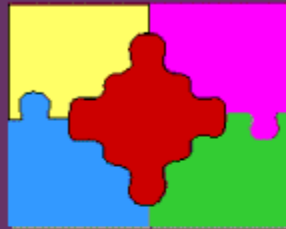


Environmental Links to Breast Cancer and Other Reproductive Health Problems
by Devra Lee Davis, Ph.D., MPH



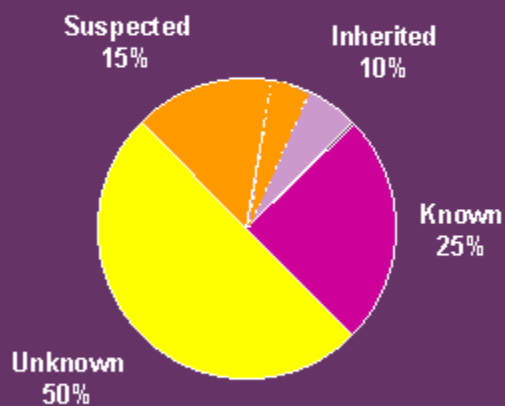
**The Environment,
Breast Cancer and Health**

Devra Davis
World Resources Institute

[Slide 1 of 86]

Most women who develop breast cancer do not inherit defective genes from their parents. In fact, fewer than 10% of cases are related to genetic abnormalities. At most, only half of all cases arise in women who have known risk factors.

Causes of Breast Cancer



[Slide 2 of 86 slides]



Fewer than 1 in ten cases of breast cancer arises in women born with genetic defects.

National Cancer Institute

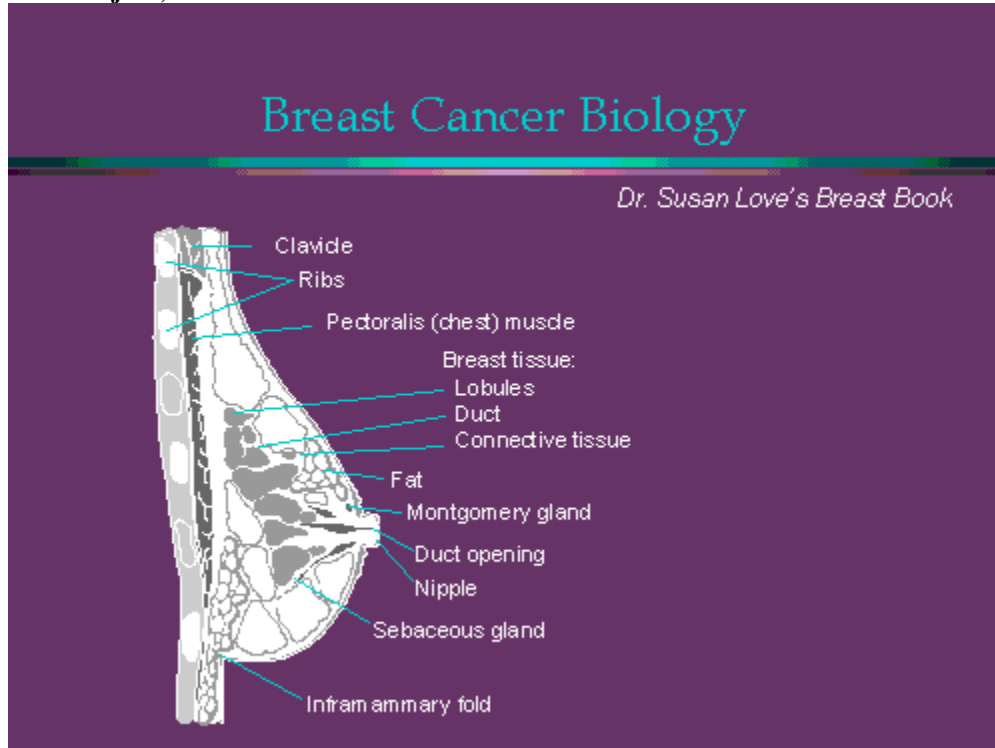
[Slide 3 of 86 slides]

The huge proportion of unknown causes may include environmental exposures of pollutants which are avoidable.

Breast cancer arises due to complex interactions between genes, hormones and the physical-chemical environment.

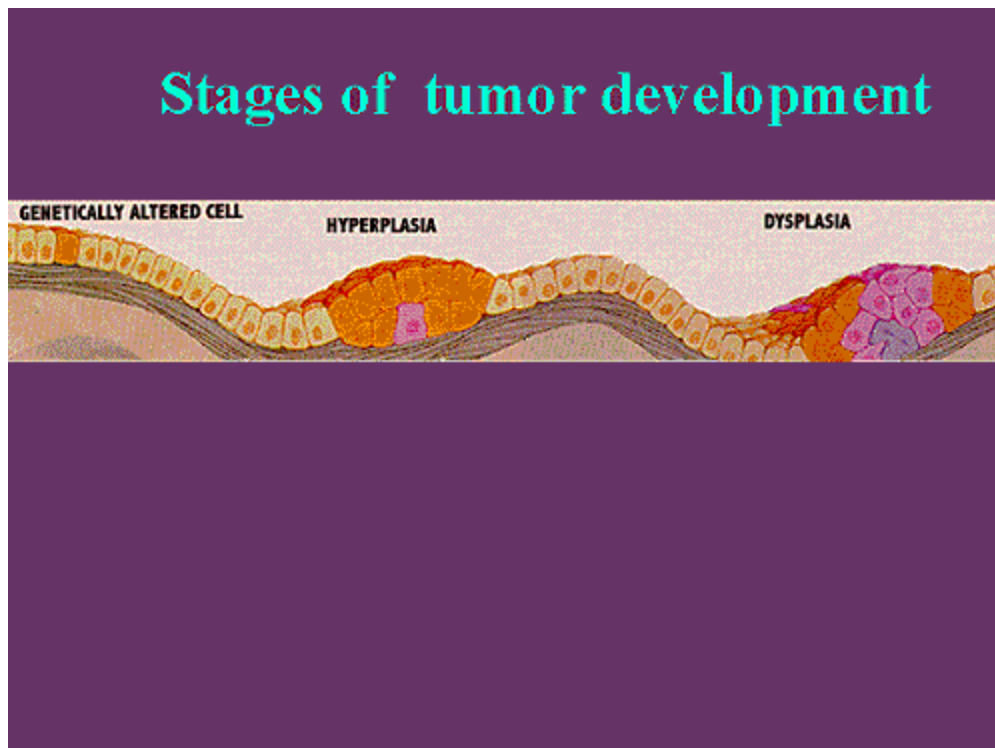
[Slide 4 of 86 slides]

The breast is mostly fat. Most cases of breast cancer arise in the terminal ductal lobular unit (TDLU) of the breast, in cells that line the milk glands and ducts. (See "All About Breast Cancer," Lawrence Berkeley National Laboratory's ELSI Project.)



[Slide 5 of 86 slides]

Breast cancer arises when cells undergo changes that allow them to proliferate beyond control. This occurs largely because of mutations, damages to genes which would normally regulate cell growth.

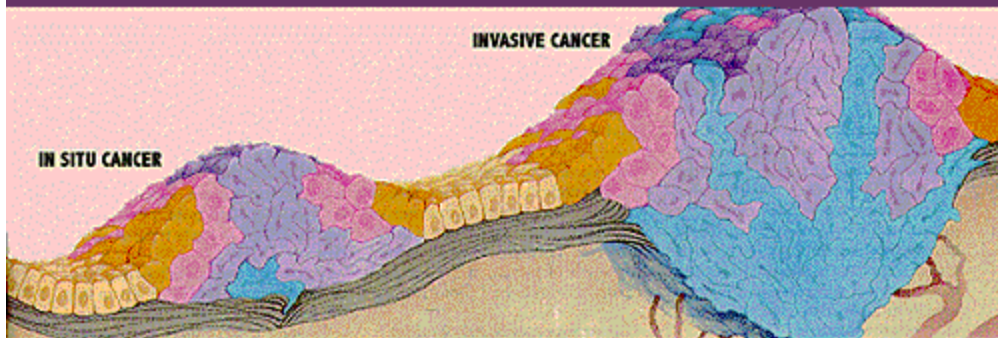


[Slide 6 of 86 slides]

Hormones, which act as the body's chemical messengers, and other substances near the cell, may

also contribute to rapid cell multiplication.

Stages of tumor development



[Slide 7 of 86 slides]

Both genetic and hormonal paths can be important for the development of breast cancer.

Invasive cancer



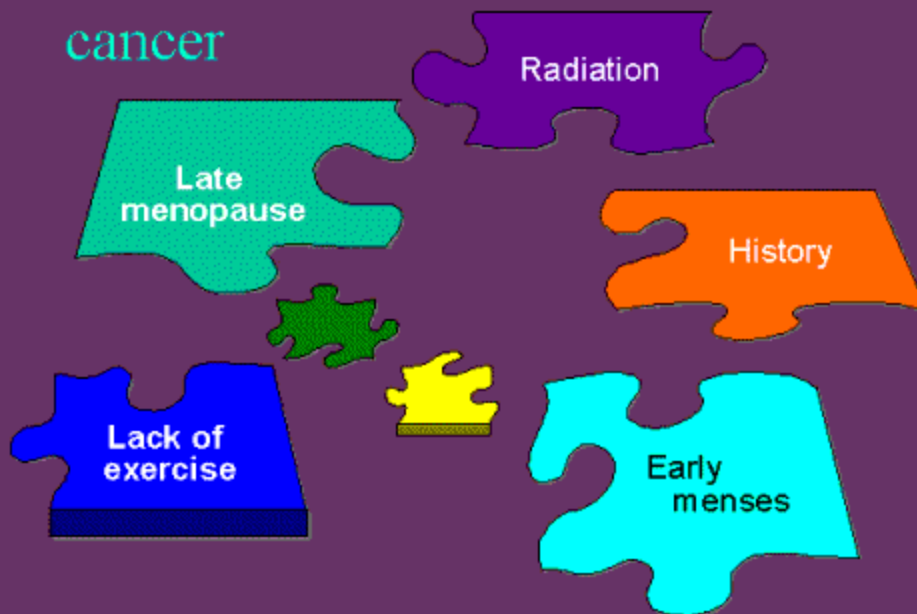
[Slide 8 of 86 slides]

Most cases of breast cancer occur in women with few of the known risk factors



[Slide 9 of 86 slides]

Known risk factors for breast cancer



[Slide 10 of 86 slides]

A risk factor is a characteristic which increases the likelihood of disease in a group of people who have the factor compared to an otherwise similar group of people who do not. The relative risk (RR) measures the likelihood of getting disease if exposed to certain risk factors. For example, women who consume 2 or more drinks of alcohol per day will be 1.4 times more likely than those who do not to develop breast cancer. This means that they have 40% more breast cancer than women who do not drink.

Risk factors for breast cancer

Risk of breast cancer in those with elevated exposures
Compared to those without such exposure



[Slide 11 of 86 slides]

Direct risk factors

- Radiation 4+
- History of breast cancer
(mother or sister pre-menopause) 2-4



[Slide 12 of 86 slides]

The relative risk (RR) is calculated as the ratio of disease risk in the exposed group compared to the risk in the unexposed group. The higher the RR, the stronger the link between a particular risk factor and disease. Most of the well established risk factors for breast cancer can be linked to hormonal exposures.

Risk factors are not necessarily causes

[Slide 13 of 86 slides]

Timing of exposure can be more important than dose



[Slide 14 of 86 slides]

Vulnerability risk factors

- Extend time during which the breast undergoes growth and development



[Slide 15 of 86 slides]

Susceptibility to toxic exposures depends on the rate of cell growth. This means that when exposures occur may be just as important as what levels of exposure occur. High levels of estrogen in utero may predispose the embryo to some types of breast cancer. In adolescence, estrogens may influence developing breast cells in making them more vulnerable to cancer causing agents. And, post-menopausal women may be more susceptible because they have endured longer exposures to the active form of estradiol over the years.

Periods of Susceptibility

◆ Embryo



Breast Cell Imprinting

◆ Adolescent



Developing Breasts

◆ Post-menopausal

*Non-ovarian hormones
or xenoestrogens*



[Slide 16 of 86 slides]

Vulnerability risk factors



Breast cell growth

- Elevated prenatal hormones 4
- Late menopause 2

[Slide 17 of 86 slides]

Contributing risk factors

- Alter hormonal environment
- Change the ratio of good to bad estrogens

[Slide 18 of 86 slides]

Contributing risk factors



Exposure to Hormones or Xenohormones

- Alcohol 1.4
- Lack of exercise 2 – 4
- Lack of fiber and vitamin D
- Obesity after menopause 2



[Slide 19 of 86 slides]

Contributing risk factors

- Age 65+ 17
- Living near a chemical facility 2 – 4
- Lifetime exposure to harmful xenohormones ??? up to 7.0
- Elevated IGF-1 (growth factor) (premenopausal) 7

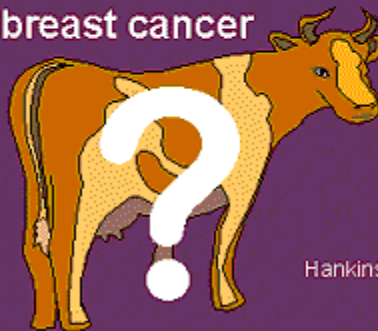
[Slide 20 of 86 slides]

IGF-1 is a powerful naturally-
occurring growth hormone

[Slide 21 of 86 slides]

Growth factors and breast cancer

Premenopausal women with
highest levels of IGF-1 in
their blood were 7 times more
likely to develop breast cancer



Hankinson et al., 1998

[Slide 22 of 86 slides]

Total Lifetime Exposure to Unbound Hormones



Links Most Known Risk Factors

[Slide 23 of 86 slides]

Most important risk factors

- Sex
- Age



[Slide 24 of 86 slides]

Protective factors

- Vegetables
- Soy
- Exercise
- Fish and olive oil
- High fiber



[Slide 25 of 86 slides]

Reduced Lifetime Exposure to
Unbound Hormones



Links Most Known Protective
Factors

[Slide 26 of 86 slides]

Reduction in hormones links most protective factors

- Soy products reduce circulating hormones
- Exercise lowers hormone levels
- High fiber diet lowers hormones
- Fish oil reduces growth of breast cancer cells
- Broccoli reduces growth of breast cancer cells

[Slide 27 of 86 slides]

There are many lines of evidence - experimental cell culture studies, mounting documentation of wildlife phenomena and human effects - which implicate the role of environmental estrogens in breast cancer. Experimental evidence consists of controlled studies using cell cultures or laboratory animals. Wildlife studies examine natural patterns in free-ranging animals and attempt to link these to environmental factors. Human studies can involve controlled observations of disease in people with and without particular exposures. And, epidemiological studies looking at disease patterns over space and time can provide clues about potential environmental risks

Breast Cancer and Environment Types of Evidence

Experimental Studies



Wildlife Studies



Human Studies



[Slide 28 of 86 slides]

Experimental evidence



[Slide 29 of 86 slides]

Cell culture studies have identified numerous compounds that disturb hormones. More than 400 chemicals have been shown to produce mammary tumors in rodents. These tumors are comparable to breast cancer in women, and continuing studies can guide us in evaluating the roles of these chemicals in human disease.

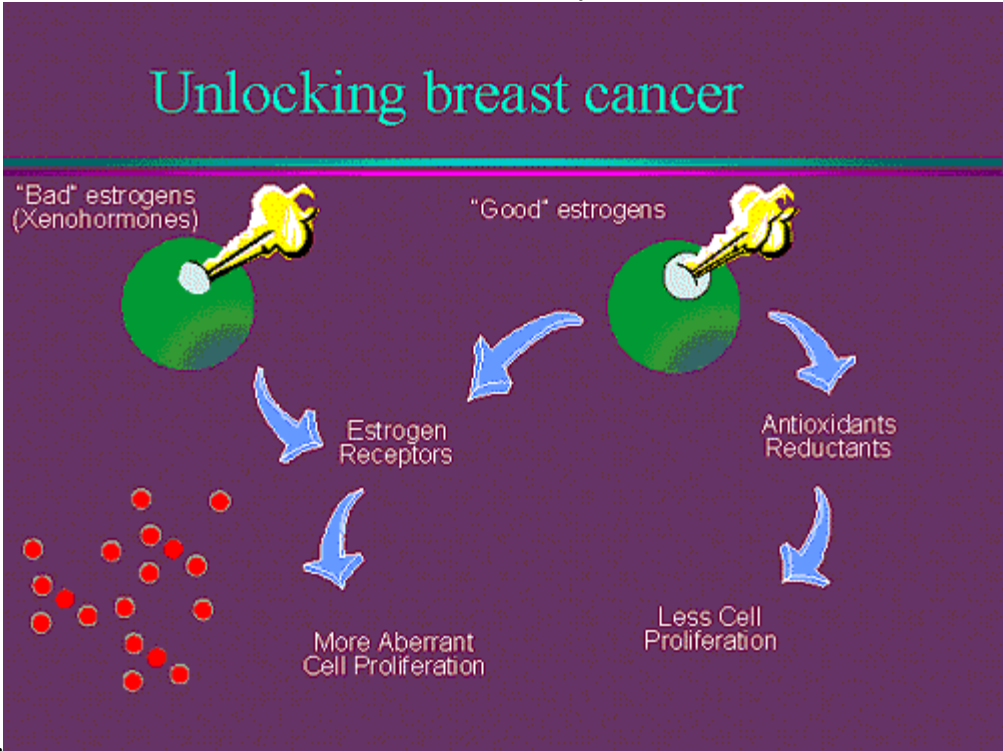
Mammary Cancer in Laboratory Animals

- ◆ Benzene
- ◆ DBCP
- ◆ DDVP
- ◆ Atrazine
- ◆ Vinyl Chloride
- ◆ DMBA
- ◆ MNU
- ◆ HCA
- ◆ PAH

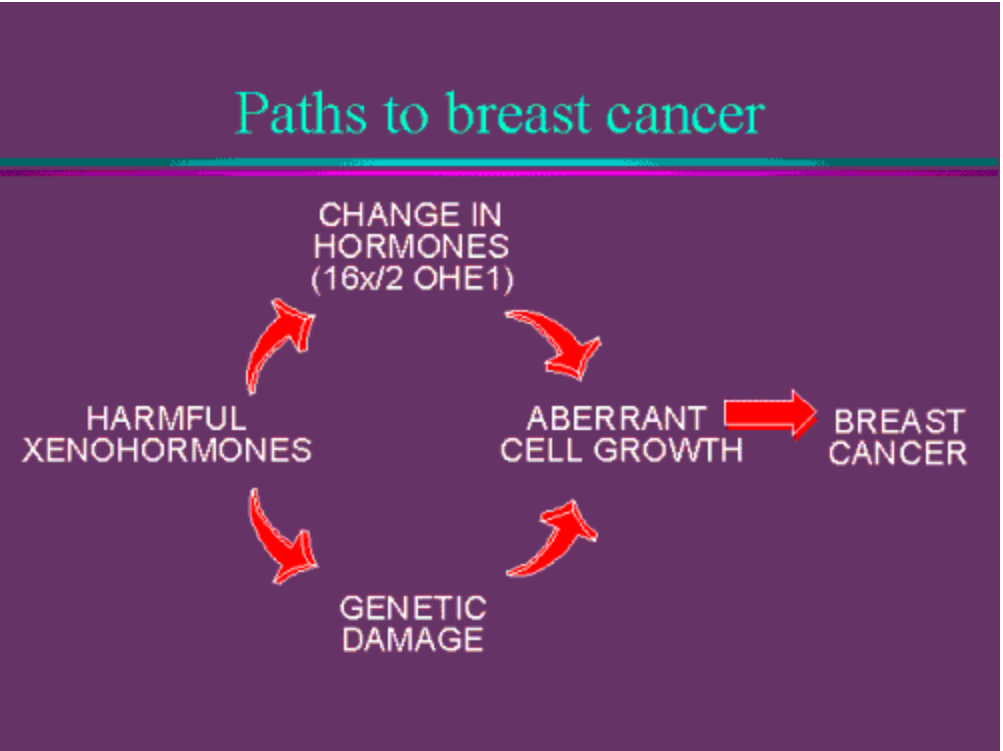
Source: Wolf, Mary S., "Breast Cancer and Environmental Risk Factors: Epidemiological and Experimental Findings" *Ann. Rev. Pharmacol. Toxicol.* 1996.

[Slide 30 of 86 slides]

Estrogen is a hormone that plays a critical role in the development and metabolism of the breast, among other organs. The breast contains receptors for hormones such as estrogen. Receptors resemble locks into which only certain keys can fit. Both the body's own natural estrogen as well as foreign materials, called xenoestrogens, can fit into these locks, or receptors, and alter how much and what types of estrogen the body produces. Once xenoestrogens reach the inside of a cell, they may promote cancer-causing behaviors in a number of ways.

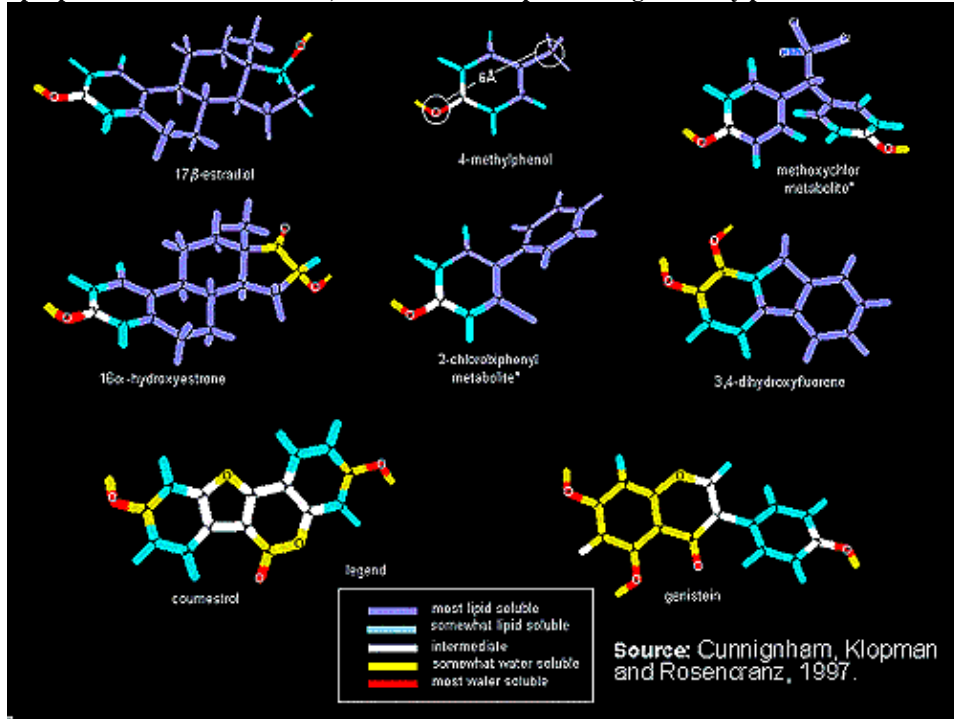


[Slide 31 of 86 slides]



[Slide 32 of 86 slides]

Some natural products such as plants can produce estrogen, as do synthetic materials such as some pesticides and plastics. In fact, the amount of estrogen produced by plants is typically thousands of times greater than the amount produced by synthetic materials. While most plant estrogens are rapidly excreted from the body, those tied with synthetic estrogens can cumulate for decades. Scientists are asking whether these products could have different effects on humans. Albert R. Cunningham, and Herbert S. Rosenkranz of the University of Pittsburgh and Gilles Klopman, of Case Western Reserve University, have developed an innovative technique for looking at the chemical structure of natural plant estrogens and synthetic ones (Environmental Health Perspectives, 105:3 (1997) 665-68). They have identified a microscopic structure that occurs in compounds that appear more toxic, tend to be attracted to fat and produce longer lived estrogen exposure in many synthetic estrogens and in the body's own 17-beta and 16-alpha estradiol. In contrast, most natural plant estrogens do not contain this structure, are water soluble and more rapidly excreted from the body. This figure shows that 17 beta, 16 alpha and synthetic estrogens contain large sections of their molecules in purple that are most attracted, while the natural plant estrogens in soy products do not include such sections.



[Slide 33 of 86 slides]

The compounds listed below are among the better known ones that have been shown in laboratory tests to be xenoestrogens. Of these, DDT . .

Proven Xenoestrogens: Chlorinated organic compounds

Compound	Use	Comment
Atrazine	Weed killer	Widely used today
Chlordane	Termite killer	Widely used before banned in 1988
DDT	Insecticide	Widely used before banned in 1972; still present in virtually everyone's body

[Slide 34 of 86 slides]

. . and certain PCBs have now been implicated in human studies as causes of breast cancer. The substances that have been banned in the U.S. persist in the environment for many years and are available in some other countries. They may appear in foods imported from abroad and may occasionally travel as air pollution.

Some Proven Xenoestrogens : Chlorinated organic compounds

Compound	Use	Comment
Endosulfan	Insecticide	Widely used today
Kepone	Bait in ant and roach traps	Banned in 1977
Methoxychlor	Insecticide	A close relative of DDT
Some PCBs	Component of electrical insulation	No longer made in the US but still found in old transformers

[Slide 35 of 86 slides]

Proven Xenoestrogens: Plastics

Compound	Use	Comment
Bisphenol A	Breakdown product of polycarbonate	Leaches out into fluids when hot
Nonylphenol	Softener for plastics	Leaches out into fluids readily at room temperature

[Slide 36 of 86 slides]

Proven Xenoestrogens: Pharmaceuticals

Compound	Use	Comment
Synthetic estrogens	Constituent of birth-control pills and estrogen-replacement therapies	One drug, diethylstilbestrol (DES), was given to several million women during pregnancy before it was essentially banned for that use in 1971
Cimetidine	Ulcer treatment	_____

[Slide 37 of 86 slides]

Proven Xenoestrogens: Fuel constituents

Compound	Use	Comment
Aromatic hydrocarbons	Components of petroleum	Can be inhaled readily from gasoline and from car exhaust

[Slide38 of 86 slides]

Wildlife evidence



Increases in Disorders
are
“Sentinel Indicators”

[Slide 39 of 86 slides]

Deformities in frogs

- Grotesquely deformed frogs in Midwest
- Frog populations declining worldwide

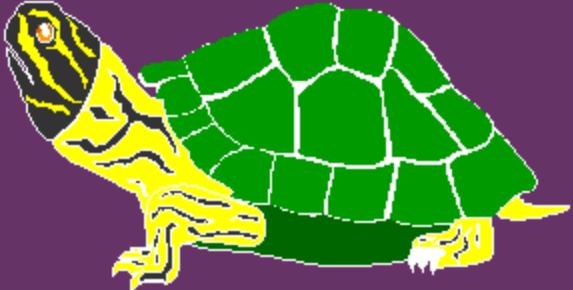


[Slide 40 of 86 slides]

A number of recent studies have linked xenoestrogens with reproductive anomalies and other disorders in wildlife. While there are many biological differences between humans and other species of animals, evidence suggests that xenoestrogens which pollute ecosystems can have an impact on the health of the entire food chain. One possible effect is sex reversal in turtles. (See, Our Stolen Future, Evidence from wildlife).

Increasing Wildlife Disorders

- ◆ Sex reversal in turtles




[Slide 41 of 86 slides]

Fish living near outlets from municipal sewers have high levels of vitellogenin, a female protein. Other phenomena include structural damage of DNA and hermaphroditism, possessing both male and female sexual characteristics.

Increasing Wildlife Disorders

- ◆ DNA base lesions in fish
- ◆ Vitellogenin (a female hormone) in male fish
- ◆ Hermaphroditism in fish



[Slide 42 of 86 slides]

A Florida lake polluted by a nearby pesticide spill has been connected to the occurrence of abnormally small genitalia in alligators hatched there. These alligators' sex organs are functioning poorly as a result.

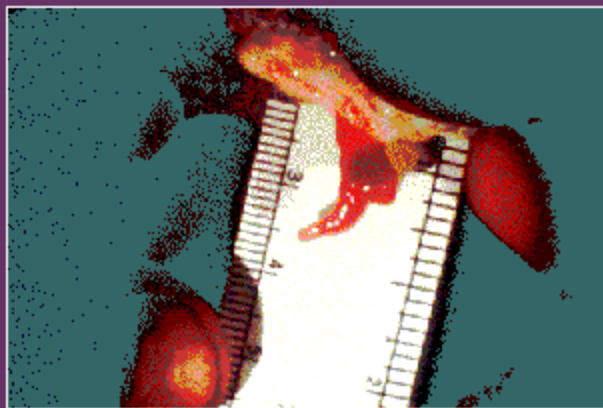
Increasing Wildlife Disorders

- ◆ Altered sex ratios and genitalia in alligators



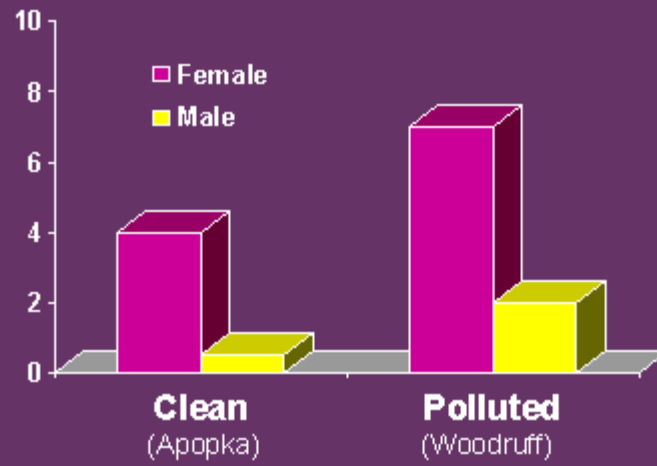
[Slide 43 of 86 slides]

Deformed Alligator Penis



[Slide 44 of 86 slides]

Alligator Hormones



[Slide 45 of 86 slides]

Increasing Wildlife Disorders

Military Dogs in Vietnam Compared to Non-Vietnam

- ◆ Testicular cancer
- ◆ Testicular atrophy
- ◆ Reduced sperm



[Slide 46 of 86 slides]

The Florida panther is estimated to be nearly extinct because of declining reproductive capacity due to a disorder called cryptorchidism, having undescended testicles, and poor sperm production. The concentrations of heavy metals and persistent chlorinated organic substances in the soil and water in South Central Florida may be involved.

Increasing Wildlife Disorders

- ◆ Cryptorchidism in Florida panthers

A detailed illustration of a Florida panther in a pouncing pose, facing left. The panther has a tawny coat with dark stripes and spots, and its eyes are glowing yellow. The background is a solid dark purple.

[Slide 47 of 86 slides]

Increasing Wildlife Disorders

- ◆ Pseudohermaphroditism or imposex in gastropods

A detailed illustration of a snail with a large, brown and yellow striped shell. The snail's body is a mottled green and brown color, and its two eye stalks are extended. The background is a solid dark purple.

[Slide 48 of 86 slides]

Human evidence



[Slide 49 of 86 slides]

Agents associated with breast cancer in humans (suspected)

- Alcoholic Beverages
- Pesticides
- Pharmaceuticals
- Diet

[Slide 50 of 86 slides]

Factors associated with breast cancer in humans (suspected)

- Plastics
- Fuel Constituents
- Solvents
- EMF
- Smoking

[Slide 51 of 86 slides]

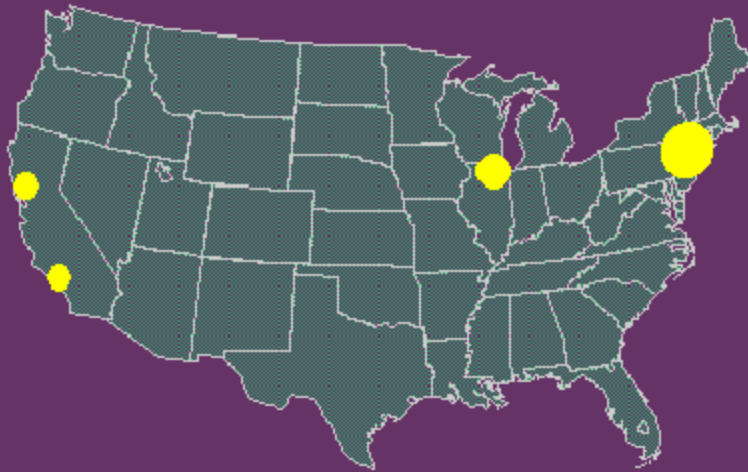
Sorting out how hormones affect breast cancer is an exciting challenge today. This involves piecing together evidence from studies of wildlife, cell cultures, experimental animals, and humans. Studying humans as models is especially difficult.

Studying Humans is Difficult

- ◆ Human studies are difficult to conduct
- ◆ People seldom know what they have been exposed to, especially early in life
- ◆ Both good and bad xenoestrogens exist
- ◆ Looking at residues in people after they have cancer can be misleading; the development of the disease can change what sorts of toxic compounds are stored in the body.

[Slide 52 of 86 slides]

Geographic hot spots for breast cancer



[Slide 53 of 86 slides]

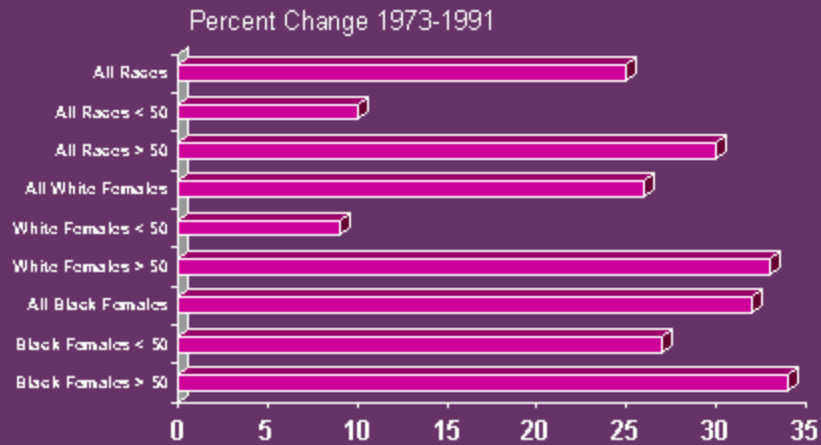
Geographic Patterns Provide Clues

- ◆ Within the U.S. white population, rates of breast cancer vary by nearly 50%.
- ◆ Highest rates occur in San Francisco, New York, and areas near the Great Lakes.
- ◆ Death rates are higher for blacks than whites, because of unequal access to screening and treatment.

[Slide 54 of 86 slides]

The largest increases in breast cancer rates occur in women of all races over the age of 50.

Female Breast Cancer Incidence Trends (United States)



Source: SEER Cancer Statistics Review 1973-1991, National Cancer Institute

[Slide 55 of 86 slides]

Evidence in New York

Post-menopausal women living near two or more chemical plants had twice the risk of developing breast cancer compared with women who lived in areas with no such facilities.



[Slide 56 of 86 slides]

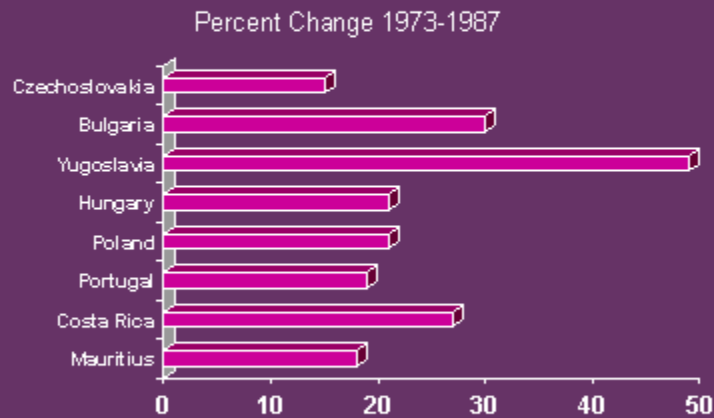
Breast cancer on Long Island

Women who lived in certain regions of Long Island for 40 or more years had four times as much breast cancer, as those who lived there less than 10 years.



[Slide 57 of 86 slides]

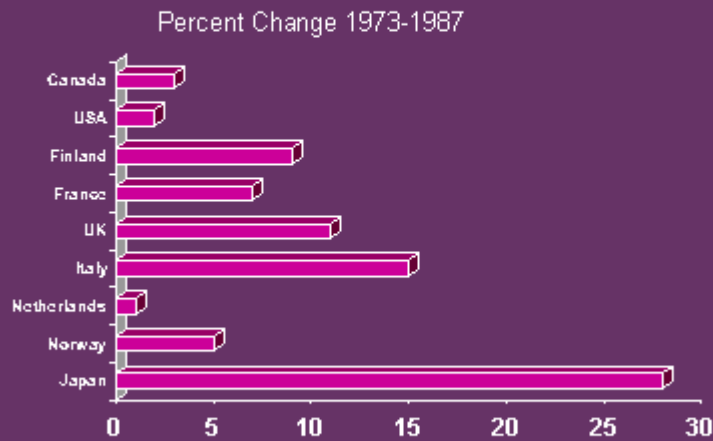
Breast Cancer Mortality in Developing Countries



Source: International Agency for Research on Cancer.

[Slide 58 of 86 slides]

Breast Cancer Mortality in Developed Countries



Source: International Agency for Research on Cancer.

[Slide 59 of 86 slides]

Relative Risk of Breast Cancer Mortality in the Workplace and Community

Exposure	Relative Risk
347 female chemists vs U.S. Population	1.65 (Also: ov, atom, panc. lym, blood increased)
U.S. counties with 2+ waste sites vs. no waste sites	6.5
24,000 blue collar women vs. U.S. population (workers exposed to solvents)	PMR 1.43 in chemical workers 1.64 in pharmaceutical workers 1.51 in electronic equipment
Women workers in FRG pesticide plant vs. E. German population	2.15
Women in counties with 2+ chem poll.	3.4

[Slide 60 of 86 slides]

In the past few years, international researchers have reported that male reproductive disorders are on the rise, and there is growing evidence that xenoestrogens may play a role in these alarming trends. The sperm count data vary dramatically worldwide, even within the U.S., and this disparity may reflect the influence of different environmental factors at play. Although breast cancer figures among men are very low, they may also be increasing. (See, Our Stolen Future, Human evidence).

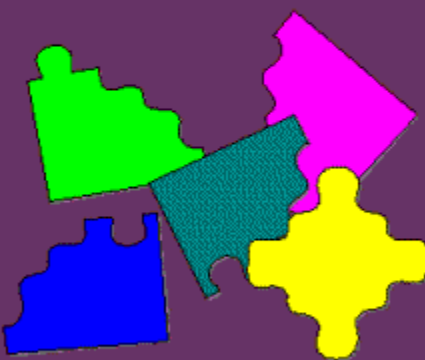
Increasing Human Male Reproductive Disorders

- ◆ Dropping sperm count
- ◆ Testicular cancer
- ◆ Malformation of genitalia
- ◆ Undescended testes
- ◆ Breast cancer?

[Slide 61 of 86 slides]

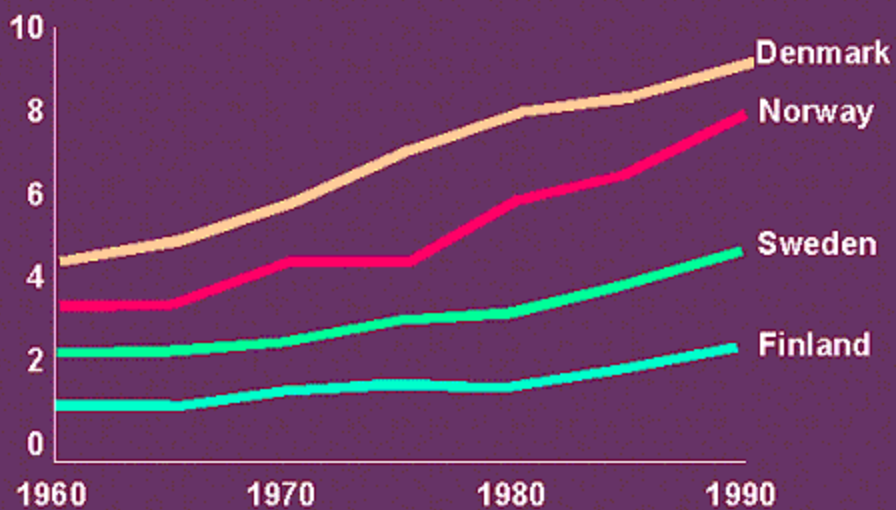
Puzzling male reproductive health problems

- Testicular cancer
- Hypospadias
- Cryptorchidism
- Infertility
- Reduced sex ratio



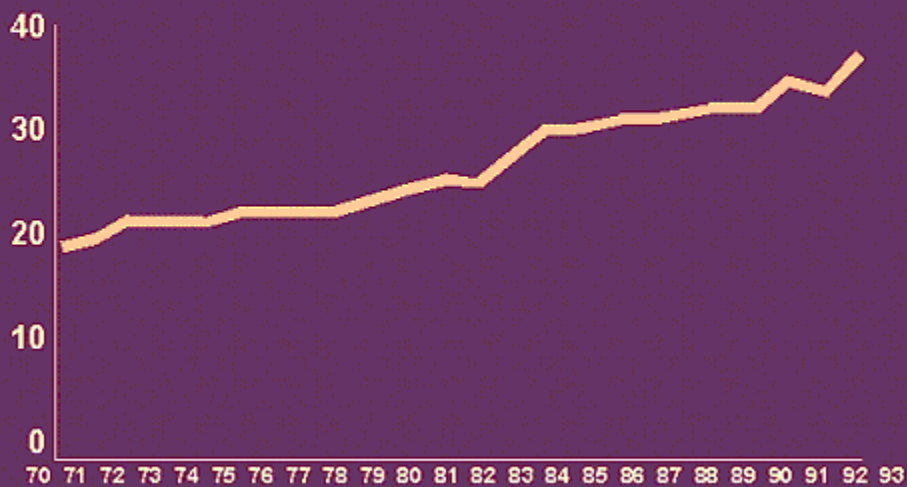
[Slide 62 of 86 slides]

Testicular cancer trends (Nordic countries)



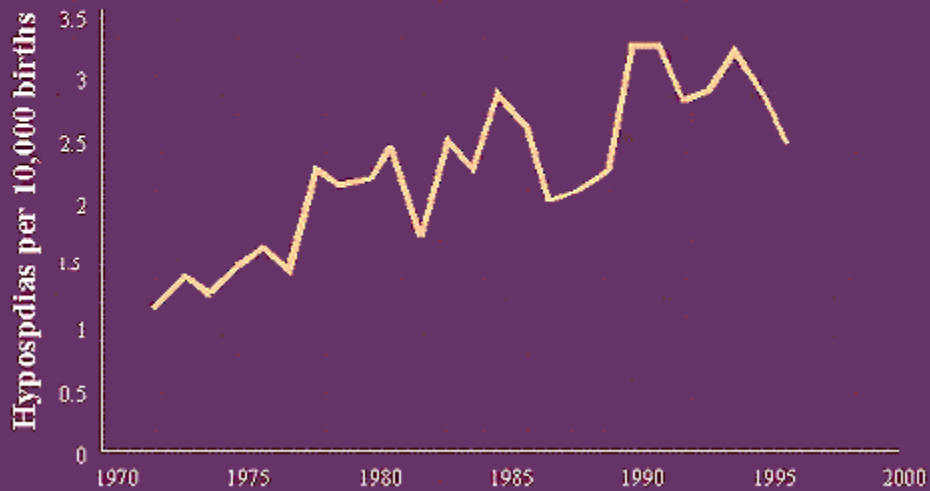
[Slide 63 of 86 slides]

Hypospadias trends (United States)



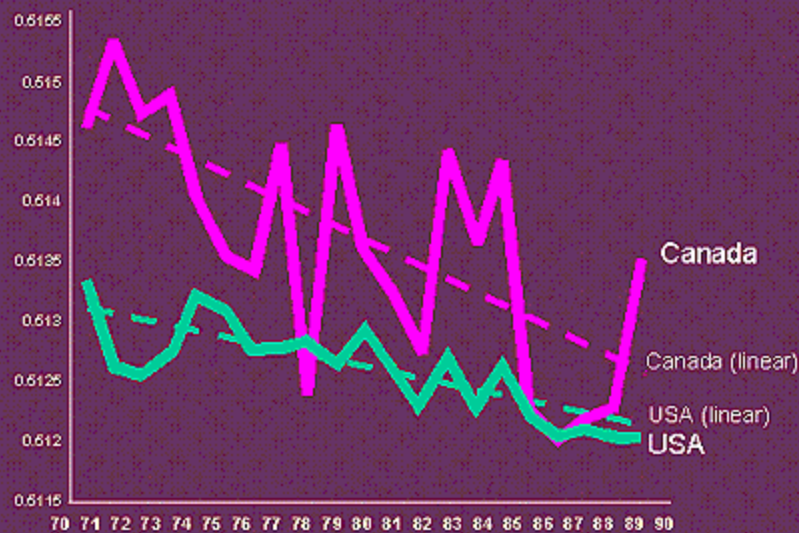
[Slide 64 of 86 slides]

Hypospadias (Japan)



[Slide 65 of 86 slides]

Proportion of male births in Canada and the U.S.



[Slide 66 of 86 slides]

Where have all the young boys gone, 1970-1990?

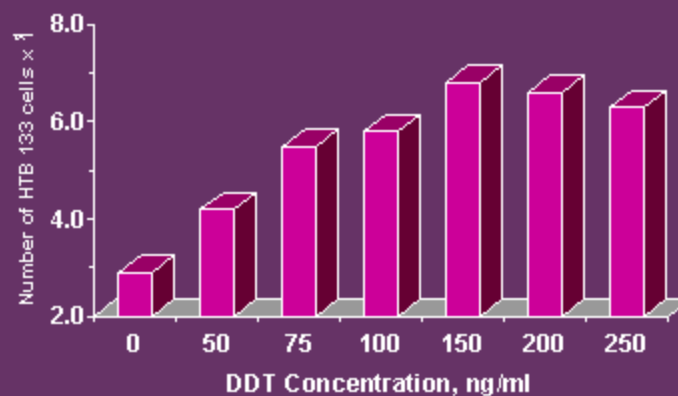
- If sex ratio had not dropped, then
- 38,000 **more** baby boys would have been born in the U.S.
- 8,600 **more** would have been born in Canada



[Slide 67 of 86 slides]

Controlled human studies suggest that DDT increases the risk of breast cancer. Women with higher DDT levels in their blood or fat have been found to have between 2 and 9 times the risk of breast cancer, when compared to women with lower DDT residues.

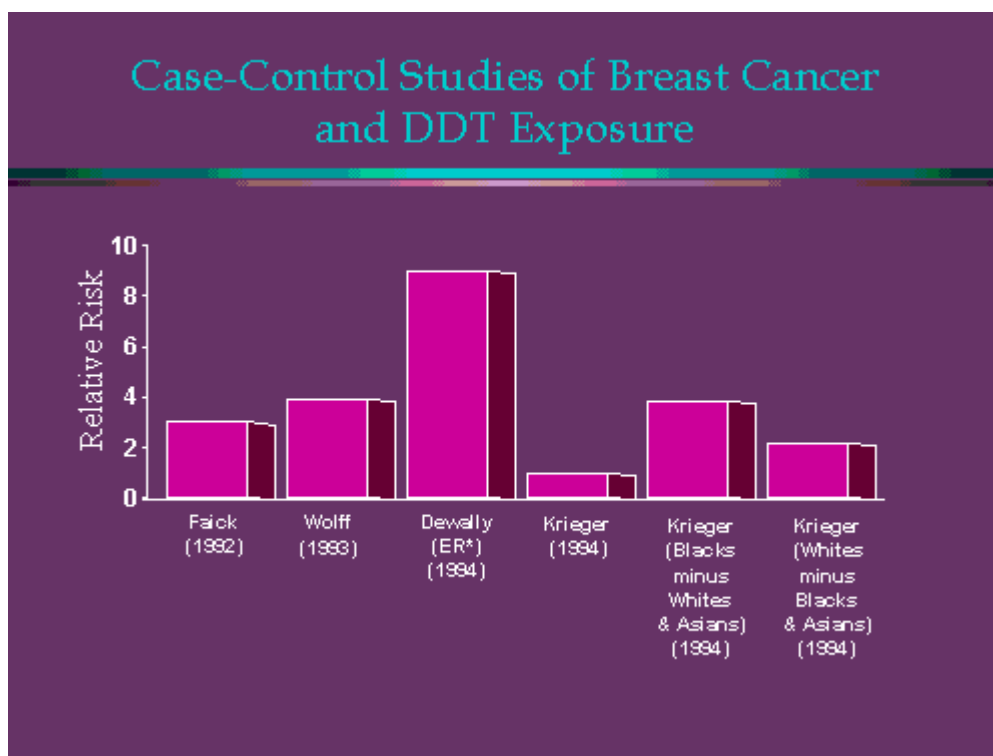
Breast Cancer Cell Growth and DDT



[Slide 68 of 86 slides]

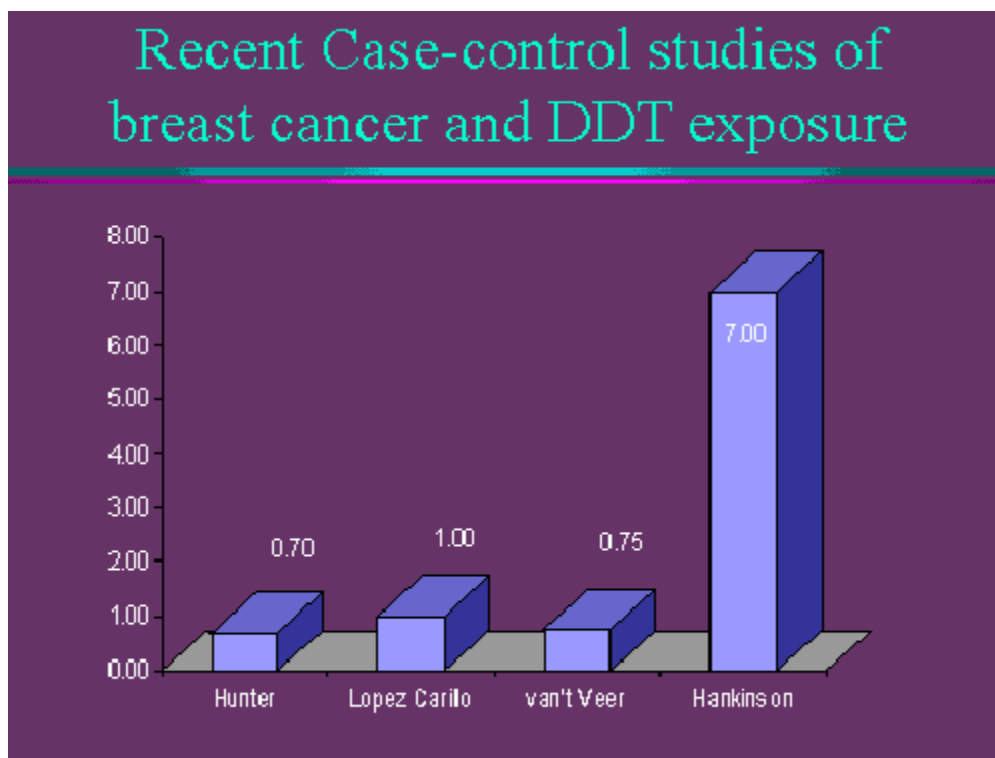
In these case control studies, the relative risk (RR) measures the likelihood of getting disease if exposed to a risk factor such as DDT. Ethnicity appears to be important in the disease profile, as Asians tend to have a lower risk of breast cancer than African-American and White women in the U.S.

Some of the early conducted studies on organochlorine residues tended to find a clear association between higher levels of PCB and DDE, either in the blood or in adipose tissue, and breast cancer (Dewailly MS, Dodin S, Verrault R, Ayotte P, Sauve L, Brisson J. High organochlorine body burden in women with estrogen receptor-positive breast cancer. *J Natl Cancer Inst* 86(3):232-234 (1994)., Glass R, Hoover RN. Rising incidence of breast cancer relationship to stage and receptor status. *J Natl Cancer Inst* 82(8):693-696 (1990).). In addition, nested case-control prospective studies in this field have tended to yield positive results (Austin H, Keil JE, Cole P. A prospective follow-up study of cancer mortality in relation to serum DDT. *Am J Public Health* 79:43-46 (1989).), especially those that have looked at estrogen receptor positive cases (Krieger N, Wolff MS, Hiatt RA, Rivera M, Vogelman J, Orentreich N. Breast cancer and serum organochlorines: A prospective study among white, black, and Asian women. *J Natl Cancer Inst* 86:589-599 (1994).). Thus, a small case-control study in Canada found that women with elevated levels of DDE had 8.9 times the risk of ER positive disease than did women with relatively lower levels of this metabolite (Hunter DJ, Hankinson SE, Laden F, Colditz GA, Manson JAE, Willet WC, Speizer FE, Wolff MS. Plasma organochlorine levels and the risk of breast cancer. *New Engl J Med* 337:1253-1258 (1997).). ER positive cases appear to be increasing overall in women over age 60, according to one report from California (56). In some studies, negative results were also described for the total cancer study population or for specific subgroups of breast cancer subjects, such as Asian women (Lopez-Carillo L, Blair A, Lopez-Cervantes M, Cebrian M, Rueda C, Reyes R, Mohar A, Bravo J. Dichlorodiphenyl trichloroethane serum levels and breast cancer risk: a case-control study from Mexico. *Cancer Res* 57:3728-3732 (1997).,57).



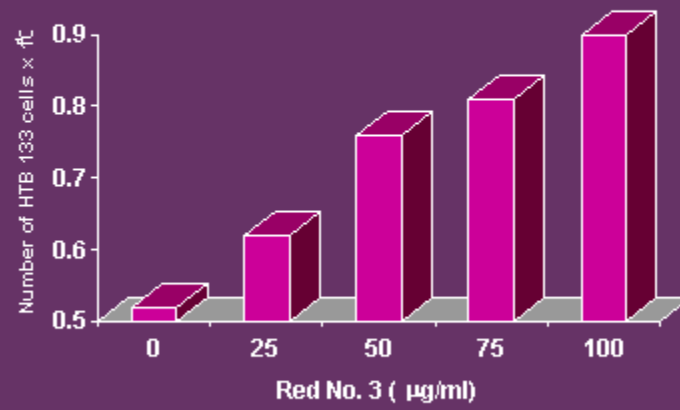
[Slide 69 of 86 slides]

Recently published studies on breast cancer have produced inconsistent results regarding breast cancer and organochlorine exposures. These recent studies have not addressed the broad array of other suspect xenohormones, many of which leave no biologic markers, such as benzo-a-pyrene, some plastics and fuels. Nor have protective factors, such as genistein and other isoflavones, been widely studied. Susan Hankinson and colleagues at the Harvard School of Public Health have recently reported that premenopausal cases of breast cancer with the highest levels of insulin-like-growth factors-1 (IGF-1) as measured 4 years or more before diagnosis had nearly a 7-fold greater risk of breast cancer compared to those without the disease (Hankinson SE, Willett WC, Colditz GA, Hunter DJ, Michaud DS, Deroo B, Rosner B, Speizer FE, Pollak M. Circulating concentrations of insulin-like growth factor I and risk of breast cancer. *Lancet* 351: 1393-96 (1998).). This finding indicates the importance of looking at a broad array of potential protective and disruptive factors, as well as the value of conducting longer term prospective studies that permit their identification. Studies which consider current levels of metabolites of pesticides in cancer patients have been described as analogous to "looking under the nearest lamppost for lost keys because that is where there is light" (63). Two critical questions must be raised: what were exposures to xenohormones during critical windows of development, including the prenatal and pre-pubescent periods, and what was the lifetime exposure to hormonally active parent compounds? Studies which look at contemporaneous measures of lipophilic metabolites of organochlorine compounds cannot resolve these questions. For more information see, D.L.Davis et al., "Rethinking Breast Cancer Risk and the Environment: The Case for the Precautionary Principle."



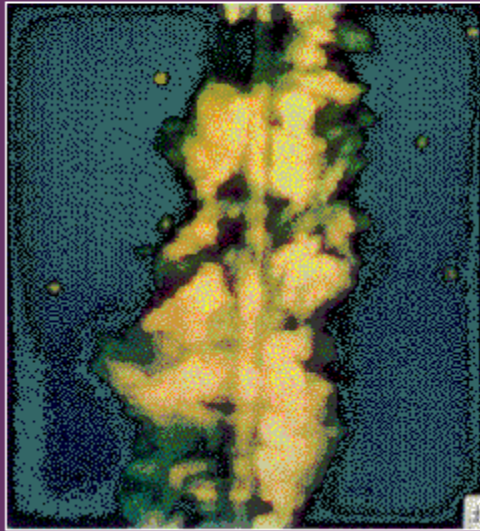
[Slide 70 of 86 slides]

Red Dye Effects on the Proliferation of Breast Cells



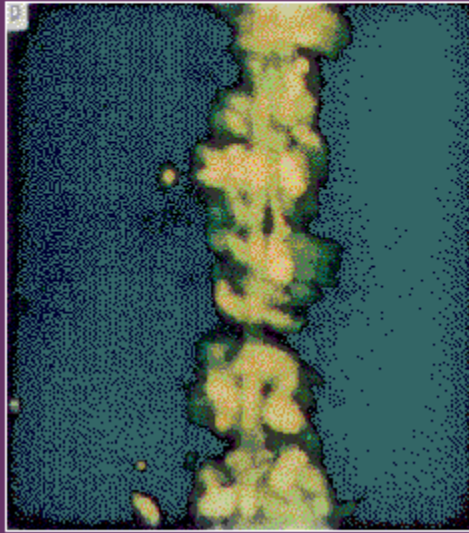
[Slide 71 of 86 slides]

Normal Cell Communication



[Slide 72 of 86 slides]

Abnormal Cell Communications after DDT



[Slide 73 of 86 slides]

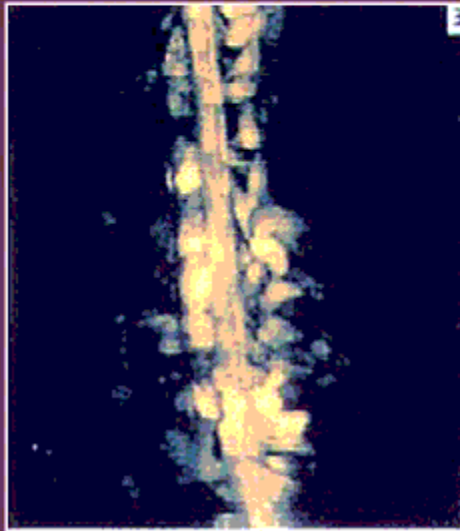
Disrupted cell communication



Source: Kang, *et al.*, 1995.

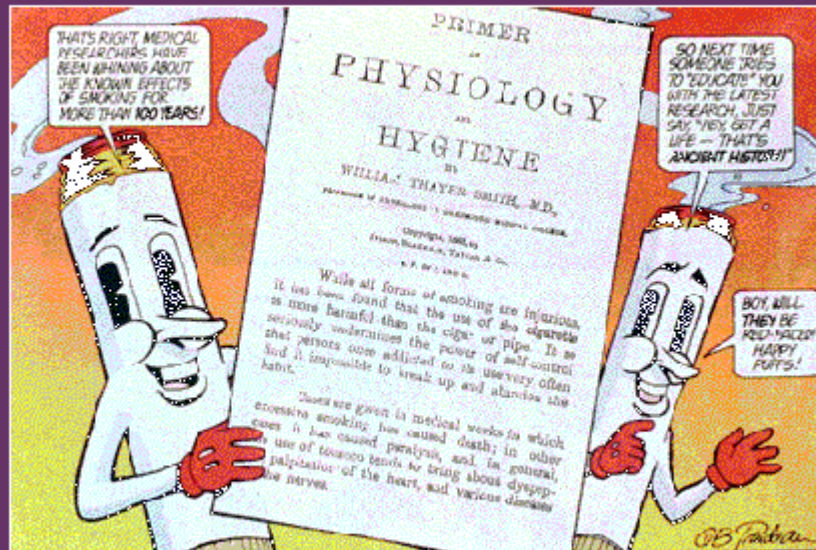
[Slide 74 of 86 slides]

Disrupted cell communication after pesticides



Source: Kang, et al., 1995.

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Important Things You Can Do to Reduce the Risk of Breast Cancer

◆ Take Care of Yourself

- » Eat vegetables, fruit and calcium
- » Reduce your fat intake
- » Get moderate exercise
- » Take caution in undergoing long-term estrogen-replacement therapy
- » Avoid long-term use of oral contraceptives before giving birth

◆ Educate Yourself

- » Raise your awareness about the connections between cancer and environmental toxins

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Important Things You Can Do to Reduce the Risk of Breast Cancer

◆ Take Care of Your Children

- » Before and during pregnancy, avoid exposures to estrogens, hazardous chemicals, cigarettes, alcohol, etc...
- » Reduce the use of toxic chemicals in household and school
- » Use public transportation, bike, or walk

◆ Empowerment

- » Become actively involved in a health promotion group to identify what you can do to help reduce the risk of breast cancer related to environmental factors

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Important Things Your Family Can Do

- ◆ Educate your children about protective behaviors during breast development
- ◆ Encourage your children to exercise
- ◆ Get regular mammograms when over age 50
- ◆ Support one another
- ◆ Encourage family discussions on reducing contaminants
- ◆ Maintain a healthy, low-fat diet

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Important Things Your Community Can Do


- ◆ Be a breast cancer resource person in your community and help educate those around you
- ◆ Encourage school sports for everyone
- ◆ Inform local/state representatives of your concern over suspect toxic materials and encourage precautionary action
- ◆ Exercise your right to know
- ◆ Get involved with organizations promoting sound national and international environmental and economic policies to promote healthy behaviors

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Important Things the Private Sector Can Do

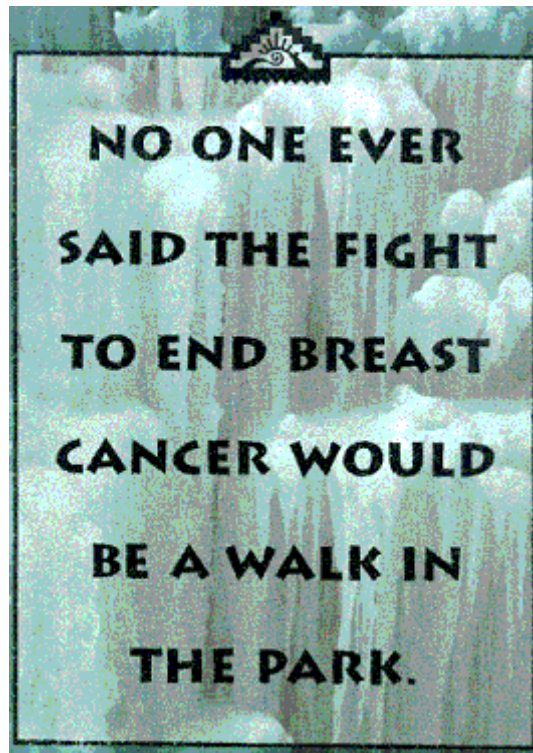
- ◆ Promote integrated pest management (IPM)
- ◆ Reduce, reuse, and recycle materials
- ◆ Encourage pollution prevention
- ◆ Promote workplace safety

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Never forget that the only thing that
changes public policy is a group
of concerned citizens

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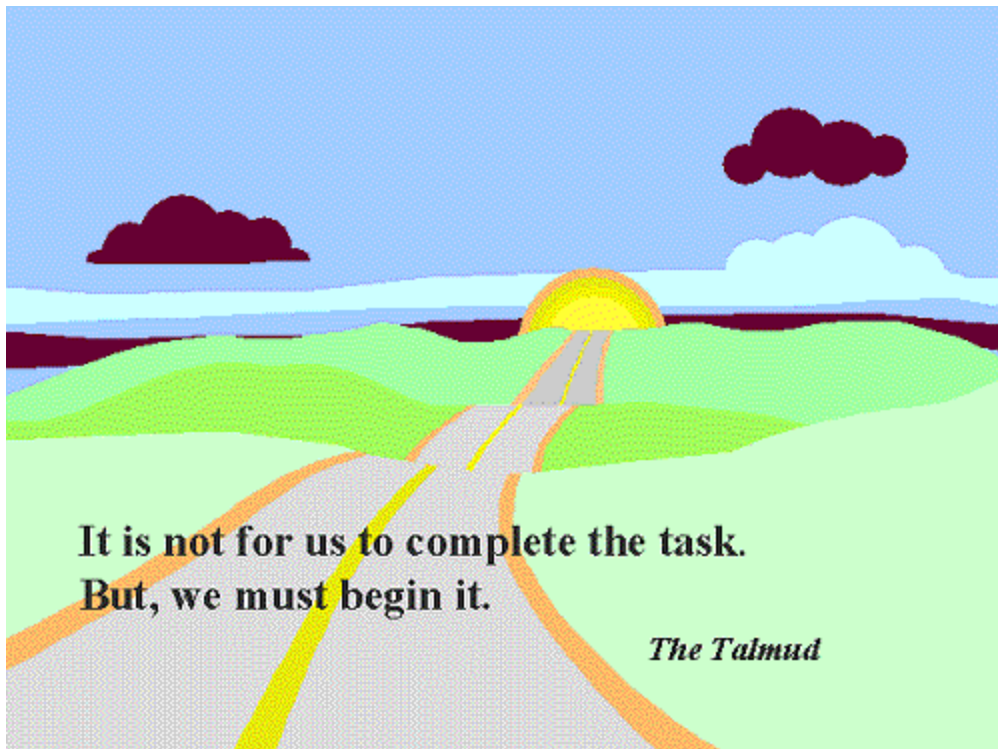


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One step at a time



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- Environmental Health Perspective is a journal devoted to exploring the links between the environment and health, and has information on breast cancer. <http://ehpnet1.niehs.nih.gov/docs/1998/106-9/toc.html>
- Environmental Health Perspective Supplement: Volume 105 Supplement 3, April 1997 Hormones, Hormone Metabolism, Environment, and Breast Cancer. <http://ehpnet1.niehs.nih.gov/docs/1997/Suppl105-3/toc.html>
- The University of Pennsylvania Cancer Center maintains a list of comprehensive information sites on breast cancer. <http://oncolink.upenn.edu/templates/types/index.cfm>
- The Our Stolen Future website provides regular updates
- about the cutting edge of science related to endocrine disruption. It also posts information about ongoing policy debates and new suggestions about what you can do as a consumer and citizen to minimize risks related to hormonally-disruptive contaminants. <http://www.ourstolenfuture.org/>

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