Chapter 17
Human Health and Environmental Risks

Three categories of human health risks

1. **Physical** – include environmental factors such as natural disasters (*cause injury or loss of life),* excessive exposure to UV radiation from the sun *(sunburns, cancer, radioactive substances such as radon).*

2. **Biological** – diseases *(any impaired function of the body with a characteristics set of symptoms)*

3. **Chemical** – exposure to chemicals ranging from naturally occurring *(arsenic)* to synthetic chemicals *(pesticides)*

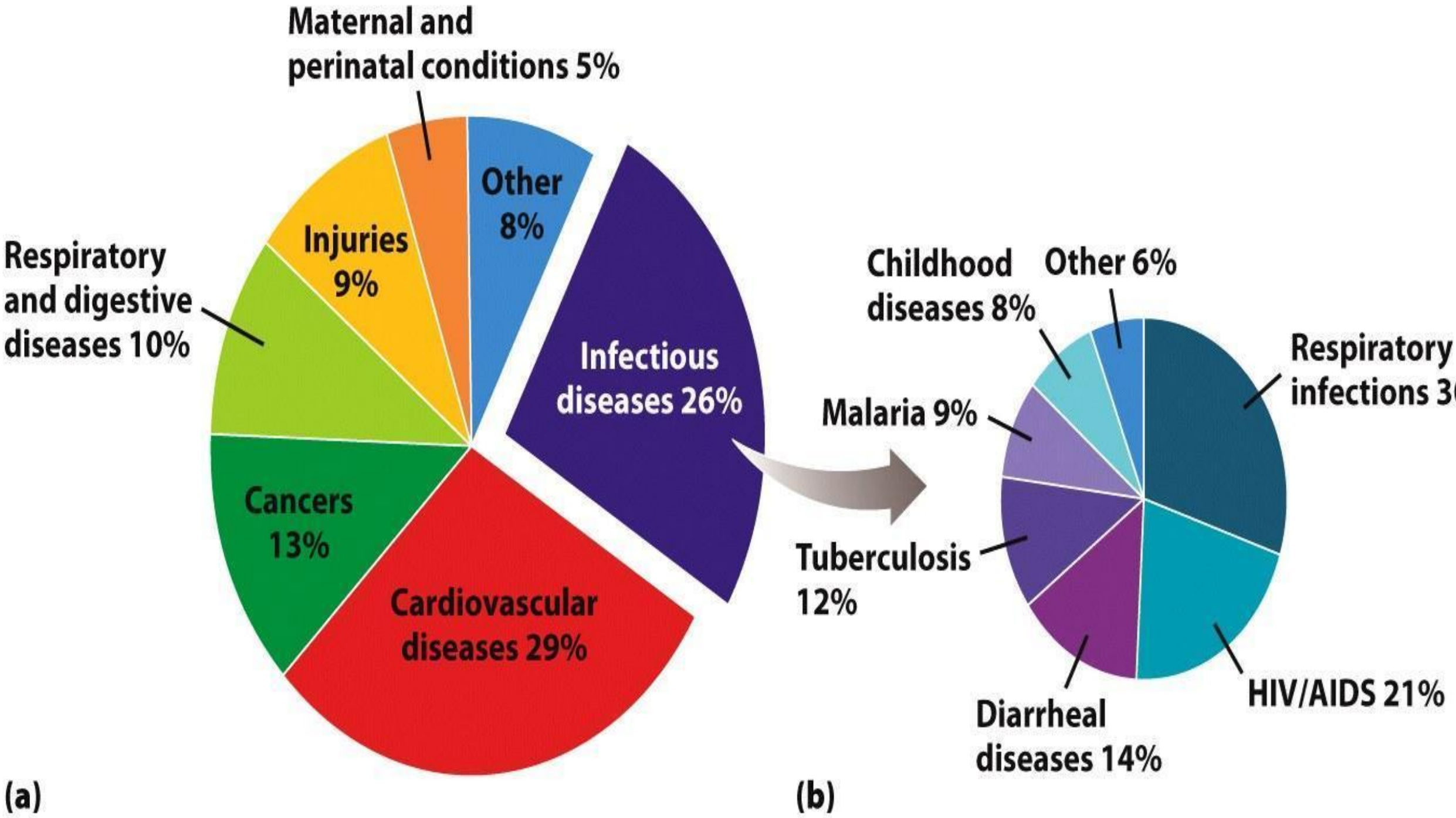
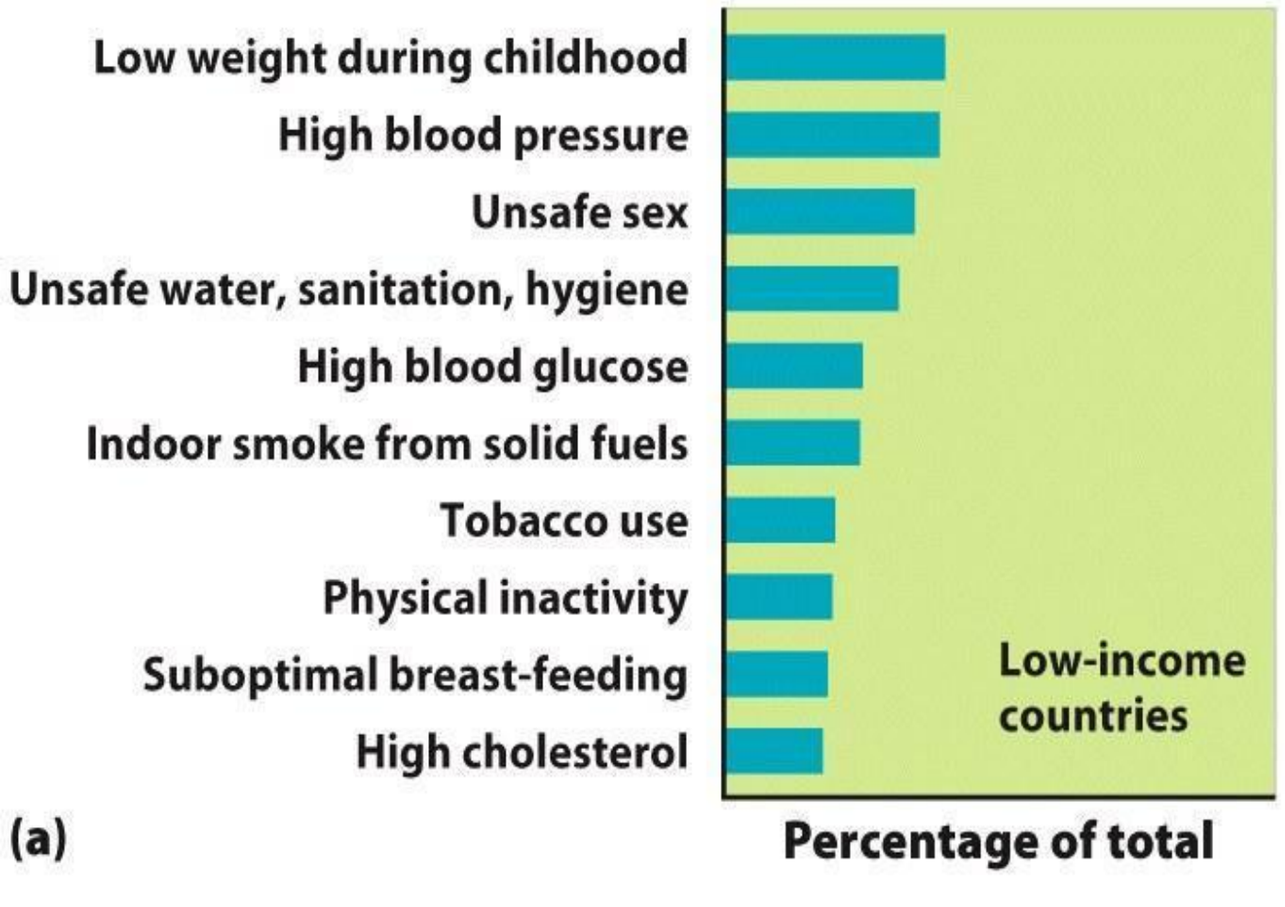


Figure 17.1
Environmental Science

Among all 3 human health risks…*Biological* risk cause the most human deaths (cardiovascular disease). **More than ¾'s of all world deaths are cause by diseases.**

Leading Health Risks for High-income vs. Low-income countries



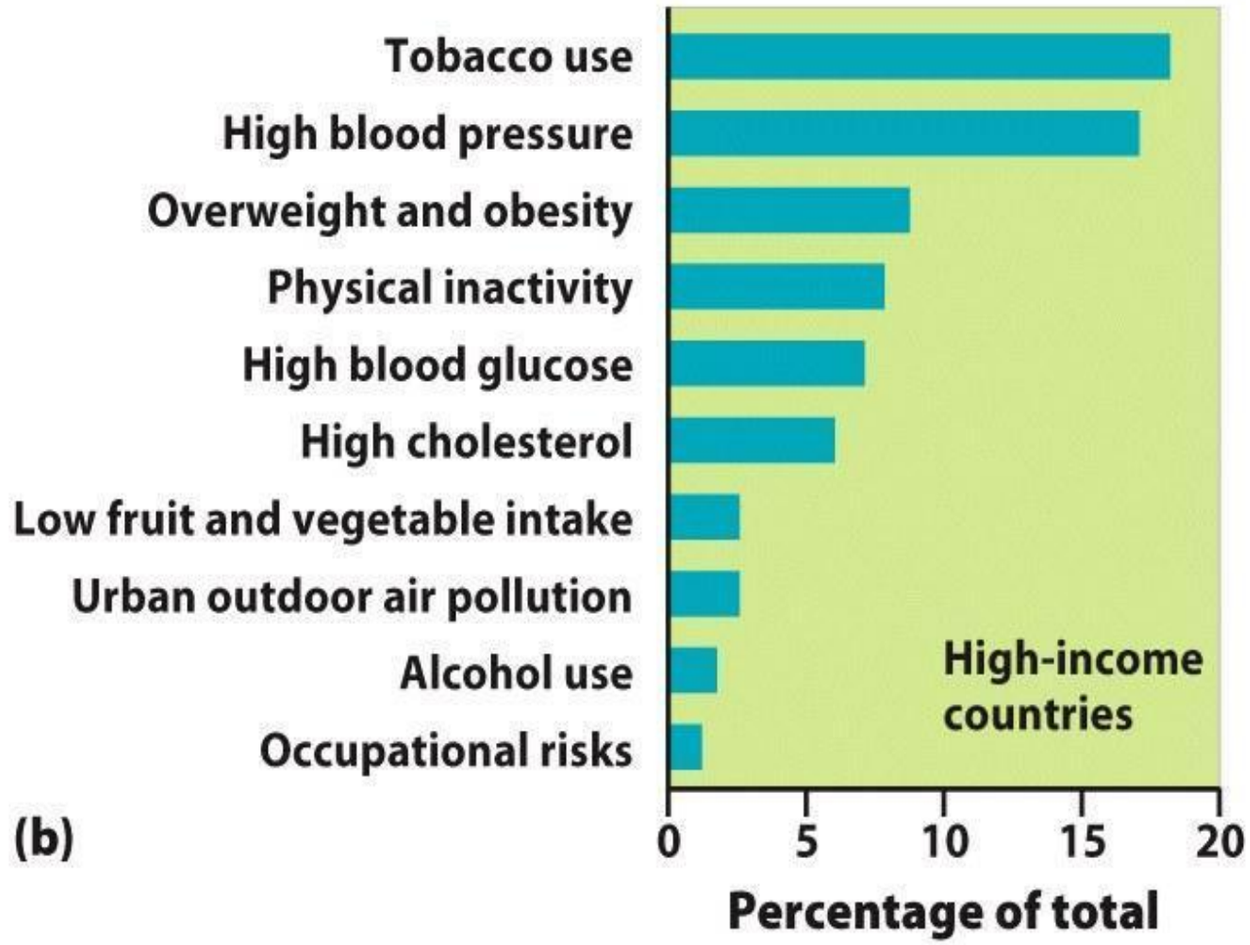


Figure 17.2
Environmental Science

Transition in economic development affects leading health risks...

Leading cause for Low-income = low nutrient (lack of food) & poor sanitation

Leading cause for high-income = inactivity, obesity, tobacco use

Biological Risks

- **Infectious diseases-** those caused by infectious agents, known as pathogens *(viruses, bacteria, fungi, protists, a group of parasitic worms called helminths).*
  - Examples: pneumonia and venereal diseases (STI's)

- Diseases not caused by pathogens include cardiovascular *(heart attack)*, respiratory *(Emphysema)* and digestive diseases *(GERD)* & most cancers.

All diseases fall into 2 categories…

- **Chronic disease-** slowly impairs the functioning of a person's body (ex. heart disease and most cancers, develop over several decades).
- **Acute diseases-** rapidly impair the functioning of a person's body. (ex. Ebola hemorrhagic fever, death comes in a matter of days or weeks)

Pathogens have evolved a wide variety of ways to infect humans.

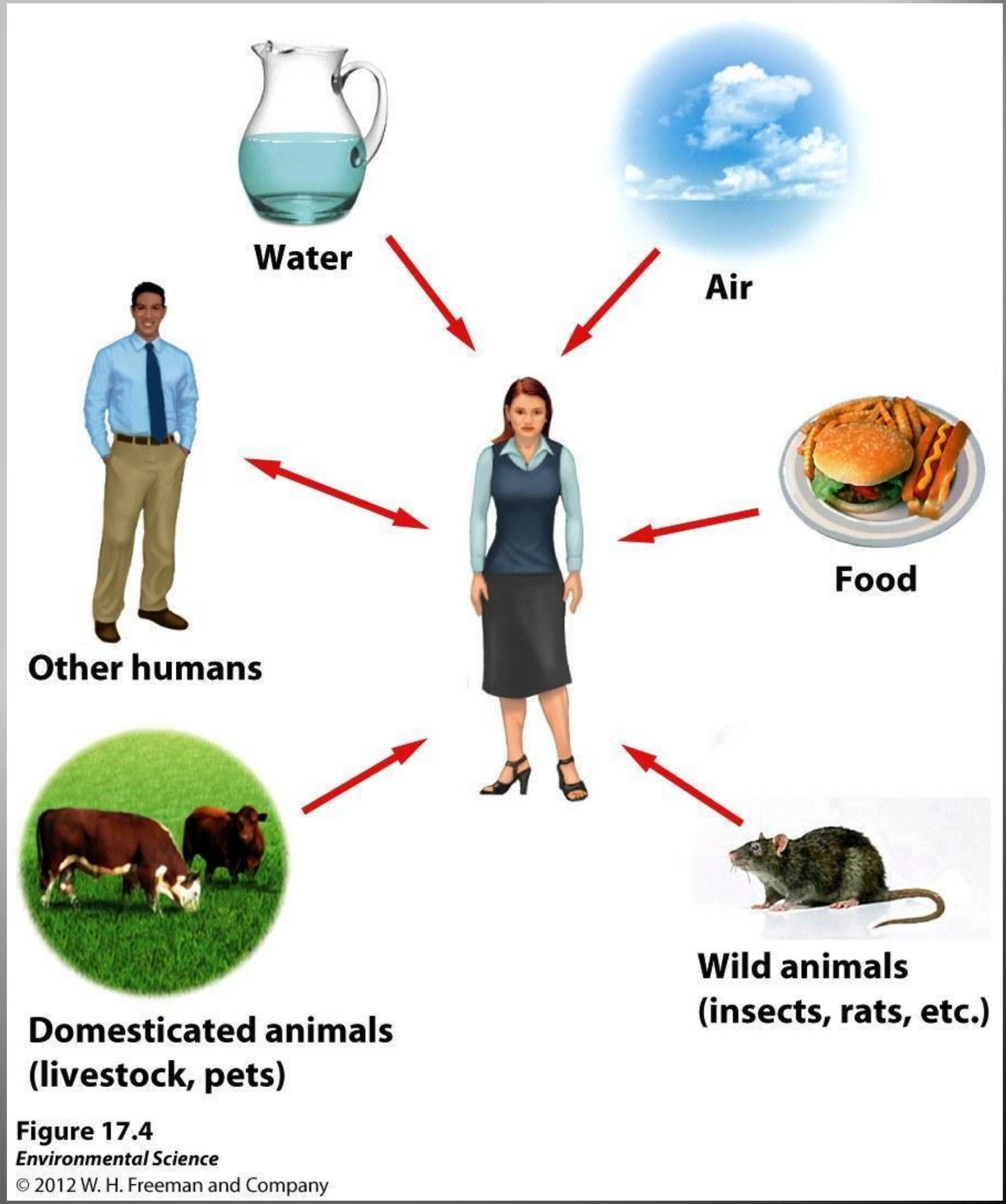


Figure 17.4
Environmental Science

Epidemic – pathogen causes a rapid increases in disease
Pandemic – epidemic occurs over a large geographic region such as an entire continent.

Historical Diseases

- **Plague** *(ex. Black Death, & bubonic plague)* – infection from a bacteria (*Yersinia pestis)* carried by fleas, killed hundreds of millions of people in the *1300s to 1800s.* Modern antibiotics are highly effective.
- **Spanish flu** – *(1918-1920 influenza pandemic)* deadliest flu infected over 500 million people globally and killed estimated 50-100 million people. No vaccinations at time to protect again influenza, no antibiotics to treat secondary bacterial infections.
- **COVID-19** *(coronavirus 2020)* infectious disease caused by a newly discovered coronavirus (strand 1 was exposed in 2002-2003), chronic respiratory disease, no vaccination at time of exposure…EARTH shut down due to pandemic. Death values??

Historical Diseases Con't

- **Bird Flu (influenza A- H5N1)**– viral infection, flu like symptoms, spread to people in close contact with birds, kills as much as half that were infected.
- **Swine flu** - mutated from bird – new strand of H1N1 – 2009 pandemic.
- **Malaria** – infection from any one of several species of protists (*Plasmodium),* commonly found in a mosquito. Millions of peoples are infected and die from each year. Efforts to eradicate have not been successful, but working toward sustainability to fight against.
- **Tuberculosis** (Tb) - highly contagious, infection from bacterium *(Mycobacterium tuberculosis),* affects the lungs, spread through inhalation, millions of people are infected and die each year. Most (most not all due to drug-resistant strains) TB can be treated with antibiotics for a year

Emergent Diseases – infectious diseases that were thought to be eradicated/not been common for over decades

- **HIV/AIDS-** viral infection, no cure, weaken immune system, spread through sexual contact &/or infected blood transfer
- **Polio (1916)** – leaves survivors with permanent disabilities, vaccination available.
- **Ebola** – (2014-2016 – ravaged W. Africa) viral infection, death w/in 2 weeks, no - treatments, spread through inhalation
- **Mad Cow Disease** – prions mutate into deadly proteins in the brain, spread through eating infected cattle, risk to humans have decreased
- **West Nile Virus** – spread by mosquitos, inflammation of the brain
- **Zika Virus** (2015 – present) spread through mosquitos, attack infants in womb, cause birth defects, no vaccinations/cures

Pathogens that normally affect animals hosts, but unexpectedly jump to human hosts. This occurs due to rapid mutations.

Chemical Risks

Chemicals whether natural or man-made, improve human health or harm, all have unexpected consequences when released into the environment.

1. **Neurotoxins**- chemicals that disrupt the nervous system
   (ex. Insecticides-interfere with insects nervous system. Pb and Hg, heavy metals that can damage internal organs)
2. **Carcinogens**- chemicals that cause cancer *(cell damage, uncontrolled growth, interfere w/ metabolic processes, damage genetic material...ex. Asbestos, radon, formaldehyde)*

3. **Teratogens**- chemicals that interfere with the normal development of embryos or fetuses *(ex. Alcohol, reduces the growth of the fetus & damages the brain and nervous system)*

4. **Allergens**- chemicals that cause allergic reactions *(not a pathogen but are capable of causing abnormally high response from the immune system ex. Peanuts, milk proteins, penicillin, pollen, etc)*

5. **Endocrine disruptors**- chemicals that interfere with the normal functioning of hormones in an animal's body *(disruptors attaches where the hormone normally would, blocking the response, lock n key method ex. Testosterone & estrogen)*

TABLE 17.1 Some chemicals of major concern

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	Fetuses with 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

Table 17.1
Environmental Science

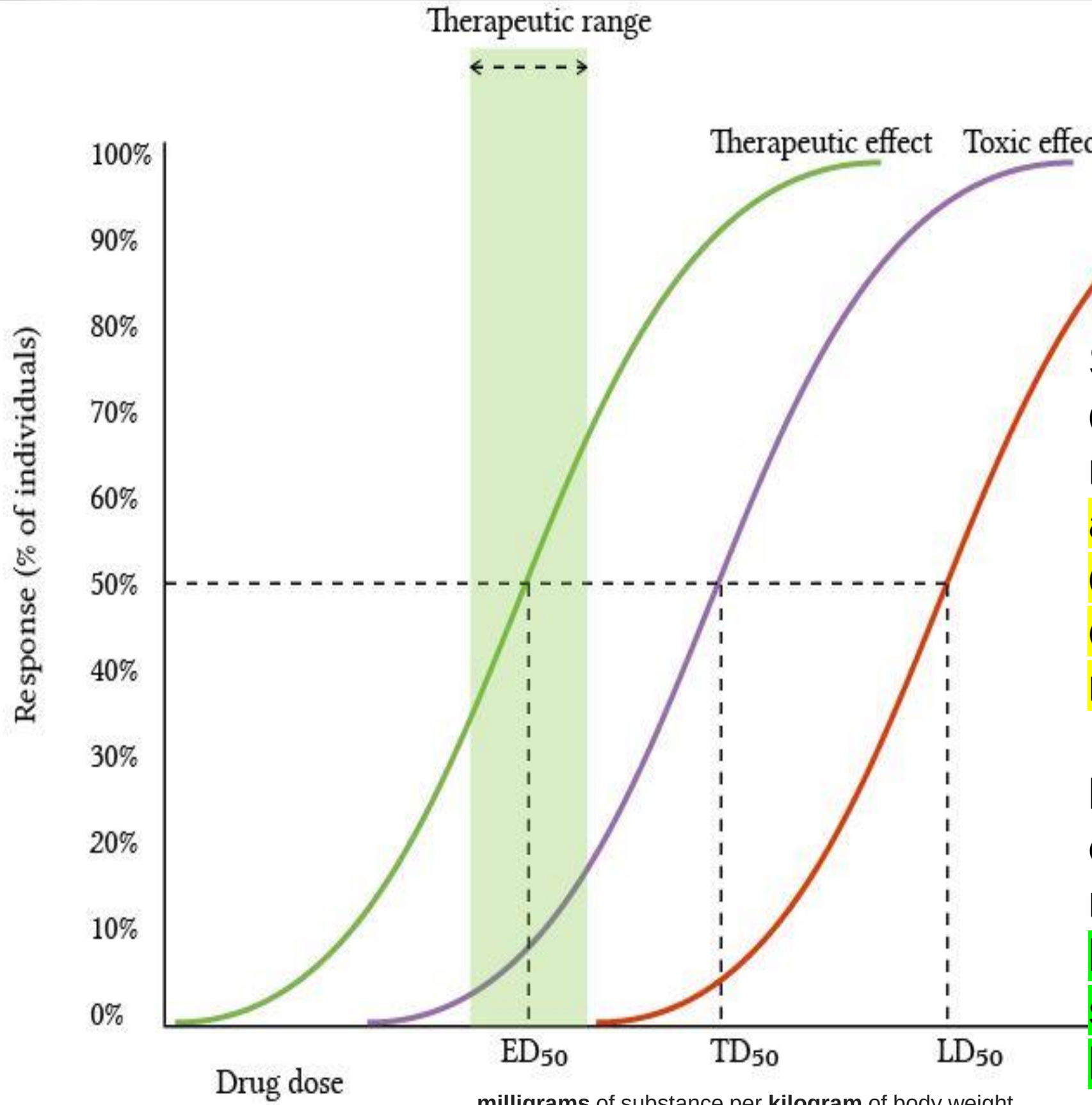
Dose-Response Studies-

~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.

(Experimental Testing)

- To assess the risk a chemical poses to any organism, scientist need to determine the concentration that cause harm in the air, water or food.
  - Measured as the dose of a chemical, amt. of chemical that is absorbed or consumed.

- **LD50**- lethal dose (divided by 10 to determine safe concentrations for wildlife) that kills 50% of the individuals
- **ED50**- effective dose that causes 50% of the animals to display the harmful but nonlethal effect



Scientists conduct dose-experiments on rats/mice. LD50 values are divided by 10 to determine safe concentrations for rats/mice.

LD50 values obtained from rats/mice are divided by 1000 to set the safe values for humans.

Acute toxicity

Life-threatening one-time doses

SUBSTANCE	FOUND IN	Lethal dose (LD50 mg/kg)	CATEGORY
Water	... Water	90000	Practically non-toxic
Sucrose	Table sugar	30000	
Monosodium glutamate	Flavor enhancer, soy, cheese	16000	
Ethanol	Alcoholic beverages	7000	
Glyphosate	Herbicide (RoundUp)	5600	
Aluminum hydroxide	Antacid, vaccine adjuvant	>5000	
Fructose	Fruits, component of sucrose	4000	Slightly toxic
Spinosad	Organic insecticide	3700	
Sodium chloride	Table salt	3000	
Eugenol	Clove oil, organic pesticide	2700	
Paracetamol (acetaminophen)	Tylenol, Panadol	2400	
Vanillin	Vanilla bean, vanilla sugar	1600	
Hydrogen peroxide 70%	Bleach, disinfectant	1000	
Theobromine	Chocolate, tea, guarana	950	
Copper sulfate	Organic fungicide	300	Moderately toxic
Chlorpyrifos	Organophosphate insecticide	230	
Caffeine	Natural pesticide, coffee plant	190	
Lead	Batteries, cables, paints	155*	
DDT	Restricted insecticide	100	
Rotenone	Restricted organic pesticide	60	
Vitamin D3	Supplements, fish, mushrooms	37	Highly toxic
Nicotine	Natural pesticide, tobacco	10	
Mycotoxin T2	Plant pathogen, moldy grain	5	
Aflatoxin	Soil fungus, moldy foods	5	
Hydrogen cyanide	Fruit pits, bitter cassava	4	
Botulinum toxin	Botox, Clostridium botulinium	0.001	

LD_{50}: Generally rat oral. Botulinum: mouse and human, nicotine: human, cyanide: mouse.
*Lead: no LD_{50}, lowest human lethal dose included. Colours: EPA toxicity categories.

Thoughtscapism

Measures of Toxicity
thoughtscapism.com

Sources: EFSA, WHO, EPA, NIH, NHS

Mommy PhD

mg/kg = milligrams of substance per kilogram of body weight (1kg =2.2lbs).

- **Epidemiology –** study of the causes of illnesses & diseases in human and wildlife populations.

- **Synergistic interactions-** when two risks come together and cause more harm that one would. For example, the health impact of a carcinogen such as asbestos can be much higher if an individual also smokes tobacco.

- **Retrospective toxicity studies** – study is done to analyze the effect of a factor on the occurrence of the disease

- **Prospective toxicity studies** – monitor health effects from future chemical exposures.

Routes of Exposure

~ways in which an individual might come into contact with a chemical .

Movement of chemicals in an environment depends in part of the **solubility** – how well a chemical dissolves in a liquid.

Water soluble (inescapable in groundwater and surface water including lakes and river) *vs*. **fat soluble** (stored in fat tissues of animals…can cause bioaccumulation)

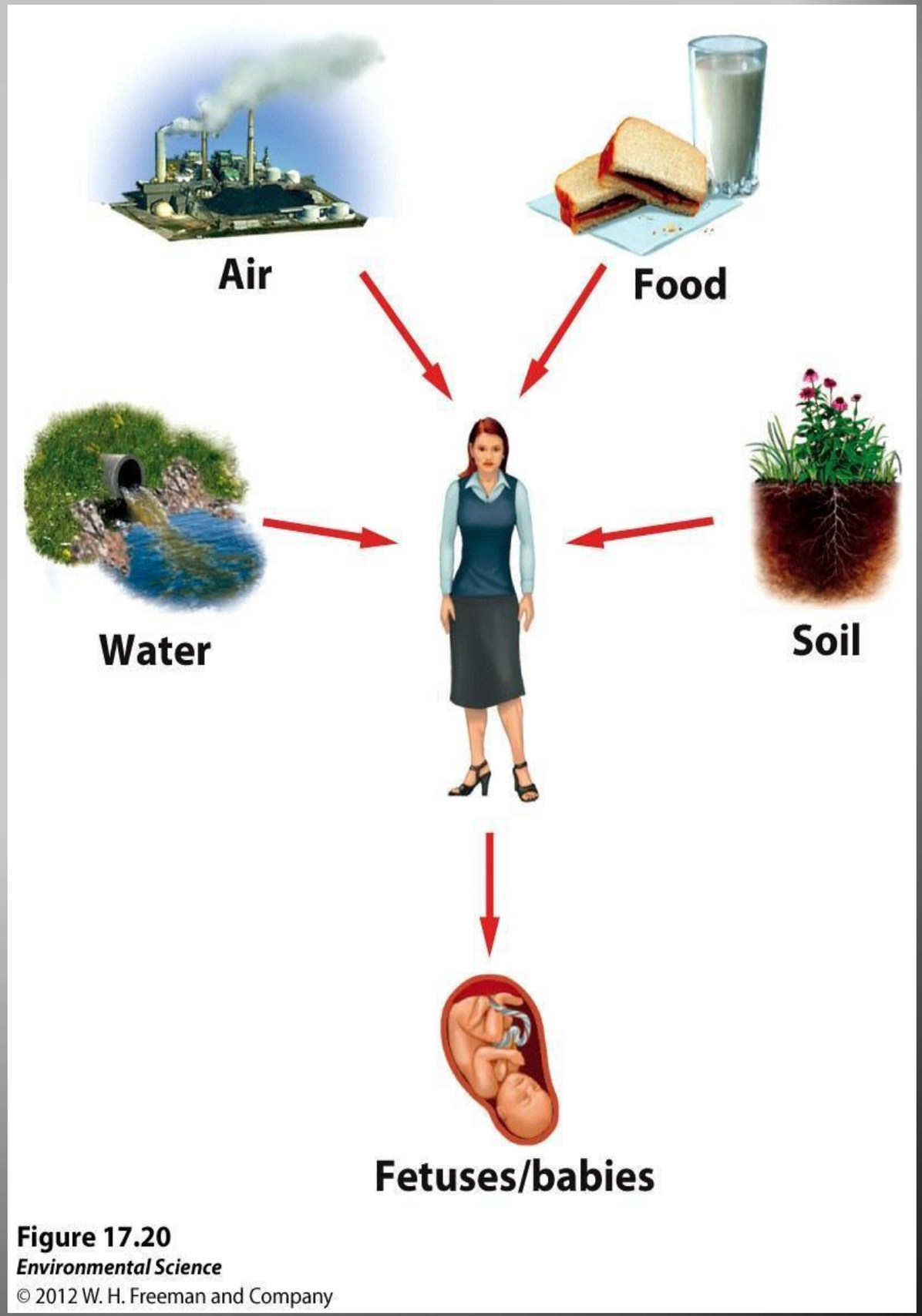
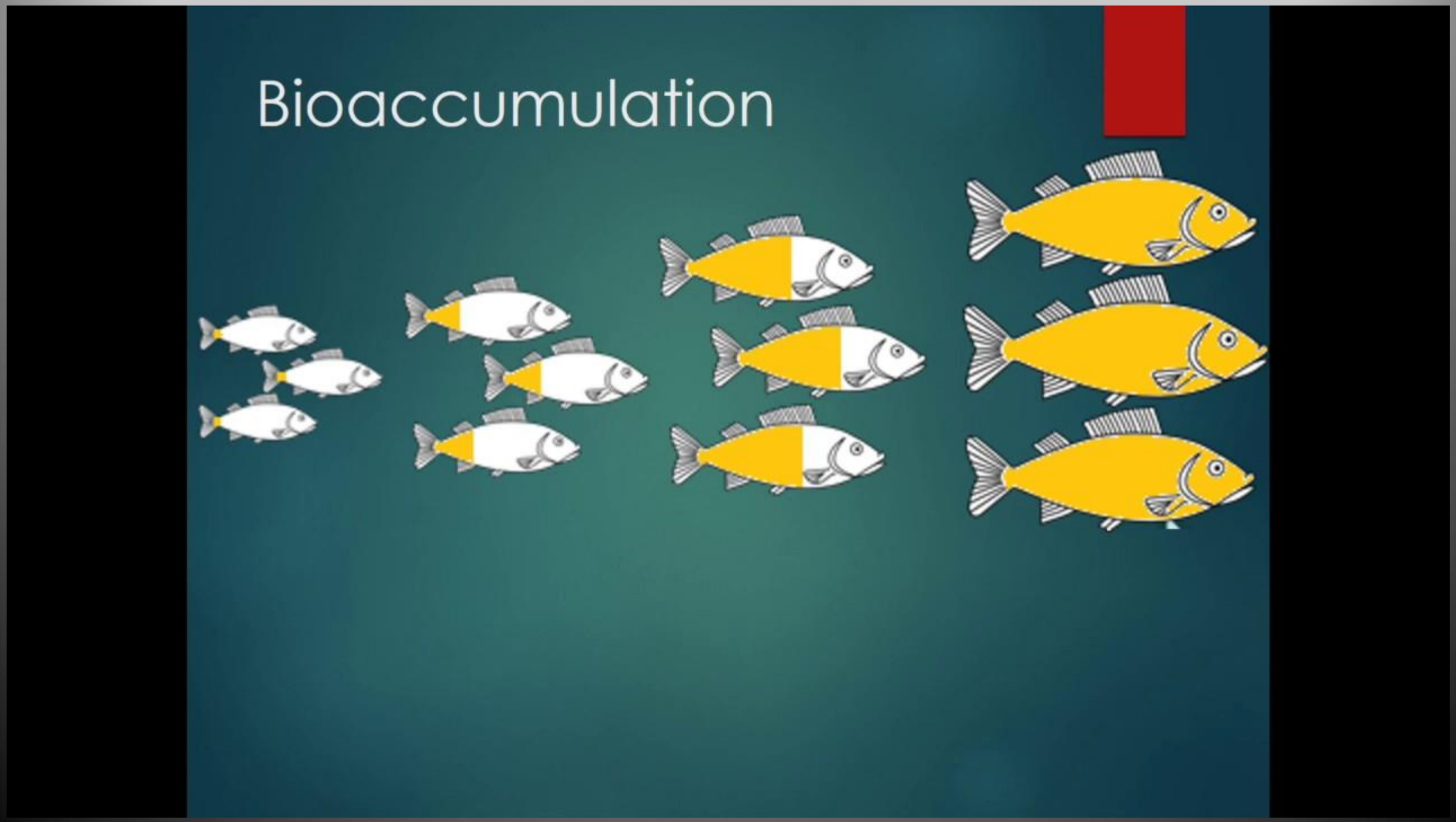


Figure 17.20
Environmental Science

Bioaccumulation

- an increased concentration of a chemical within an organism over time



Biomagnification

- the increase in a chemical concentration in animal tissues as the chemical moves up the food chain.

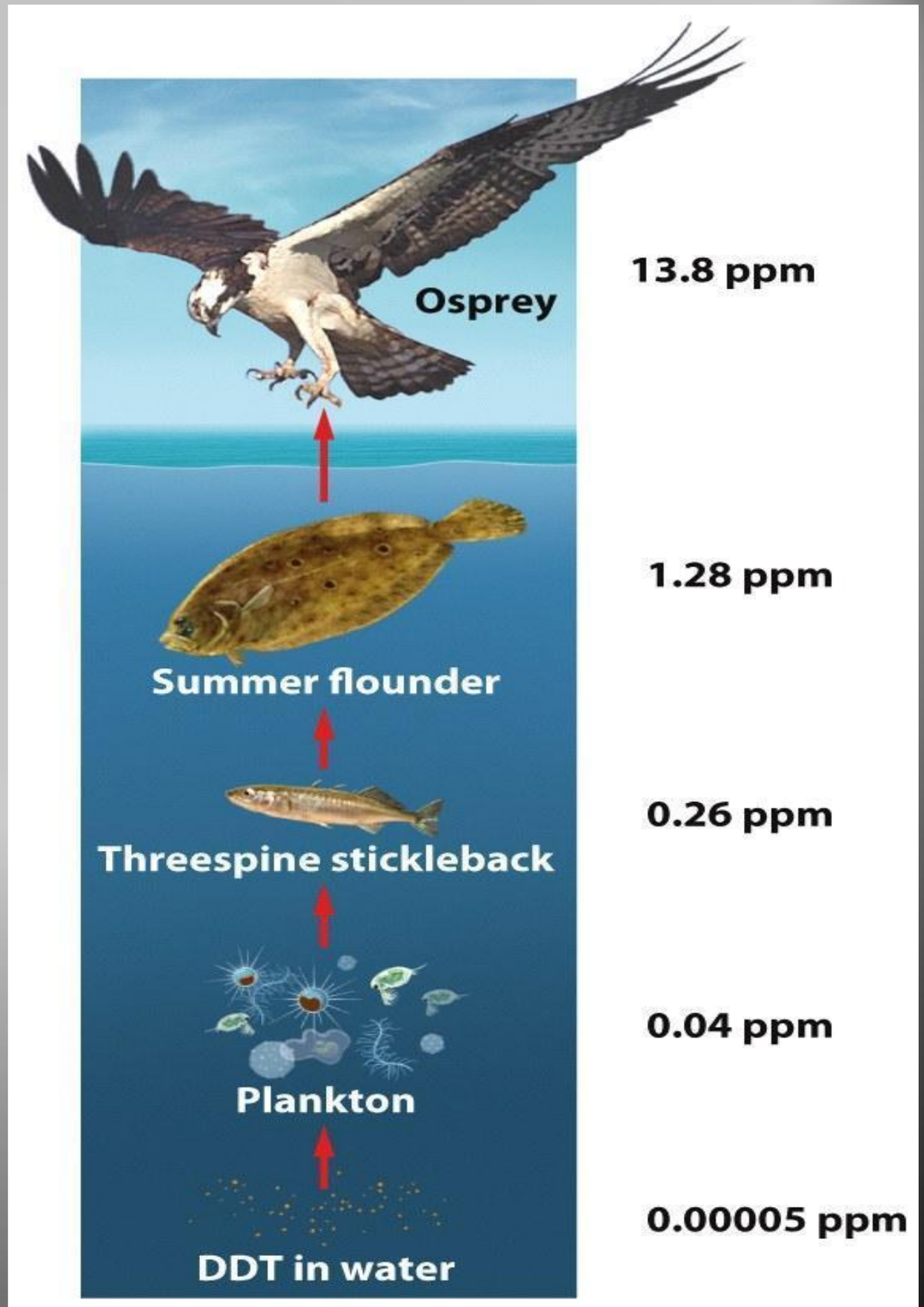
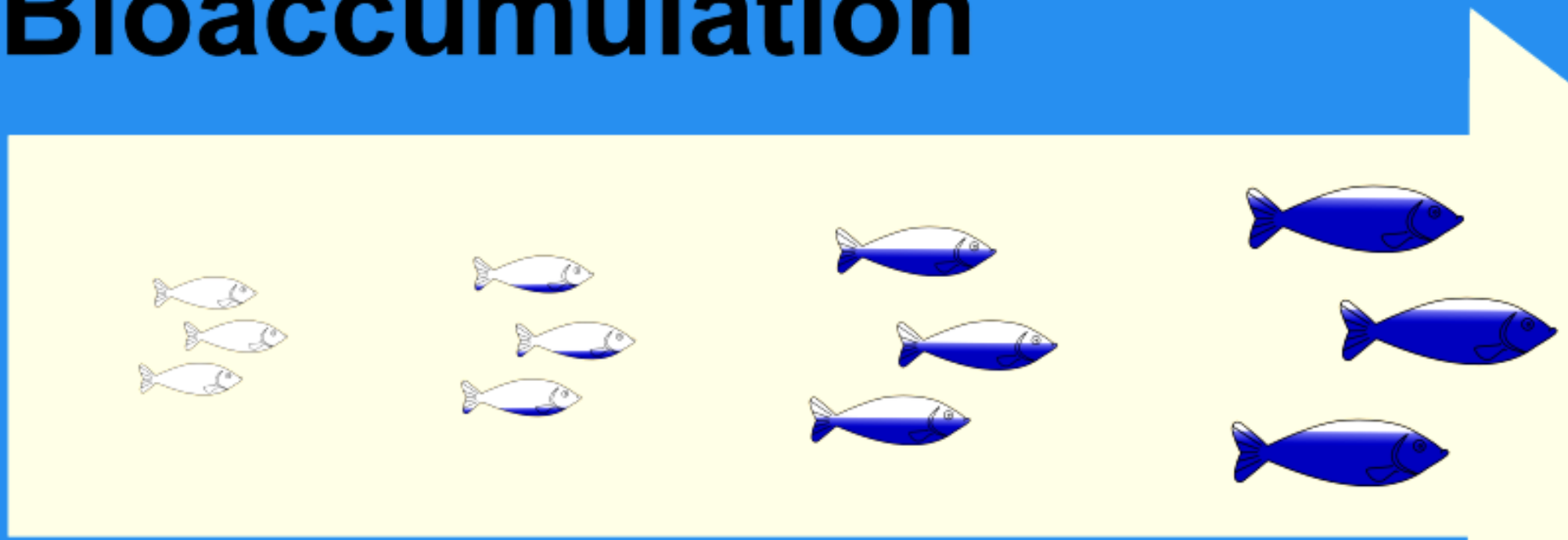


Figure 17.21
Environmental Science

Bioaccumulation



TIME

Contaminant Levels

Contaminant Levels

Biomagnification

Persistence

~how long a chemical remains in the environment

Persistence depends on temperature, pH, whether chemical is in water or soil, degrades by sunlight, and/or can be broken down by microbes.

Measure by the time needed for a chemical to degrade to half its original concentration, *half life of the chemical*

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

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

Source: Hazardous Substances Data Bank, http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB/.

Table 17.2
Environmental Science

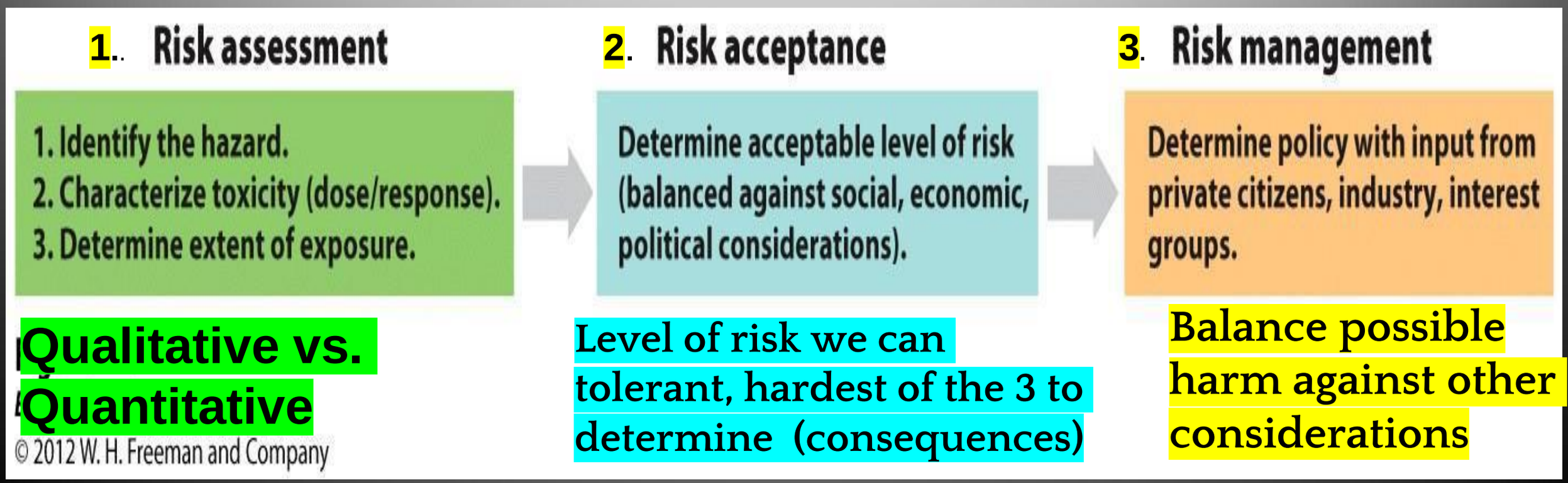
The concentration off chemical exposure depends on….Persistence & solubility of the chemical

Risk Analysis

Environmental hazard – anything in our environment that can potentially cause harm.

~Hazards include pollutants (air pollution), chemical contaminants, human activities such as draining swamps, logging & smoking or natural disasters (volcanos & earthquakes)

Assessing the risk of different hazards, agencies, environmental scientists, & policy makers follow 3 steps…



Qualitative Risk Assessment

- Making a judgment of the relative risks of various decisions
  - Ex. Choosing to slow down on a wet highway or buying a more expensive car b/c it is safer
- We make our judgements based on our perceptions

- **Probability**- the statistical likelihood of an event occurring and the probability of that event causing harm

- Perceived vs. actual risk - the risk of flying vs. driving a car.

Quantitative Risk Assessment

- The approach to conducting a quantitative risk assessment is:

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

Ex. **Risk of dying on a plane**... probability of the plane crash (very low) multiplied by the probability of dying in the crash (near 100%)

Estimates of harm can come from acute and chronic dose-response experiments (LD50), retrospective studies, & prospective studies (statistical evidence)

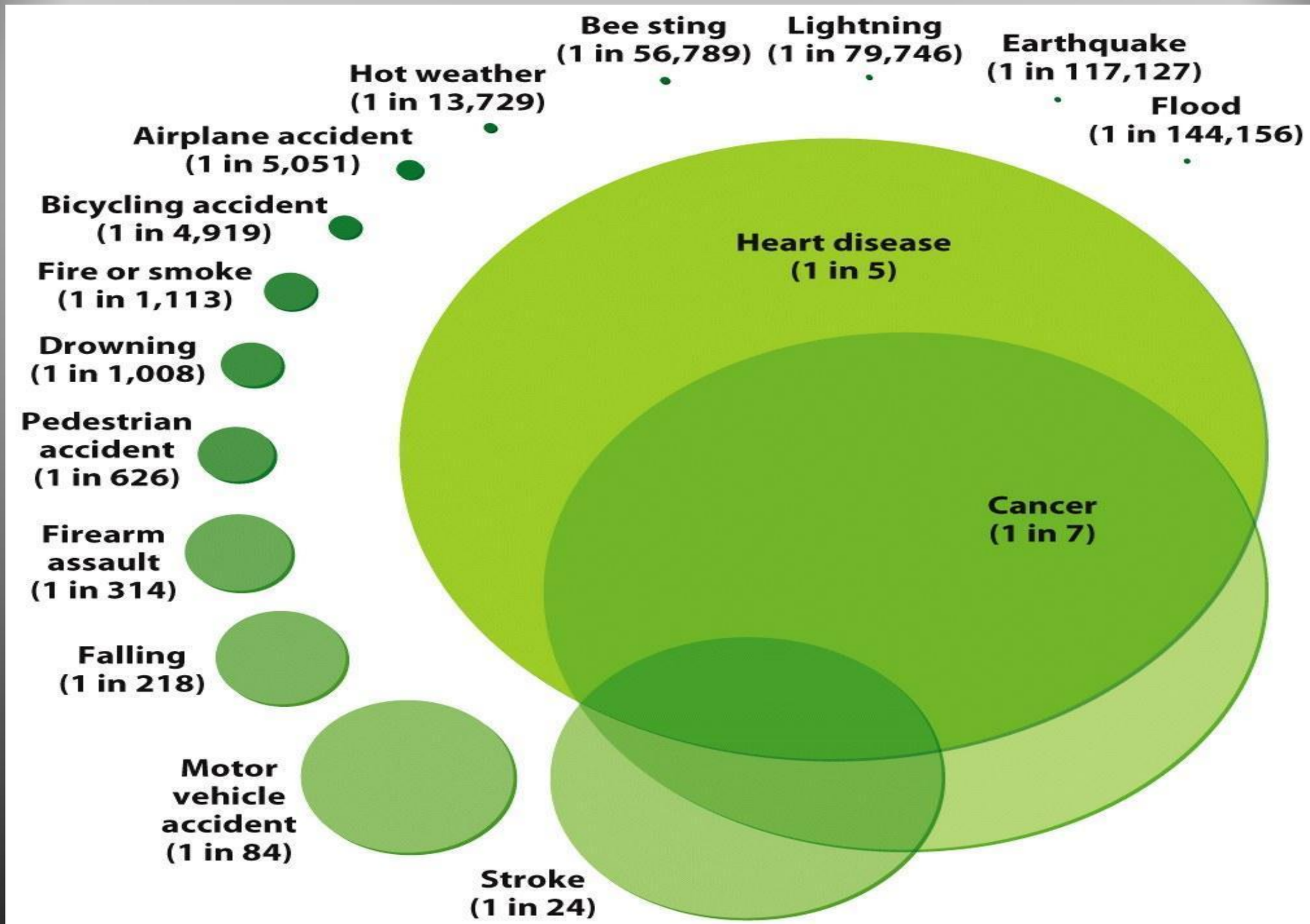


Figure 17.23
Environmental Scienc

Probabilities of death in the U.S….assess greatest to lowest risk .

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 *("dirty dozen")***
- These include *DDT, PCBs*, and certain chemicals that are by-products of manufacturing processes (caused endocrine disruptors)
- In 2009, 9 additional chemicals were added to the *"dirty dozen"*
- **REACH –** ***(R**egistration, **E**valuation, **A**uthorization (approval), **CH**emical (restriction of)*...agreement embraces the precautionary principle by putting more responsibility on them chemical companies to confirm that chemicals used in the environment pose to risk to people or the environment.