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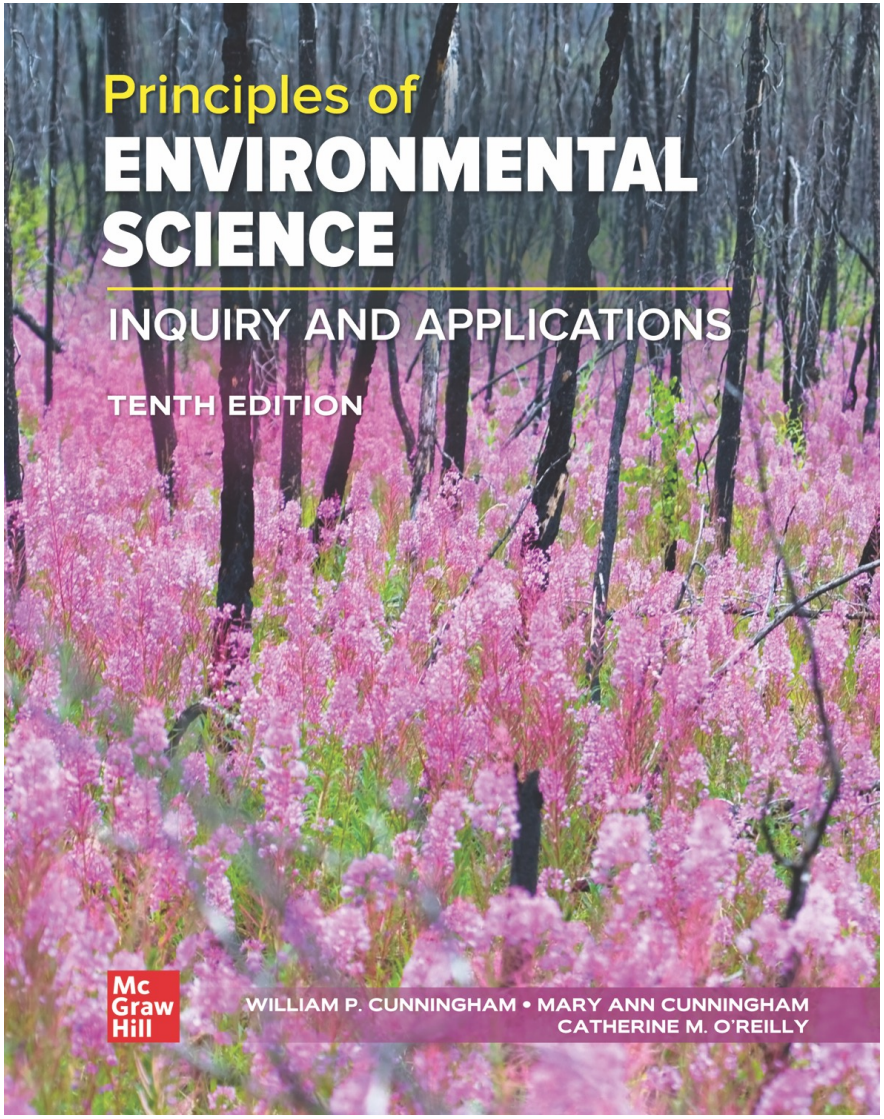
# Chapter 8 Lecture Outline



# Learning Outcomes

***After studying this chapter, you should be able to answer the following questions:***

- What is environmental health?
- What health risks should worry us most?
- Emergent diseases seem to be more frequent now.
- What human factors may be involved in this trend?
- When Paracelsus said, “The dose makes the poison,” what did he mean?
- What makes some chemicals dangerous and others harmless?
- What factors influence how we perceive risk?

***To wish to become well is a part of becoming well.***

**–Seneca**

# CASE STUDY: The Once and Future Pandemic

Most emerging viruses occur when a virus mutates and jumps from another species to humans.

Emergent viruses include Ebola, SARS, and SARS-CoV-2.



Lucia Terui/Moment Open/Getty Images

# 8.1 Environmental Health

**Health** is a state of complete physical, mental, and social wellbeing, not merely the absence of disease or infirmity.

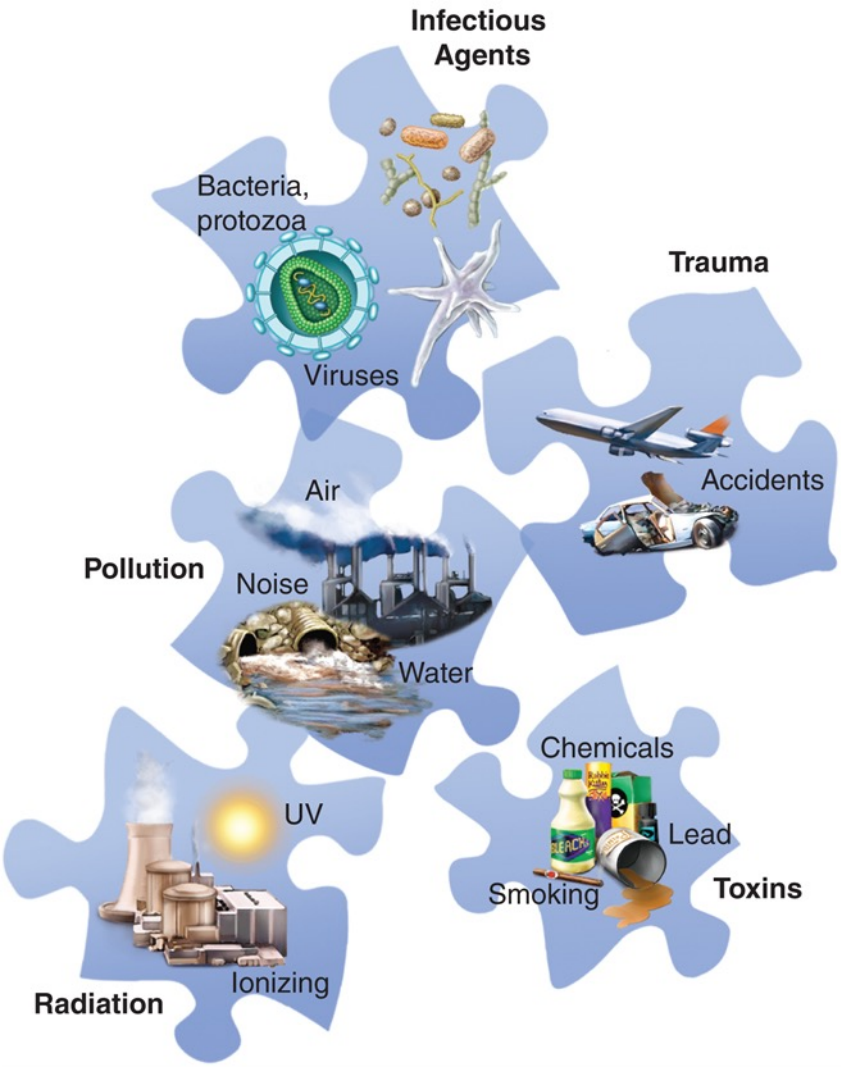
A **disease** is an abnormal change in the body's condition that impairs important physical or psychological functions.

**Morbidity** means illness.

**Mortality** means death.

**Environmental health** focuses on factors that cause disease, including elements of the natural, social, cultural, and technological worlds in which we live.

# Major Sources of Environmental Health Risks

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# Global Disease Burden Is Changing

Health organizations used to focus on the leading causes of death as a measure of world health.

Health agencies now calculate **disability-adjusted life years (DALYs)** as a measure of disease burden.

The world is now undergoing a dramatic epidemiological transition. Chronic conditions, such as cardiovascular disease and cancer, no longer afflict only wealthy people. Meanwhile, traditional killers in developing countries—infections, maternal and perinatal (birth) complications, and nutritional deficiencies—still take a terrible toll.

# Chronic Conditions Now Outweigh Infectious Diseases

**TABLE 8.1** | Global Disease Burden, Ranked by Percentage of DALYs[1]

| 1990 | % | 2019 | % |
|---|---|---|---|
| Childbirth[2] | 9.4 | Heart disease | 13.3 |
| Heart disease | 9.0 | Childbirth | 6.3 |
| Respiratory, TB[3] | 8.6 | Diabetes, CKD | 4.4 |
| Intestinal infections | 7.2 | Tumors | 4.1 |
| Malnutrition | 3.1 | Respiratory, TB | 3.6 |
| Tumors | 2.5 | Intestinal infections | 3.0 |
| COPD[4] | 2.2 | COPD | 2.5 |
| Infectious diseases | 2.0 | Malnutrition | 1.8 |
| Diabetes, CKD[5] | 1.9 | HIV/AIDs, STDs | 1.5 |
| Substance abuse | 0.9 | Substance abuse | 1.4 |

[1]Disability adjusted life years. Data source: Institute for Health Metrics and Evaluation, 2021

[2]Maternal and neonatal disorders

[3]Respiratory illnesses and tuberculosis

[4]Chronic obstructive pulmonary disorders

[5]Chronic kidney disease

Source: "Global Burden of Cardiovascular Diseases and Risk Factors, 1990–2019." Institute for Health Metrics and Evaluation, 2021
http://www.healthdata.org/research-article/global-burden-cardiovascular-diseases-and-risk-factors-1990%E2%80%932019.

# Infectious Diseases Still Kill Millions of People


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# Pathogens Are Disease-Causing Organisms

A wide variety of pathogens afflict humans, including viruses, bacteria, protozoans (single-celled animals), parasitic worms, and flukes.

The greatest loss of life from an individual disease in a single year was the great influenza pandemic of 1918.

**TABLE 8.4** | Lifetime Odds of Death, United States, 2018

| CAUSE | ODDS (1 IN X) |
|---|---|
| Heart disease | 6 |
| Cancer | 7 |
| Chronic respiratory disease | 26 |
| Suicide | 86 |
| Opioid overdose | 98 |
| Motor-vehicle crash | 106 |
| Fall | 111 |
| Gun assault | 298 |
| Pedestrian incident | 541 |
| Motorcycle riding | 890 |
| Drowning | 1,121 |
| Fire or smoke | 1,399 |
| Choking on food | 2,618 |
| Bicycling | 4,060 |
| Sunstroke | 7,770 |
| Accidental gun discharge | 9,077 |
| Electrocution, radiation | 12,484 |
| Sharp objects | 29,483 |
| Hornet, wasp, bees | 53,989 |
| Cataclysmic storm | 54,699 |
| Dog attack | 118,776 |
| Lightning | 180,746 |
| Riding on an airplane | NA[1] |

[1]Too few deaths in 2018 to calculate odds
Data source: National Safety Council, 2021.

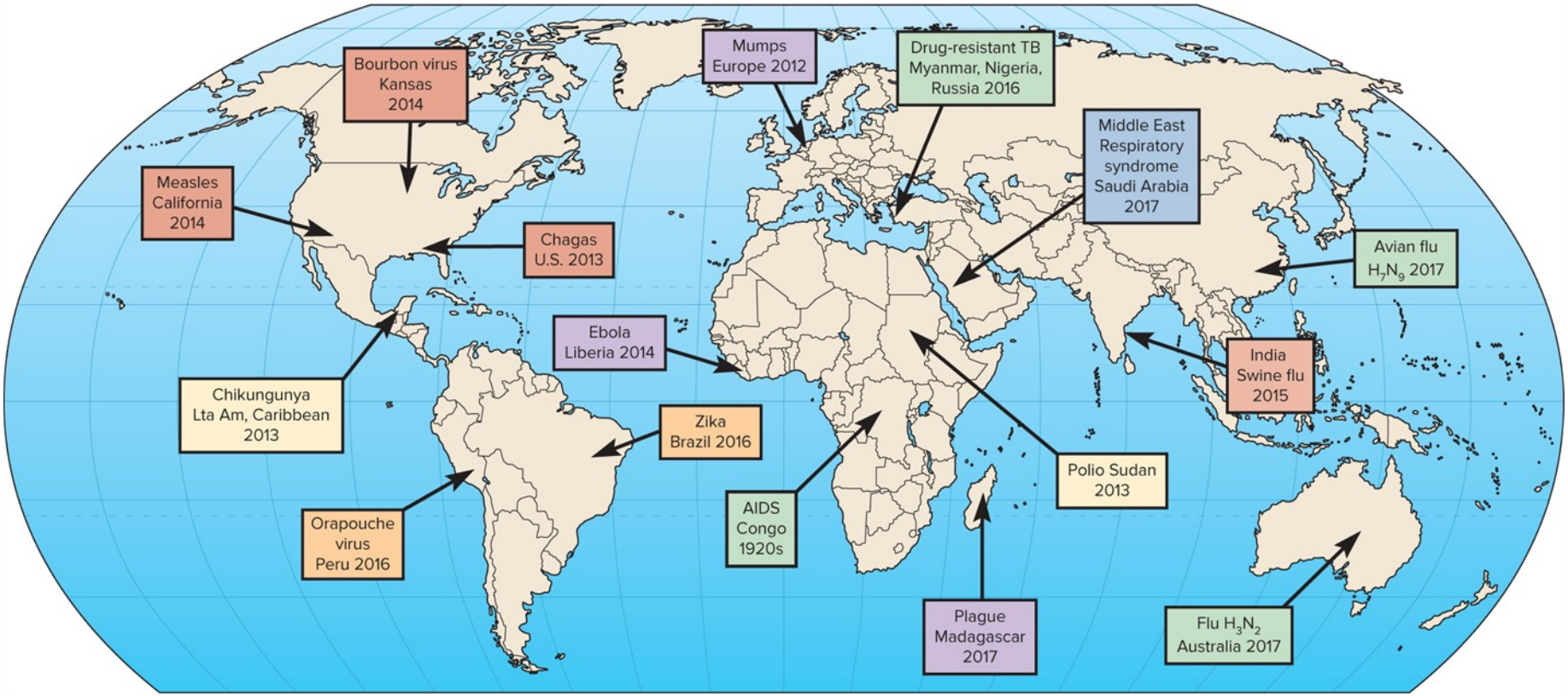
# Emergent Diseases Jump to Humans from Wild Species

Malaria is one of the most prevalent remaining infectious diseases. Every year about 500 million new cases of this disease occur, and about one million people die from it.

**Emergent diseases** are those not previously known or that have been absent for at least 20 years.

- The H1N1 new strain of bird flu that spread around the world in 2009.
- There have been at least 40 outbreaks of emergent diseases over the past two decades, including the Ebola and Marburg fevers.

# Outbreaks of Infectious Diseases

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Data from U.S. Center for Disease Control and Prevention, 2018.

# The Spread of Ebola

The 2014 Ebola oubreak in West Africa illustrations how rapidly infectious diseases can spread.

Ebola, caused by a filovirus, causes a high fever and diarrhea followed by acute bleeding.

Spread is rapid from person to person through contact with infected bodily fluids such as blood.

Kenzo Tribouillard/AFP/Getty Images

# Novel Diseases Also Threaten Wild Species

Humans aren't the only ones to suffer from new and devastating diseases. Wildlife also experience widespread epidemics, which are sometimes called **ecological diseases**.

We are coming to recognize that the delicate ecological balances that we value so highly—and disrupt so frequently—are important to our own health.

**Conservation medicine** attempts to understand how our environmental changes threaten our own health as well as that of the natural communities on which we depend for ecological services.

# Frogs and Toads Are Succumbing to a Deadly Disease



Rosalie Kreulen/Shutterstock

# Overuse of Antibiotics Breeds Super Bugs

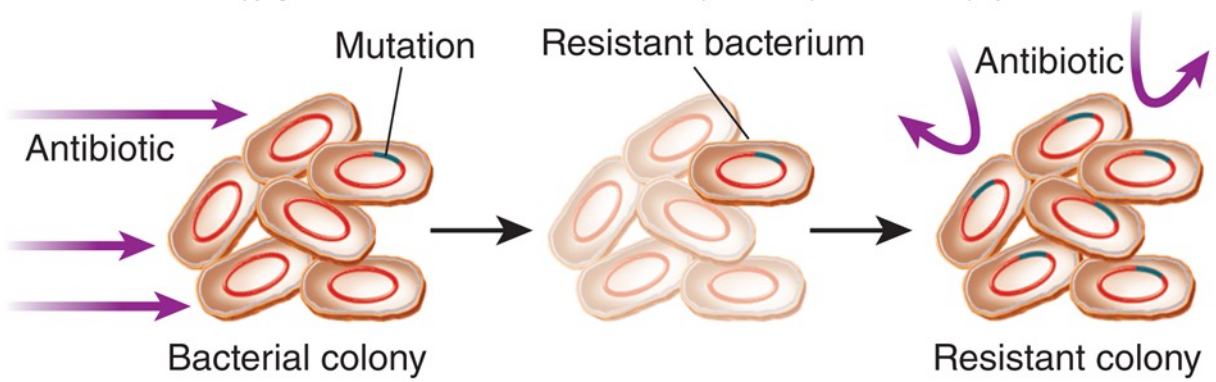
In recent years, health workers have become increasingly alarmed about the rapid spread of methicillin-resistant *Staphylococcus aureus (MRSA).*

Why have vectors, such as mosquitoes, and pathogens, such as bacteria or the malaria parasite, become resistant to pesticides and antibiotics?

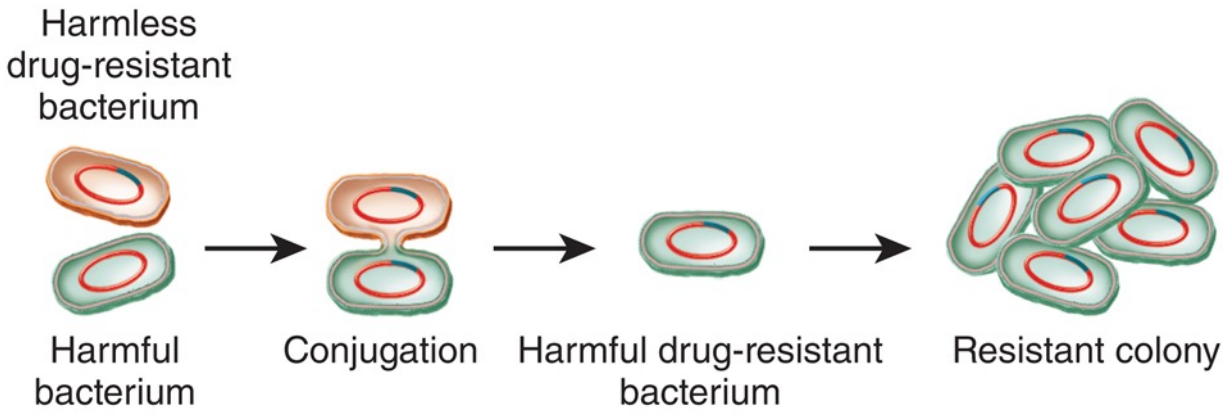
Part of the answer is natural selection and the ability of many organisms to evolve rapidly.

Another factor is the human tendency to use control measures carelessly.

# How Microbes Acquire Antibiotic Resistance




a) Mutation and selection create drug-resistant strains.




b) Conjugation transfers drug resistance from one strain to another.



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# 8.2 Environmental Toxics

**Toxicology** is the study of the adverse effects of external factors on an organism or a system.

This includes environmental chemicals, drugs, and diet as well as physical factors, such as ionizing radiation, UV light, and electromagnetic forces.

Toxins often are harmful even in extremely dilute concentrations. In some cases, billionths, or even trillionths, of a gram can cause irreversible damage.

**Environmental toxicology** specifically deals with the interactions, transformation, fate, and effects of toxins in the biosphere, including individual organisms, populations, and whole ecosystems.

# Top 20 Toxic and Hazardous Substances

**TABLE 8.2** | Top 20 Toxic and Hazardous Substances

| MATERIAL | MAJOR SOURCES |
|---|---|
| 1. Arsenic | Treated lumber |
| 2. Lead | Paint, gasoline |
| 3. Mercury | Coal combustion |
| 4. Vinyl chloride | Plastics, industrial uses |
| 5. Polychlorinated biphenyls (PCBs) | Electric insulation |
| 6. Benzene | Gasoline, industrial use |
| 7. Cadmium | Batteries |
| 8. Benzo(a)pyrene | Waste incineration |
| 9. Polycyclic aromatic hydrocarbons | Combustion |
| 10. Benzo(b)fluoranthene | Fuels |
| 11. Chloroform | Water purification, industry |
| 12. DDT | Pesticide use |
| 13. Aroclor 1254 | Plastics |
| 14. Aroclor 1260 | Plastics |
| 15. Trichloroethylene | Solvents |
| 16. Dibenz (a, h)anthracene | Incineration |
| 17. Dieldrin | Pesticides |
| 18. Chromium, hexavalent | Paints, coatings, welding, anticorrosion agents |
| 19. Chlordane | Pesticides |
| 20. Hexachlorobutadiene | Pesticides |

Source: Data from U.S. Environmental Protection Agency.

# How Do Toxins Affect Us?

**Allergens** are substances that activate the immune system.

- Some allergens act directly as antigens.

**Antigens** are substances (pollen, bacteria, etc.) recognized as foreign by white blood cells and stimulate the production of specific antibodies.

**Antibodies** are proteins produced by our bodies that recognize and bind to foreign cells or chemicals.

# Sick Building Syndrome

Formaldehyde is a good example of a widely used chemical that is a powerful sensitizer of the immune system.

Widely used in plastics, wood products, insulation, glue, and fabrics, formaldehyde concentrations in indoor air can be thousands of times higher than in normal outdoor air.

**Sick building syndrome** is a condition characterized by headaches, allergies, and chronic fatigue caused by poorly vented indoor air contaminated by various contaminants.

# Classes of Harmful Agents

**Neurotoxins** are a special class of metabolic poisons that specifically attack nerve cells (neurons).

**Mutagens** are agents, such as chemicals and radiation, that damage or alter genetic material (DNA) in cells.

**Teratogens** are chemicals or other factors that specifically cause abnormalities during embryonic growth and development.

**Carcinogens** are substances that cause cancer.

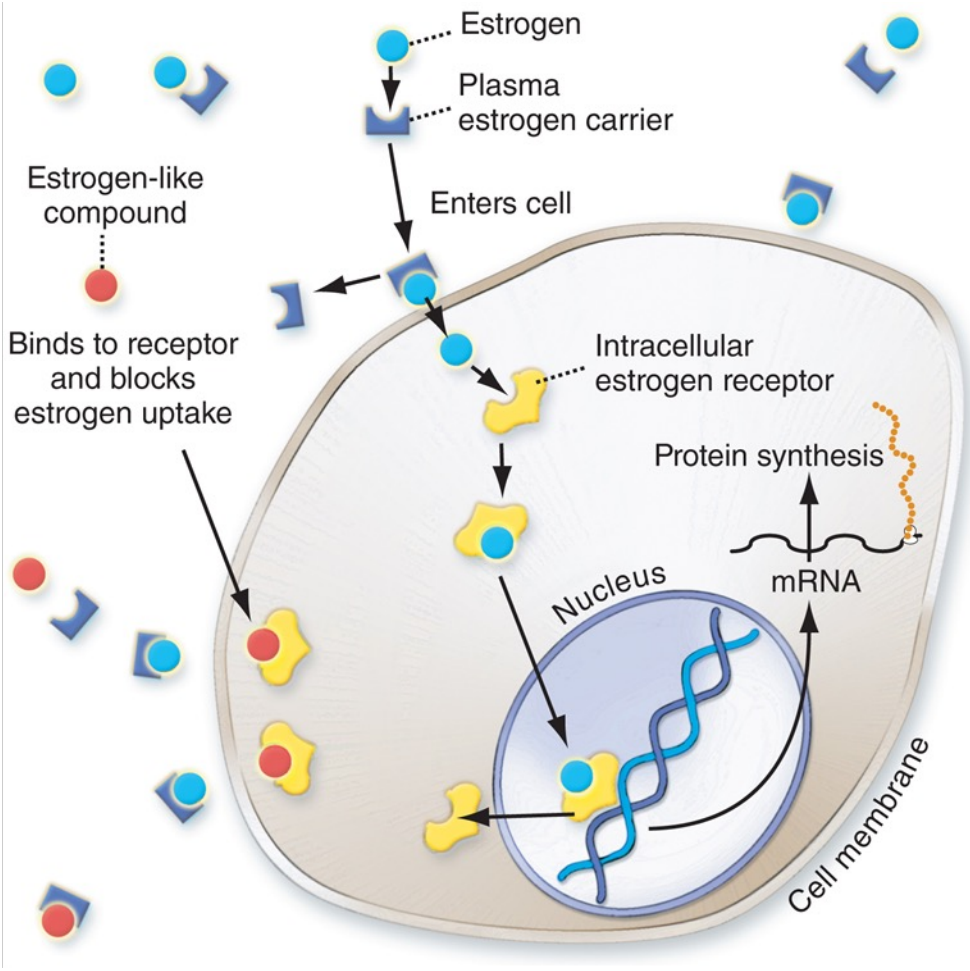
# Endocrine Disrupters Affect Hormones

**Endocrine hormone disrupters** are chemicals that interrupt the normal endocrine hormone functions.

Some of the most insidious effects of persistent chemicals, such as DDT and PCBs, are that they interfere with normal growth, development, and physiology of a variety of animals at very low doses.

These chemicals are sometimes called **environmental estrogens** or **androgens**, because they often cause reproductive health problems in females or feminization of males.

# Effects of Steroid Hormones on a Cell

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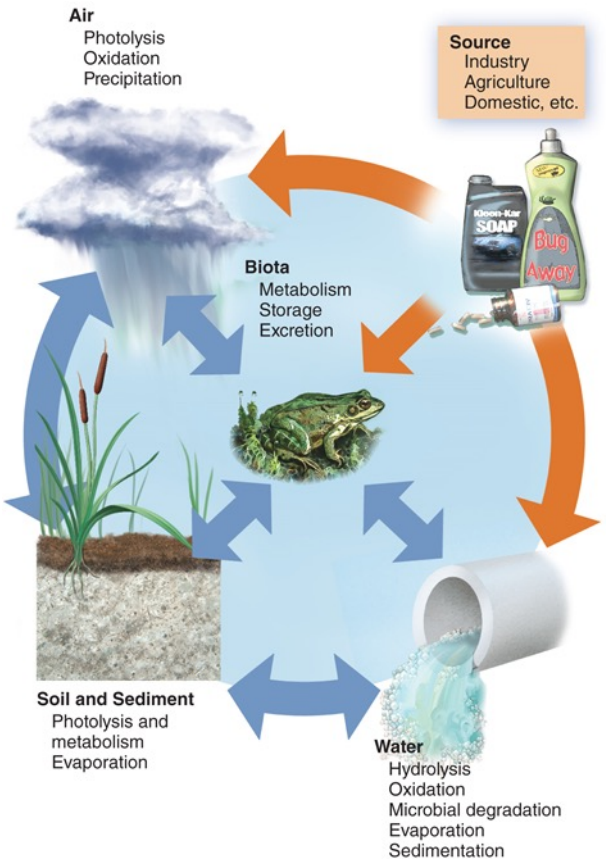
# 8.3 Mobility of Toxic Substances

We can think of both individuals and an ecosystem as sets of interacting compartments between which chemicals move, based on molecular size, solubility, stability, and reactivity

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# Factors in Environmental Toxicity

**TABLE 8.3** | Factors in Environmental Toxicity

| FACTORS RELATED TO THE TOXIC AGENT |
| --- |
| 1. Chemical composition and reactivity |
| 2. Physical characteristics (such as solubility, state) |
| 3. Presence of impurities or contaminants |
| 4. Stability and storage characteristics of toxic agent |
| 5. Availability of vehicle (such as solvent) to carry agent |
| 6. Movement of agent through environment and into cells |
| **FACTORS RELATED TO EXPOSURE** |
| 1. Dose (concentration and volume of exposure) |
| 2. Route, rate, and site of exposure |
| 3. Duration and frequency of exposure |
| 4. Time of exposure (time of day, season, year) |
| **FACTORS RELATED TO THE ORGANISM** |
| 1. Resistance to uptake, storage, or cell permeability of agent |
| 2. Ability to metabolize, inactivate, sequester, or eliminate agent |
| 3. Tendency to activate or alter nontoxic substances so they become toxic |
| 4. Concurrent infections or physical or chemical stress |
| 5. Species and genetic characteristics of organism |
| 6. Nutritional status of subject |
| 7. Age, sex, body weight, immunological status, and maturity |

# Some Compounds Dissolve in Water, Others in Oils

Solubility is one of the most important characteristics in determining how, a toxic material will move through the environment or through the body to its site of action.

Chemicals can be divided into 2 major groups:

- Water soluble compounds move rapidly and widely through the environment because water is ubiquitous.
- Molecules that are oil- or fat-soluble generally need a carrier to move through the environment.

# Exposure and Susceptibility Determine How We Respond [1]

There are many routes for toxins to enter our bodies.

Airborne toxins generally cause more ill health than any other exposure source; however, food, water, and skin contact can also expose us to a wide variety of hazards.

Age matters and general health matters: healthy adults, for example, may be relatively insensitive to doses that are very dangerous to young children or to someone already weakened by other diseases.

Lead is the most common toxin in children.

# Exposure and Susceptibility Determine How We Respond 2


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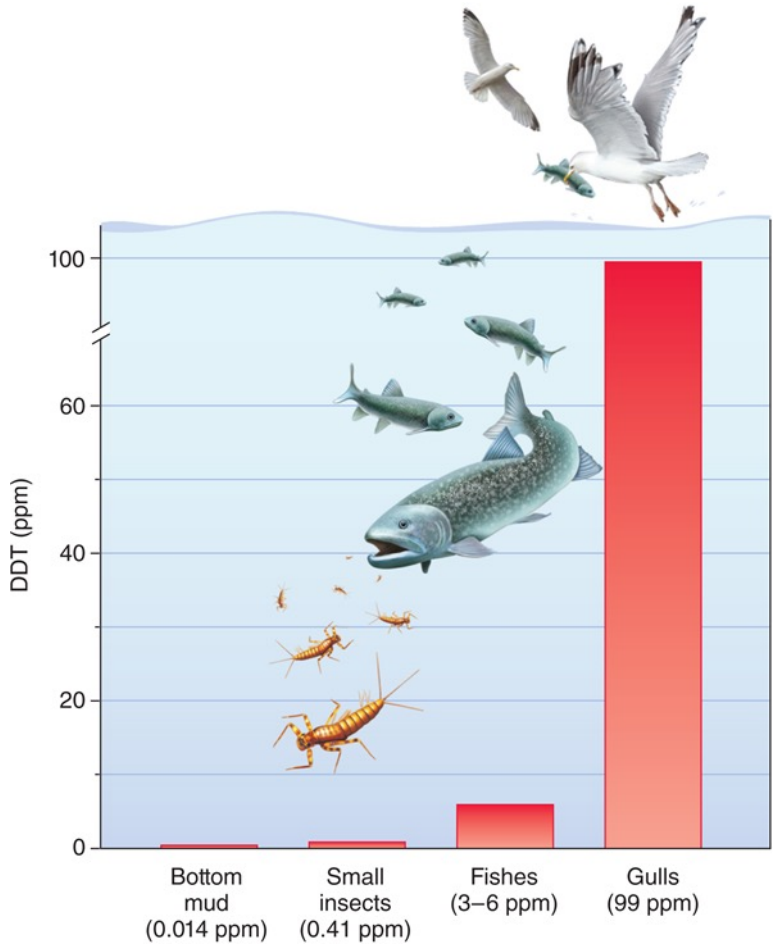
# Bioaccumulation and Biomagnification

**Bioaccumulation** refers to the fact that organisms may selectively absorb and store toxins in their bodies.

**Biomagnification** occurs when the toxic burden of a large number of organisms at a lower trophic level is accumulated and concentrated by a predator at a higher trophic level.

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# Persistence Makes Some Organic Pollutants Especially Harmful

Many substances degrade when exposed to sun, air, and water. This can destroy them or convert them to inactive forms.

Some materials are persistent and can last for years or even centuries as they cycle through ecosystems.

Examples:

- Heavy metals: lead and mercury.
- Many organic compounds, such as PVC plastics and chlorinated hydrocarbon pesticides.

# Chemical Interactions Can Increase Toxicity

Some materials produce **antagonistic reactions**. That is, they interfere with the effects or stimulate the breakdown of other chemicals.

Other materials are **additive** when they occur together in exposures.

**Synergism** is an interaction in which one substance exacerbates the effects of another.

# 8.4 Toxicity and Risk Assessment

“The dose makes the poison” — this means that almost everything is toxic at very high levels, but can be safe if diluted enough.

This remains the most basic principle of toxicology.

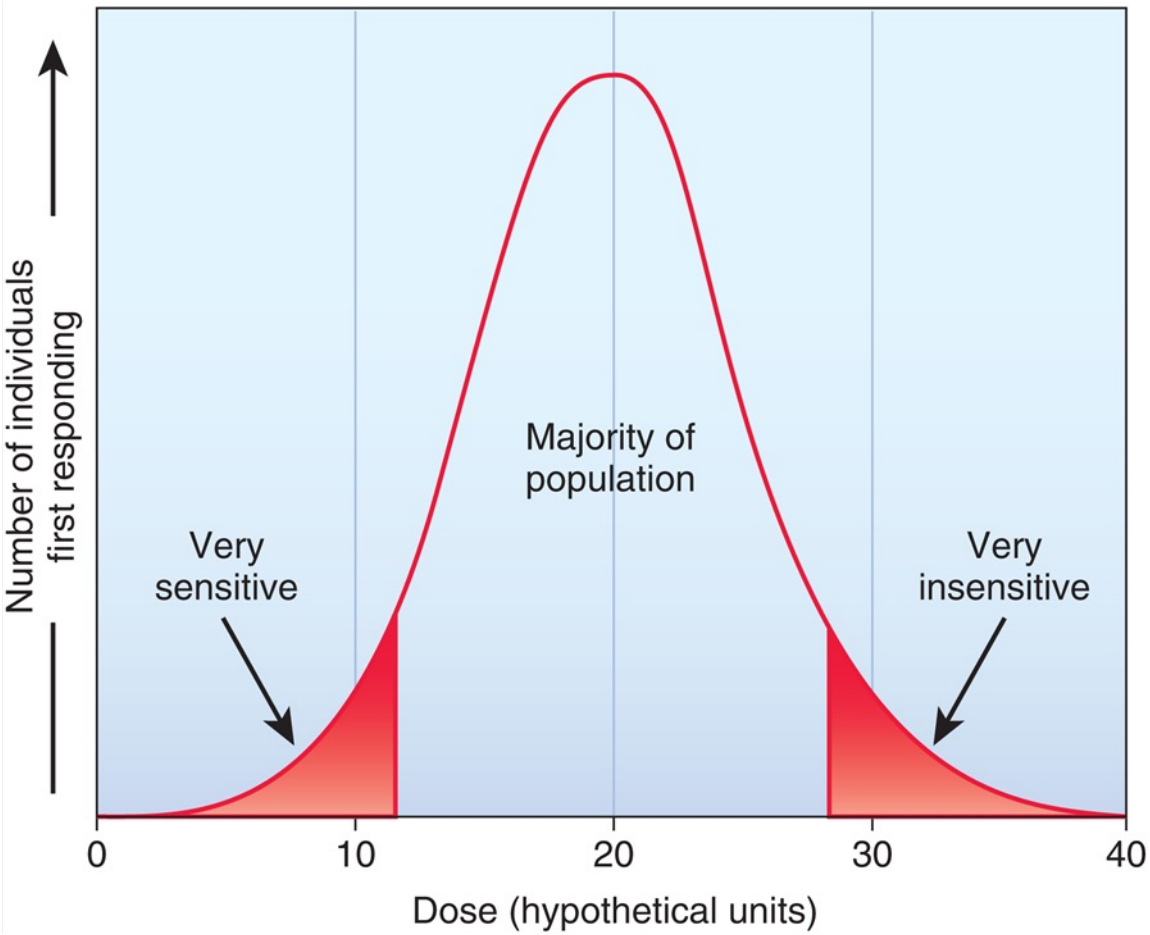
How a material is delivered and at what rate plays a vital role in determining toxicity.

# We Usually Test Toxic Effects on Lab Animals

The most commonly used and widely accepted toxicity test is to expose a population of laboratory animals to measured doses of a specific substance under controlled conditions.

It commonly takes hundreds—or even thousands—of animals, several years of hard work, and hundreds of thousands of dollars to thoroughly test the effects of a toxic at very low doses.

# Animal Testing Is Complicated by Differences in Toxic Sensitivity Between Individual Animals

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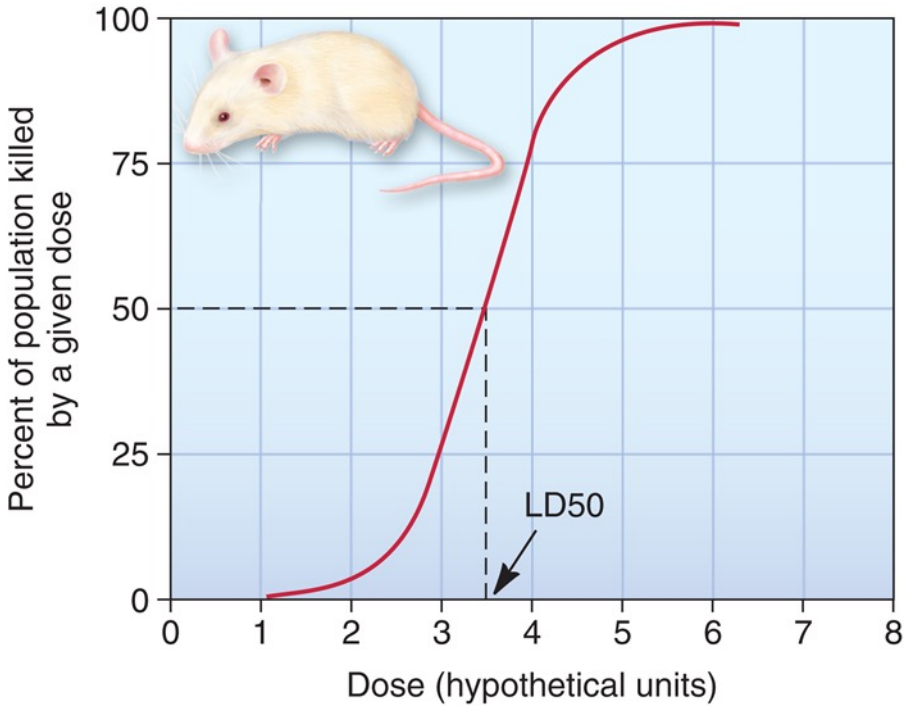
# Dose Response Curves Help Us Determine Toxicity

A convenient way to describe toxicity of a chemical is to determine the dose to which 50 percent of the test population is sensitive.

In the case of a lethal dose (LD), this is called the **LD50**.

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# There Is a Wide Range of Toxicity

It is useful to group materials according to their relative toxicity.

A moderately harmful toxin takes about 1 gram per kilogram of body weight to make a lethal dose.

Very toxic materials take about 1/10 of that amount.

Extremely toxic substances take 1/100 as much (only a few drops) to kill most people.

Supertoxic chemicals are extremely potent; for some, a few micrograms (millionths of a gram) is enough for a lethal dose.

# Toxins Can Have Acute or Chronic Doses and Effects

**Acute effects** are caused by a single exposure to the toxin and result in an immediate health crisis.

**Chronic effects** are long-lasting, perhaps even permanent. A chronic effect can result from a single dose of a very toxic substance, or it can be the result of a continuous or repeated sublethal exposure.

Unlike acute effects, it is usually difficult to assess the specific health risks of chronic exposures because other factors, such as aging or normal diseases, act simultaneously with the factor under study.

# Degree of Toxicity Varies Widely

A complication in assessing risk is that the effects of low doses of some toxins and health hazards can be nonlinear.

They may be either more or less dangerous than would be predicted from exposure to higher doses.

For example, low doses of DHEP suppress activity of an enzyme essential for rat brain development. This is surprising because higher doses stimulated this enzyme.

# Risk Assessment

Even if we know with some certainty how toxic a specific chemical is in laboratory tests, it is still difficult to determine risk**.**

**Risk** is the probability of harm times the probability of exposure if that chemical is released into the environment.

Many factors complicate the movement and fate of chemicals both around us and within our bodies.

Public perception of environmental hazards can be inconsistent with actual risks.

# Our Perception of Risks Is Not Always Rational

A number of factors influence how we perceive relative risks associated with different situations.

People with social, political, or economic interests tend to downplay certain risks and emphasize others that suit their own agendas.

Our personal experiences often are misleading. When we have not personally experienced a bad outcome, we feel it is more rare and unlikely to occur than it actually may be.

We have an exaggerated view of our own abilities to control our fate.

# How Risky Is Skateboarding?



Drpixel/Shutterstock

# How Much Risk Is Acceptable?

How much is it worth to minimize and avoid exposure to certain risks?

Most people will tolerate a higher probability of occurrence of an event if the harm caused by that event is low. Conversely, harm of greater severity is acceptable only at low levels of frequency.

The EPA generally assumes that a risk of 1 in 1 million is acceptable for most environmental hazards. For activities that we enjoy, we are often willing to accept far greater risks than this general threshold.

# Relative Risks of Death from Various Causes

**TABLE 8.4** | Lifetime Odds of Death, United States, 2018

| CAUSE | ODDS (1 IN X) |
|---|---|
| Heart disease | 6 |
| Cancer | 7 |
| Chronic respiratory disease | 26 |
| Suicide | 86 |
| Opioid overdose | 98 |
| Motor-vehicle crash | 106 |
| Fall | 111 |
| Gun assault | 298 |
| Pedestrian incident | 541 |
| Motorcycle riding | 890 |
| Drowning | 1,121 |
| Fire or smoke | 1,399 |
| Choking on food | 2,618 |
| Bicycling | 4,060 |
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| Sharp objects | 29,483 |
| Hornet, wasp, bees | 53,989 |
| Cataclysmic storm | 54,699 |
| Dog attack | 118,776 |
| Lightning | 180,746 |
| Riding on an airplane | NA[1] |

[1]Too few deaths in 2018 to calculate odds

Data source: National Safety Council, 2021.

# Take-Away Points

We have made marvelous progress in reducing some of the worst diseases that have long plagued humans.

However, chronic conditions that once were confined to richer countries have now become leading health problems nearly everywhere.

New, emergent diseases are appearing at an increasing rate. With increased international travel, diseases can spread around the globe in a few days.

In addition, modern industry is introducing thousands of new chemicals every year, most of which aren't studied thoroughly for long-term health effects.


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