Human Health & Environmental Risks

Chapter 17

VI. Pollution (25-30%)

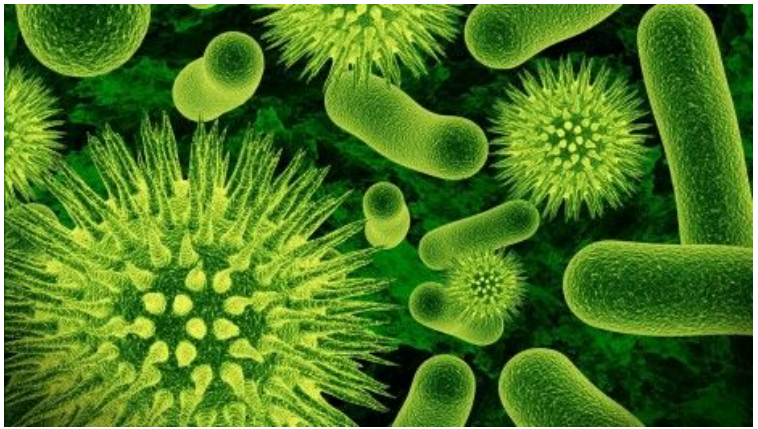
B. Impacts on the Environment and Human Health

Module 56: Human Diseases

After this module you will be able to……

1) Identify the different types of human diseases
2) Understand risk factors for human chronic diseases
3) Discuss historically important human diseases
4) Identify major emergent infectious diseases
5) Discuss future challenges for improving human health

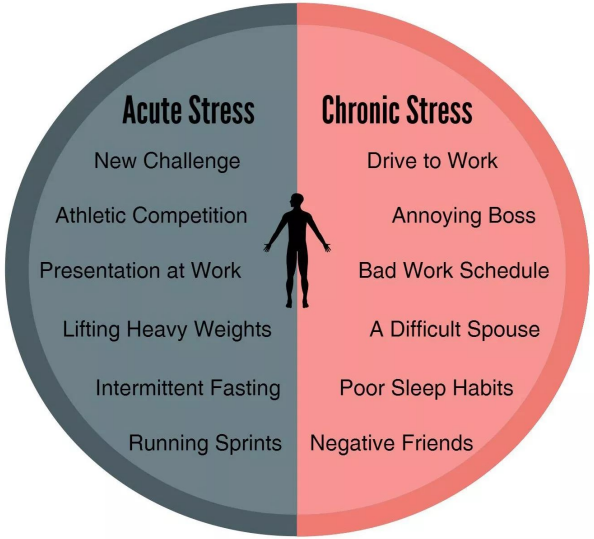
Human Diseases



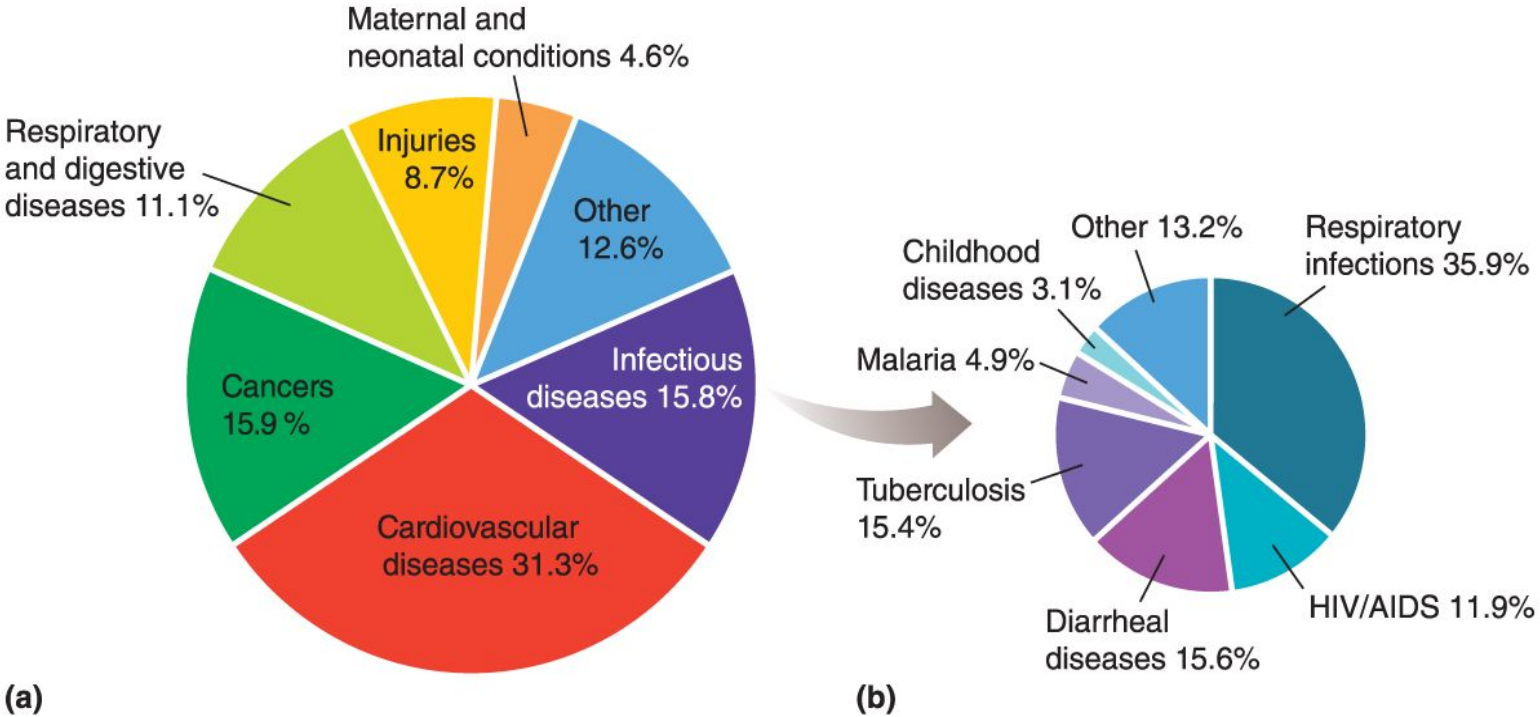
A **disease** is any impaired function of the body with a characteristic set of symptoms.

Infectious diseases are diseases caused by infectious agents, known as pathogens, and cause about ¼ of worldwide deaths. Noninfectious diseases are not caused by pathogens and include most cardiovascular diseases, respiratory and digestive diseases, and most cancers.

Human Disease



Acute diseases rapidly impair the functioning of a person's body. **Chronic diseases**, however, is a disease that slowly impairs the functioning of a person's body.



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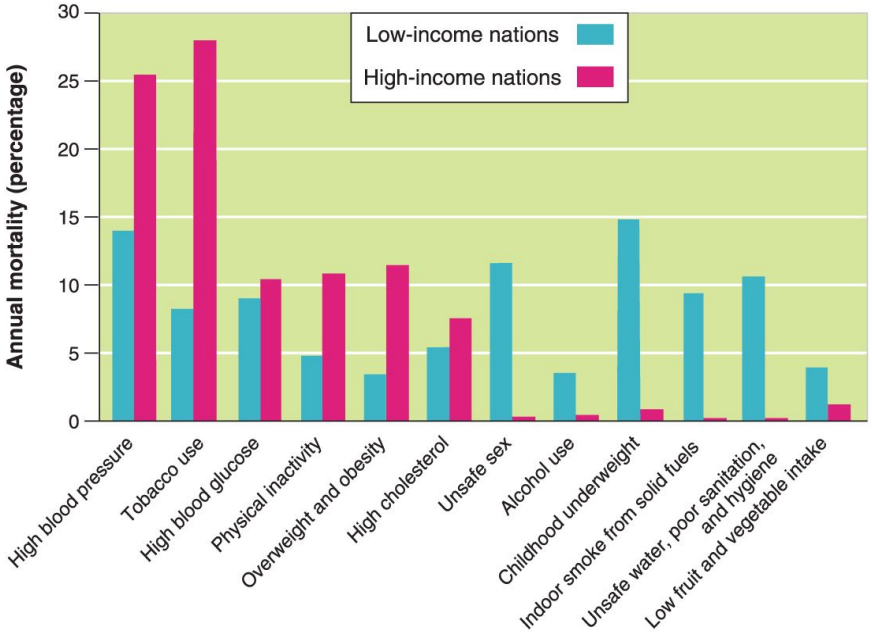
Data from Global Health Estimates 2015: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2015. Geneva, World Health Organization, 2016.

FIGURE 56.1 Leading causes of death in the world. (a) More than three-quarters of all world deaths are caused by diseases, including respiratory and digestive diseases, various cancers, cardiovascular diseases, and infectious diseases. (b) Among the world's deaths caused by infectious diseases, 94 percent are caused by only six types of diseases.

Risk Factors

Numerous factors cause people to be at greater risk for chronic diseases such as cancer, cardiovascular diseases, diabetes, and chronic infections diseases. The WHO has found that these risk factors differ substantially between low-income and high-income countries.

In low-income countries, risk factors leading to chronic diseases are associated with poverty while affluent nations have risk factors associated with less-active lifestyles, overeating, and tobacco availability. This change in risk factors occurs overtime as countries become more affluent.



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Data from World Health Organization, 2009.

FIGURE 56.2 Leading health risks in the world. If we consider all deaths that occur and separate them into different causes, we can examine which categories cause the highest percentage of all deaths. The leading health risks for low-income countries include issues related to low nutrition and poor sanitation. The leading risks for high-income countries include issues related to tobacco use, inactivity, obesity, and urban air pollution.

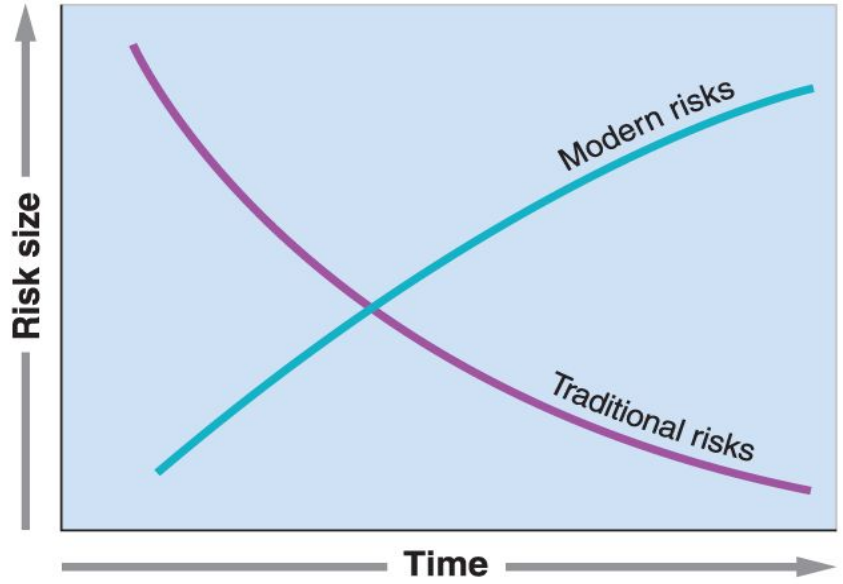

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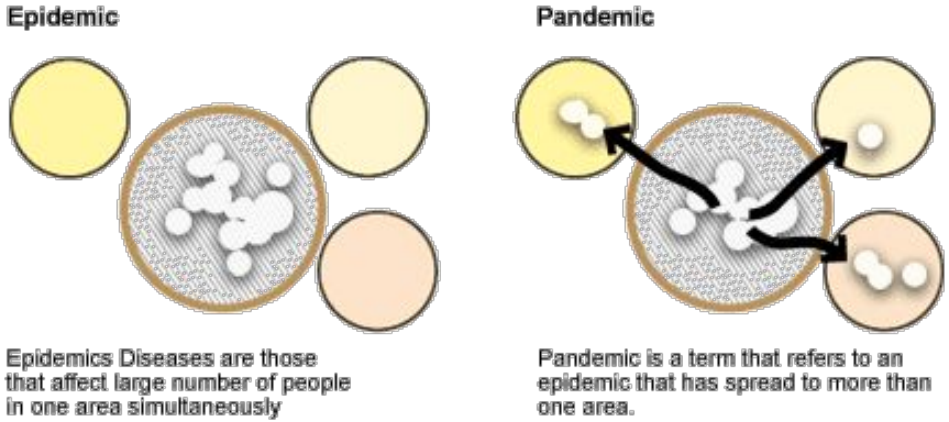
FIGURE 56.3 The transition of risk. As a nation becomes more developed over time and attains higher income levels, the risks of inadequate nutrition and sanitation decline while the risks of tobacco, obesity, and poor urban air quality rise.

Historic Diseases

When a pathogen causes a rapid increase in disease, we call it an **epidemic**. When this occurs over a large geographic region, such as an entire continent, we call it a **pandemic**. Some historic diseases that are passed between hosts include *plague*, *malaria*, and *tuberculosis*.



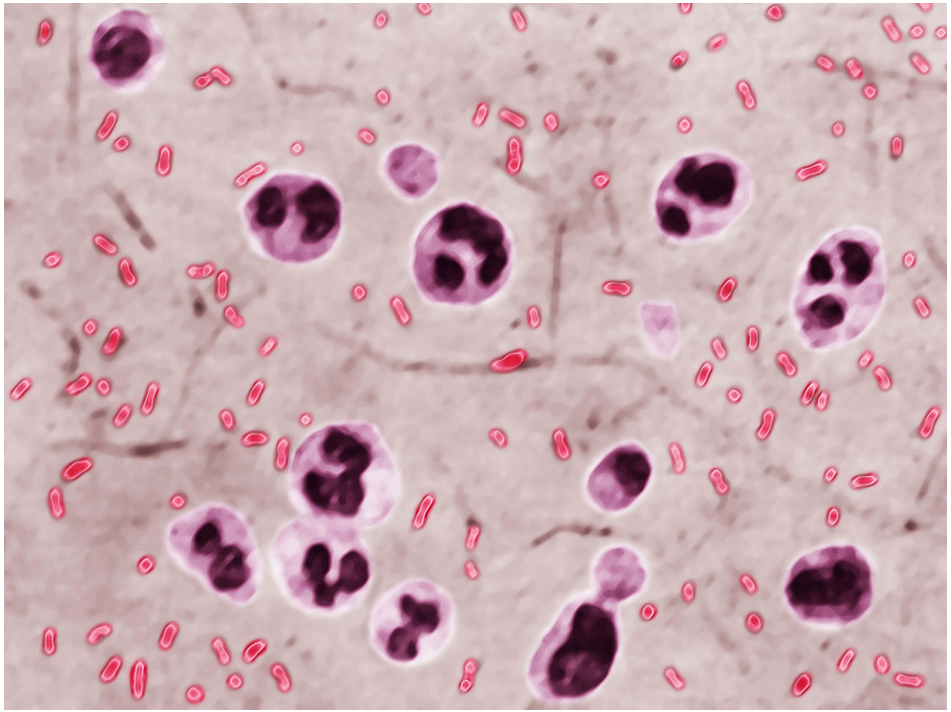
Historic Diseases - Plague

Plague is caused by an infection from a bacterium (*Yersinia pestis*) that is carried by fleas. The fleas attach to rodents to which increases their mobility. Historical names that are very common are *bubonic plague* and *Black Death*.

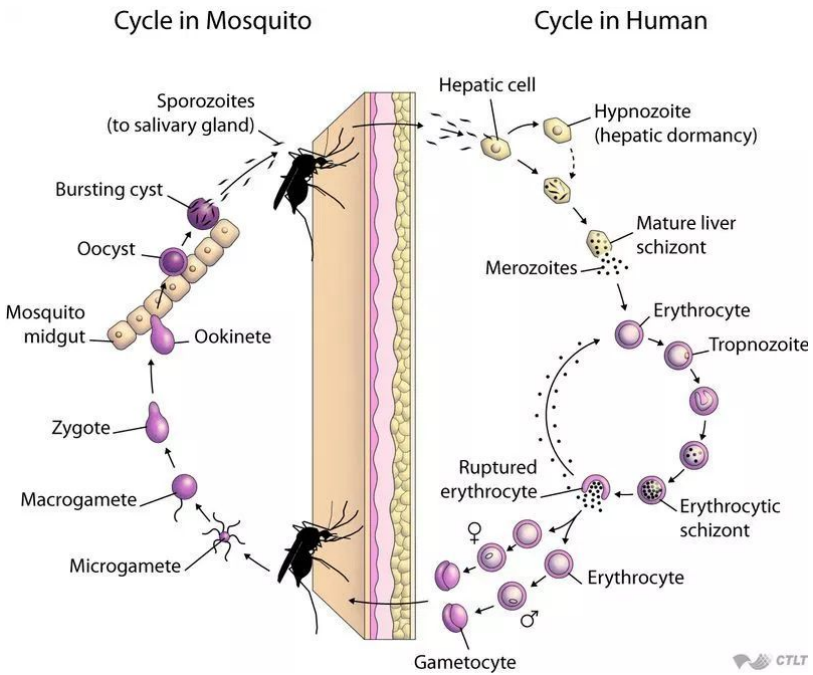
Infected individuals experience swollen glands, black spots on their skin, and extreme pain. Plague is estimated to have killed hundreds of millions of people throughout history, including nearly ¼ of the European population in the 1300's.

The last major pandemic of plague occured in Asia in the early 1900's. Today, there are still small outbreaks, such as the one in Madagascar in 2017 which infected more than 2,000 people. Fortunately, modern antibiotics are effective at killing the bacterium and preventing human death.

Historic Diseases - Plague



Historic Diseases - Malaria



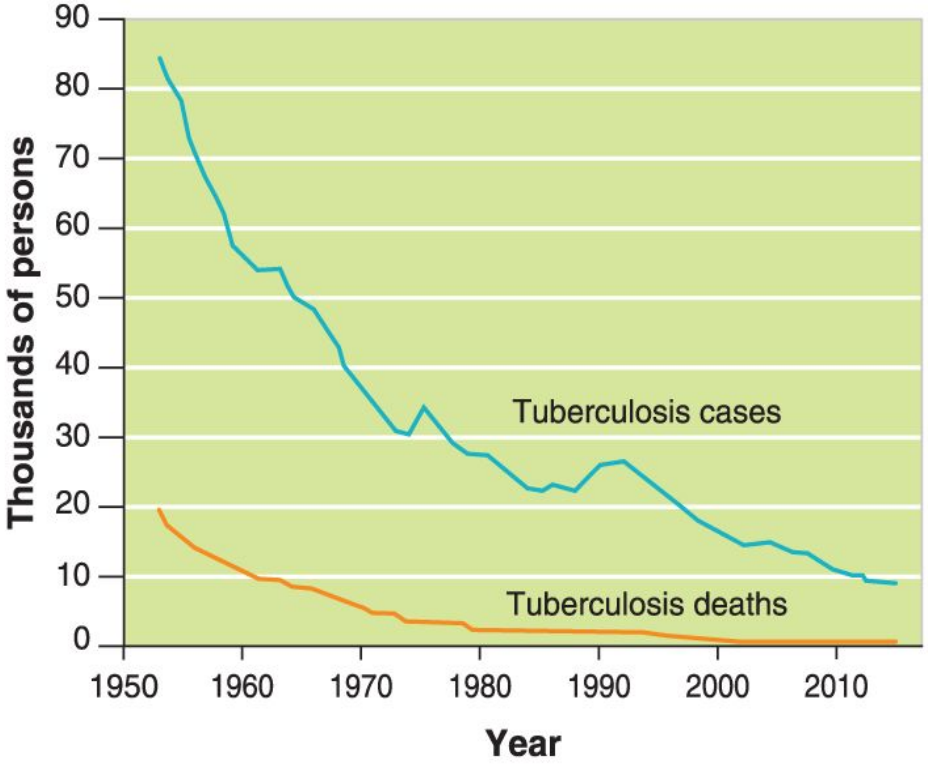
Malaria is caused by an infection from several species of protists in the genus *Plasmodium*. Malaria has also killed millions of people over the centuries. The malaria parasite spends one state of its life inside a mosquito and another stage of its life inside a human. The regions most affected by malaria include sub-Saharan Africa, Asia, the Middle East, and Central and South America.

The malaria parasite has been eliminated from the United States since 1951 by mosquito eradication programs. Although there are more than 1,000 cases of malaria diagnosed each year in the United States, they are from people who have returned from regions of the world where the malaria parasite lives.

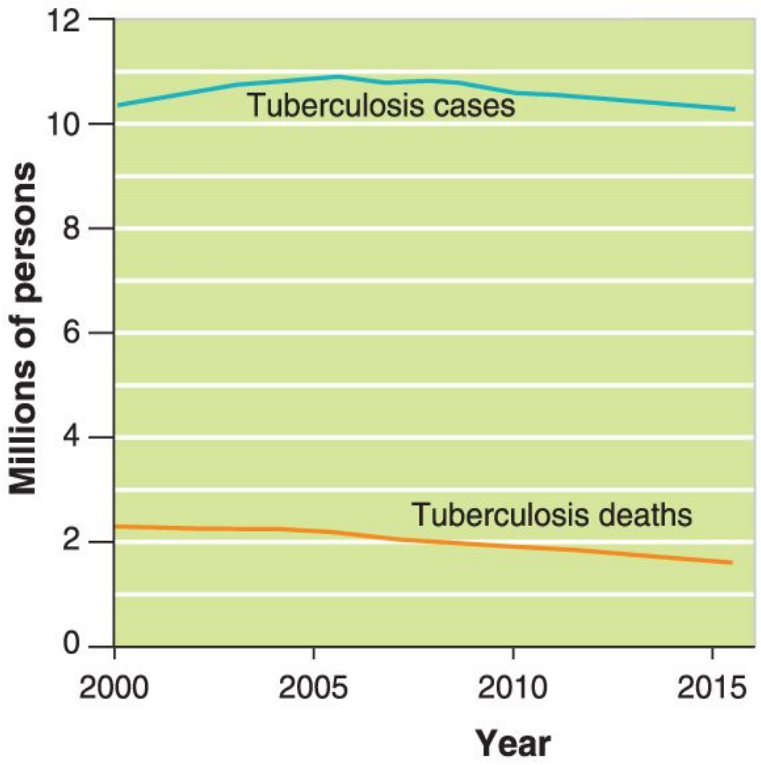
Historic Diseases - Tuberculosis

Tuberculosis is a highly contagious airborne disease caused by *Mycobacterium tuberculosis* that primarily infects the lungs. Symptoms include malaise, night-sweating, fever, and coughing up blood. As the case with many pathogens, a person can be infected but not develop the TB disease.

A year-long course of antibiotics can treat most TB infections and in developed countries, such as the United States, there has been a dramatic drops in TB cases. However, drug-resistant bacteria can be a problem if people do not finish taking the antibiotics.



(a) United States



(b) Worldwide

FIGURE 56.6 Tuberculosis cases and deaths. (a) Due to effective and available medicines, tuberculosis has gone from being one of the most deadly diseases in the United States to a disease that rarely kills. (b) Worldwide, tuberculosis has continued to infect and kill millions of people, especially in low- and middle-income countries.

Emergent Infectious Diseases

Emergent infectious diseases are diseases that have not been previously described or has not been common for at least 20 years. Since the 1970's, the world has observed an average of one emergent disease each year. Many of these diseases are due to pathogens that jump from animals to humans after a mutation. Many of the high-profile diseases that we tend to talk about are *HIV/AIDS*, *Ebola*, *mad cow disease*, *bird flu*, *SARS*, and *West Nile virus*.

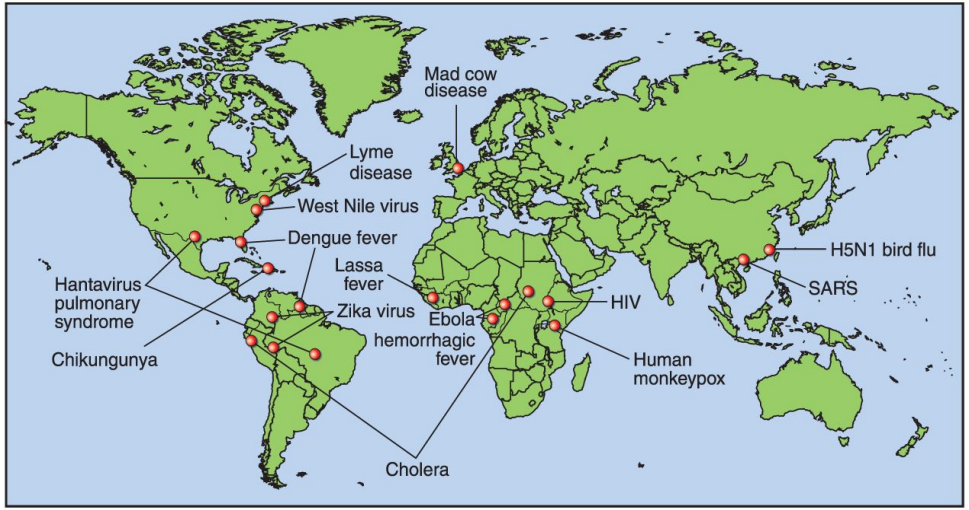


FIGURE 56.7 The emergence of new diseases. Since the 1970s, new diseases, or diseases that have been rare for more than 20 years, have been appearing throughout the world at a rate of approximately one per year.

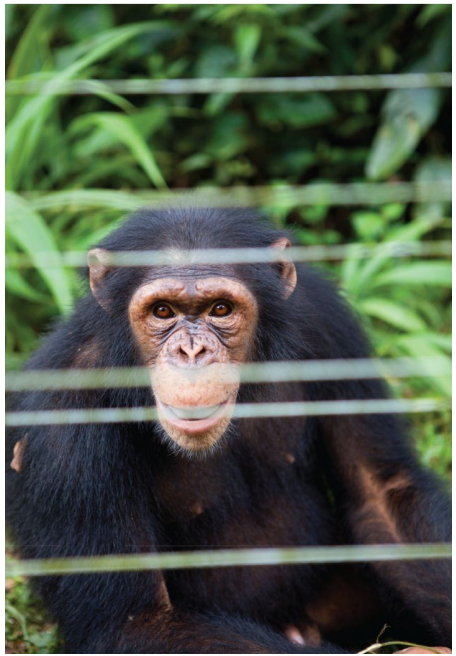


FIGURE 56.8 The source of HIV.
In 2006, researchers found that chimpanzees in Cameroon carried a virus that was genetically very similar to HIV. Thus, these chimps are the most likely source of this emerging human disease.

HIV/AIDS

In the late 1970's, rare types of pneumonia and cancer began appearing in individuals with weak immune systems. The condition responsible for the weakened immune systems was the disease **Acquired Immune Deficiency Syndrome (AIDS)**, which is caused by **Human Immunodeficiency Virus (HIV)**.

In 2006, researchers hypothesized that local hunters were exposed to the virus when butchering or eating chimps in the African community nation of Cameroon. According to the WHO, more than 70 million people in the world have been infected with HIV and about 35 million people have died from HIV-related illnesses. Fortunately, new antiviral drugs are able to maintain low HIV populations inside the human body.

Ebola Hemorrhagic Diseases

FIGURE 56.9 Ebola hemorrhagic fever. The Ebola virus is highly lethal to humans and there are only experimental drugs for treatment. When treating a person infected with the virus, such as this patient who escaped hospital quarantine from Elwa hospital in Monrovia, Liberia, researchers and medical workers have to exercise extreme caution to avoid getting infected.

In 1976, researches first discovered **Ebola hemorrhagic fever**, an infectious disease with high death rates (50-90%), caused by several species of Ebola viruses. It was first discovered near the Ebola River in the Democratic Republic of Congo when it infected several hundred humans and a variety of other primates from several countries in central Africa. Infections have been sporadic, but there was a large outbreak in 2014 that infected thousands of people.

Symptoms include vomiting, fever, and internal an external bleeding. Death usually occurs within 2 weeks. Currently, only experimental drugs exist to combat the virus.

Mad Cow Disease

In the 1980's, scientists first described a neurological disease known as **mad cow disease (bovine spongiform encephalopathy or BSE)**, which is a disease in which prions mutate into deadly pathogens and slowly damage a cow's nervous system. The cow loses coordination of its body and dies. This disease is caused by **prions**, or proteins that misfold and mutate into deadly proteins that act as pathogens in the brains of cattle. These prions are difficult to destroy by cooking, thus can be passed to humans in a form called Creutzfeldt-Jakob Disease (CJD).

FIGURE 56.10 Mad cow disease. Cows that have been fed the remains of dead cows and sheep can become infected with harmful prions. These prions damage the nervous system and cause the cows to develop glazed eyes, body tremors, and a loss of coordination, eventually leading to death. Humans who consume beef from infected cows can become infected and suffer a similar fate.

Mad Cow Disease

Note that mutant prions cannot be transmitted among cattle that only live together. Transmission requires an uninfected cow to consume the nervous system of an infected cow. As a result, when cattle feed on grass together in a pasture, a rare mutation in a prion would be restricted to a single cow and not spread to other cattle.

However, in the 1980's, the diets of European cattle commonly included the ground-up remains of dead cattle as a source of additional protein. This allows the prions to spread rapidly throughout the entire cattle population and then infect humans who ate the beef. It's estimated that several thousand people are currently infected, however, the prions can exist in the human body for many years before they begin to cause symptoms.

The European Union temporarily banned British beef imports in 1996 and the British government destroyed tens of thousands of cattle. Only six cases of mad cow disease were detected in from 2003 - 2018.

Swine Flu & Bird Flu

Swine flu is a type of flu caused by the H1N1 virus. The latest pandemic of swine flu was in 2009 and 2010 when it caused more than 18,000 deaths. In 2006, reports emerged from Asia that related to a virus known as H5N1, or **bird flu**. As of 2016, more than 800 people have become infected by H5N1 and over half of them died. Currently, bird flu is not easily passed among people, however, scientists estimate that H5N1 has the potential to kill 150 million people if there is a future mutation.

SARS and MERS

In 2003, an unusual form of pneumonia was spreading through the human populations in Southeast Asia that was eventually named **severe acute respiratory syndrome (SARS)**. While symptoms are similar to the flu, SARS is caused by a virus known as coronavirus. During this outbreak, it had an 11% fatality rate.

In 2012, another coronavirus known as *Middle Eastern Respiratory Syndrome (MERS)*, appeared in the Arabian Peninsula. To date, approximately 400 people have died from MERS.

West Nile Virus

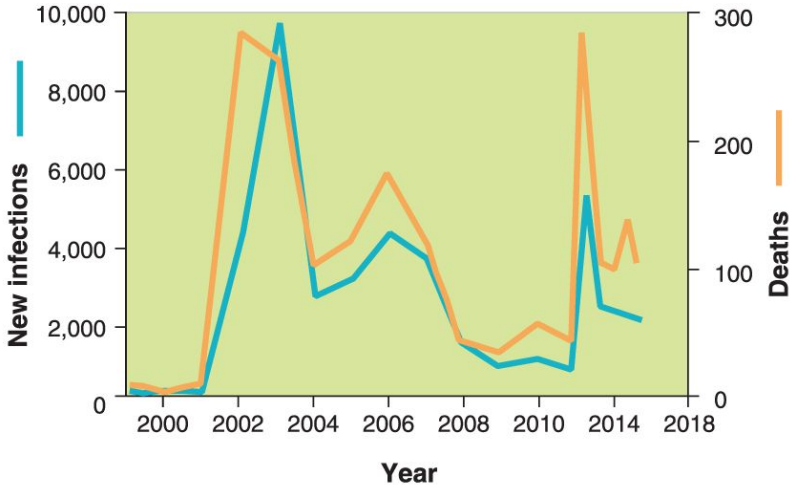


FIGURE 56.12 West Nile virus in the United States. Following the first appearance of West Nile virus in the United States in 1999, the number of human infections and deaths rapidly increased. Efforts to control populations of mosquitoes that carry the virus are helping to reduce the prevalence of the disease.

The **West Nile virus** lives in hundreds of species of birds and is transmitted among birds by mosquitoes. The virus is highly lethal to some birds, but most can survive the infection.

The first human case was identified in 1937 in the West Nile region of Uganda. In humans, the virus causes an inflammation of the brain leading to illness and sometimes death. There have been a few spikes of the West Nile virus in the last twenty years, but efforts to combat mosquito populations have helped decrease the overall infection rate.

Lyme Disease

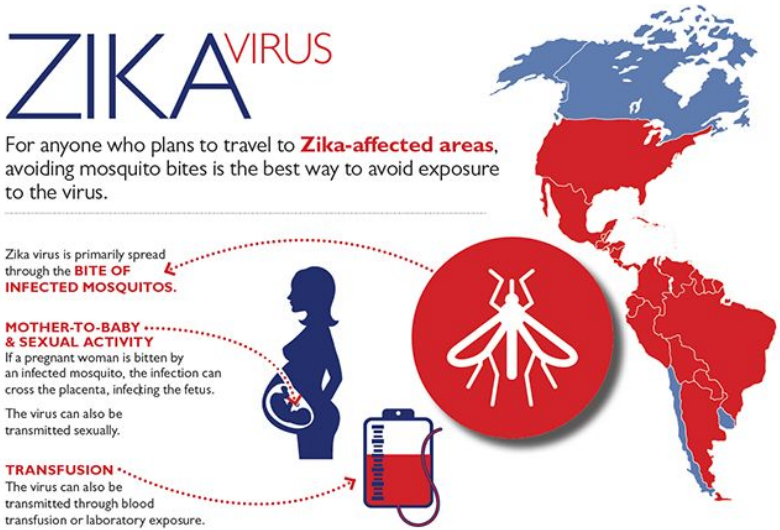
FIGURE 56.13 Deer tick. When deer ticks attach to birds and rodents infected by the Lyme bacteria, the pathogen can be transferred to the tick. After the tick drops off the bird or rodent and attaches to a person, the pathogen can be transferred to the person.

Lyme disease is a disease caused by a bacterium (*Borrelia burgdorferi*) that is transmitted by ticks, the primary vector being the deer tick.

The CDC estimates that there are between 20,000 and 30,000 cases of Lyme disease in the United States annually, with most infections happening in the northeastern United States. Symptoms include a red bullseye at the site of tick attachment, flu-like symptoms, arthritis, and various neurological disorders. Most victims can be cured with modern antibiotics, although some people have persistent health problems years after becoming infected.

Lyme disease was first discovered in Lyme, Connecticut in the 1970's. However, researchers have recently discovered the bacteria in a frozen mummy found in the European Alps.

Zika Virus Disease



The **Zika virus disease** is caused by a pathogen that causes babies to be born with unusually small heads and damaged brains. The virus is carried by mosquitoes and can be transmitted to humans either by both mosquito bites and sexual contact with an infected person. Symptoms usually begin with a rash, fever, and headaches.

Although it was first discovered in a monkey in 1947, it was only found in 14 people until 2007. That year more than 10,000 people became infected in Southeast Asia. 2018 brought more than 28,000 infections in Tahiti and in 2015 more than 1 million people became infected in Brazil.

There is no known treatment for zika virus and attempts to control the virus are focused on reducing mosquito population.

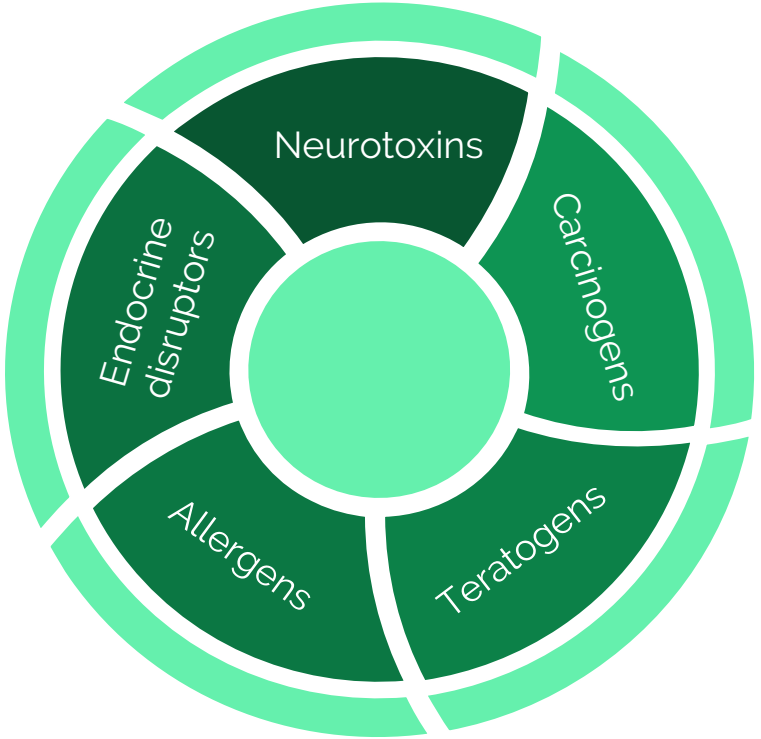
Module 57: Toxicology and Chemical Risks

After this module you will be able to……

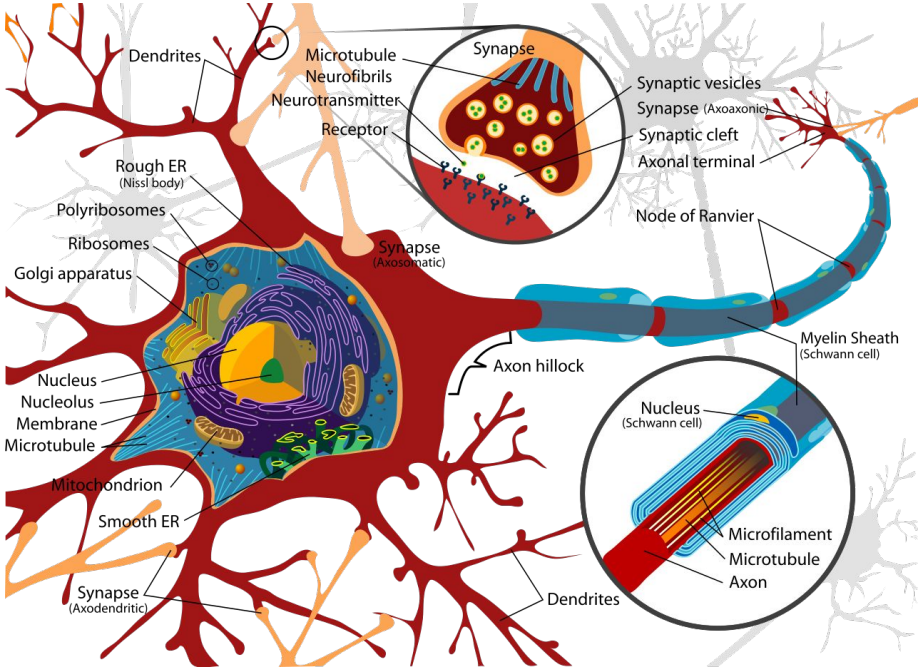
1) Identify the major types of harmful chemicals
2) Explain how scientists determine the concentrations of chemicals that harm organisms

Harmful Chemicals

Chemicals can have many different effects on organisms. We can group these chemicals into 5 categories: *neurotoxins*, *carcinogens*, *teratogens*, *allergens*, and *endocrine disruptors*.



Neurotoxins



Neurotoxins are chemicals that disrupt the nervous system of animals. Many insecticides are neurotoxins that interfere with an insect's ability to control its nerve transmission. Other important neurotoxins include lead (Pb) and mercury (Hg), which can damage human kidneys, brain, and nervous system.

Carcinogens

Carcinogens are chemicals that cause cancer by causing cell damage and uncontrolled growth of these cells by interfering with the normal metabolic processes of the cell or by damaging the genetic material of the cell. Carcinogens that cause damage to the genetic material of a cell are called **mutagens**, although, not all mutagens are carcinogens.

Some of the most well-known carcinogens are asbestos, radon, formaldehyde, and the chemicals found in tobacco.

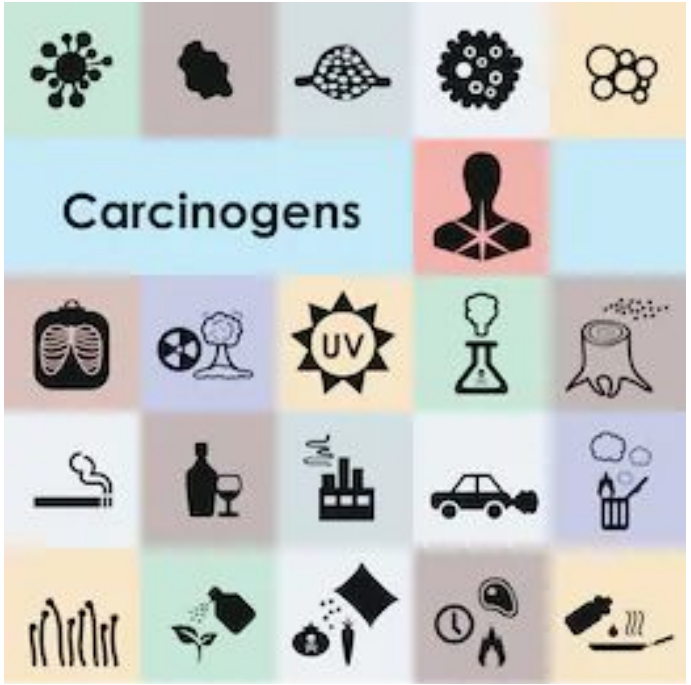


FIGURE 57.1 The effects of thalidomide. Thalidomide was widely prescribed to pregnant women in the late 1950s to alleviate the symptoms of morning sickness, but it had the unanticipated effect of causing birth defects in tens of thousands of newborn children.

Teratogens

Teratogens are chemicals that interfere with the normal development of embryos or fetuses. One of the most infamous teratogens was the drug thalidomide, prescribed to pregnant women during the late 1950s and early 1960s to combat morning sickness. Thalidomide would cause many birth defects until it was taken off the market in 1961.

A common modern teratogen is alcohol. Excessive alcohol consumption reduces the growth of the fetus and damages the brain and nervous system, a condition known as fetal alcohol syndrome.

Allergen

Allergens are chemicals that cause allergic reactions. Although allergens are **not** pathogens, they are capable of causing an abnormally strong response from the immune system. Some common allergens include the chemicals naturally found in peanuts and milk as well as several drugs including penicillin and codeine.

Endocrine Disruptors

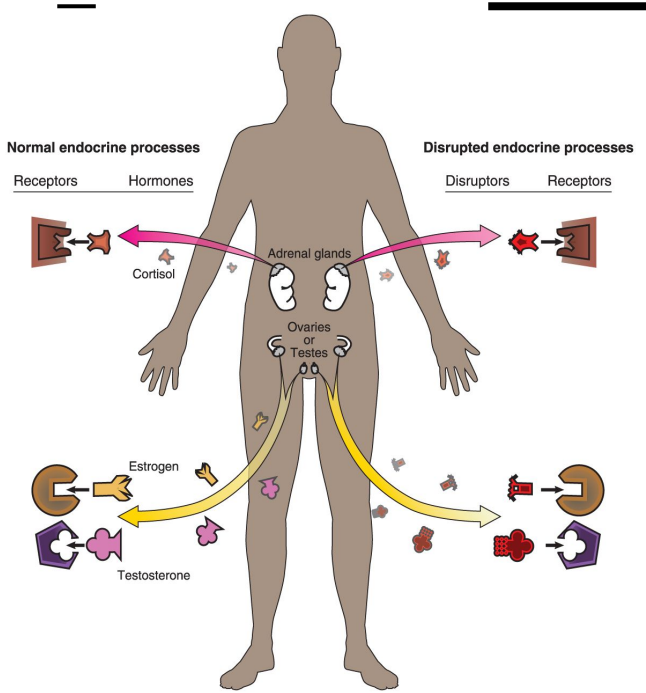
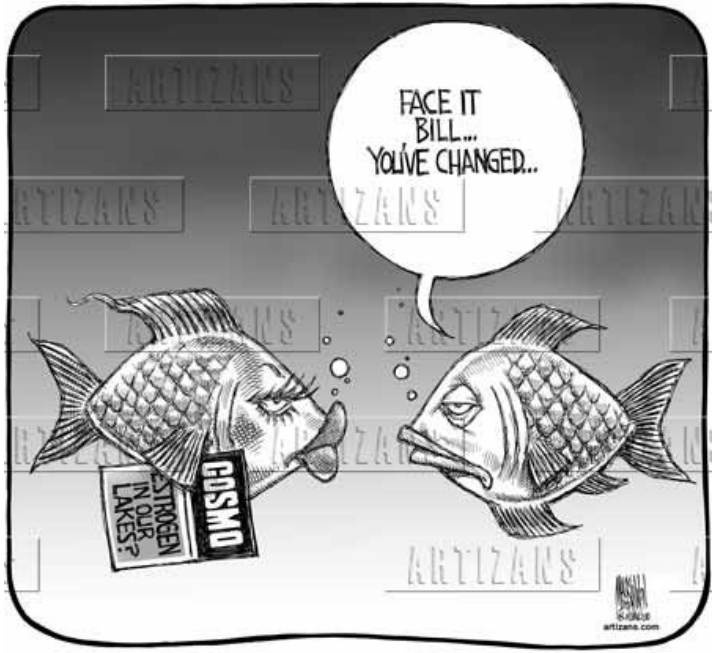


FIGURE 57.2 Endocrine disruption. In normal endocrine processes, hormones bind with receptors on cells to regulate the functioning of the body including growth, metabolism, and the development of reproductive organs. Hormone-disrupting chemicals mimic the hormones in the body and also bind to receptive cells and cause the cell to respond in ways that are not beneficial to the organism.

Endocrine disruptors are chemicals that interfere with the normal functioning of hormones in an animal's body. Normally, hormones are manufactured in the endocrine system and released into the bloodstream in very low concentrations binding to specific cells. The binding stimulates the cell to respond in a way that regulates the functioning of a body including growth, metabolism, and the development of reproductive organs. Endocrine disruptors binds to receptor cells and cause the cell to respond in non beneficial ways.

Endocrine Disruptors



One high-profile example of endocrine disruptors in our environment is the group of reproductive hormones that can be found in wastewater. Wastewater may contain hormones from a variety of sources including animal-rearing facilities, human birth control pills, and pesticides that mimic animal hormones. Scientists are increasingly finding that male fish, reptiles, and amphibians are becoming feminized due to higher concentrations of estrogen.

Chemical	Sources	Type	Effects
Lead	Paint, gasoline	Neurotoxin	Impaired learning, nervous system disorders, death
Mercury	Coal burning, fish consumption	Neurotoxin	Damaged brain, kidneys, liver, and immune system
Arsenic	Mining, groundwater	Carcinogen	Cancer
Asbestos	Building materials	Carcinogen	Impaired breathing, lung cancer
Polychlorinated biphenyls (PCBs)	Industry	Carcinogen	Cancer, impaired learning, liver damage
Radon	Soil, water	Carcinogen	Lung cancer
Vinyl chloride	Industry, water from vinyl chloride pipes	Carcinogen	Cancer
Alcohol	Alcoholic beverages	Teratogen	Reduced fetal growth, brain and nervous system damage
Atrazine	Herbicide	Endocrine disruptor	Feminization of males, low sperm counts
DDT	Insecticide	Endocrine disruptor	Feminization of males, thin eggshells of birds
Phthalates	Plastics, cosmetics	Endocrine disruptor	Feminization of males

Dose-Response Studies

Dose-response studies expose animals or plants to different amounts of chemical and then look for a variety of possible responses including mortality or changes in behavior or reproduction. Tadpoles are used to study concentrations of various pesticides that cause 50 percent of the animals to die.

Experiments that expose organisms to an environmental hazard for a short duration are called **acute studies**, while **chronic studies** are conducted for longer periods of time. At the end of a dose-response study, scientists count how many individuals die after exposure to each concentration. Usually the data follows an S-shaped curve (sigmoidal). To compare the harmful effects of different chemicals scientists measure the **LD50**, which is an abbreviation for the lethal dose that kills 50 percent of the individuals in a dose-response study.

(a)

(b)

FIGURE 57.3 Conducting dose-response experiments. (a) Researchers determine how chemicals affect the mortality of animals using dose-response experiments in the laboratory. (b) In the experiment shown, researchers are examining the effects of different insecticide concentrations on the survival of tadpoles.

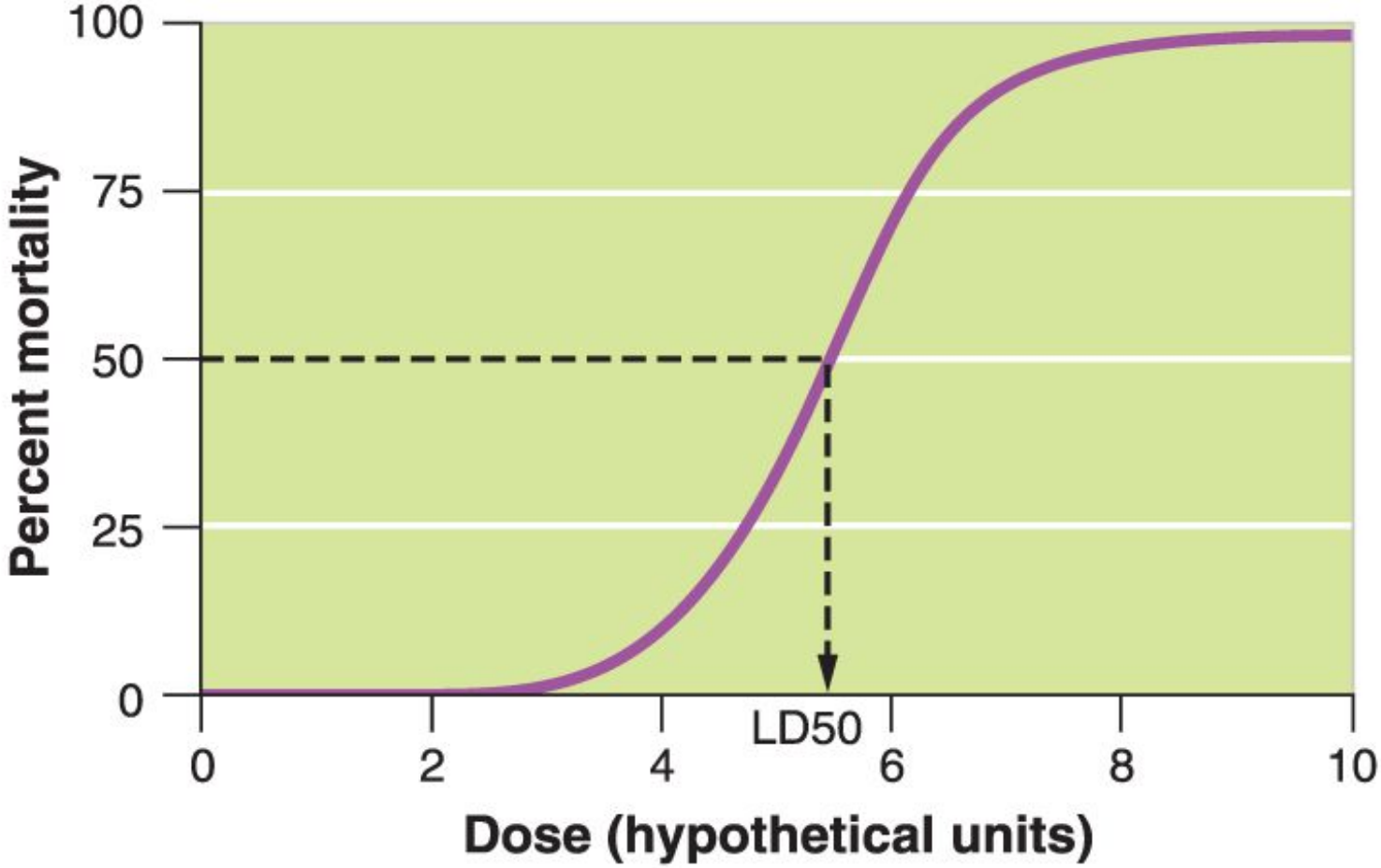


FIGURE 57.4 LD50 studies. To determine the dose of a chemical that causes a 50 percent death rate, scientists expose animals to different doses of a chemical and determine what proportion of the animals die at each dose. Such an experiment typically produces an S-shaped curve.

Dose-Responsive Studies

Note that not all dose-responsive studies measure death as a response to chemicals. Sometimes scientists are interested in harmful effects such as chemicals acting as a teratogen, carcinogen, or neurotoxin. When exposure to a chemical does not kill an organism but impairs its behavior, physiology, or reproduction, we say the chemical has **sublethal effects**. These experiments are conducted to determine **ED50**, which is the effective dose that 50 percent of the individuals in a dose-response study displays a harmful, but non lethal effect. In addition to quantifying LD50 and ED50 values, researchers commonly determine the **No-observed-effect level (NOEL)**, which is the highest concentration of a chemical that causes no lethal or sublethal effects.

Testing Standards

In the United States, chemicals that affect humans and other species are regulated by the EPA. The Toxic Substances Control Act of 1976 gives the EPA the authority to regulate many chemicals, but does not include food, cosmetics, and pesticides. Pesticides are regulated under a separate law - the Federal Insecticide, Fungicide, and Rodenticide Act of 1996.

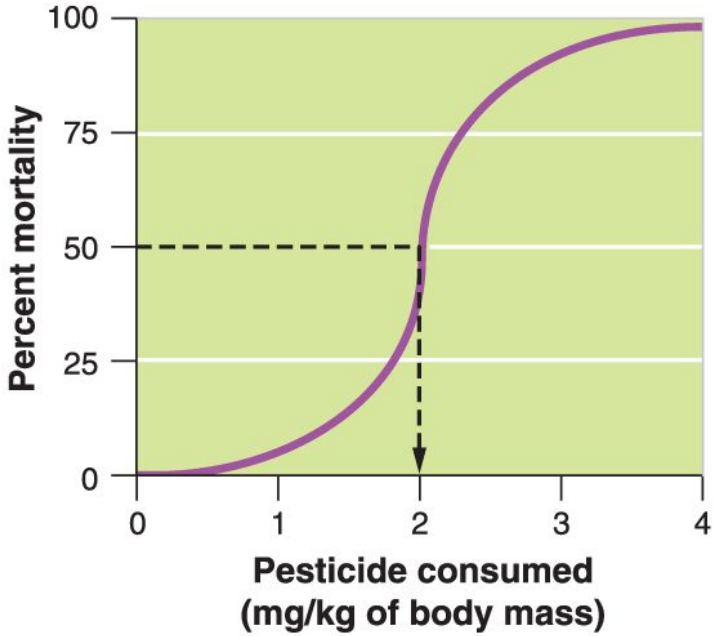
Scientists have devised a system of testing a few species, a bird, mammal, fish, and invertebrate, which are thought to be the most sensitive in the world. Note that the particular species tested from each four animal groups can vary. Currently, we conduct LD50 studies on mice and rats to represent all mammals.

To determine safe values, scientists take the LD50 and divide it by 10. In humans, this number is often divided by 10 again to reflect that mice bay be less sensitive to a chemical than humans. Finally, this value is once more divided by 10 to ensure an extra level of caution. In short, the LD50 and ED50 values obtained from rats and mice are divided by 1,000 to set the safe values for humans.

Do the Math

Let's imagine that you are a scientist charged with determining the safe levels for mammals of a pesticide in the environment. Using lab rats, you feed them a diet that contains different amounts of the pesticide, ranging from 0 to 4 mg of pesticide per kg of the rat's mass. After feeding them these diets for 4 days, you count how many rats are still alive.

What is the LD50 value for lab rats? Based on this LD50 study, what amount of pesticide would be considered safe for mammals to ingest? What amount would be safe for humans to digest?



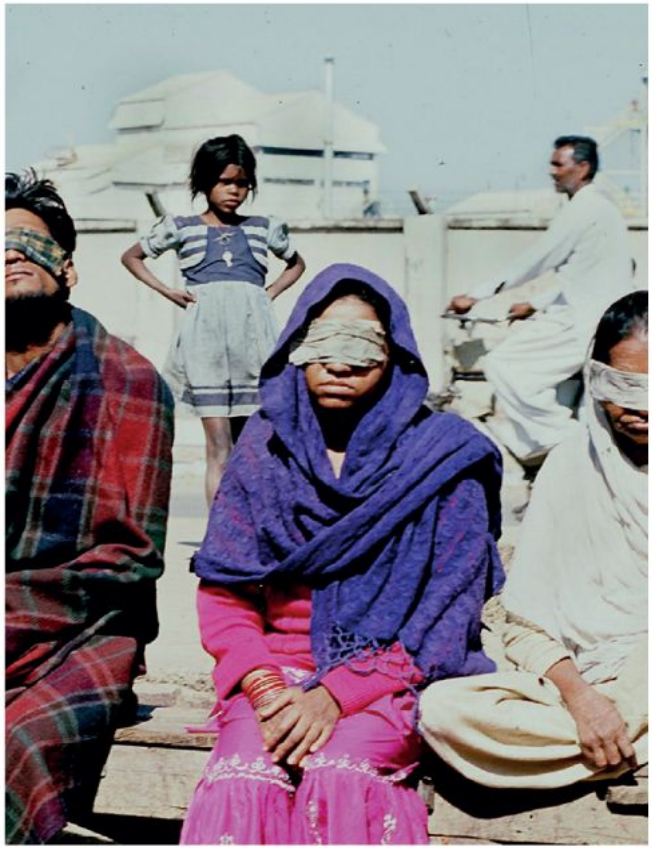
Retrospective vs Prospective Studies

An alternative approach to studying chemical effects on animals is to examine large populations of humans or animals that are exposed to chemicals in their everyday lives. This type of investigation falls within the study of epidemiology, a field of science that strives to understand the causes of illness and disease in human and wildlife populations. There are two ways of conducting this kind of research: *retrospective studies* and *prospective studies*.

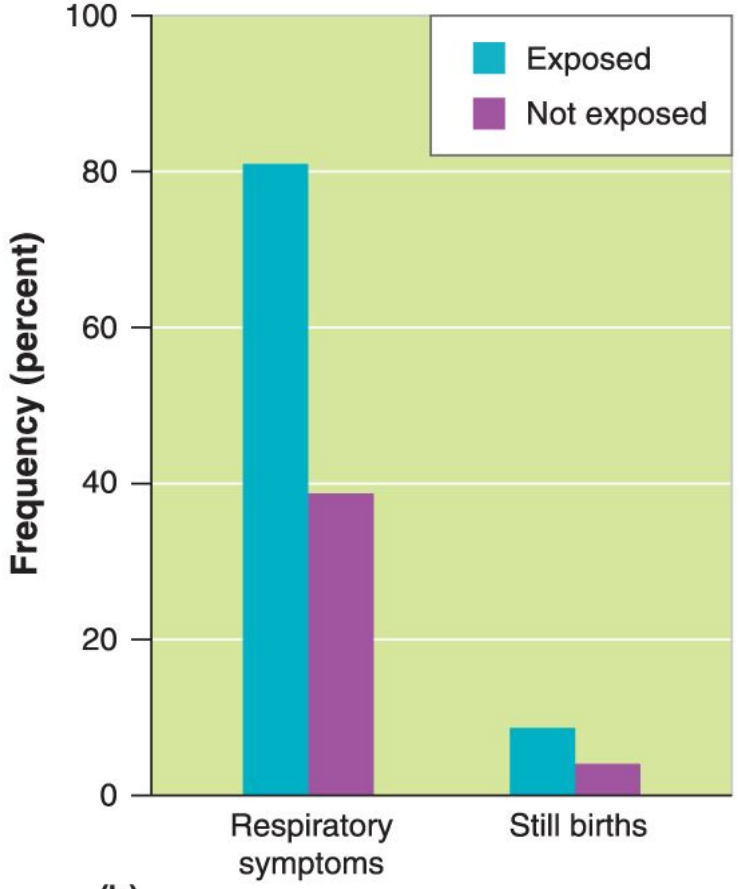
Retrospective Study

Retrospective studies monitor people who have been exposed to an environmental hazard, such as a harmful chemical, at some time in the past. Scientists identify a group of people who have been exposed and a group who has not been exposed to a potentially harmful chemical. Both groups are monitored for years to see if the exposed group experiences more health problems.

In 1984 there was an accidental release of methyl isocyanate gas from a Union Carbide pesticide factory in India. More than 36,000 kg of hazardous gas spread throughout the city of 500,000 inhabitants. An estimated 2,000 people died that night and another 15,000 died later from effects related to the exposure. Retrospective studies on this incident have found that approximately 100,000 people are still suffering illnesses from the accidental exposure to the gas.



(a)



(b)

FIGURE 57.5 The chemical disaster in Bhopal, India. (a) In 1984, a massive release of methyl isocyanate gas killed and injured thousands of people. (b) Retrospective studies that followed the survivors of the accident have identified a large number of longer-term health effects from the accident.

Prospective Studies

Prospective studies monitor people who might become exposed to an environmental hazard, such as a harmful chemical, at some time in the future. An example of this is scientists selecting a group of participants and asking them to keep track of the food they eat, tobacco they use, and alcohol they drink over several decades.

Synergistic interactions is when two risks together cause more harm than the expected base on the separate effects of each risk alone.

Routes of Exposure

Routes of exposure is the ways in which an individual might come into contact with an environmental hazard, such as a chemical.

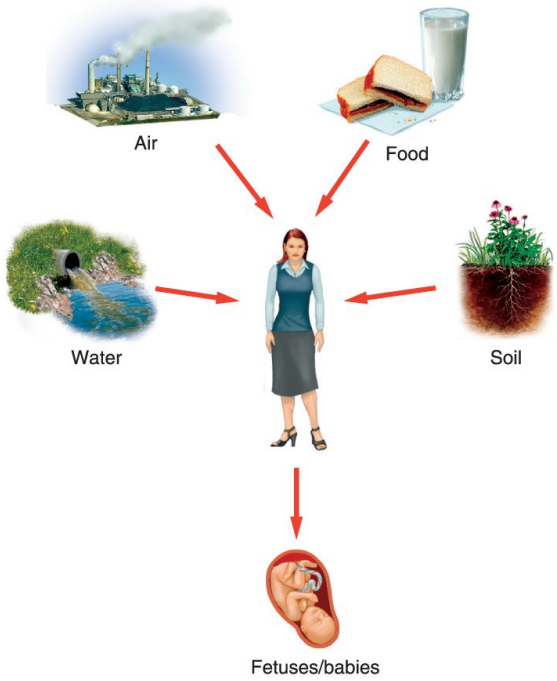
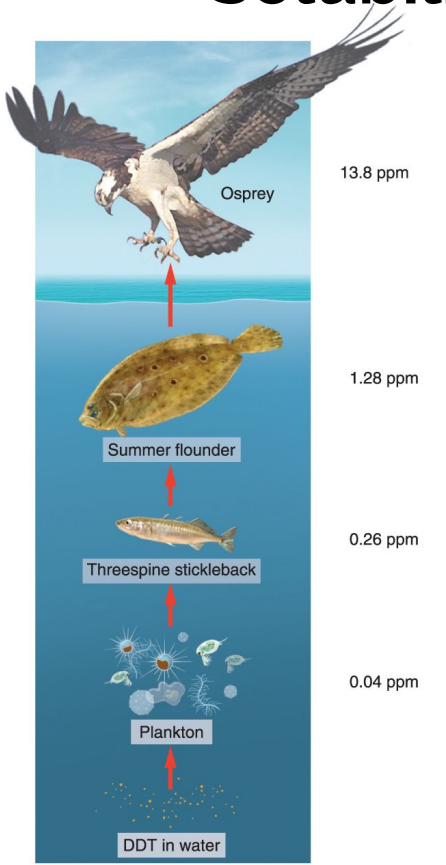


FIGURE 57.6 Routes of exposure. Despite a multitude of potential routes of exposure to chemicals, most chemicals have a limited number of major routes.

Solubility, Bioaccumulation, & Biomagnification



Solubility is how well a chemical dissolves in liquid. Water soluble chemicals are often found in groundwater, while fat-soluble chemicals are found bound in soils, including the benthic soils that underlie bodies of water. **Bioaccumulation** is an increased concentration of a chemical within an organism over time (e.g. DDT), most often stored in fat tissue. **Biomagnification** is the increase in chemical concentration in animal tissues as the chemical moves up the food chain (e.g. DDT).

Persistence

Persistence is the length of time a chemical remains in the environment and depends on a number of factors, such as temperature, pH, whether the chemical is in water or soil, and whether it can be degraded by sunlight or broken down by microbes. Scientists often measure persistence by observing the time needed for a chemical to degrade to half its original concentration.

Chemical	Source	Half-Life
Malathion	Insecticide	1 day
Radon	Rocks and soil	4 days in air
Vinyl chloride	Industry, water from vinyl chloride pipes	4.5 days in air
Phthalates	Plastics, cosmetics	2.5 days in water
Roundup	Herbicide	7 to 70 days in water
Atrazine	Herbicide	224 days in wetland soils
Polychlorinated biphenyls (PCBs)	Industry	8 to 15 years in water
DDT	Insecticide	30 years in soil

Module 58: Risk Analysis

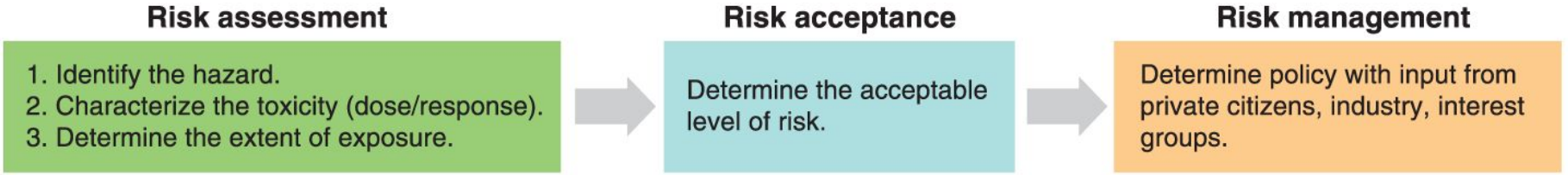
After this module you will be able to……

1) Explain the processes of qualitative versus quantitative risk assessment
2) Understand how to determine the amount of risk that can be tolerated
3) Discuss how risk management balances potential harm against other factors
4) Contrast the innocent-until-proven-guilty principle and the precautionary principle

Risk Analysis

Most people face some kind of environmental hazard every day. They may be voluntary (e.g. smoking tobacco) or involuntary (e.g. exposed to air pollution). When analyzing risk, policy makers usually follow three steps:

1) Risk assessment
2) Risk acceptance
3) Risk management



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Risk Assessment

The first step, risk assessment, seeks to identify a potential hazard and determine the magnitude of the potential harm. Risk can be assessed either qualitatively or quantitatively.

Environmental hazard is anything in our environment that can potentially cause harm, including substances such as pollutants or other chemical contaminants, human activities such as driving cars of flying, or natural catastrophes such as volcanoes and earthquakes.

Risk Assessment

Qualitative judgements are based on relative risk and perceptions, but not based on data. Examples include slowing down an ice road or not flying in an airplane due to the possibility of it crashing.

Quantitative risk estimates are based on real data, such as data collected and calculated by researchers. The most common approach to conducting a quantitative risk assessment can be expressed with a simple equation.

Risk = Probability of being exposed to a hazard x probability of being harmed if exposed

Risk Assessment

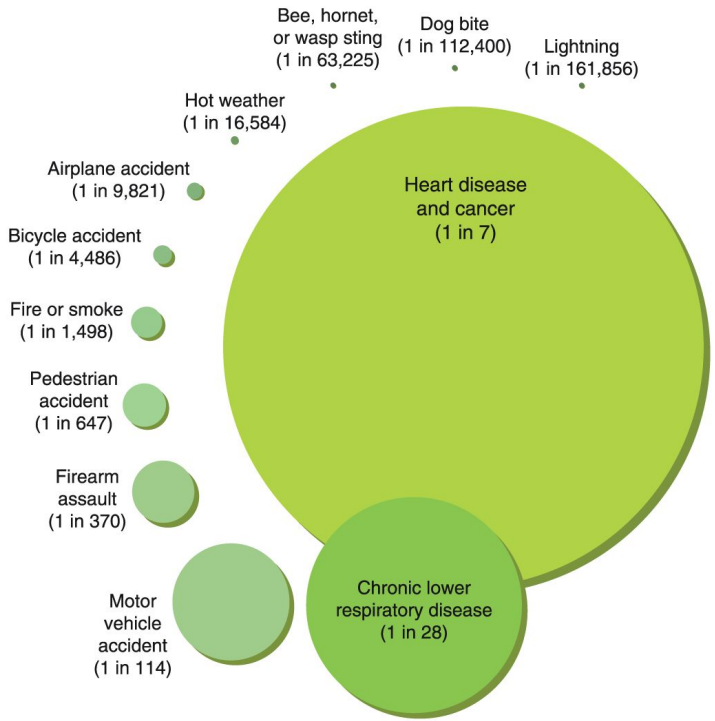

FIGURE 58.2 The probabilities of death in the United States. Some causes of death that people perceive as having a high probability of occurring, such as dying in an airplane crash, actually have a low probability of occurring. In contrast, some causes of death that people rate as having a low probability of occurring, such as dying from heart disease, actually have a very high probability of occurring.

Risk Acceptance

The second step to risk analysis is to determine risk acceptance - the level of risk that can be tolerated. This could be the most difficult of the three steps since no amount of information on the extent of the risk will overcome the conflict between those who are willing to live with some amount of risk and those who are not.

According to the EPA, a risk of 1 in 1 million chance of death is acceptable for most environmental hazards.

Risk Management

The third step seeks to balance possible harm against other considerations. Risk management integrates the the scientific data on risk assessment and the analysis of acceptable levels of risk with a number of additional factors including economic, social, ethical, and political issues. This is usually carried out by local, national, or international government agencies.

Worldwide Standards of Risk

The **innocent-until-proven-guilty principle** is based on the belief that a potential hazard should not be considered a real hazard until the scientific data definitely demonstrates that it actually causes harm.

The **precautionary principle** is based on the belief that when a hazard is plausible but not yet certain, we should take actions to reduce or remove the hazard.

Use of the precautionary principle has been growing throughout many parts of the world, but the United States continues to use the innocent-until-proven-guilty principle.

FIGURE 58.5 The risks of asbestos dust. Despite nearly a century of studies on the risks of asbestos dust to human health, only recently have workers been required to go to great lengths to prevent exposure. Today, they dress in chemical suits and respirators when removing asbestos from a building. Applying the precautionary principle would have required protection of workers many decades earlier and saved hundreds of thousands of lives.

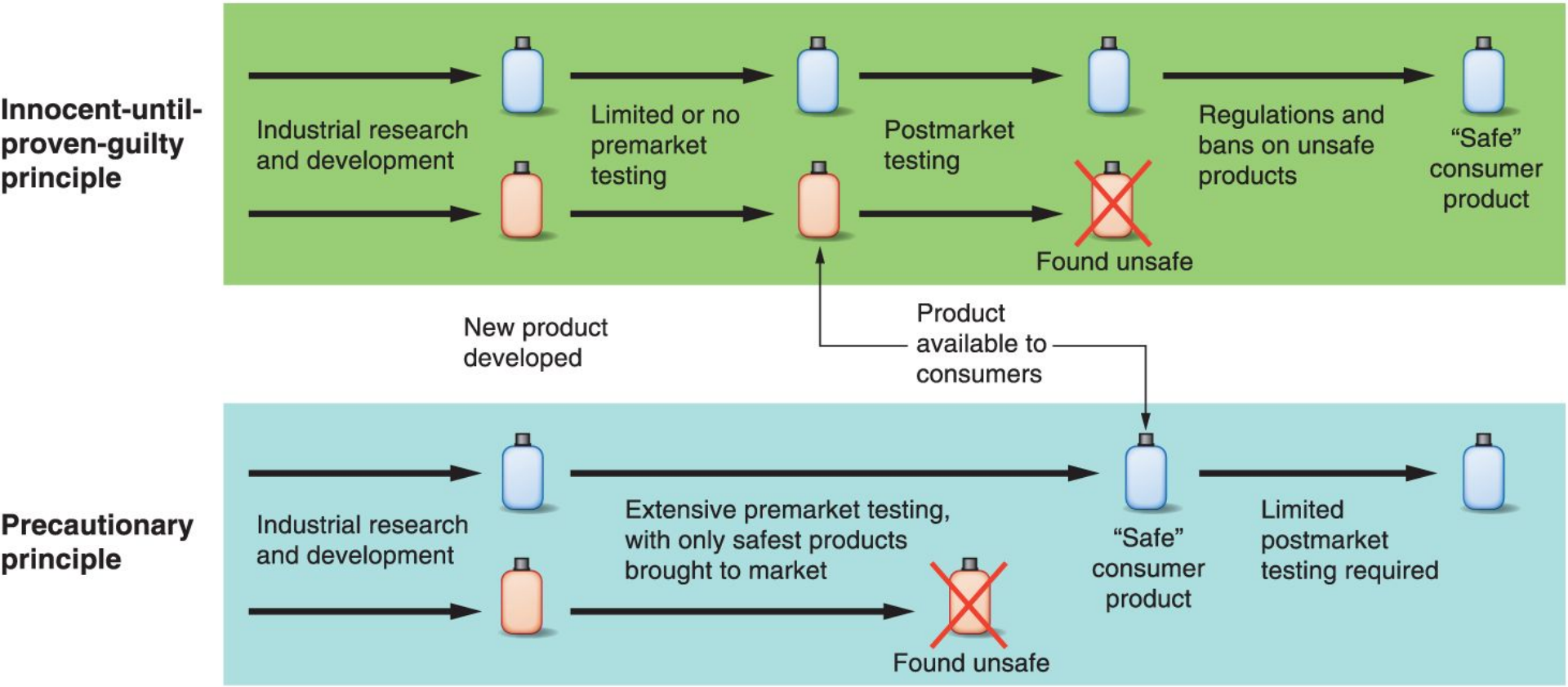

FIGURE 58.4 The two different approaches to managing risk. The innocent-until-proven-guilty principle requires that researchers prove harm before the chemical is restricted or banned. The precautionary principle requires that when there is scientific evidence that demonstrates a plausible risk, the chemical must then be further tested to demonstrate it is safe before it can continue to be used.

International Agreements

In 2001, a group of 127 nations gathered in Stockholm, Sweden to reach an agreement on restricting the global use of some chemicals. The agreement, known as the **Stockholm Convention**, produced a list of 12 chemicals to be banned, phased out, or reduced. These chemicals came to be known as the “dirty dozen.” All chemicals were known to be endocrine disruptors. By 2017, the Convention listed 32 chemicals that should be eliminated.

International Agreements

In 2007, the 27 nations of the European Union put into effect an agreement on how chemicals should be regulated within the European Union. Known as **REACH**, an acronym for registration, evaluation, authorization, and restriction of chemicals, the agreement embraces the precautionary principle by putting more responsibility on chemical manufacturers to confirm that chemicals used in the environment pose no threat.