Environmental Health, Toxicology and Risk Assessment

There are many types of environmental hazards

- **Environmental health** = assesses environmental factors that influence human health and quality of life
  - Natural and human-caused factors are both considered

What Major Health Hazards Do We Face?

- *We face health hazards from biological, chemical, physical, and cultural factors, and from the lifestyle choices we make.*

We Face Many Types of Hazards

1. Biological:

   Pathogens are organisms that causes disease in other organisms.

2. Chemical

3. Physical

4. Cultural

5. Lifestyle choices

Write down two examples of each.

Four types of environmental hazards

(a) Physical hazard

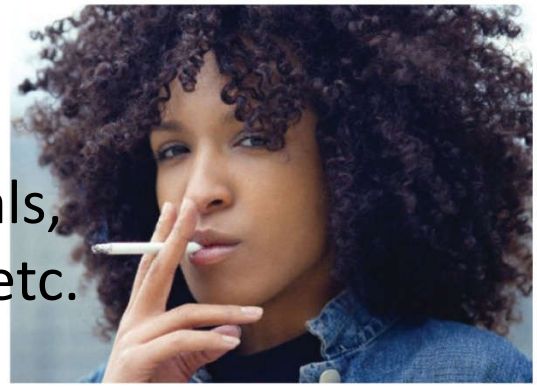
Physical:
Sun exposure,
Fire,
Earthquakes,
etc.

(c) Biological hazard

Biological:
Viruses, bacteria
Other pathogens
& diseases

(b) Chemical hazard

Chemical:
Pesticides,
Pharmaceuticals,
Disinfectants, etc.



(d) Cultural hazard

Cultural:
Smoking,
Diet & nutrition,
Transportation,
etc.

What Types of Biological Hazards Do We Face?

- *The most serious biological hazards we face are infectious diseases such as flu, AIDS, tuberculosis, diarrheal diseases, and malaria.*

Some Diseases Can Spread from One Person to Another, Others Cannot

- **Infectious disease**
  - Pathogen invades the body and multiplies
- **Transmissible disease**
  - Contagious or *communicable* disease
  - Infectious disease transmitted between people
  - Flu, tuberculosis, measles
- **Nontransmissible disease**
  - Not caused by living organisms
  - Heart disease, most cancers, diabetes

Which of these are communicable?

HIV

Malaria

Asthma

Ebola

Flu

Vast Improvements…

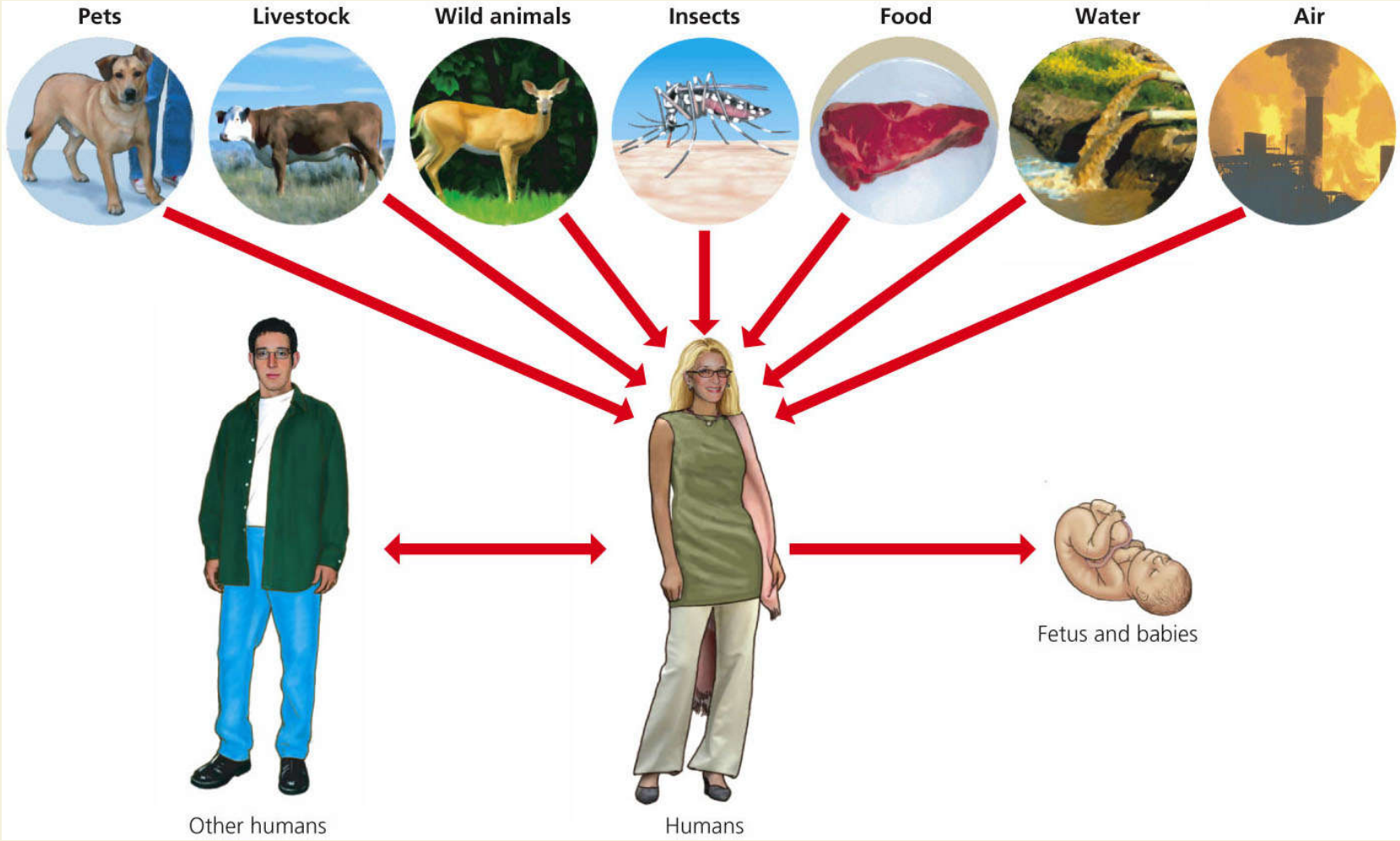
- Since 1950, death from infectious diseases have declined due to:
  - Better health care
  - Better sanitation
  - Antibiotics
  - Vaccines

However … Infectious Diseases Are Still Major Health Threats

- Infectious diseases spread through:
  - Air
  - Water
  - Food
  - Body fluids

- Epidemics and pandemics
- Resistance of bacteria and insects to drugs and pesticides

Science: Pathways for Infectious Diseases in Humans



We Can Reduce the Incidence of Infectious Diseases

- Good news
  - Vaccinations on the rise
  - Oral rehydration therapy
- Bad news
  - More money needed for medical research in developing countries

Solutions: Infectious Diseases

Solutions

Infectious Diseases

- Increase research on tropical diseases and vaccines
- Reduce poverty
- Decrease malnutrition
- Improve drinking water quality
- Reduce unnecessary use of antibiotics
- Educate people to take all of an antibiotic prescription
- Reduce antibiotic use to promote livestock growth
- Require careful hand washing by all medical personnel
- Immunize children against major viral diseases
- Provide oral rehydration for diarrhea victims
- Conduct global campaign to reduce HIV/AIDS

Toxicology

- **Toxicology =** the study of the effects of poisonous substances on humans and other organisms
- **Toxicity =** the degree of harm a toxicant can cause
- **Toxicant =** any toxic agent

Environmental toxicology

- Deals with toxic substances that come from or are discharged into the environment
- Studies the health effects on humans, other animals, and ecosystems
  - Focus mainly on humans, using other animals as test subjects
  - Can serve as indicators of health threats

What Types of Chemical Hazards Do We Face?

- *There is growing concern about chemicals in the environment that can cause cancers and birth defects, and disrupt the human immune, nervous, and endocrine system.*

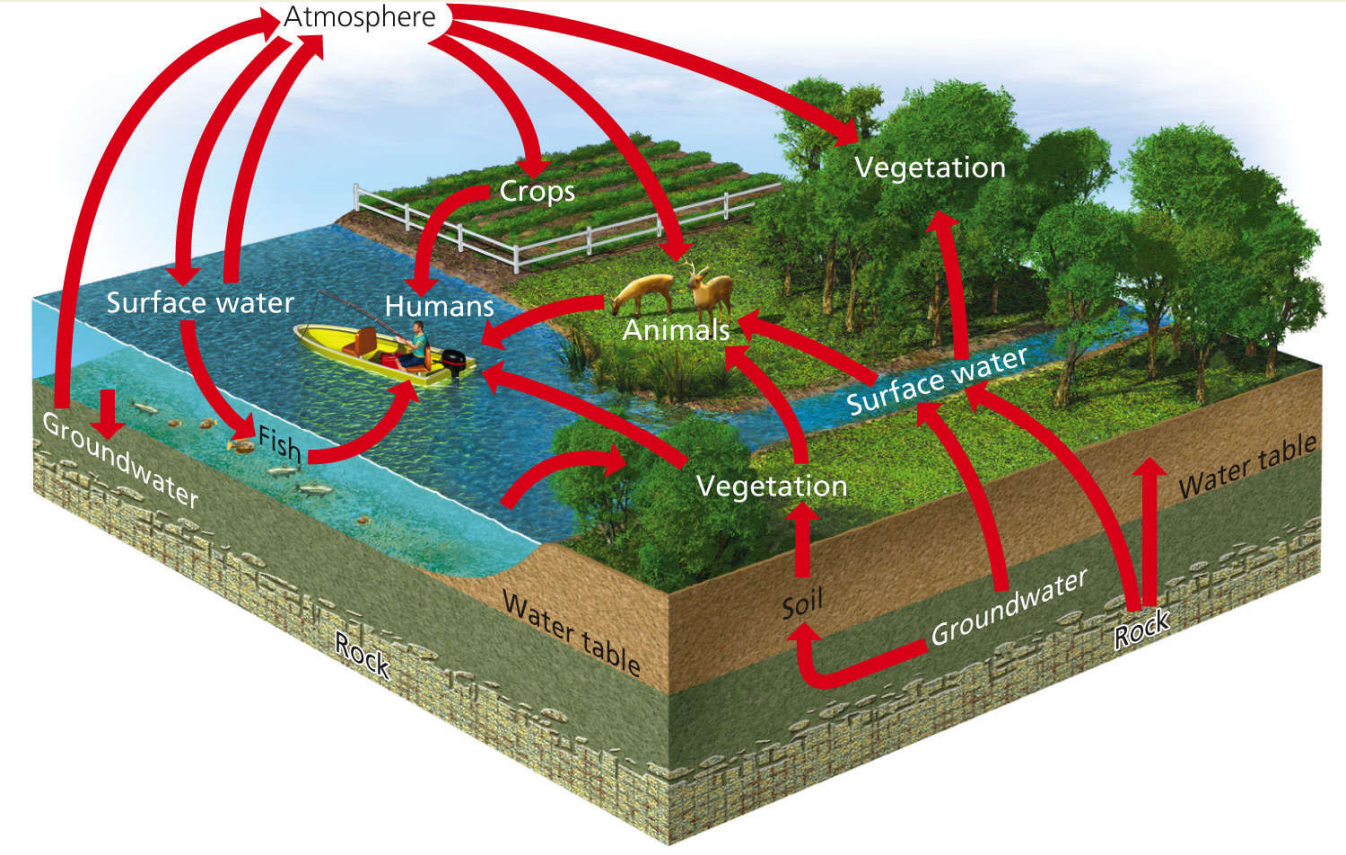
Some Chemicals Can Cause Cancers, Mutations, and Birth Defects

- **Toxic chemicals**
  - **Carcinogens**
    - Chemicals, types of radiation, or certain viruses; the cause or promote cancer
  - **Mutagens**
    - Chemicals or radiation that cause mutations or increase their frequency
  - **Teratogens**
    - Chemicals that cause harm or birth defects to a fetus or embryo

Top 5 Toxic Substances—Human and Environmental Health

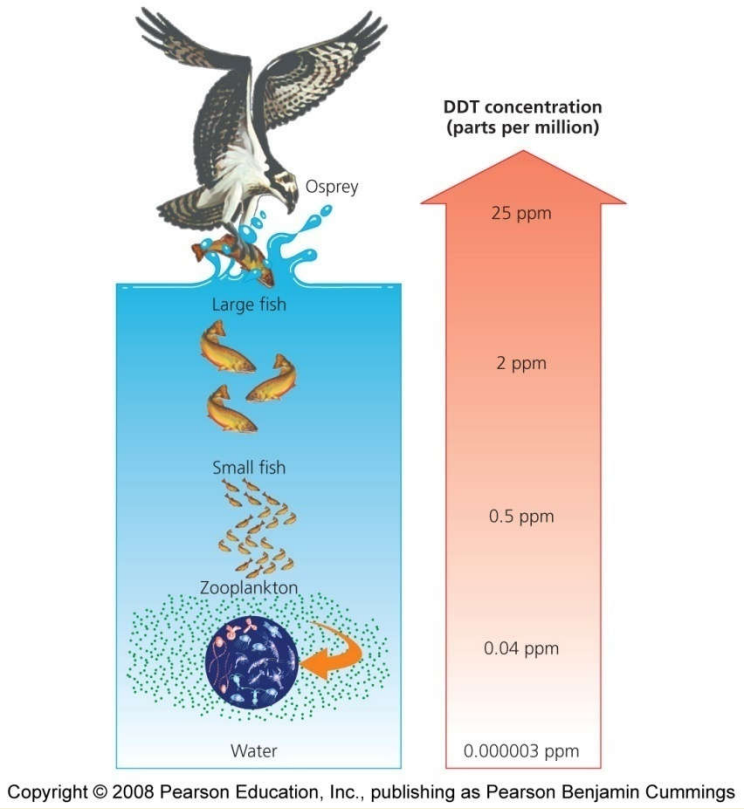
- Arsenic
- Lead
- Mercury
- Vinyl chloride
  - Used to make PVC plastics
- Polychlorinated biphenyls
  - PCBs

Potential Pathways on Which Toxic Chemicals Move Through the Environment



PCBs and other **persistent** toxic chemicals can move through the living and nonliving environment on a number of pathways.

Toxicants can accumulate



- **Bioaccumulation** = toxicants build up in animal tissues
- **Biomagnification** = toxicants concentrate in top predators

Some Chemicals May Affect Our Immune and Nervous Systems

- Some natural and synthetic chemicals in the environment can weaken and harm:
  - Immune system
  - Nervous system
    - Neurotoxins: PCBs, arsenic, lead, some pesticides
  - Endocrine system
    - Hormones

Science Focus: Mercury's Toxic Effects (1)

- Hg: teratogen and potent neurotoxin
  - Once airborne, persistent and not degradable
  - 1/3 from natural sources
  - 2/3 from human activities
  - Enters the food chain: biomagnification

- How are humans exposed?
  1. Inhalation: vaporized Hg or particulates
  2. Eating fish with high levels of **methylmercury**

     Under certain conditions in aquatic environments, bacteria can convert inorganic mercury compounds to highly toxic methylmercury, which can be biomagnified in food chains/ webs.
  3. Eating high-fructose corn syrup??

Science Focus: Mercury's Toxic Effects (2)

- Effects of Hg on humans
  - Damage nervous system, kidneys, lungs
  - Harm fetuses and cause birth defects

- Who is most at risk?
  - Pregnant women
  - 75% of exposure comes from eating fish

Solutions: Mercury Pollution

Solutions

Mercury Pollution

Prevention

Phase out waste incineration

Remove mercury from coal before it is burned

Switch from coal to natural gas and renewable energy resources

Control

Sharply reduce mercury emissions from coal-burning plants and incinerators

Label all products containing mercury

Collect and recycle batteries and other products containing mercury

How Can We Evaluate and Deal with Chemical Hazards?

- *Scientists use live laboratory animals, case reports of poisonings, and epidemiological studies to estimate the toxicity of chemicals, but these methods have limitations.*

- *Many health scientists call for much greater emphasis on pollution prevention to reduce our exposure to potentially harmful chemicals.*

Many Factors Determine the Harmful Health Effects of a Chemical (1)

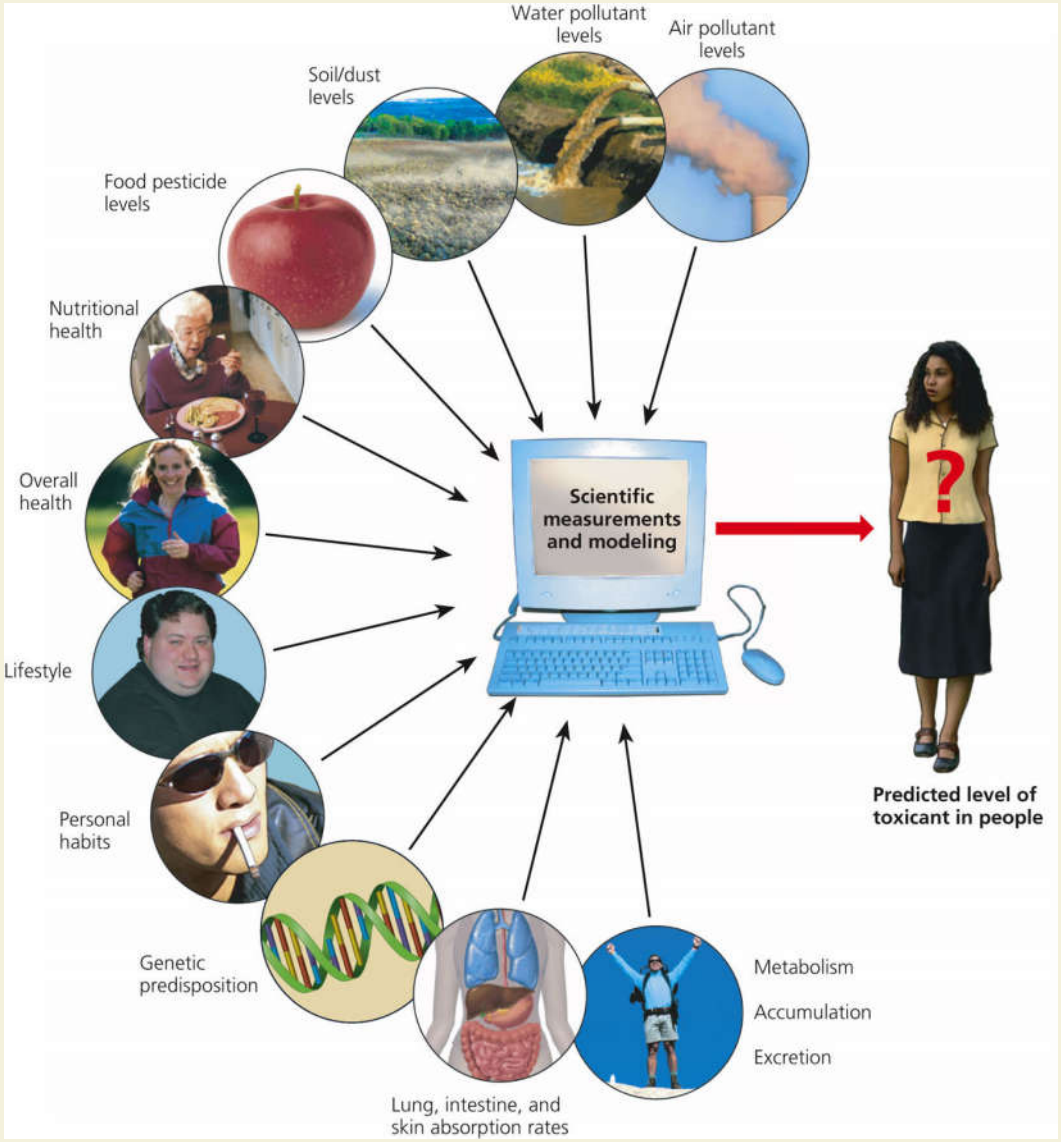
- **Toxicology**

- **Toxicity** dependent on
  - **Dose**
  - Age
  - Genetic makeup
  - Multiple chemical sensitivity (MCS)
  - Solubility
  - Persistence
  - Biomagnification

Many Factors Determine the Harmful Health Effects of a Chemical (2)

- **Response**
  - Acute effect: immediate or rapid
  - Chronic effect: permanent or long-lasting

Science: Estimating Human Exposure to Chemicals and Measuring Their Effects



Scientists Use Live Lab Animals and Nonanimal Tests to Estimate Toxicity (1)

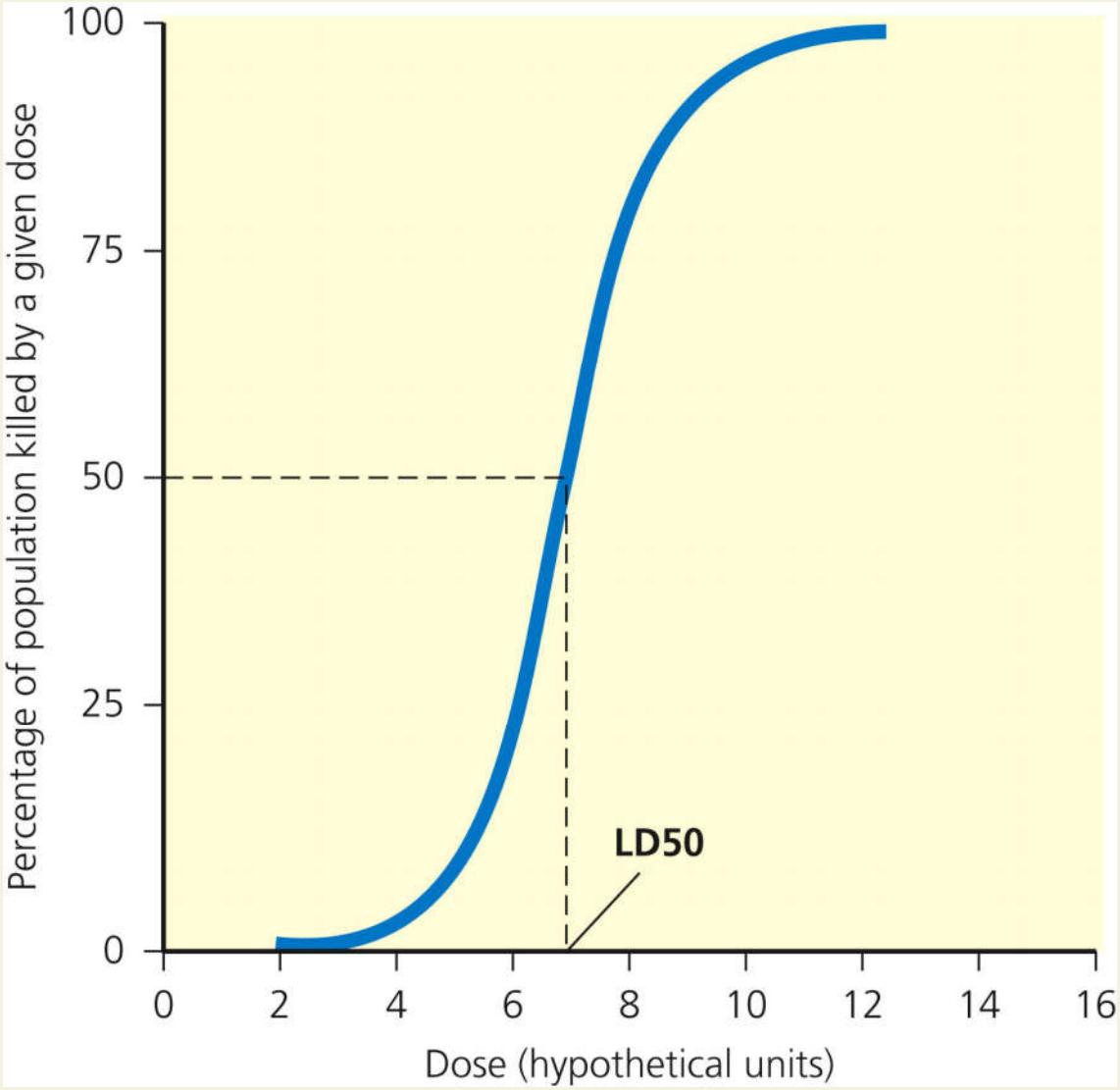
- Mice and rats
  - Systems are similar to humans
  - Small, and reproduce rapidly
  - Is extrapolation to humans valid?

- **Dose-response curve**: median lethal dose (LD50)
  - Nonthreshold dose-response model
  - Threshold dose-response model

Scientists Use Live Lab Animals and Nonanimal Tests to Estimate Toxicity (2)

- More humane methods using animals
- Replace animals with other models
  - Computer simulations
  - Tissue culture and individual animal cells
  - Chicken egg membranes
- What are the effects of mixtures of potentially toxic chemicals?

Hypothetical Dose-Response Curve Showing Determination of the LD50 (median lethal dose)



*** LD50 is the dose required to be lethal for 50% of the test population.**

Toxicity Ratings and Average Lethal Doses for Humans

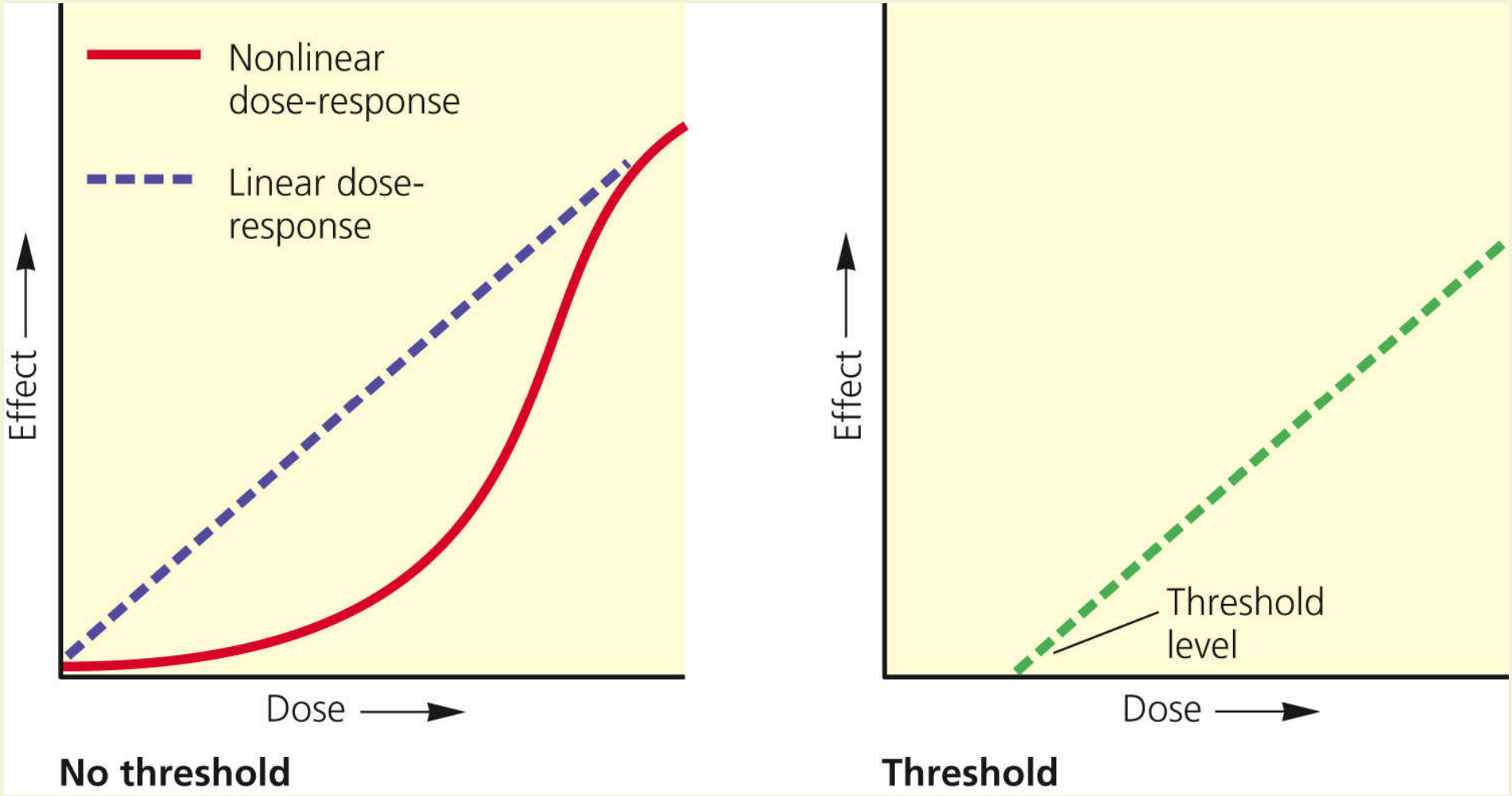
Table 17-1 Toxicity Ratings and Average Lethal Doses for Humans

Toxicity Rating	LD50 (milligrams per kilogram of body weight)*	Average Lethal Dose**	Examples
Supertoxic	Less than 5	Less than 7 drops	Nerve gases, botulism toxin, mushroom toxin, dioxin (TCDD)
Extremely toxic	5–50	7 drops to 1 teaspoon	Potassium cyanide, heroin, atropine, parathion, nicotine
Very toxic	50–500	1 teaspoon to 1 ounce	Mercury salts, morphine, codeine
Moderately toxic	500–5,000	1 ounce to 1 pint	Lead salts, DDT, sodium hydroxide, sodium fluoride, sulfuric acid, caffeine, carbon tetrachloride
Slightly toxic	5,000–15,000	1 pint to 1 quart	Ethyl alcohol, Lysol, soaps
Essentially nontoxic	15,000 or greater	More than 1 quart	Water, glycerin, table sugar

*Dosage that kills 50% of individuals exposed.

**Amounts of substances in liquid form at room temperature that are lethal when given to a 70-kilogram (150-pound) human.

Science: Two Types of Dose-Response Curves



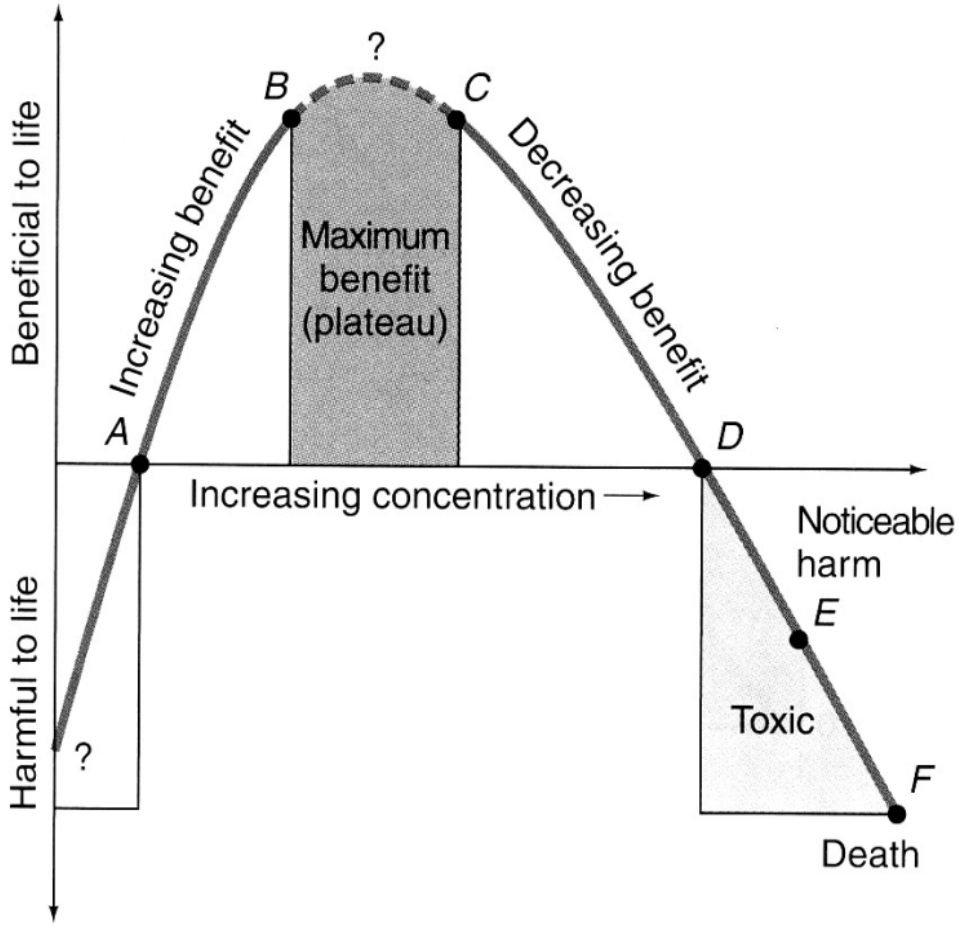


Figure 15.11 Generalized dose–response curve. Low concentrations of a chemical may be harmful to life (below point *A*). As the concentration of the chemical increases from *A* to *B*, the benefit to life increases. The maximum concentration that is beneficial to life lies within the benefit plateau (*B*–*C*). Concentrations greater than this plateau provide less and less benefit (*C*–*D*) and will harm life (*D*–*F*) as toxic concentrations are reached. Increased concentrations above the toxic level may result in death.

Why Do We Know So Little about the Harmful Effects of Chemicals?

- Severe limitations estimating toxicity levels and risks
- Only 2% of 100,000 chemicals have been adequately tested