Chapter 7
Human Health and Environmental Toxicology
Overview of Chapter 7

- 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
- Vary greatly between countries
  - Developed countries
  - Developing countries
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
  - Cardiovascular disease, Cancer, Lung Disease

- Premature deaths caused by lifestyle
  - Poor diet, Lack of exercise, Smoking, Obesity
Health in Developing Countries

- Biggest problems
  - Malnutrition, unsafe water, poor sanitation

- Life Expectancy
  - Overall is 65 years
  - Very poorest developing countries = 45 years
    - Due to AIDS epidemics

- Childhood mortality is high
  - Diarrheal diseases
  - Malnutrition
  - Malaria
  - AIDS/HIV
Emerging and Reemerging Diseases

- **Emerging Disease** - not previously observed in humans
  - Usually jumps from animal host
  - Ex: AIDS, lime disease, West Nile Virus

- **Reemerging Disease** - existed in the past and are recently increasing in incidence
  - Ex: tuberculosis, yellow fever, malaria
Reasons for Emergence/Reemergence

- Evolution of disease so it transitions to human host
- Evolution of antibiotic resistance in disease
- Urbanization and overcrowding
- Increased pop. of elderly - susceptible to disease
- Pollution and environmental degradation
- Growth in international travel and commerce
- Poverty and social inequality
Environmental Pollution and Disease

- Pathways of Pollution
  - Often difficult to link pollutants to their effects on people
    - Persistence
    - Bioaccumulation & magnification

Pollution contaminates air, water, soil, and food (both plants and animals)
Human contact with pollution occurs by inhalation, drinking, eating, and skin contact
Exposure to pollution may cause adverse health effects
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: DDT
- Natural decomposers (bacteria) have not evolved a way to break it down
Bioaccumulation

- The buildup of a persistent toxic substance in an organism’s body, often in fatty tissues
  - Synthetic chemical do not metabolize well
  - They remain in the body for extended periods of time
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
Endocrine Disrupters

- A chemical that mimics or interferes with the actions of the endocrine system in humans and wildlife

- Examples include:
  - PCBs, Dioxins
  - Heavy metals - lead and mercury
  - DDT

- Animals exposed to these chemicals have altered reproductive development and are often sterile
Endocrine Disrupters

- **Case Study: 1980 chemical spill into Lake Apopka, FL**
  - Male alligators began to exhibit low testosterone levels and high estrogen levels
Endocrine Disrupters and Humans

- Infertility and hormonally related cancers are increasing
  - Breast cancer and testicular cancer
- Phthalates have been implicated as potential endocrine disrupters
  - Common ingredient in: cosmetics, fragrances, nail polish, medication, toys, food packaging
Determining Health Effects of Pollutants

- Toxicology is the study of the effect of toxicants on the human body
  - Toxicant - chemical with adverse human health effects
- 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
Toxicology

- **Acute toxicity**
  - Adverse effects occur within a short period after exposure to toxin

- **Chronic toxicity**
  - Adverse effects occur some time after exposure, or after prolonged exposure to toxin
Toxicity

- **LD50**
  - Lethal dose to 50% of the test organisms
  - Smaller the LD50, the more lethal the chemical
  - Determined for all new synthetic chemicals

<table>
<thead>
<tr>
<th>Chemical</th>
<th>LD50 (mg/kg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>1750.0</td>
</tr>
<tr>
<td>Ethanol</td>
<td>1000.0</td>
</tr>
<tr>
<td>Morphine</td>
<td>500.0</td>
</tr>
<tr>
<td>Caffeine</td>
<td>200.0</td>
</tr>
<tr>
<td>Heroin</td>
<td>150.0</td>
</tr>
<tr>
<td>Lead</td>
<td>20.0</td>
</tr>
<tr>
<td>Cocaine</td>
<td>17.5</td>
</tr>
<tr>
<td>Sodium cyanide</td>
<td>10.0</td>
</tr>
<tr>
<td>Nicotine</td>
<td>2.0</td>
</tr>
<tr>
<td>Strychnine</td>
<td>0.8</td>
</tr>
</tbody>
</table>

*Administered orally to rats.  
*Source: M. D. Josten and J. L. Wood.*
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: ED50

(a) Percent of population showing response vs. Logarithm of dose (mg/kg of body weight)

(b) Percent of population showing response vs. Logarithm of dose (mg/kg of body weight) for two toxicants A and B, with ED50 values indicated.
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
- Diagram (right)
  - Children in foothills not exposed to pesticides
  - Children in valley were exposed
Identifying Cancer Causing Substances

- **Toxicologist**
  - Dose rats with varying levels of chemicals to see if they develop cancer
  - Difficult to extrapolate results to humans

- **Epidemiologists**
  - Look at historical exposure of groups of humans
  - See if exposed group have increased cancer rate
Chemical Mixtures

- Most studies look at one chemical, but humans tend to be exposed to chemical mixtures
  - Ex: automobile exhaust

- Chemical Mixtures interact by
  - Additivity
  - Synergy
  - Antagonism

- These studies are expensive and take a while to complete
Ecotoxicology

- 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”
Case Study: The Ocean

- Land based nutrient and pollution runoff into ocean is affecting microorganisms
  - Ex: Red Tide
    - Red pigmented poisonous algal blooms
    - Toxins kill off fish and make humans sick
Risk Assessment

- Risk - probability that a particular adverse effect will result from some exposure or condition

- We assess risk daily with four steps
  - Hazard identification
  - Dose response assessment
  - Exposure assessment
  - 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).

Agricultural workers have a greater than average exposure to chemicals such as pesticides.

**Graph:**
- Blood level of DDT (ng/g)
- General population: 100 - 300 ng/g
- Mexican-Americans: 600 - 700 ng/g
## Risk Assessment

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

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

*Probability of risk is in parentheses.

Source: D. Ropeik and G. Gray.
Ecological Risk Assessment

- Difficult to assess because effects occur at wide range of scales
  - Individual plants and animals
  - Ecological communities over wide regions
- Human-induced environmental stressors also range greatly
- There is a need to quantify risks to the environment