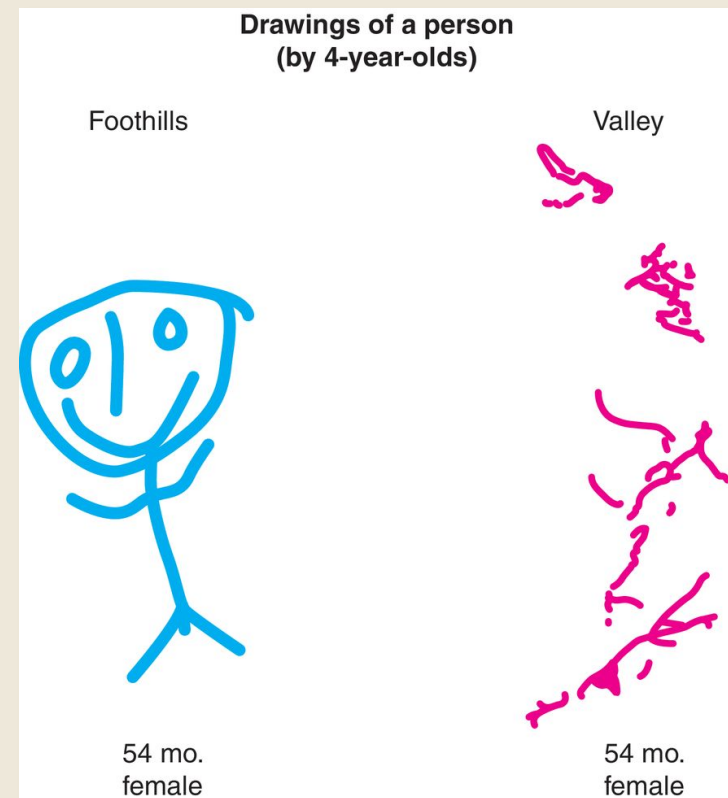




Lecture 13: Environmental Toxicology and Human Health

Humans and the environment are interacting

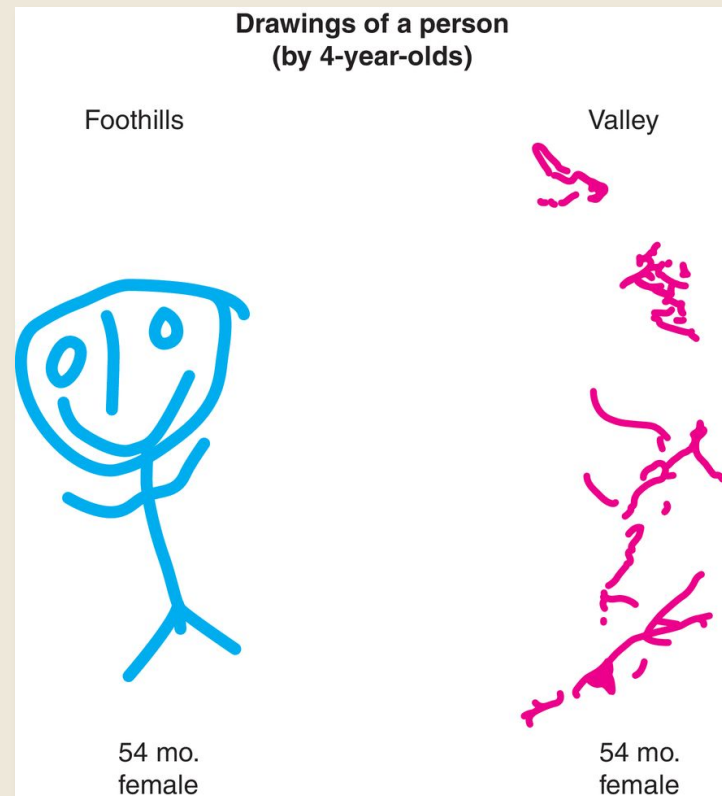
- Human activity affects the environment
- Environmental health affects human health?
- Children driven to school instead of walking
 - ▣ How does this behavior change the environment?
 - ▣ How does this behavior change the children?



Sonora, Mexico, Yaqui indian in valleys (pestidice) vs. foothills (no pesticide)

Children and Chemical Exposure

- Children more susceptible to chemicals
 - Weigh less than adults
 - Bodies are still developing
 - Play on floors and lawns
 - Put things into their mouths
- Developmental effects
 - Children in foothills not exposed to pesticides
 - Children in valley were exposed



Children and Chemical Exposure

- Chronic *in utero* exposure or short term exposure during specific time *in utero* can cause lifelong effects
 - Brain development, central nervous system, everything
- California study – pregnant women and pesticide exposure (2003)
 - Delayed mental and general development
- Current problem includes lead in city soils
 - Affects neurosystem

Lecture Overview

- Human Health
 - In developed countries
 - In developing countries
- Environmental Pollution and Disease
 - Environmental Contaminants
 - Endocrine Disrupters
- Determining Health Effects of Pollutants - Ecotoxicology
- Risk Assessment

Human Health

- Two indicators of human health
 - Life expectancy - how long people are expected to live
 - Infant mortality - how many children die before age of 1 year per 1,000 live births



Hierry Falise / Getty Images

Vary greatly between countries

- ▣ Developed countries
 - Infant mortality-Japan 0.26%
- ▣ Developing countries
 - Zambia 7%

Health in Highly Developed Countries

- Health is generally good in these countries
- Average life expectancy
 - Men = 75 years
 - Women = 80 years
- Leading causes of death in US (chronic)
 - Cardiovascular disease, Cancer, Lung Disease (associated with aging)
- Premature deaths caused by lifestyle
 - Poor diet, Lack of exercise, Smoking, Obesity, Diabetes
 - Reduction of life expectancy by 1.3 years in women of poorer counties in the US.

Health in Developing Countries

- Biggest problems
 - Malnutrition, unsafe water, poor sanitation, air pollution
- Life Expectancy
 - Overall is 65 years
 - Very poorest developing countries = 45 years
 - Due to AIDS epidemics (Africa) (37 million)
- Childhood mortality is high
 - Diarrheal diseases
 - Malnutrition
 - Malaria
 - AIDS/HIV (37 million)
- Unhealthy habits: smoking, high caloric foods



Emerging and Reemerging Diseases

- New diseases are always developing
- **Emerging Disease** - not previously observed in humans
 - Usually jumps from animal host
 - **Ex: AIDS**, lime disease, West Nile Virus, new strains of influenza
- **Reemerging Disease** existed in the past and are recently increasing in incidence
 - Ex: tuberculosis, yellow fever, malaria
- 75% of new infectious diseases (in the last ten years) caused by pathogens originated in animal and animal products



Reasons for Emergence/Reemergence

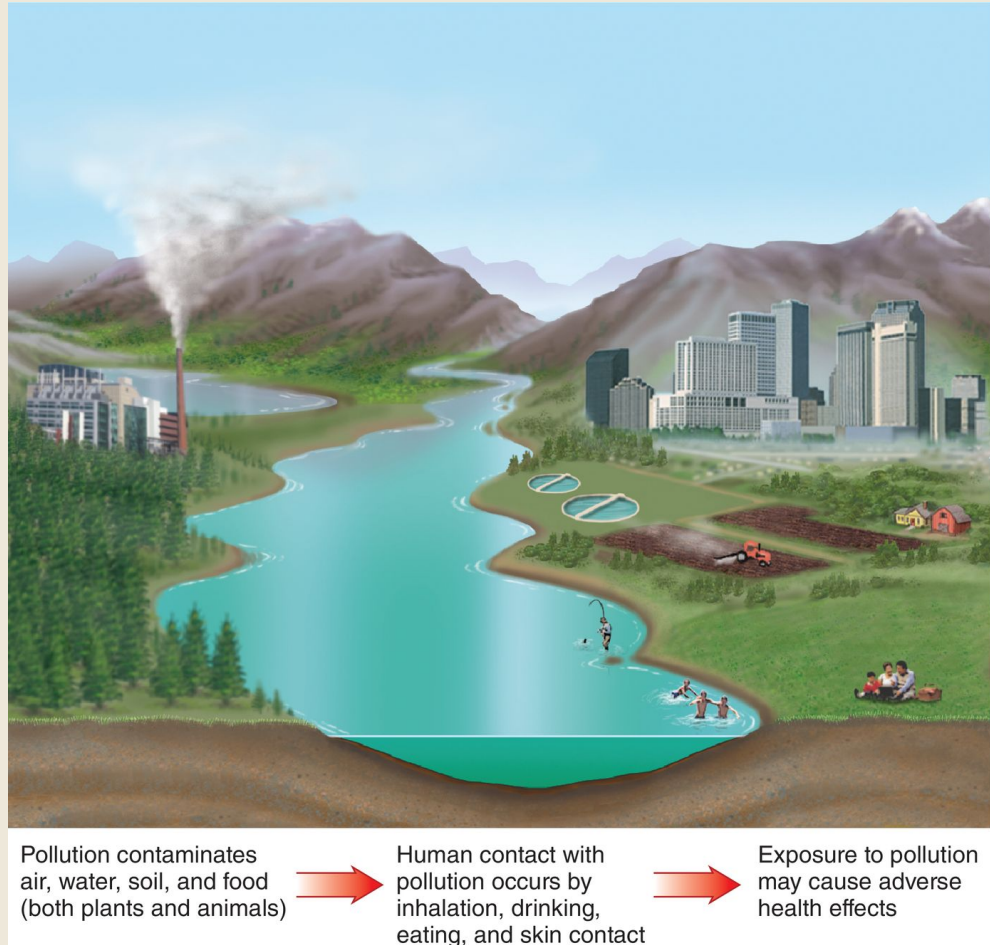
- Evolution of disease so it transitions to human host
- Evolution of antibiotic resistance in disease
- Urbanization and overcrowding
- Increased population that is susceptible to disease
- **Pollution and environmental degradation and changing weather**
- Growth in international travel and commerce
- Poverty and social inequality



Lynn Johnson/National Geographic Creative

Environmental Pollution and Disease

- It's estimated that ~40% of deaths worldwide are pollution-related
- Pathways of Pollution
- Often difficult to link pollutants to their effects on people
 - Differ with people genetics, lifestyle, age, socioeconomics, etc.
 - Persistence
 - Bioaccumulation
 - Biological magnification

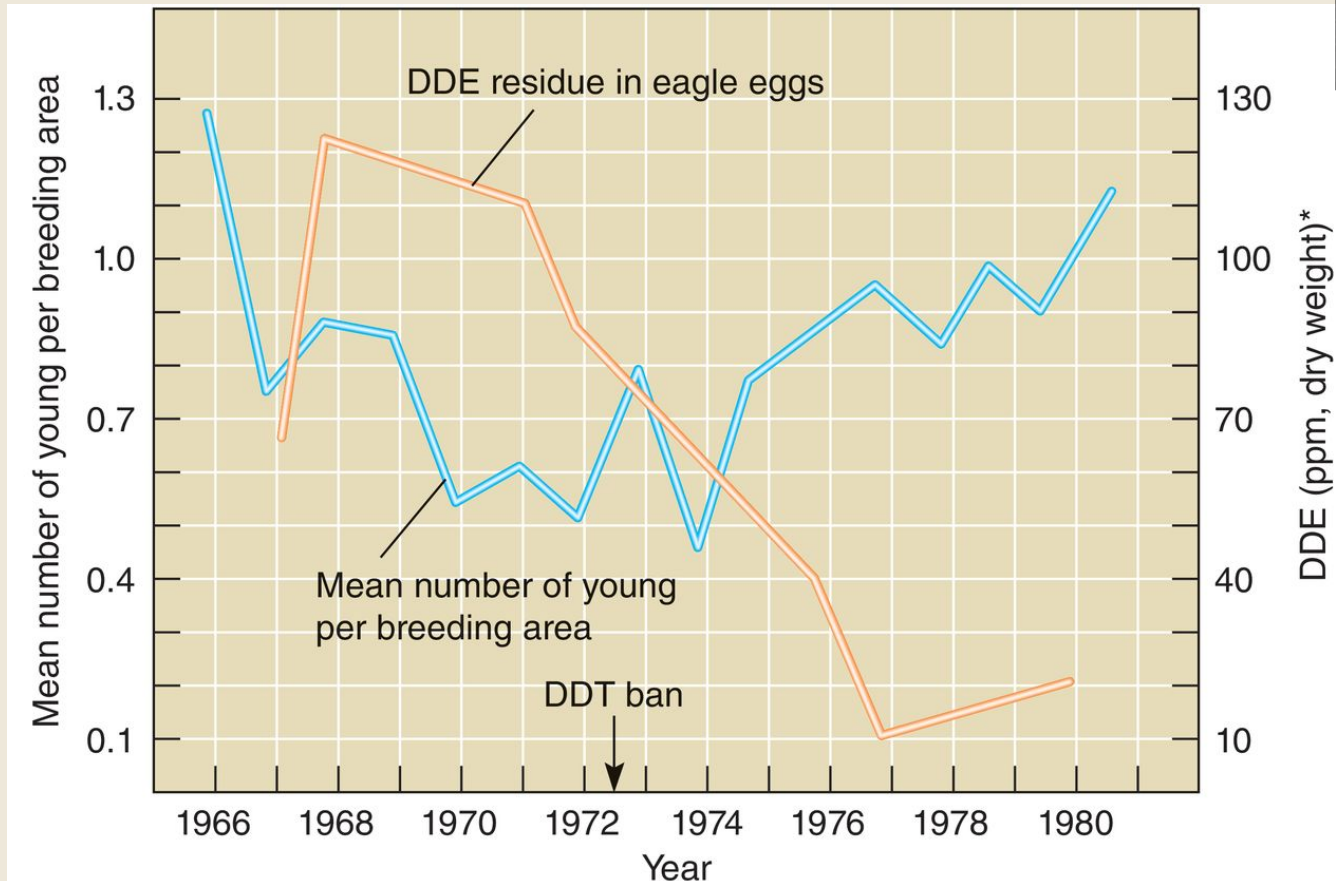


Persistence

- ❑ A characteristic of certain chemicals that are extremely stable and may take many years to be broken down into simpler forms by natural processes
 - ❑ Synthetic chemicals (those not found in nature)
 - ❑ Ex: pesticide DDT, heavy metals
- ❑ Natural decomposers (bacteria) have not evolved a way to break it down



Effect of DDT on Bald Eagles

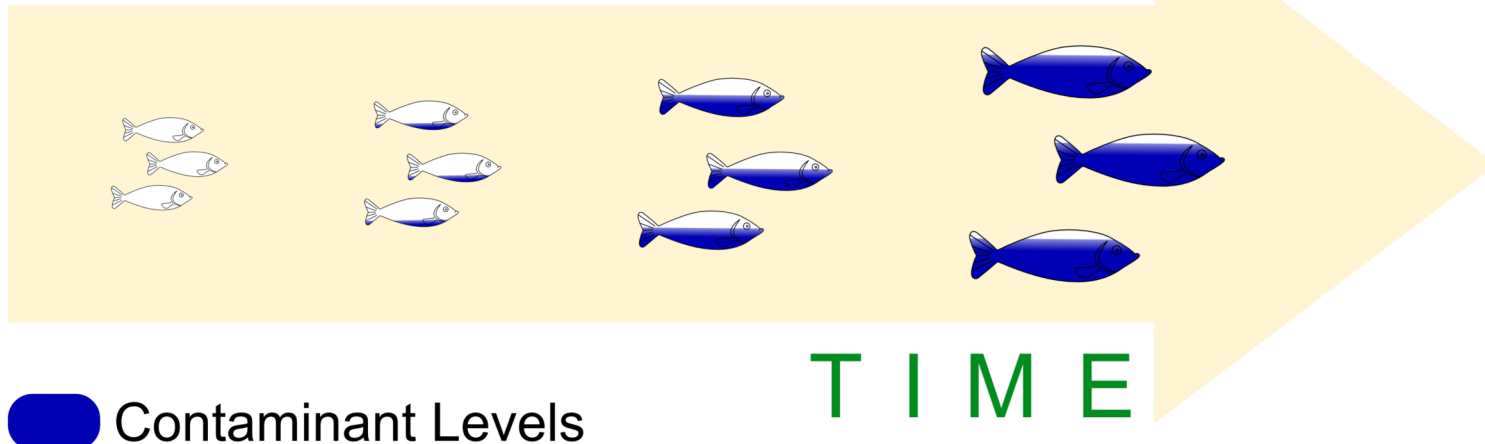


*DDT is converted to DDE in the birds' bodies

Bioaccumulation

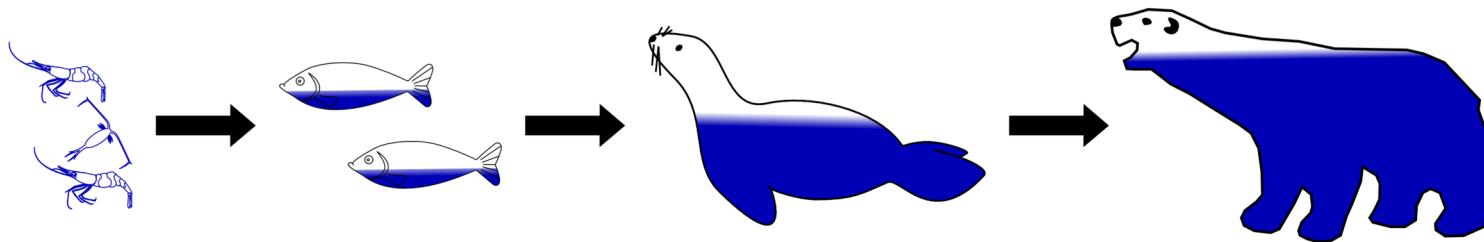
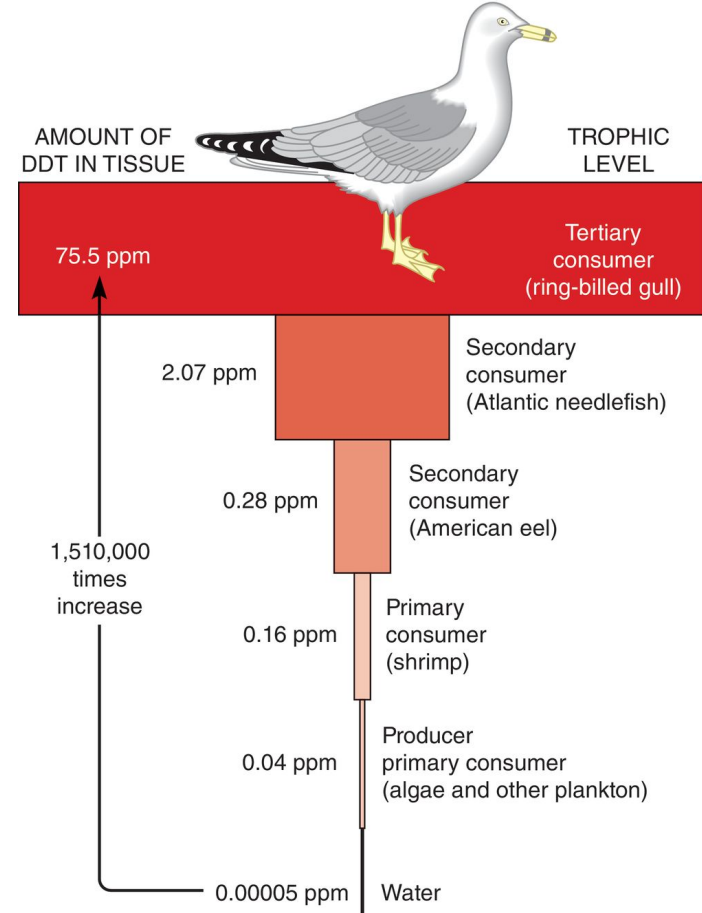
- Or bioconcentration
- The buildup of a persistent toxic substance in an organism's body, often in fatty tissues
 - Synthetic chemicals do not metabolize well
 - They remain in the body for extended periods of time

Bioaccumulation



Biomagnification

- The increased concentration of toxic chemicals in the tissues of organisms that are at higher levels in food webs
- Diagram (right) is example of biomagnification of DDT



 Contaminant Levels

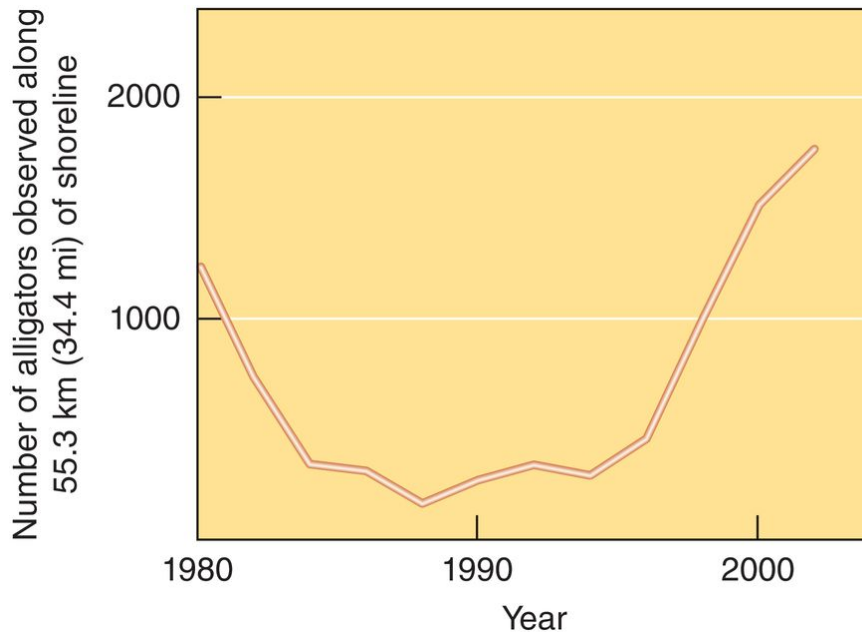
Biomagnification

Endocrine Disrupters

- A chemical that mimics or interferes with the actions of the endocrine system in humans and wildlife
- Examples include:
 - PCBs (polychlorinated biphenyl), Dioxins
 - Heavy metals – lead and mercury
 - DDT
- Animals exposed to these chemicals have altered reproductive development and are often sterile
- Hormones: chemical messengers that bind to a receptor to regulate important biological processes (Ex. Estrogens)

Endocrine Disrupters

- Case Study: 1980 chemical spill into Lake Apopka, FL
 - Included DDT and other agricultural chemicals
 - Male alligators began to exhibit low testosterone levels and high estrogen levels.
 - Reproductive organs were feminized or abnormally small.
 - High egg mortality lead to population crash



Stuart Bauer

Endocrine Disrupters in Humans

- Infertility and hormonally related cancers are increasing
 - Breast cancer and testicular cancer
 - Sperm counts have declined 50% in men worldwide
- Phthalates: have been implicated as potential endocrine disrupters
 - Common ingredient in: cosmetics, fragrances, nail polish, medication, toys, food packaging

Endocrine Disruptors and Humans

- **Bisphenol A (BPA):** chemical in hard plastics, such as baby and drink bottles
 - Contested whether BPA is a problem (at what concentrations?)
 - Banned in many countries and CA, not in U.S. and Australia
- Science is uncertain
 - Limited # of human studies (lack baseline studies)
 - Acute versus chronic use
 - Limited by funding and testing

You Tube break

- https://www.youtube.com/watch?v=V4Y_5a0vwn8

How does BPA may affect humans?

Determining Health Effects of Pollutants

Toxicology

- Is the study of the effect of toxicants on the human body as well as the ways to prevent or minimize these effects
 - Toxicant - chemical with adverse human health effects

Toxicity

The extent at which adverse effects are produced by various doses of a toxicant

Toxicity

- Acute toxicity
 - Adverse effects occur within a short period after exposure to toxin (from nausea to death)
- Chronic toxicity
 - Adverse effects occur some time after exposure (damage of organs such as kidneys), or after prolonged exposure to toxin (less known because it mimics those of chronic diseases)
- Toxicity measured by dose and response
 - **Dose:** amount that enters that body of an exposed organism
 - **Response:** the amount of damage caused by a specific dose

Toxicity Studies

- **Dose:** amount that enters that body of an exposed organism
- Measure in animals and extrapolate to humans
- Lethal dose
- Sub-lethal dose
- **LD₅₀**
 - Lethal dose to 50% of the test organisms
 - Smaller the LD₅₀, the more lethal the chemical
 - Determined for all new synthetic chemicals

Table 7.2 LD₅₀ Values for Selected Chemicals

<i>Chemical</i>	<i>LD₅₀ (mg/kg)*</i>
Aspirin	1750
Ethanol	1000
Morphine	500
Caffeine	200
Heroin	150
Lead	20
Cocaine	17.5
Sodium cyanide	10.0
Nicotine	2.0
Strychnine	0.8

*Administered orally to rats.

Toxicity

- **ED₅₀**
 - Effective dose to 50% of the test organisms
 - ED₅₀ causes 50% of the population to exhibit whatever effect is under study
- **Dose-Response Curve**
 - Illustrates the effect of different doses on a population
 - Threshold Level
 - Maximum dose with no measurable effects

Toxicity

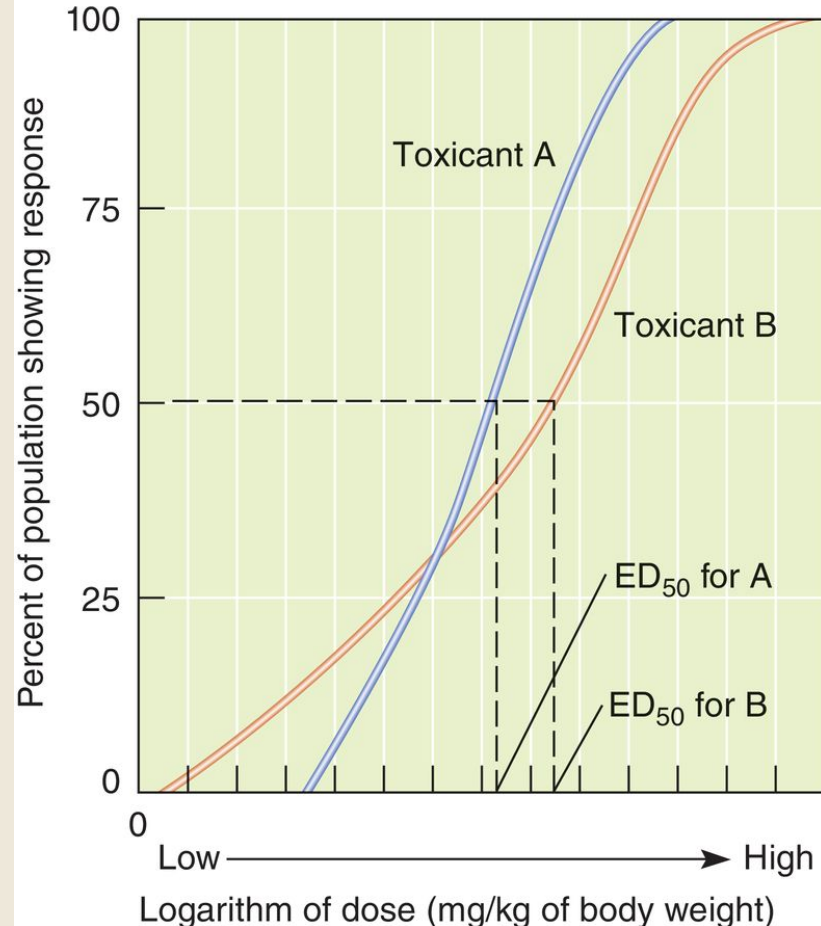
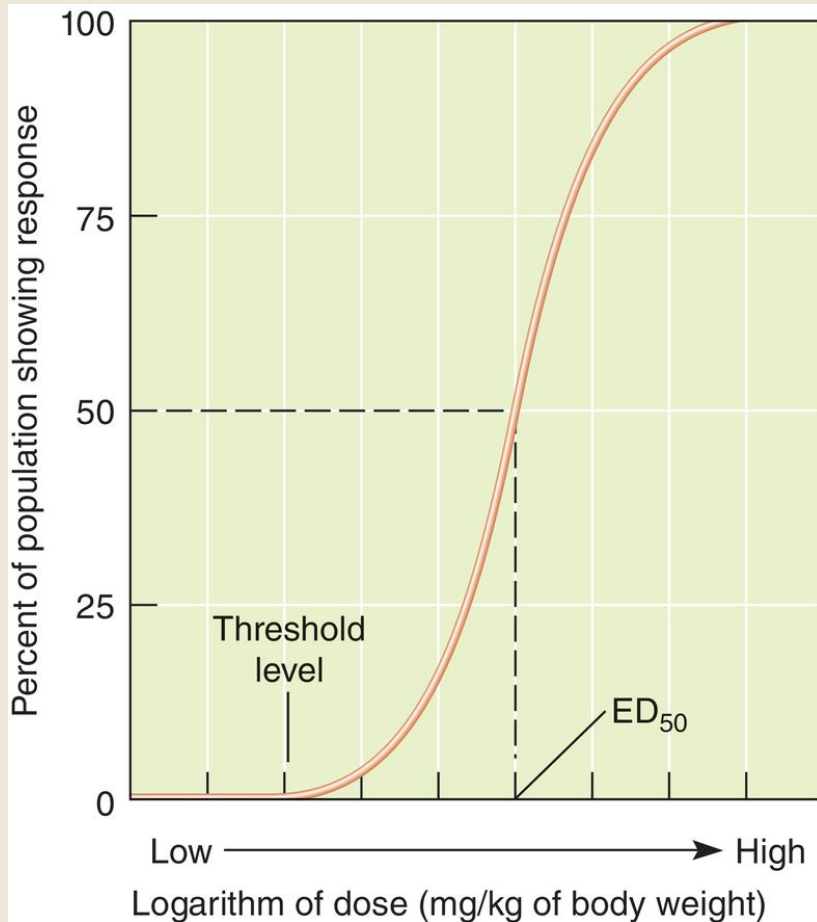
Table 7.3 Hypothetical Data Set for Animals Exposed to a Chemical

<i>Number of Animals in Test</i>	<i>Number of Animals with Cancer</i>	<i>Dose (mg/kg/day)</i>	<i>Probability of Cancer*</i>
50	0	0.0	0
50	2	5.0	0.04
50	6	10.0	0.12
50	22	20.0	0.44

*The probability of getting cancer at a given dose is the number of animals with cancer at that dose level divided by the total number exposed at that dose level.

Dose–response curves

Toxicity: ED_{50}



Typical: as dose increases, the response increases.
Responses occur only after threshold

Ecotoxicology Paradigms

- Dilution Paradigm is not valid
 - “Dilution is the solution to pollution”
- Boomerang Paradigm is accepted
 - “What you throw away can come back and hurt you”
- Ecotoxicology
 - The study of contaminants in the biosphere and their harmful effects on ecosystems
 - Helps policy makers determine costs and benefits of industrial and technological “advances”

Risk Assessment

- A tool for decision making and risk management
- **Risk:** probability that a particular adverse effect will result from some exposure or condition (0 to 1)
- We assess (quantify) risk for adverse health effects with four steps
 1. Hazard identification
 2. Dose response assessment
 3. Exposure assessment
 4. Risk characterization

Risk Assessment

1 Hazard identification

Does exposure to substance cause increased likelihood of adverse health effect such as cancer or birth defects?

2 Dose-response assessment

What is the relationship between amount of exposure (dose) and seriousness of adverse health effect? A person exposed to a low dose may have no symptoms, whereas exposure to a high dose may result in illness.

3 Exposure assessment

How much, how often, and how long are humans exposed to a substance in question? Where humans live relative to emissions is also considered.

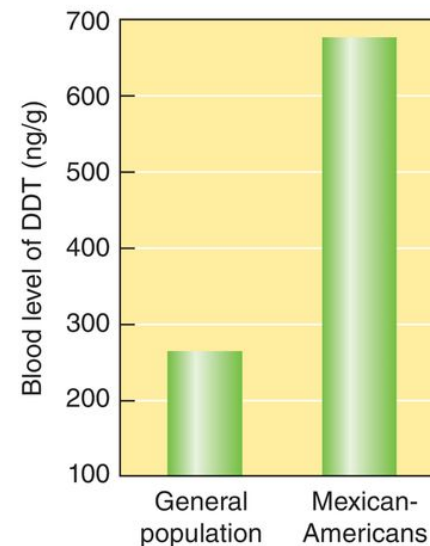
4 Risk characterization

What is probability of individual or population having adverse health effect? Risk characterization evaluates data from dose-response assessment and exposure assessment. Risk characterization indicates that Mexican-Americans, many of whom are agricultural workers, are more vulnerable to pesticide exposure than other groups (see photo and graph).



Sisse Brimberg/National Geographic Creative

Agricultural workers have a greater than average exposure to chemicals such as pesticides. (Sisse Brimberg/National Geographic Image Collection)



Risk Assessment

Table 7.5 Probability of Death by Selected Causes for a U.S. Citizen

<i>Cause of Death</i>	<i>One-Year Odds*</i>	<i>Lifetime Odds*</i>
Cardiovascular disease	1 in 300 (3.3×10^{-3})	1 in 4 (2.5×10^{-1})
Cancer, all types	1 in 510 (2.0×10^{-3})	1 in 7 (1.4×10^{-1})
Motor vehicle accidents	1 in 6700 (1.5×10^{-4})	1 in 88 (1.1×10^{-2})
Suicide	1 in 9200 (1.1×10^{-4})	1 in 120 (8.3×10^{-3})
Homicide	1 in 18,000 (5.6×10^{-5})	1 in 240 (4.2×10^{-3})
Killed on the job	1 in 48,000 (2.1×10^{-5})	1 in 620 (1.6×10^{-3})
Drowning in bathtub	1 in 840,000 (1.1×10^{-6})	1 in 11,000 (9.1×10^{-5})
Tornado	1 in 3,000,000 (3.3×10^{-7})	1 in 39,000 (2.6×10^{-5})
Commercial aircraft	1 in 3,100,000 (3.2×10^{-7})	1 in 40,000 (2.5×10^{-5})
Hornet, wasp, or bee sting	1 in 6,100,000 (1.6×10^{-7})	1 in 80,000 (1.3×10^{-5})

*Probability of risk is in parentheses.

Probabilities calculated by L. Berg from multiple sources.

Precautionary Principle

- No action should be taken when science is inconclusive but risks are unknown

Ecological Risk Assessment (ERA)

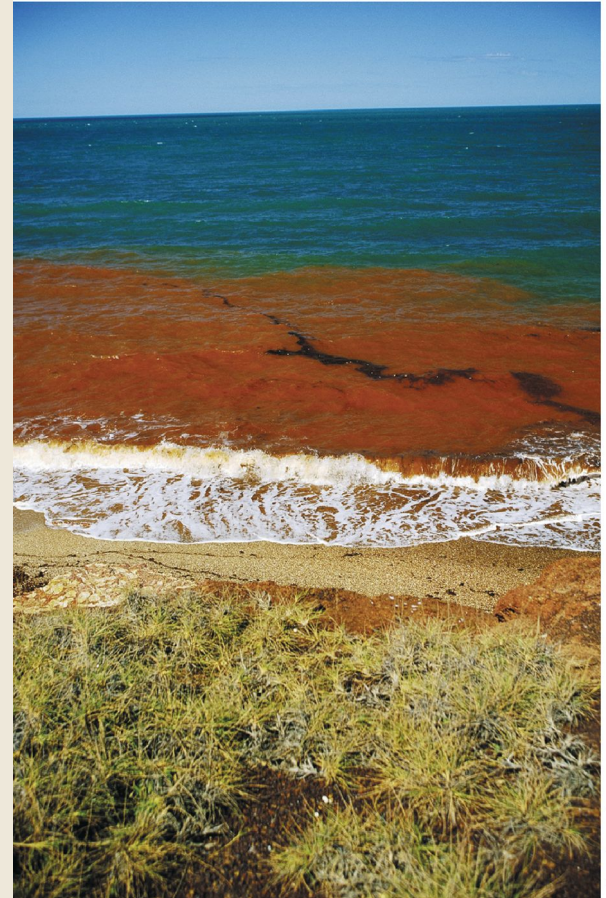
- ❑ Aims to Identify Stressors and their Impacts on ecosystems
- ❑ Large uncertainty
 - ❑ Difficult to assess because effect occur at wide range of scales (ecosystems)
 - ❑ Individual plants and animals
 - ❑ Ecological communities over wide regions
 - ❑ Human-induced environmental stressors also range greatly
 - ❑ Agriculture, oil spill, invasive sp. arrival
 - ❑ There is a need to quantify risks to the environment



Courtesy NASA

Case Study: The Ocean

- Land based nutrient and pollution runoff, wastewater, into ocean is affecting microorganisms
- Ex: Red Tide
 - Red pigmented poisonous algal blooms
 - Toxins kill off fish and make humans sick
 - Causes are unknown – climate change?, dust clouds from Africa?- thus no controls



Bill Bachman/Science Source