Types of Chemicals

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurotoxins</td>
<td>Disrupt nervous system</td>
<td>Insecticides, Lead, Mercury</td>
</tr>
<tr>
<td>Carcinogens</td>
<td>Create cancers</td>
<td>Asbestos, radon, formaldehyde, tobacco, cadmium, PCB's</td>
</tr>
<tr>
<td>Teratogens</td>
<td>Interfere with embryo/fetus development</td>
<td>Thalidomide, alcohol</td>
</tr>
<tr>
<td>Allergens</td>
<td>Allergic reactions</td>
<td>Peanuts, milk, whey, penicillin</td>
</tr>
<tr>
<td>Endocrine Disruptors</td>
<td>Interfere with hormones</td>
<td>DDT, atrazine, Phthalates</td>
</tr>
</tbody>
</table>

Endocrine Disruptors

- Animal hormone injections
- Human birth control
- Pesticides
- Feminization
Toxicity and Dose-Response Studies

- **Dose-Response Studies**: expose animals or plants to different amounts of a chemical and then observe a variety of possible responses including mortality or changes in behavior or reproduction
  - **Acute Studies**: most dose-response studies last for 1-4 days

**Lethal Dose-50**

- **LD50**: the lethal dose that kills 50 percent of the individuals
  - Important for assessing the relative toxicity of a chemical
  - Conducting LD50 studies on humans is unethical
    - Studies on mice and rats are extrapolated to humans
    - Different organisms used to represent entire categories of animals
      - Mice and Rats are used to represent all mammals
      - Pigeons and Quail are used to represent all birds
      - Trout are used to represent all fish
      - Water fleas are used to represent all invertebrates
      - There are currently no tests for Amphibians or Reptiles
**LD-50**

- **Threshold**: Lowest dosage administered where deaths (mortalities) occurred
  - These individuals are usually poorer in health or genetically intolerant to the chemical

![LD-50 graph](image)

**Effective Dose-50 and Testing Standards**

- **ED-50**: Experiments conducted to determine the effective dose that causes 50 percent of the individuals to display harmful, but nonlethal effects
  - **Sublethal effects**: study of how chemicals affect organisms, but does not kill them
    - Includes acting as a teratogen, carcinogen, or neurotoxin that could alter animal behavior
  - **Toxic Substances Control Act of 1976**: gives the EPA the authority to regulate many chemicals, through excluding food, cosmetics and pesticides

**Extrapolating LD50 and ED50 Values**

- Environmental Protection Agency can determine concentrations in environment that should not cause harm
  - For most animals, take the LD50 value and divide it by 10 (should cause few to no animal deaths)
  - For Humans, LD50 or ED50 results from mice and rats divided by 10
  - Number divided again by 10 because mice/rats might be less sensitive to the chemical than us
  - Finally, number again divided by 10 to ensure extra level of caution
  - Summary: LD50 and ED50 numbers from mice/rats divided by 1,000 to set safe values for humans
Table 7.1 LD₅₀ Values for Selected 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
Children and Chemical Exposure

- Children more susceptible to chemicals
  - Weigh less than adults
  - Bodies are still developing
  - Play on floors and lawns
    - Exposed to cleaning products and pesticides
    - Put things into their mouths

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: RETROSPECTIVE STUDIES

artificial sweeteners debate
Aspartame Rat Experiment Proves Dangers

Problems of Determining Carcinogens
- Rats: short term exposure to high levels
- Humans long term exposure to low levels
- Can we compare two different species
- Same effects in both organisms?

Retrospective Studies
- Case Study: Bhopal India
  - Pesticide plant released 36,000 kg of gas
Retrospective Studies

• Case Study: Chernobyl Nuclear Accident

Increased Radiation Dose Across Europe - 3 May 1986

In the map, the Chernobyl region is highlighted with red circles indicating increased radiation dose. The colors represent different dose ranges:
- No detectable dose
- 10⁻² - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 100
- 100+

The map shows the extent of radiation across Europe with marked regions having higher doses.
Chemical Mixtures

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

- Chemical Mixtures interact synergistically

- These studies are expensive and take a while to complete (20 + years) (PROSPECTIVE STUDIES)

Factors determining Concentrations in Organisms

- (1) Route of Exposure
(2) Solubility, Bioaccumulation, Biomagnification

- Water-v-fat soluble
- Oil soluble chemicals stored in fatty tissues
- Ex: mercury, DDT, PCB’s
- DDT in birds that eat fish is 8 million times that found in water

(2) Solubility, Bioaccumulation, Biomagnification cont.

- **Solubility**: how well a chemical can dissolve in a liquid
  - Water-soluble chemicals can be pervasive in groundwater and surface waters
  - Fat-soluble chemicals are found in higher concentrations in soils and are also readily stored in fat tissues of animals
- **Bioaccumulation**: an increased concentration of a chemical within an organism over time
  - Small amounts accumulate over time
- **Biomagnification**: the increase in chemical concentration in animal tissues as the chemical moves up the food chain
  - DDT is classic example

![Diagram of DDT levels in different trophic levels](image)

- Tertiary consumer (humpback whale)
- Secondary consumer (halibut and mackerel)
- Primary consumer (clams and mussels)
- Producer (algae and other plankton)
- Water

The concentration of DDT tends to increase as the trophic level of organisms at higher levels.

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(3) Persistence

- **Persistence**: How long the chemical remains in the environment

**TABLE 17.2** The persistence of various chemicals in the environment, measured in terms of their half-life

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion insecticide</td>
<td>1 day</td>
</tr>
<tr>
<td>Radon</td>
<td>4 days in air</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>4.5 days in air</td>
</tr>
<tr>
<td>Phthalates</td>
<td>4.5 days in water</td>
</tr>
<tr>
<td>Roundup herbicide</td>
<td>7 to 70 days in water</td>
</tr>
<tr>
<td>Atrazine herbicide</td>
<td>224 days in wetland soils</td>
</tr>
<tr>
<td>Polychlorinated biphenyls (PCBs)</td>
<td>8 to 15 years in water</td>
</tr>
<tr>
<td>DDT</td>
<td>30 years in soil</td>
</tr>
</tbody>
</table>


**Perceived Risk vs. Actual Risk**

- Bee sting (1 in 86,789)
- Lightning (1 in 79,746)
- Earthquake (1 in 117,157)
- Flood (1 in 144,156)
- Heart disease (1 in 5)
- Cancer (1 in 7)
- Stroke (1 in 24)
- Motor vehicle accident (1 in 84)
- Falls (1 in 218)
- Firearm assault (1 in 314)
- pedestrian accident (1 in 626)
- Drowning (1 in 3,088)
- Fire or smoke (1 in 1,113)
- Airplane accident >
- Hot weather (1 in 13,729)
**Worldwide Standard of Risk**

- **Innocent-until-proven-guilty principle**: based on the philosophy that a potential hazard should not be considered a hazard until the scientific data can definitely demonstrate that a potential hazard actually causes harm.
  - Harmful chemicals can affect humans and wildlife for decades before sufficient scientific evidence can confirm.

- **Precautionary principle**: based on the philosophy that when a hazard is plausible but not yet certain, we should take actions to reduce or remove the hazard.
  - If chemicals found safe, could be delayed for many years and reduced financial motivation for investments.

**Stockholm Convention**

- In 2001, a group of 127 nations gathered in Stockholm, Sweden, to reach an agreement on restricting the global use of some chemicals.
- 12 chemicals were to be banned, phased out, or reduced.
- These include DDT, PCBs, and certain chemicals that are by-products of manufacturing processes.