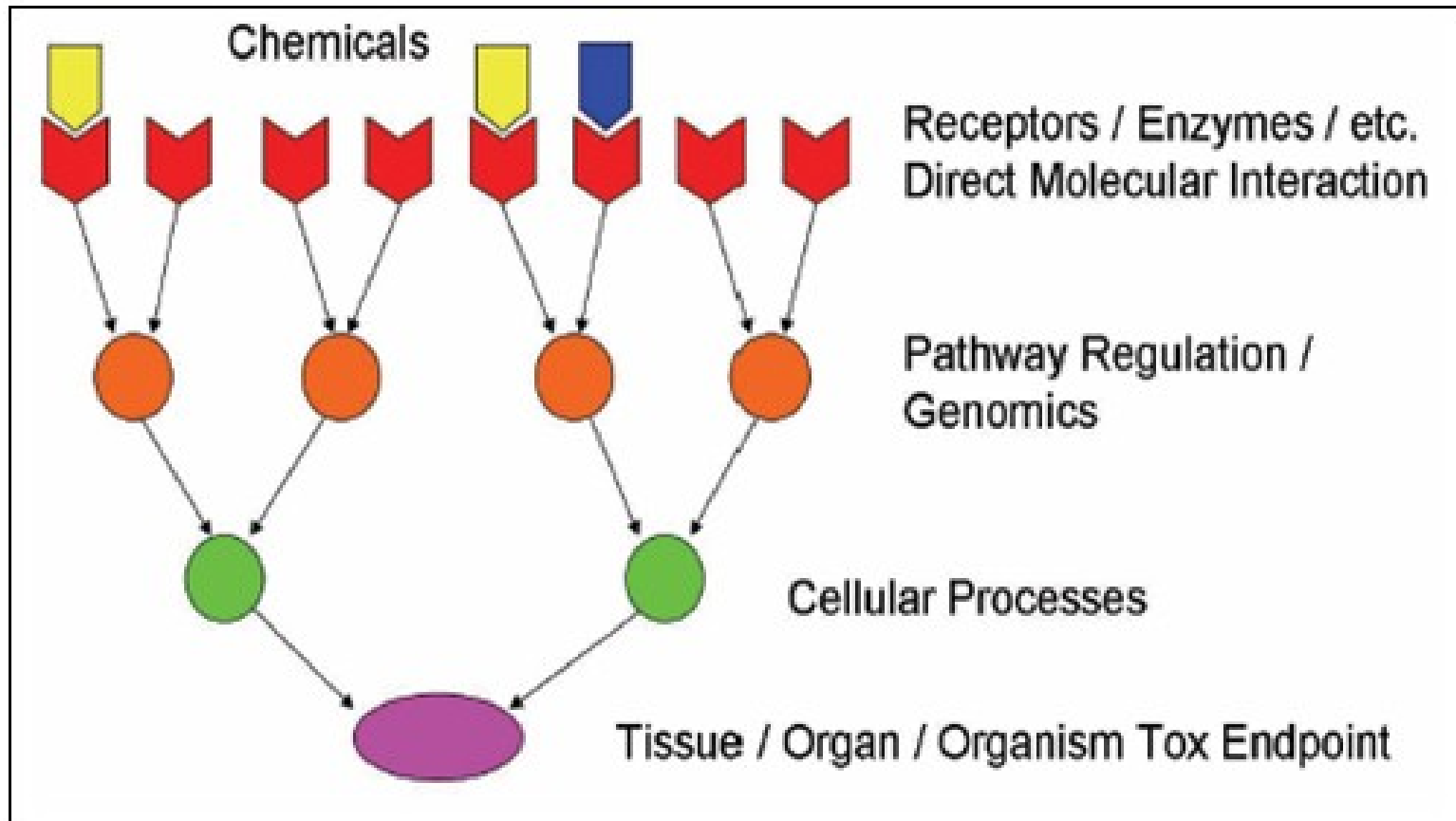


**Figure 3.1 Biological levels of organization. The dimensions of time and space are less important for the investigation up to the levels of populations and biocoenoses.**

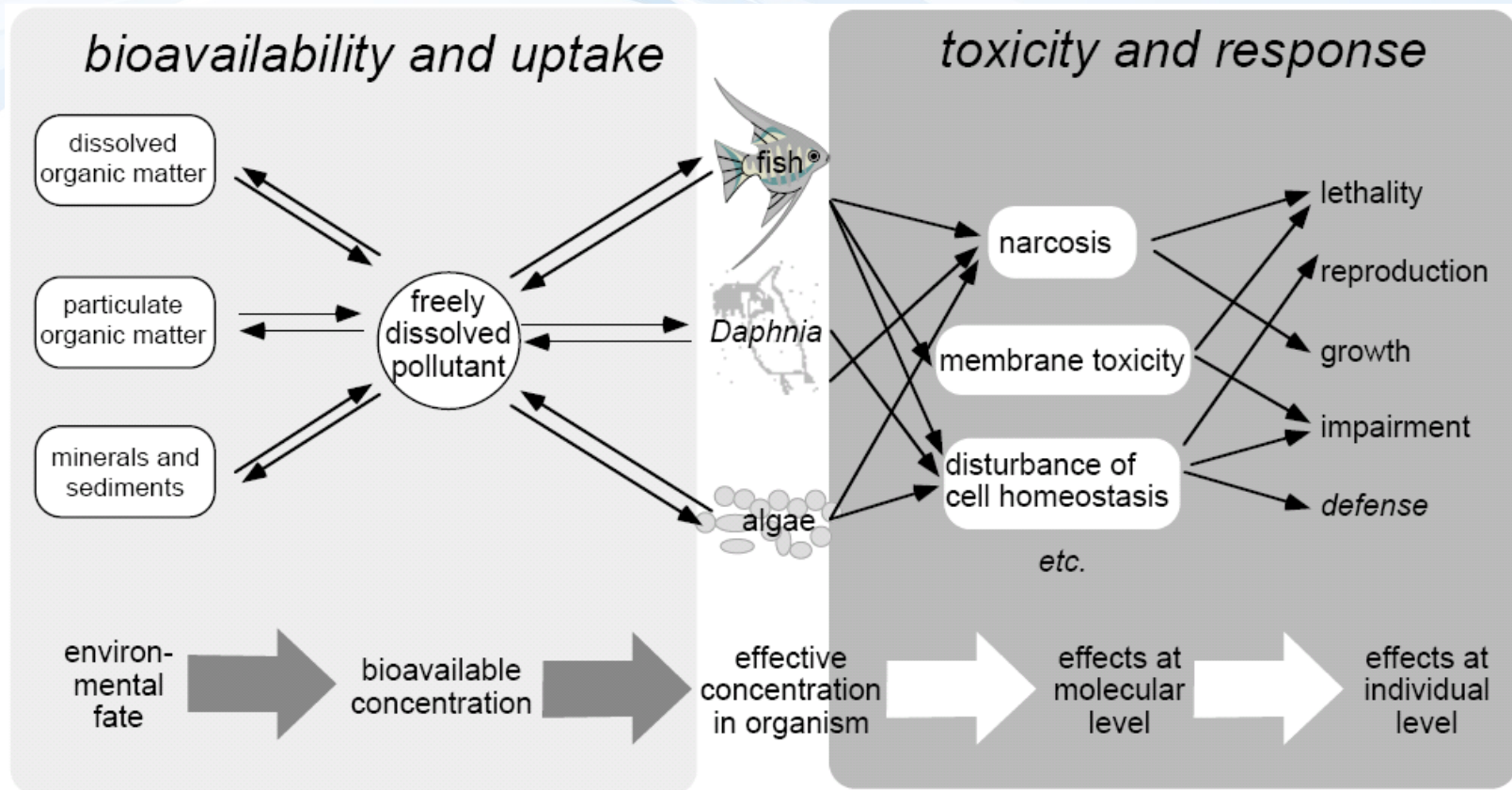


# From molecules to individuals → to populations

## MECHANISMS OF TOXICITY



# Ecotoxic effects



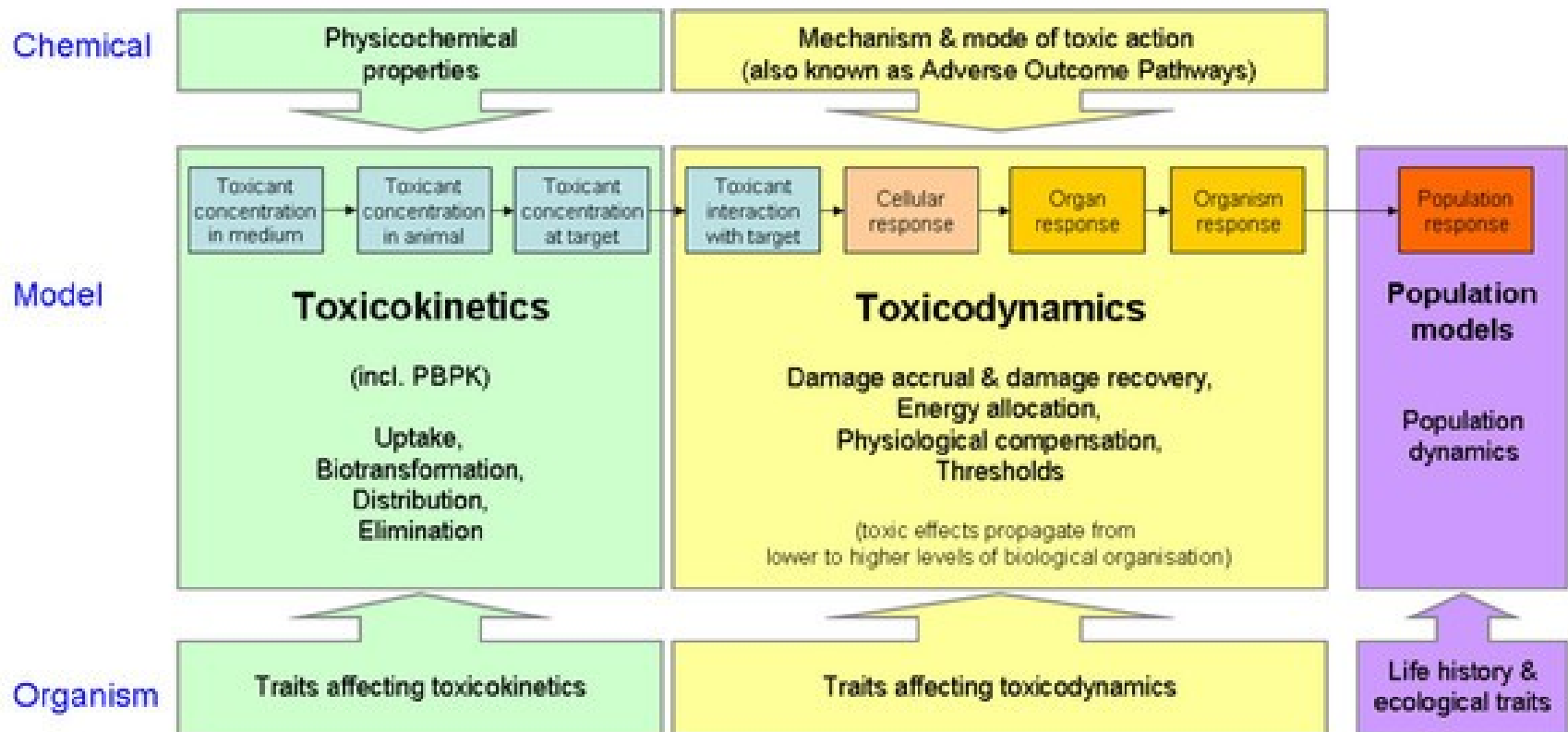
**Figure 1** The effective concentration of a pollutant in an organism (e.g. fish, daphnia, algae) or at the target site inside the organism is the link between the environmental fate of a pollutant and its toxic effect.

Escher, B. I., Behra, R., Eggen, R. I. L., Fent, K. (1997), "Molecular mechanisms in ecotoxicology: an interplay between environmental chemistry and biology", *Chimia*, **51**, 915-921.

# From molecules to individuals → to populations

## ADVERSE OUTCOME PATHWAYS

### Mechanistic effect models for ecotoxicology



→ Arrows indicate a causal relationship

See also: Ashauer & Escher *JEM* (2010), Rubach *et al. IEAM* (2011), Jager *et al. ES&T* (2011), Ashauer *et al. ET&C* (2011)

[www.ecotoxmodels.org](http://www.ecotoxmodels.org)

**From ecosystems  
→  
down the mechanisms**



**OR**

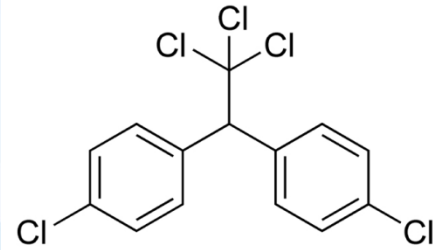
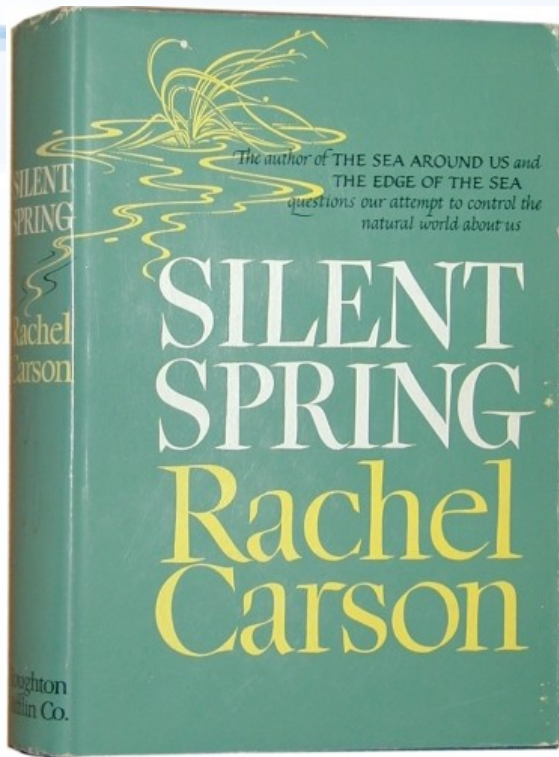
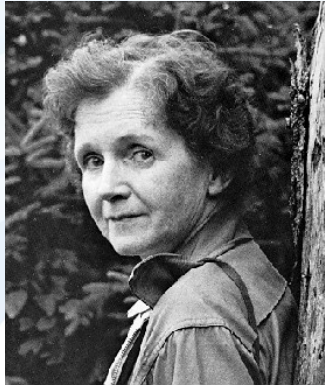
**?**

**From mechanisms (molecules)  
→  
up to effects and ecosystems**





1962



© Patuxent Wildlife Refuge, MA, USA

**"DDT is good for me-e-e!"**

The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.

Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.

**GOOD FOR STEERS**—Beef grows meatier nowadays . . . for it's a scientific fact that—compared to untreated cattle—beef steers gain up to 50 pounds extra when protected from horn flies and many other pests with DDT insecticides.

**GOOD FOR THE HOME**—helps to make healthier, more comfortable homes . . . protects your family from dangerous insect pests. Use Knox-Out DDT Powders and Sprays as directed . . . then watch the bugs "bite the dust"!

**GOOD FOR DAIRIES**—Up to 20% more milk . . . more butter . . . more cheese . . . tests prove greater milk production when dairy cows are protected from the annoyance of many insects with DDT insecticides like Knox-Out Stock and Barn Spray.

**GOOD FOR FRUITS**—Bigger apples, juicier fruits that are free from unsightly worms . . . all benefits resulting from DDT dusts and sprays.

**GOOD FOR ROW CROPS**—25 more barrels of potatoes per acre . . . actual DDT tests have shown crop increases like that! DDT dusts and sprays help truck farmers pass these gains along to you.

**KNOX FOR INDUSTRY**—Food processing plants, laundries, dry cleaning plants, hotels . . . dozens of industries gain effective bug control, more pleasant work conditions with Pennsalt DDT products.

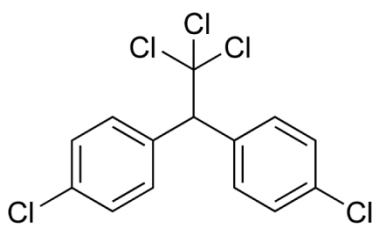
**PENN SALT**  
CHEMICALS  
87 Years' Service to Industry • Farm • Home  
PENNSYLVANIA SALT MANUFACTURING COMPANY  
WIDENER BUILDING, PHILADELPHIA 7, PA.

Bitman et al. *Science* 1970, 168(3931): 594



## Biochemistry

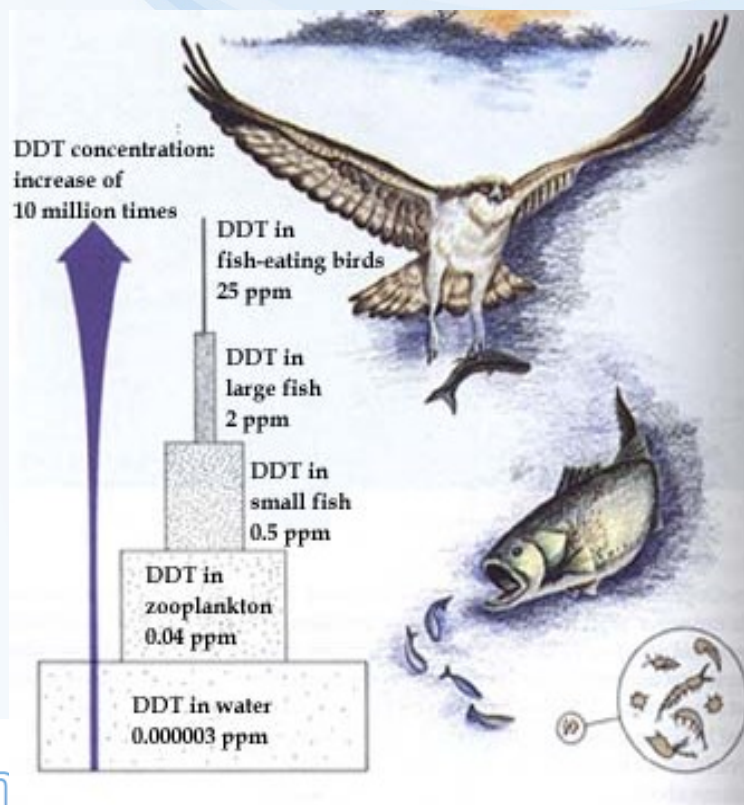
bird carbonate dehydratase



**In vivo:** shell thinning



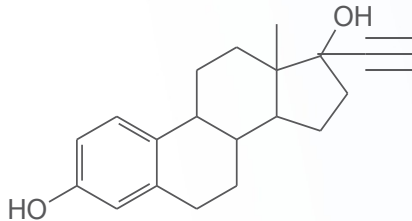
**In situ:** bioaccumulation  
**-> bird population decline**





# AOP Example: Activation of ER - estrogen receptor (e.g. by EE2) leads to reproductive disorders and population decline in fish

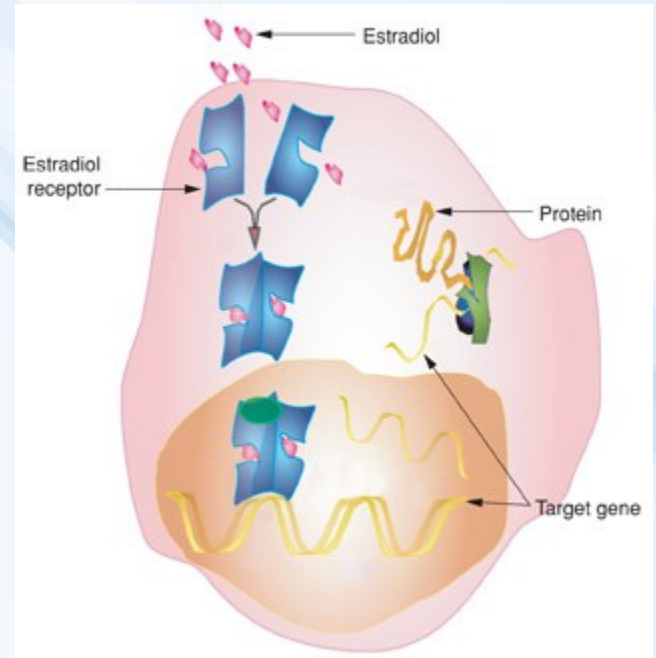
## Ethinylestradiol (EE2)



**Binds to ESTROGEN RECEPTOR**

### Target genes

- Proliferation/Apoptosis (sexual organs)
- Synthesis of egg yolk (fish, amphibia)



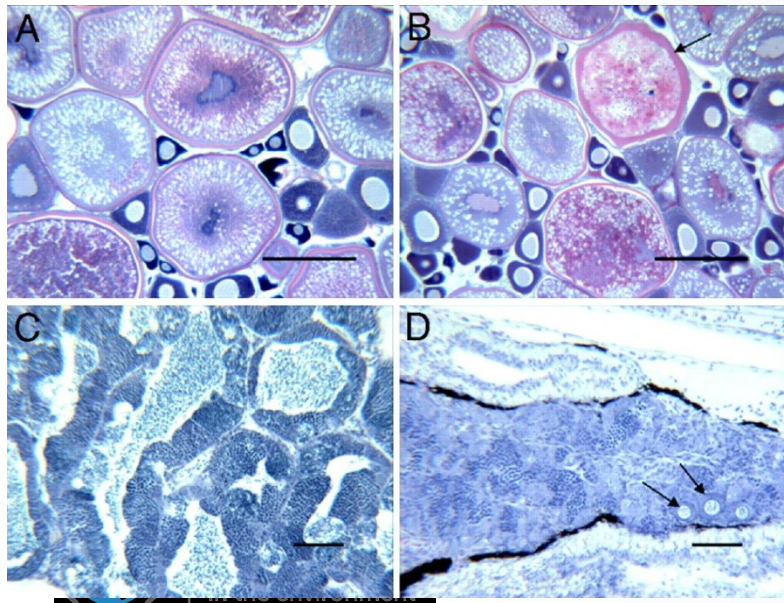
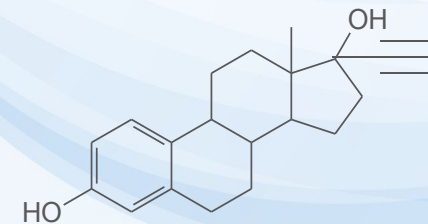
### Effects

- Females: reproduction regulation
- Males: feminization  
(+ e.g. cancer promotion, development, immunomodulation)

Kidd, K.A. et al. 2007. **Collapse of a fish population** following exposure to **a synthetic estrogen**. *Proceedings of the National Academy of Sciences* 104(21):8897-8901

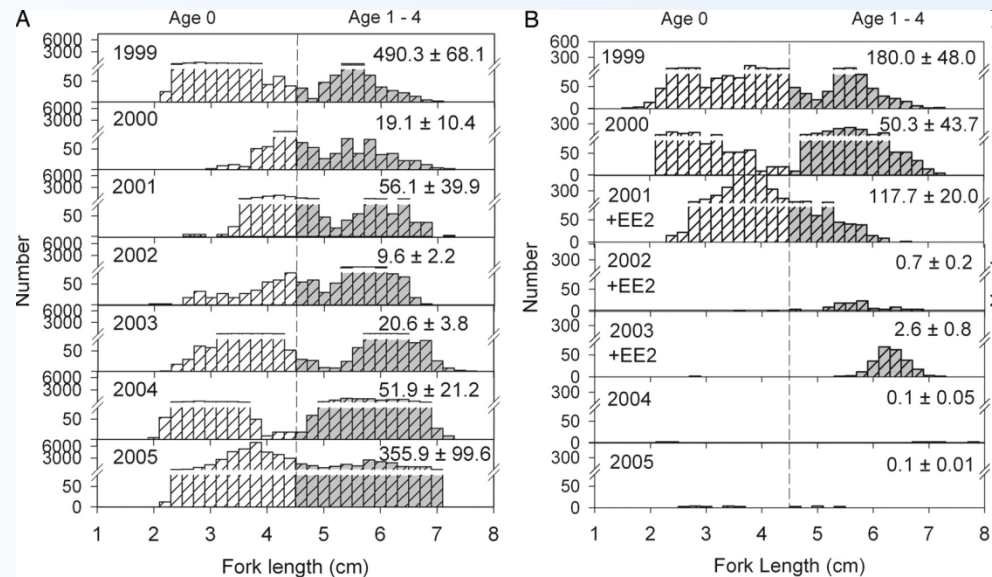


**5 ng/L (!)**  
**7 years**



**Controls**

**+ Ethinylestradiol**





# WRAP UP ... take home message

- Ecotoxicology as a science with close links to practical environmental protection
  - Understand the importance and links between ECOTOXICITY --- BIODIVERSITY --- ECOSYSTEM SERVICES
- From molecular events to higher levels
  - Be aware of different biological levels - from molecules to communities
  - Know example(s) of „Adverse Outcome Pathway(s)“