Food Production

06 April 2007
34th class meeting

READINGS
Friday 06 April:
Pesticides and Pseudoestrogens:
Colborn 1997; Gore 1994
Monday 09 April:
Water:
Postel 2001; EPA website; 3Gorges:
http://news.bbc.co.uk/2/hi/asia-pacific/5000092.stm)

Lab 04/06 April:
meet in COMPUTER lab
(CC311)
Lab 11/13 April: meet at van s-side BSE
Exam Friday 13 April (→ pseudoestrogens)

Environmental Biology (ECOL 206)
University of Arizona, spring 2007

Kevin Bonine, Ph.D.
Anna Tyler, Graduate TA

http://eebweb.arizona.edu/courses/Ecol206/206_Page2007.html

Levidow 1999 (Regulating Bt Maize in the U.S. and Europe)

Bt = *Bacillus thuringiensis* bacterium
(contains gene that codes for protein toxic to some insects)
Genetically Modified Crops (cotton, potatoes, maize)

Costs and Benefits
- Yields and Fewer Agrochemicals
- Agriculture, Environment (Monarchs), Humans
- Resistance, Arms Race, 'Genetic Treadmill'
- Herbicide and Ampicillin markers

IRM = Insect Resistance Management
"High-Dose/Refuge" Strategy
3-5 year time window

Solutions
Crop Rotation, IPM etc.

EPA, EU

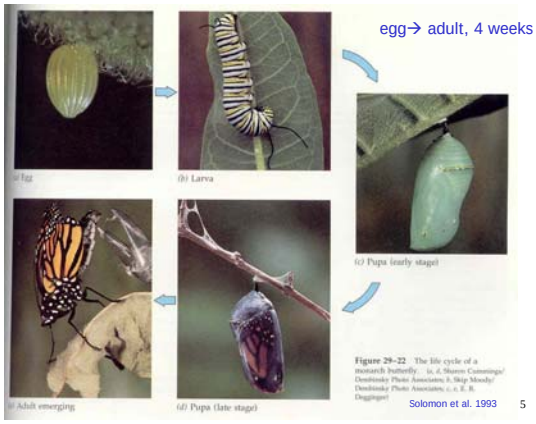
Monarch Butterfly
Danaus plexippus

-Lepidoptera (order)
-Papilionoidea
-Danaidae
Milkweed Butterflies

Figure 52–4 Emigration (movement away from a specific area) and immigration (movement into a specific area) are important factors in the population sizes of migratory animals. Shown here is a population of monarch butterflies spending the winter in the mountains of central Mexico. Monarch butterflies migrate into the United States and Canada for the summer months and return to Mexico for the winter. A round trip often involves several generations. Somehow, individual monarchs know where to winter in Mexico without having seen the sites before. (William E. Bergmann)

Solomon et al. 1993

Migration - 2000 miles
Canada <–> Mexico
(Hawaii, Australia)
Millions
Multiple Generations!



egg→ adult, 4 weeks

Figure 29–22 The life cycle of a monarch butterfly. (a, d, Sharon Cummings/Dembinsky Photo Associates; b, Skip Moody/Dembinsky Photo Associates; c, e, E. R. Degginger)

Solomon et al. 1993

Mullerian Mimicry

Figure 17–19 Müllerian mimicry. These various butterflies are all unpalatable. (L. E. Gilbert, University of Texas, Austin/Biological Photo Service)

Solomon et al. 1993

Milkweed
(foliage, flowers, buds, fluid)
Poisonous cardenolides

~ Losey et al. 1999

Bacillus thuringiensis
Bt corn pollen -->
milkweed

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Ecological Colonialism

Jeremy Rifkin
Beyond Beef
1992

the temperate regions of the world. Cattle grazing is a primary cause of the spreading desertification process that is now enveloping whole continents. Cattle ranching is responsible for the destruction of much of the earth's remaining tropical rain forests. Cattle raising is partially responsible for the rapid depletion of fresh water on the planet, with some reservoirs and aquifers now at their lowest levels since the end of the last Ice Age. Cattle are a chief source of organic pollution; cow dung is poisoning the freshwater lakes, rivers, and streams of the world. Growing herds of cattle are exerting unprecedented pressure on the carrying capacity of natural ecosystems, edging entire species of wildlife to the brink of extinction. Cattle are a growing source of global warming, and their increasing numbers now threaten the very chemical dynamics of the biosphere.

Rifkin 1992 (Beyond Beef, Ecological Colonialism)

Domesticated Cattle

-Soil Erosion (vs. soil formation)
-Desertification

-Tropical Rainforest Depletion
-Global Warming

-Nonnative grasses, weeds, grains
-Old --> New World
-Ecological Change

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Some Environmental Consequences of Meat Production

CONNECTIONS

The meat-based diet of affluent people in developed and developing countries has the following environmental effects:

- More than half of the world's cropland (19% in the United States) is used to produce livestock feed grain (mostly field corn, sorghum, and soybeans).
- Livestock and fish raised for food consume about 36% of the world's grain production (65% of U.S. production).
- Livestock use more than half the water withdrawn from rivers and aquifers each year, mostly to (1) irrigate crops fed to livestock and (2) wash away manure from crowded livestock pens and feedlots.
- Manure washing off the land or leaking from lagoons used to store animal wastes is a source of water pollution that kills fish by depleting dissolved oxygen.
- About 14% of U.S. topsoil loss is directly associated with livestock grazing.
- Overgrazing of sparse vegetation and trampling of the soil by too many livestock is the major cause of desertification in arid and semiarid areas (Figure 9-6).
- Cattle belch out about 16% of the methane (a greenhouse gas about 25 times more potent than carbon dioxide) released into the atmosphere.
- Some of the nitrogen in commercial inorganic fertilizer used to grow livestock feed is converted to nitrous oxide, a greenhouse gas released from the soil into the atmosphere.
- More than one-third of all raw materials and fossil fuels consumed in the United States are used in animal production.
- Livestock in the United States produce 20 times more waste (manure) than is produced by the country's human population. Only about half of this nutrient-rich livestock waste is recycled into the soil.

Some environmentalists have called for reducing livestock production (especially cattle) to reduce its environmental effects and to feed more people. This would decrease the environmental impact of livestock production, but it would not free up much land or grain to feed more of the world's hungry people.

Cattle and sheep that graze on rangeland use a resource (grass) that humans cannot eat, and most of this land is not suitable for growing crops. Moreover, because of poverty, insufficient economic aid, and the nature of global economic and food distribution systems, very little if any additional grain grown on land used to raise livestock or livestock feed would reach the world's hungry people.

Critical Thinking

Are you willing to eat less meat or not eat any meat? Explain.

Miller, 2003
Chapter 9 (= p. 160 chapter 8 in 2005)

See Rifkin 1992

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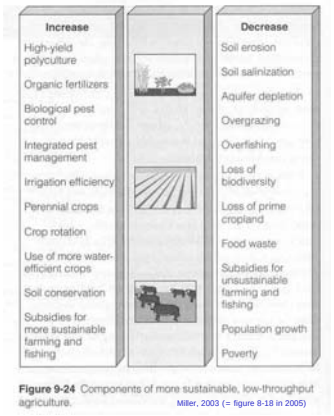

Figure 9-24 Components of more sustainable, low-throughput agriculture.
Miller, 2003 (= figure 8-18 in 2005)

Toward Solutions

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Food Production

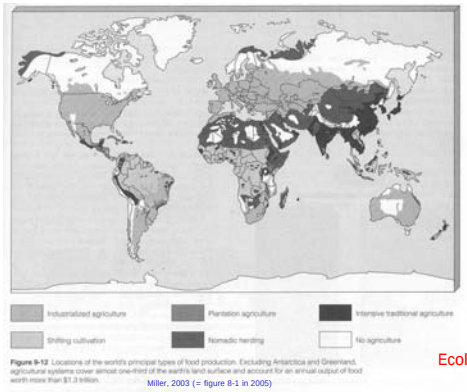

Figure 9-12 Locations of the world's principal types of food production. Excluding Antarctica and Greenland, agricultural systems cover almost one-third of the earth's land surface and account for an annual output of food worth more than $1.3 trillion.
Miller, 2003 (= figure 8-1 in 2005)

Monoculture

Polyvarietal

Interplanting/ Intercropping - >1 crop
Polyculture -difft times

Agroforestry -with trees

Ecological Theme

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Local Ideas:

Tucson CSA (community supported agriculture) food from Organic farm in Glendale

Terra Cycle Farms (located near Rio Rico)?

Tucson COOP (4th Ave.)

17th Street Market

Farmers Markets

CONSUMER DRIVEN CHANGE!

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Flies, Manure &
Industrial Meat Production

Antibiotic Resistance

Horizontal Gene Transfer

Burgers and Flies

Grab that flyswatter! Public-health entomologists have discovered antibiotic-resistant bacteria lurking in the guts of houseflies buzzing around fast-food joints. Ludek Zurek and Lilia Maccowi of Kansas State University in Manhattan, Kansas, captured more than 200 houseflies at five restaurants in a northeastern Kansas town. The entomologists isolated and cultured bacteria from the flies' guts, then exposed the bacteria to antibiotics. Two-thirds of the bacteria survived treatment with a single common antibiotic, and, of those, half survived treatment with two or more antibiotics. Zurek and Maccowi also identified genes that confer immunity in most of the resistant bacteria's DNA.

The houseflies may have come from farms, the entomologists say. In the U. S., livestock are regularly dosed with antibiotics to encourage growth, and so their gut bacteria often evolve resistance to the drugs. Houseflies that develop in and feed on the animals' waste swallow bacteria when they eat. Then, being long-distance aviators, they can fly to town—hence their nickname in Zurek's lab: "flying manure."

Houseflies enjoy many of the same foods people do, including cooked meat and sweets. And they go to the same restaurants. They eat messily, spitting and regurgitating on their meal before digging in. In the process, a house-

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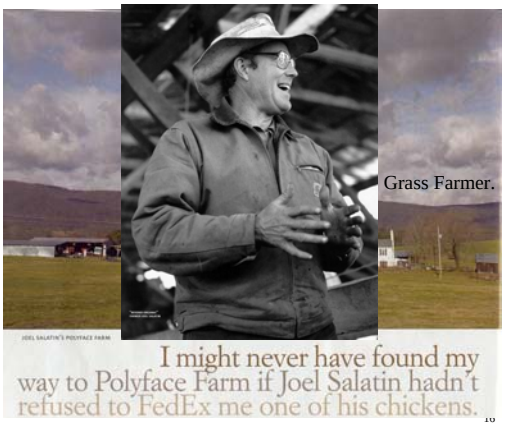

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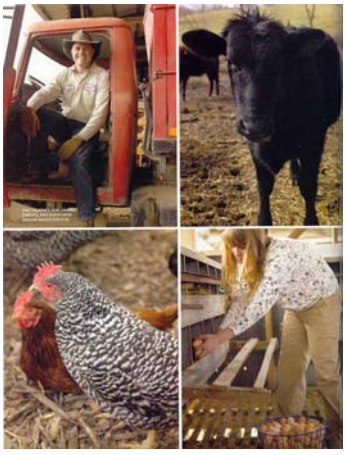

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Pesticides and Pseudoestrogens

Fertility today, gone tomorrow

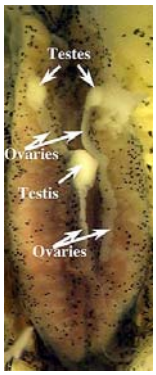
(Most Slide Text Thanks to Jessie Cable, EEB, 2004)

Atrazine, a top selling weed killer in the United States and
the world, has been found to dramatically affect the sexual
them into
h male and female
ower than those
ental Protection Agency

t atrazine could cause such
Tyrone Hayes, an
at the University of
dy.

es, living near atrazine-
w the same
nimals in Tyrone Hayes'

oundwater, 102 ppb in
4 ppb in streams in the
ree environment, says
Hayes, who adds that the herbicide has been used for 40 years in over 80 countries.



Abnormal gonads in a male *Xenopus* frog, the result of exposure to the herbicide atrazine. The frog has become a hermaphrodite, that is, it has both male (testes) and female (ovaries) sex organs. *Credit: Tyrone Hayes/UC Berkeley, courtesy PNAS*

the science behind the story

Pesticides and Child Development in Mexico's Yaqui Valley

Drawings by children in the foothills

Drawings by children in the valley

Brennan and Withgott 2005

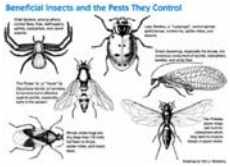
Pesticides

- What are they?
  - "pest" = competes with us, destroys what we have/need, spreads disease
  - "-icide" = kill
- What is the ideal pesticide?
  - Target specific
  - Breaks down into harmless compounds
  - Genetic resistance doesn't occur

Pesticides – the good, the bad, the ugly

- GOOD
  - Save human life against malaria, plague, typhus
  - Increase food supply, lower costs
  - Increase farmer profit
  - Fast acting, long shelf life, easily shipped
  - Newer pesticides are safer
  - Used at lower rates than before
- BAD
  - Accelerate genetic resistance of pests
  - Broad spectrum – kills predators of pests
  - Do not stay put – little of what is applied reaches the target
  - Harm wildlife and human health

Pesticides



- Alternatives
  - Change cultivation practices
    - Crop rotation, change planting time, polyculture
  - Genetic engineering
    - Pest-proof the plants
  - Biological pest control
    - Bacteria, viruses, parasites, natural predators

Pesticides

- Alternatives
  - Insect birth control
    - Sterilize males
  - Pheromones
    - Luring into traps
  - Irradiation

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Pesticides

- Alternatives
  - INTEGRATED PEST MANAGEMENT
    - Evaluation of pests and crops on an individual basis (NOT a band aid for every situation)
    - Includes combination of methods (cultivation, biological, chemical)
    - Specifically timed
    - Pollution prevention
    - Successful in many countries

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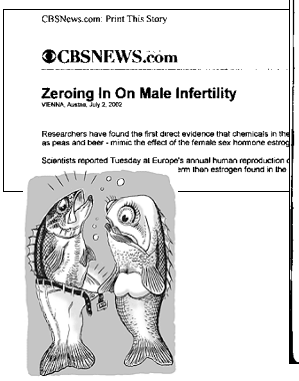
Pesticides: the ugly


CBSNews.com: Print This Story

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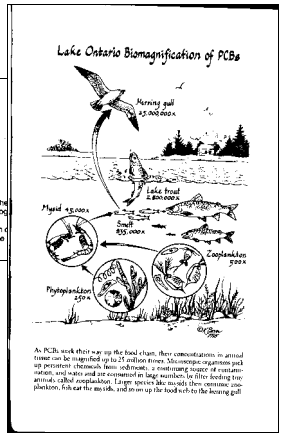
Zeroing In On Male Infertility

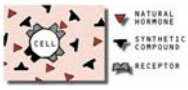
VIENNA, Austria, July 2, 2002

Researchers have found the first direct evidence that chemicals in the
as peas and beer - mimic the effect of the female sex hormone estrog

Scientists reported Tuesday at Europe's annual human reproduction
rm than estrogen found in the



Pseudoestrogens



- Endocrine disruptors
- Synthetic compounds that interfere with endocrine function
- Mimic hormones
- Can block receptors, attach to receptors to induce response
- Ultimately: feminization of males

Dr. Shane Snyder
R&D Project Manager
Southern Nevada Water Authority

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Pseudoestrogens: Endocrine Disruptors

- Where are they found?
  - Pesticides
  - Natural and synthetic hormones
  - Plant constituents
  - Plastics
  - Detergents
  - Environmental pollutants
  - Sewage effluent

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Some scientists say estrogen mimics could also explain the growing incidence of breast cancer and perhaps prostate cancer as well. The putative endocrine disrupters have structures akin to real hormones, and seem to include:

- breakdown products of several pesticides that are now banned, such as DDT

- dioxins, a group of toxic chemical byproducts from paper production and incineration, and

- PCBs, a persistent group of chemicals still found in electrical equipment that pollutes lake and stream sediments in many industrial regions

- chemicals found in the epoxy lining of "tin" cans, plastics used for storing food, dental sealants, and Vinclozolin, a fungicide used on fruit.

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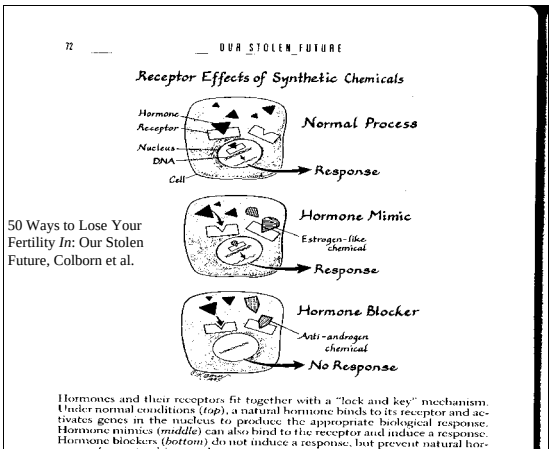

50 Ways to Lose Your Fertility *In*: Our Stolen Future, Colborn et al.

Pseudoestrogens: Endocrine Disruptors

Table 2 POSSIBLE EFFECTS OF EDCS

Males	*Female*	*Wildlife*
Decreased sperm counts or quality	breast cancer	infertility
testicular cancer	cardiovascular effects	sex-changes (imposex)
undescended testes		developmental abnormalities
malformed penis		thyroid dysfunction
intelligence deficit	intelligence deficit	behavioural abnormalities
neurological problems	neurological problems	dysfunctional immune system

Source: IEH, WWF

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Diethylstilbestrol (DES)

Between the 1940s and 1970s, doctors prescribed an artificial estrogen named diethylstilbestrol, or DES, to prevent miscarriages in millions of pregnant women.

Only long after the fact did doctors find that DES had caused a rare form of cervical cancer in some of their daughters.

Detail from an ad for Grant Chemical Company's DES product, circa 1955. Courtesy Independent Television Service (ITVS), 1997.

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Hypospadias occurs in about 4 of 1000 male births. There is some family risk, about a 20% chance of finding it in another family member.

Hypospadias is most commonly caused by failure of adequate or continuous hormone production during the development of a fetus from about 10 weeks into gestation. It can be detected by ultrasound or specialist inspection as often the foreskin will be malformed.

http://www.hypospadiashelp.fsnet.co.uk/What%20is%20hypospadias.html

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Pseudoestrogens

- The Omens: reproductive failure in wildlife
- Bald Eagles - Florida 1952
  - Not interested in mating
- Otters - England late 1950's
  - Dieldrin pesticide suspected
- Mink - Lake Michigan mid-1960's
  - PCB contaminated food (fish)

From: Our Stolen Future
Colborn et al.

Pseudoestrogens

- Herring Gulls – Lake Ontario 1970
  - Deformed/dead chicks, possible Dioxin contamination
- Western Gulls – Channel Islands, CA 1970's
  - Females nesting together, thin shells
- Alligators – Lake Apopka, FL 1980's
  - Low hatching rate, feminization of males

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Pseudoestrogens

- Seals – Northern Europe 1988
  - 18,000 dead, pollution?, disease?
- Striped Dolphins – Mediterranean Sea 1990's
  - >1,100 dead, PCB
- Human sperm – Copenhagen 1992
  - Abnormalities, global drop in sperm count
  - Increase in testicular cancer
  - Genital abnormalities

BioMagnification
BioAccumulation

PCBs

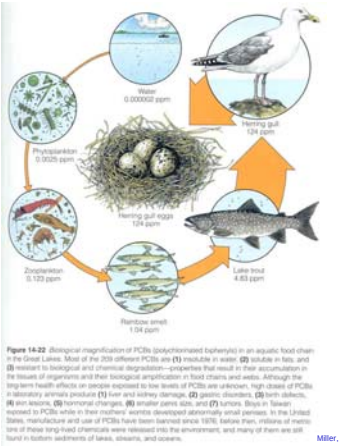

Figure 14-22 *Biological magnification of PCBs (polychlorinated biphenyls) in an aquatic food chain in the Great Lakes.* Most of the 209 different PCBs are **(1)** insoluble in water, **(2)** soluble in fats, and **(3)** resistant to biological and chemical degradation—properties that result in their accumulation in the tissues of organisms and their biological amplification in food chains and webs. Although the long-term health effects on people exposed to low levels of PCBs are unknown, high doses of PCBs in laboratory animals produce **(1)** liver and kidney damage, **(2)** gastric disorders, **(3)** birth defects, **(4)** skin lesions, **(5)** hormonal changes, **(6)** smaller penis size, and **(7)** tumors. Boys in Taiwan exposed to PCBs while in their mothers' wombs developed abnormally small penises. In the United States, manufacture and use of PCBs have been banned since 1976; before then, millions of metric tons of these long-lived chemicals were released into the environment, and many of them are still found in bottom sediments of lakes, streams, and oceans.

Miller, 2003 (other)

Pseudoestrogens

- Big Picture of Problems?
  - In each scenario
    - Defective sex organs
    - Loss of fertility
    - Abnormal mating behavior
    - Death of young
    - Huge die-offs

Rachel Carson, *Silent Spring*
Theo Colborn et al., *Our Stolen Future*

What to do about it?