Chapter 18
Case Study: A Black Day in Bhopal, India

- The world’s worst industrial accident occurred in 1984 at a pesticide plant in Bhopal, India.
  - An explosion at Union Carbide pesticide plant in an underground storage tank released a large quantity of highly toxic methyl isocyanate (MIC) gas.
  - 15,000-22,000 people died
  - Indian officials claim that simple upgrades could have prevented the tragedy.
Central Case: Lake Apopka alligators

- Alligators in Lake Apopka, Florida, had reproductive problems
- The lake had high levels of agricultural runoff
- Chemical contaminants were disrupting the endocrine systems of alligators during egg development
- Because alligators and humans share the same hormones, chemicals can affect people, too
RISKS AND HAZARDS

- Risk is a measure of the likelihood that you will suffer harm from a hazard.
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

- **Physical hazards** = occur naturally in our environment
  - Earthquakes, volcanoes, fires, floods, droughts
  - We can’t prevent them, but we can prepare for them
  - We increase our vulnerability by deforesting slopes (landslides), channelizing rivers (flooding), etc.
  - We can reduce risk by better environmental choices
Chemical and biological environmental hazards

- **Chemical** = synthetic chemicals such as pesticides, disinfectants, pharmaceuticals
  - Harmful natural chemicals also exist

- **Biological** = result from ecological interactions
  - Viruses, bacteria, and other pathogens
  - **Infectious** (communicable, or transmissible) disease = other species parasitize humans, fulfilling their ecological roles
  - We can’t avoid risk, but we can reduce the likelihood of infection
Cultural environmental hazards

- **Cultural** = result from the place we live, our socioeconomic status, our occupation, our behavioral choices
  - Smoking, drug use, diet and nutrition, crime, mode of transportation
Disease is a major focus of environmental health

- Despite our technology, disease kills most of us
- Disease has a genetic and environmental basis
  - Cancer, heart disease, respiratory disorders
  - Poverty and poor hygiene can foster illnesses

(a) Leading causes of death across the world
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Infectious diseases kill millions

- Infectious diseases kill 15 million people per year
  - Half of all deaths in developing countries
  - Developed countries have better hygiene, access to medicine, and money

- **Vector** = an organism that transfers pathogens to a host

(b) Leading causes of death by infectious disease

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Many diseases are increasing

- Tuberculosis, acquired immunodeficiency syndrome (AIDS), and the West Nile virus
- Our mobility spreads diseases
- Diseases are evolving resistance to antibiotics
- Climate change will expand the range of diseases
- To predict and prevent diseases, experts deal with complicated interrelationships
Chemical Hazards

Most chemical hazards are man made.
“ALL SUBSTANCES ARE POISONS, THERE IS NONE WHICH IS NOT A POISON. THE RIGHT DOSE DIFFERENTIATES A POISON AND A REMEDY.”
Toxicology

- The study of the interaction between chemical agents and biological systems.

- Toxicity is the relative ability of a substance to cause adverse effects in living organisms.
Toxic agents in the environment

- The environment contains countless natural chemicals that may pose health risks
- But, synthetic chemicals are also in our environment
  - Every human carries traces of industrial chemicals

80% of U.S. streams contain at least trace amounts of 83 wastewater contaminants
Very few chemicals have been thoroughly tested

- 100,000 chemicals are on the market today
  - 72,000 industrial
  - 8,700 food additives
  - 2,000 new chemicals introduced per year
- We don’t know the effects, if any, they have
*Silent Spring* began public debate over chemicals

- Rachel Carson published *Silent Spring* in 1962
  - Brought together studies to show DDT risks to people, wildlife, and ecosystems
  - In the 1960s, pesticides were mostly untested and were sprayed over public areas, assuming they would do no harm
- The book generated significant social change
Typical variations in sensitivity to a toxic chemical within a population, mostly because of genetic variation.
Factors Influencing Toxicity

- Duration and Frequency of Exposure
- Route of Exposure
- Interspecies Variations (man vs. man) and Intraspecies Variations (man vs. animal)
  - age and maturity
  - gender and hormonal status
  - genetic makeup
  - state of health
Factors Influencing Toxicity (continued)

- Chemical Combinations
  - synergists: combination of chemicals causes a greater than additive effect
  - potentiation: the potentiator has the ability to increase toxicity of other chemicals
  - antagonists: combination of chemicals lessens the predicted effect
Factors Influencing Toxicity (continued)

- Environmental Factors
  - Temperature
  - Humidity
  - Elevation and Oxygen Concentration
  - Light/Dark
  - Radiant Heat
Common Terms

- Ceiling Values: maximum exposure level that no worker is to be subjected at any time.
- Short Term Exposure Limit: a 15-minute exposure limit that an employee can be exposed to without any adverse effects.
- Time Weighted Average: an 8-hour average limit that an employee can be exposed to without any adverse effects.
Common Terms (continued)

- Permissible Exposure Limit (PEL): action level set that accounts for the TWA and STEL during an average work day.
- Threshold Limit Value (TLV): a set of standards established by the American Council of Governmental Hygienists (ACGIH) for airborne substances and used to establish OSHA limitations.
Teratogenicity

- A substance that can cause the abnormal development of an embryo.

- Contamination can occur directly or indirectly through contact with a contaminated individual or equipment.
Dose Response Relationship

- Health Impact Studies determine an LD_{50} or LC_{50}
- Lethal Dosage or Lethal Concentration that will kill one-half of the population

Increasing Dose (mg/l)

100%

50%
Dose-response analysis

- **Dose-response analysis** = measuring how much effect a toxicant produces at different doses
  - Animal testing
  - **Dose** = the amount of toxicant the test animal receives
  - **Response** = the type or magnitude of negative effects of the animal
  - **Dose-response curve** = the plot of dose given against response
Dose response curves

- **LD$_{50}$/ED$_{50}$** = the amount of toxicant required to kill (affect) 50% of the subjects
- **Threshold** = the dose level where certain responses occur
  - Organs can metabolize or excrete low doses of a toxicant
  - Some toxicants show a J-shaped, U-shaped, or inverted curve
- Scientists extrapolate downward from animal studies to estimate the effect on humans
  - Regulatory agencies set allowable limits well below toxicity levels in lab studies
The type of exposure affects the response

- **Acute exposure** = high exposure for short periods of time to a hazard
  - Easy to recognize
  - Stem from discrete events: ingestion, oil spills, nuclear accident

- **Chronic exposure** = low exposure for long periods of time to a hazard
  - Hard to detect and diagnose
  - Affects organs gradually: lung cancer, liver damage
  - Cause and effect may not be easily apparent
Routes of Entry

- Inhalation: mist, fumes, dust, aerosols or vapor
- Absorption: liquid
- Ingestion: liquid or solid
- Injection: liquid or solid
Airborne toxicants travel widely

- Because chemicals can travel by air, their effects can occur far from the site of chemical use
- **Pesticide drift** = airborne transport of pesticides
- Synthetic chemical contaminants are found globally
  - They appear in arctic polar bears, Antarctic penguins, and people living in Greenland
Some toxicants persist for a long time

- Toxins can degrade quickly and become harmless
  - Or, they may remain unaltered and persist for decades
  - Rates of degradation depends on temperature, moisture, and sun exposure
- Persistent chemicals have the greatest potential for harm
- **Breakdown products** = toxicants degrade into simpler products
  - May be more or less harmful than the original substance
  - DDT degrades into DDE, which is also highly persistent
Toxicants can accumulate and biomagnify

- Some toxicants can be excreted or metabolized
  - Fat-soluble toxicants are stored in fatty tissues
- **Bioaccumulation** = toxicants build up in animal tissues
- **Biomagnification** = toxicants concentrate in top predators
  - Near extinction of peregrine falcons and brown pelicans
Not all toxicants are synthetic

- Chemical toxicants also exist naturally and in our food
  - Don’t assume natural chemicals are all healthy and synthetic ones are all harmful

- Some scientists feel that natural toxicants dwarf our intake of synthetic chemicals
  - Natural defenses against toxins are effective against synthetic ones, too
  - Critics say natural toxins are more readily metabolized and excreted, and synthetic chemicals persist and accumulate
Indicators of Overexposure

Observable Indicators

- Complexion Changes
- Loss of Coordination
- Change in Demeanor
- Excessive Salivation
- Dilation/Contraction of the Pupils
- Changes in Speech Pattern
- Coughing, Sneezing, Wheezing
Indicators of Overexposure: Non-Observable Indicators

- Headaches
- Dizziness
- Blurred Vision, Hallucinations
- Cramps
- Irritation on the skin, lungs
- Behavioral changes
- Heart Rate, Respiration Rate increases
What is Hazardous?

- According to OSHA, a substance is hazardous if it:
  - Carcinogen
  - Corrosive
  - Irritant
  - Sensitizer
  - Toxic
  - Highly Toxic
  - Target Organ Effects
If a substance has a target organ effect, exposure to the substance will cause a distinct and exact adverse health effect.

**Target Organs:** Eyes, Pulmonary System, Skin, Liver, Kidneys, Reproductive Organs, Bone Marrow and Blood.
Substances causing toxic responses to the eye

- Acids and Alkalis
- Organic Solvents
- Vessicants
- Lacrimators
- Drugs
- Airborne Irritants
- Bacteria
Responses to the Eye

- Blindness
- Scratches or tears in the Cornea
- Conjunctivitis
- Pupil Dilation
- Blocked Tear Ducts
Substances causing toxic pulmonary responses

- Inorganic Toxicants
- Particles
- Organic Chemicals
- Metals
Responses to the lungs

- Irritation
- Necrosis
- Asphyxiation
- Fibrosis
- Emphysema
- Sensitization
- Carcinogenensis
Substances causing toxic responses to the liver

- Hepatotoxins
- Alcohols
- Ketones
Responses to the liver

- Scerosis of the liver
- Liver failure
Substances causing toxic responses to the kidneys

- Nephrotoxins
- Metals
- Drugs
Responses to the kidneys

- Nephritis
- Nephrosis
- Renal Failure
Substances causing toxic responses to the neural net

- Neurotoxins
- Therapeutic Agents
- Metals and Metalloids
- Industrial Chemicals
- Bacteria
- Mold By-products
Responses to the nervous system

- Nerve damage
- Confusion
- Paralysis
- Agitation
- Shaking, trembling
Substances causing toxic responses to the skin

- Dermotoxins
- Physical toxins
- Chemical substances
Responses to the skin

- Eczema, Inflammation and Hives
- Burns
- Necrosis
- Light Sensitization
- Changes in elasticity and pigmentation
• Contact Dermatitis on the hands and arms
Toxic Responses to blood and bone marrow

- Hematotoxins
- Changes in the number of red blood cells
- Changes in the number and kind of white blood cells
- Changes in the number of platelets
Substances causing toxic effects to the immune system

- Immunotoxins
- Polychlorinated Biphenyls (PCBs)
- Heavy Metals
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Aromatic Amines
- Oxidant gases
- Asbestos and Smoking
Effects of Chemicals on the Immune, Nervous, and Endocrine Systems

- Long-term exposure to some chemicals at low doses may disrupt the body’s:
  - **Immune system**: specialized cells and tissues that protect the body against disease and harmful substances.
  - **Nervous system**: brain, spinal cord, and peripheral nerves.
  - **Endocrine system**: complex network of glands that release minute amounts of hormones into the bloodstream.
Effects to the immune system

- Acquired Immune Deficiency Syndrome (AIDS)
- Illness
Evidence for hormone disruption

- Frogs also have gonadal abnormalities
  - Male frogs became feminized from atropine concentrations well below EPA guidelines
- PCB-contaminated human babies were born weighing less, with smaller heads
Male sperm counts are dropping

- Scientists attribute the shocking drop in men’s sperm counts to endocrine disruptors
  - The number and motility of sperm has dropped 50% since 1938
- Testicular cancer, undescended testicles, and genital birth defects are also increasing

![Graph of declining sperm count in men, based on 61 studies](a)

![Graph of increasing incidence of testicular cancer](b)
Endocrine disruption research is controversial

- Research results are uncertain, which is inherent in any young field
- Negative findings pose economic threats to chemical manufacturers
  - Banning a top-selling chemical could cost a company millions of dollars
  - Bisphenol-A, found in plastics, can cause birth defects, but the plastics industry protests that the chemical is safe
- Studies reporting harm are publicly funded, but those reporting no harm are industry funded
Additional Health Hazards
Substances causing cancer

- Carcinogens
- Radiation
- Personal Habits
- Synthetic Chemicals
- Natural Materials
- Synthetic or Natural Aromatics
Heat Stress

- Four environmental factors that affect heat stress:
  - temperature
  - humidity
  - radiant heat
  - air velocity
Heat Stresses and Treatment

- Fainting or heat syncope is the loss of consciousness temporarily.
  - remove victim to a cool area
- Heat rash or prickly heat is a skin rash caused by sweat that is not removed from the skin.
  - treatment with creams
  - prevent by allowing body to dry thoroughly
Heat cramps are caused when water is replenished but not the essential salts.
-replenish body fluids with fortified drinks
Heat Stresses and Treatment (continued)

- Heat exhaustion is caused by a loss of fluid and is characterized by fatigue, giddiness, nausea, headaches, clammy-moist skin, pale and flushed face, body temperature is normal.
  - replenish body fluids with water or electrolytes
Heat stroke is caused by the body’s inability to regulate internal temperature and is characterized by cessation of sweating, mental confusion, hot and dry skin and a body temperature above 106°F.

- remove victim to a cool area and soak with cool water
- immediate attention is required
Prevention of Heat Related Work Stressors

- Adjust work schedule
- Provide shelter
- Maintain body fluids
- Maintain fitness levels
- Training
- Provide Cooling Devices
Personal Heat Tolerances

- Each individual responds to heat differently based on
  - acclimatization
  - physical condition
  - weight
  - age
  - alcohol and drug consumption
  - smoking
In order to properly protect yourself from the heat it is important to know the environmental conditions.

- heat stress index
- effective temperature
- wet bulb globe temperature
By monitoring your own physiological state, you may be able to prevent heat stress from adversely affecting your health.

- heart rate
- oral temperature
- body water loss
Noise Effects

- Effects of high noise pollution can cause
  - temporary threshold shifts
  - permanent threshold shifts
  - communication interference
  - physiological effects
Noise Prevention and Control

- Engineering controls
- Work practices
- Process substitution
- Enclosure
- Hearing Protection
Hearing Protection

- Hearing protection is required by OSHA if the noise level is greater than 85 decibels.
- If hearing protection is required, annual audiometric testing is required as part of the medical maintenance program.
Specific Toxicological Effects
Carbon Monoxide

- Product of combustion
- CO has a compounding effect, “shampoo” effect
- Exposure can lead to headaches, flushed face, dizziness, weakness and chest tightness, death
- Remove victim to fresh air
Organic Solvents

- Most organic solvents are aromatic and volatile
- Can be carcinogens
- “Nuisance” odors can give the perception of overexposure
- Can cause headaches, nausea, skin and eye irritation
Heavy Metals

- Heavy metals can bioaccumulate
- Lead can cause learning dysfunctions and behavioral problems in small children; only a doctor can detoxify a victim
- Aluminum can cause neurological dysfunctions; example: Alzheimer’s disease has been linked to Al exposure
RCRA 8 Heavy Metals

- Arsenic
- Barium
- Cadmium
- Chromium
- Lead
- Mercury
- Selenium
- Silver
Mercury Rising
What form does it take?
Where does it come from?

- Mercury is a naturally occurring metal found throughout the environment. Mercury enters the environment as the result of the normal breakdown of minerals in rocks and soil from exposure to wind and water, and from volcanic activity.
- Ionic forms of mercury are released to the air, primarily from fossil fuel combustion, mining, and smelting, and from solid waste incineration.
  - About 40% is specifically the combustion of coal.
  - About 15% of the total is released to the soil from fertilizers, fungicides, and municipal solid waste (for example, from waste that contains discarded batteries, electrical switches, or thermometers).
  - An additional 5% is released from industrial wastewater to water in the environment.
  - Hospitals and light bulbs also contribute Hg to the environment.
Health effects of mercury

- Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages.
  - Research shows that most people's fish consumption does not cause a health concern. However, it has been demonstrated that high levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system, making the child less able to think and learn.
Ecological effects of mercury

- Birds and mammals that eat fish are more exposed to mercury than other animals in water ecosystems. Similarly, predators that eat fish-eating animals may be highly exposed. At high levels of exposure, methylmercury's harmful effects on these animals include death, reduced reproduction, slower growth and development, and abnormal behavior.
Lead

- Lead is a toxic metal that was used for many years in products found in and around our homes.
  - Paint
  - Gasoline
  - Pipe fittings and solder joints
- You can still find lead in
  - Older homes that have peeling paint
  - Soil
  - Dust
  - Toys and jewelry
  - Some water samples
Dangers of Lead

- If not detected early, children with high levels of lead in their bodies can suffer from:
  - Damage to the brain and nervous system
  - Behavior and learning problems, such as hyperactivity
  - Slowed growth
  - Hearing problems
  - Headaches

- Lead is also harmful to adults. Adults can suffer from:
  - Reproductive problems (in both men and women)
  - High blood pressure and hypertension
  - Nerve disorders
  - Memory and concentration problems
  - Muscle and joint pain
What is a high level?

- The body cannot remove most of the lead ingested and so it accumulates in soft tissue and bone.
  - 40 µg/dL
  - A physician must de-toxify an exposed individual
Lead Legislation

- **Residential Lead-Based Paint Hazard Reduction Act of 1992:**
  - An amendment to TSCA
  - Homes must be inspected by a trained professional
  - Any home built prior to 1978 must be remediated

- **Safe Drinking Water Act (SDWA):** sets a regulatory limit of 0.015 mg/L of Lead in drinking water

- **Clean Water Act (CWA):** sets discharge limits on Lead.

- **RCRA:** sets limits of Lead in hazardous waste.
Asbestos

- Asbestos is a mineral fiber that has been used commonly in a variety of building construction materials for insulation and as a fire-retardant. Because of its fiber strength and heat resistant properties, asbestos has been used for a wide range of manufactured goods, mostly in building materials (roofing shingles, ceiling and floor tiles, paper products, and asbestos cement products), friction products (automobile clutch, brake, and transmission parts), heat-resistant fabrics, packaging, gaskets, and coatings.
Where do you find asbestos?

- Floor Tile and Mastic
- Insulation
- Pipe Fittings and Insulation
- Siding
- Automotive Parts
- High Heat Industrial auxiliaries
Friable and Non-friable

- When asbestos-containing materials are damaged or disturbed by repair, remodeling or demolition activities, microscopic fibers become airborne (friable) and can be inhaled into the lungs, where they can cause significant health problems.
  - It isn’t a problem UNTIL it becomes airborne.
Exposure Hazards

- Exposure to asbestos increases your risk of developing lung disease. That risk is made worse by smoking. In general, the greater the exposure to asbestos, the greater the chance of developing harmful health effects. Disease symptoms may take several years to develop following exposure. If you are concerned about possible exposure, consult a physician who specializes in lung diseases.
Asbestosis

- Asbestosis is a serious, progressive, long-term non-cancer disease of the lungs. It is caused by inhaling asbestos fibers that irritate lung tissues and cause the tissues to scar. The scarring makes it hard for oxygen to get into the blood. Symptoms of asbestosis include shortness of breath and a dry, crackling sound in the lungs while inhaling. There is no effective treatment for asbestosis.
Lung cancer causes the largest number of deaths related to asbestos exposure. People who work in the mining, milling, manufacturing of asbestos, and those who use asbestos and its products are more likely to develop lung cancer than the general population. The most common symptoms of lung cancer are coughing and a change in breathing. Other symptoms include shortness of breath, persistent chest pains, hoarseness, and anemia.
Mesothelioma is a rare form of cancer that is found in the thin lining (membrane) of the lung, chest, abdomen, and heart and almost all cases are linked to exposure to asbestos. This disease may not show up until many years after asbestos exposure. This is why great efforts are being made to prevent school children from being exposed.
Acids and Bases

- Acids and strong bases can cause first, second or third degree burns and scarring; skin and eye irritation
- Tissue damage can be permanent
- Some acids are so strong that they will infiltrate to skeletal system and begin to leech important minerals (HF)
Environmental health hazards exist indoors

- **Radon** = a highly toxic, radioactive gas that is colorless and undetectable
  - Can build up in basements
- **Lead poisoning** = from lead pipes
  - Damages organs; causes learning problems, behavior abnormalities, and death
- **Asbestos** = insulates, muffles sounds, and resists fire
  - **Asbestosis** = scarred lungs may cease to function
A recently recognized hazard

- Polybrominated diphenyl ethers (PBDEs) = has fire-retardant properties
  - Used in computers, televisions, plastics, and furniture
  - Persist and accumulate in living tissue
  - **Endocrine disruptors** = compounds that mimic hormones and interfere with the functioning of animals’ endocrine (hormone) systems
  - Affect brain and nervous system development, and may cause cancer
Airborne biological contaminants can cause headaches, nausea, symptomatic allergic reactions.

Legionella bacteria can cause serious illness and/or death.

There are toxigenic fungi and mold and fungi that are listed as indoor air quality concerns.
Etiological Hazards
BIOLOGICAL HAZARDS:
DISEASE IN DEVELOPED AND DEVELOPING COUNTRIES

- Diseases not caused by living organisms cannot spread from one person to another (nontransmissible disease), while those caused by living organisms such as bacteria and viruses can spread from person to person (transmissible or infectious)
Transmissible Disease

- Pathway for infectious disease in humans.

Figure 18-4
WHO estimates that each year the world’s seven deadliest infections kill 13.6 million people – most of them the poor in developing countries.

- Pneumonia and flu (bacteria and viruses): 3.2 million
- HIV/AIDS (virus): 3.0 million
- Malaria (protozoa): 2.0 million
- Diarrheal diseases (bacteria and viruses): 1.9 million
- Tuberculosis (bacteria): 1.7 million
- Hepatitis B (virus): 1 million
- Measles (virus): 800,000

Figure 18-5
Case Study: Growing Germ Resistance to Antibiotics

- Rabidly producing infectious bacteria are becoming genetically resistant to widely used antibiotics due to:
  - *Genetic resistance*: Spread of bacteria around the globe by humans, overuse of pesticides which produce pesticide resistant insects that carry bacteria.
  - *Overuse of antibiotics*: A 2000 study found that half of the antibiotics used to treat humans were prescribed unnecessarily.
Case Study: The Growing Global Threat from Tuberculosis

- The highly infectious tuberculosis (TB) kills 1.7 million people per year and could kill 25 million people 2020.
- Recent increases in TB are due to:
  - Lack of TB screening and control programs especially in developing countries due to expenses.
  - Genetic resistance to the most effective antibiotics.
Viral Diseases

- Flu, HIV, and hepatitis B viruses infect and kill many more people each year than highly publicized West Nile and SARS viruses.
  - The influenza virus is the biggest killer virus worldwide.
    - Pigs, chickens, ducks, and geese are the major reservoirs of flu. As they move from one species to another, they can mutate and exchange genetic material with other viruses.
Avian Flu

- Online NewsHour: Thailand Prepares for Deadly Avian Flu -- April 7, 2005
Early on, a bout with SARS may feel like the flu. SARS patients tend to first develop a fever of over 100.4 degrees Fahrenheit as their first symptom, possibly accompanied by a headache, body aches or overall discomfort. After two to seven days, patients may develop a dry cough or have trouble breathing. Some patients may eventually be unable to breathe on their own because their lungs are so congested. A small percentage of patients eventually die from the disease because it has damaged their lungs so severely.
What causes SARS?

- A virus that has never before been seen in humans. The virus comes from the coronavirus family, which is also the source of one of the viruses that cause the common cold. Viruses in this family also cause severe illnesses in animals. According to researchers in Hong Kong, the SARS virus comes from animals -- a finding that may eventually help scientists in their search for a vaccine.
How do I get it?

- SARS is most commonly spread through close contact with someone who has the disease. People can catch the virus by getting it on their hands and then touching their eyes, nose or mouth. This could happen if they touch something that an infected person has recently coughed or sneezed on.
Although SARS continues to spread to new regions, the CDC has highlighted several hard-hit areas in its travel warnings. They are suggesting that people may wish to postpone trips to mainland China and Hong Kong; Singapore; and Hanoi, Vietnam. The WHO offered similar travel recommendations for Asia, except that its warnings for trips to China did not pertain to the entire mainland – just the Shanxi and Guangdong Provinces and the city of Beijing.

Toronto, Canada is also struggling to contain SARS. The CDC is advising that those visiting the city observe certain precautions, such as avoiding locations — like hospitals caring for SARS patients — where the virus is likely to be transmitted.
Online NewsHour: Working With Fear of SARS -- April 18, 2003
Viral Diseases

- HIV is the second biggest killer virus worldwide. Five major priorities to slow the spread of the disease are:
  - Quickly reduce the number of new infections to prevent further spread.
  - Concentrate on groups in a society that are likely to spread the disease.
  - Provide free HIV testing and pressure people to get tested.
  - Implement educational programs.
  - Provide free or low-cost drugs to slow disease progress.
How Would You Vote?

Should developed and developing nations mount an urgent global campaign to reduce the spread of HIV and to help countries afflicted by the disease?

- a. No. A global AIDS campaign could divert attention and resources from efforts to combat other serious threats.
- b. Yes. The disease is decimating the populations and destroying the economies of many developing countries.
Malaria kills about 2 million people per year and has probably killed more than all of the wars ever fought.
Economists estimate that spending $2-3 billion on malaria treatment may save more than 1 million lives per year.
Case Study: Malaria – Death by Mosquito

- Spraying insides of homes with low concentrations of the pesticide DDT greatly reduces the number of malaria cases.
  - Under international treaty enacted in 2002, DDT is being phased out in developing countries.
Gates vs. Malaria
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
- Careful hand washing by all medical personnel
- Immunize children against major viral diseases
- Oral rehydration for diarrhea victims
- Global campaign to reduce HIV/AIDS
Mostly because of human activities, infectious diseases are moving at increasing rates from one animal species to another (including humans).

Ecological (or conservation) medicine is devoted to tracking down these connections between wildlife and humans to determine ways to slow and prevent disease spread.
Risk Assessment
The Occupational Safety and Health Act of 1970 created an organization under the Department of Labor to protect the industrial worker.

- Occupational Safety and Health Administration (OSHA)

The goal of OSHA is to make the workplace a safe environment

- 29 CFR 1910: General Industry
- 29 CFR 1926: Construction
• **Intrinsically Safe**: A device, instrument or component that will not produce any spark or thermal effects under any conditions that are normal or abnormal that will ignite a specified gas mixture.

• **Inherent safety** is a concept particularly used in the chemical and process industries. An inherently safe process has a low level of danger even if things go wrong.
Risk assessment

- **Risk** = the probability that some harmful outcome will result from a given action
  - Exposure to environmental health threats doesn’t automatically produce an effect
  - Rather, it causes some probability (likelihood) of harm

- **Probability entails**
  - Identity and strength of threat
  - Chance and frequency that an organism will encounter it
  - Amount of exposure to the threat
  - An organism’s sensitivity to the threat
What is acceptable?

- According to the U.S. EPA, an acceptable level of risk is 1 in a million
Analyzing risk quantitatively

- **Risk assessment** = the quantitative measurement of risk and the comparison of risks involved in different activities or substances
  - It is a way of identifying and outlining problems
- Several steps:
  - Scientific study of toxicity
  - Assessing an individual or population’s likely extent of exposure to the substance, including frequency, concentrations, and length of exposure
- Studies are often performed by industry-associated scientists, which may undermine the study’s objectivity
Risk management

- Combines decisions and strategies to minimize risk
- Scientific assessments are considered with economic, social, and political needs and values
- Developed nations have federal agencies to manage risk
  - The U.S. has the Centers for Disease Control (CDC), the EPA, and the Food and Drug Administration (FDA)
- Comparing costs and benefits is hard
  - Benefits are economic and easy to calculate
  - Health risks (costs) are hard-to-measure probabilities of a few people being affected
The process of risk management

Scientific results and measurement of probability

Risk assessment

Scientific data on:
- Hazard identification
- Toxicity characterization
- Extent of exposure

Information, opinion, and lobbying from:
- Private citizens
- Industry and manufacturing
- Nonprofit interest groups

Risk management

Political, social, economic, and ethical considerations

Policy

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One approach to determining safety

- **Innocent until proven guilty approach:** product manufacturers must prove a product is safe
  - Benefits: now slowing down technological innovation and economic advancement
  - Disadvantage: putting into wide use some substances that may later on turn out to be dangerous
Scientists have developed ways to evaluate and compare risks, decide how much risk is acceptable, and find affordable ways to reduce it.
RISK ANALYSIS

- Estimating risks from using many technologies is difficult due to unpredictability of human behavior, chance, and sabotage.

\[
\text{System reliability (\%) } = \frac{\text{Technology reliability}}{\times} \frac{\text{Human reliability}}{
\]

- Reliability of a system is multiplicative:
  - If a nuclear power plant is 95% reliable and human reliability is 75%, then the overall reliability is \((0.95 \times 0.75 = 0.71)\) 71%. 
• Annual deaths in the U.S. from tobacco use and other causes in 2003.
Number of deaths per year in the world from various causes. Parentheses show deaths in terms of the number of fully loaded 400-passenger jumbo jets crashing every day of the year with no survivors.
Perceiving Risk

- Most individuals evaluate the relative risk they face based on:
  - Degree of control.
  - Fear of unknown.
  - Whether we voluntarily take the risk.
  - Whether risk is catastrophic.
  - Unfair distribution of risk.

- Sometimes misleading information, denial, and irrational fears can cloud judgment.
Perceiving risks

- Everything we do involves some risk
- We try to minimize risk, but we often misperceive it
  - Flying versus driving
- We feel more at risk when we cannot control a situation
  - We fear nuclear power and toxic waste, but not smoking or overeating

![Bar chart showing the loss of life expectancy (days) for various risks.](chart.png)
RISK ANALYSIS

- Comparisons of risks people face expressed in terms of shorter average life span.
Becoming Better at Risk Analysis

- We can carefully evaluate or tune out of the barrage of bad news covered in the media, compare risks, and concentrate on reducing personal risks over which we have some control.
Two approaches for determining safety

<table>
<thead>
<tr>
<th>Sequence of events</th>
<th>“Innocent until proven guilty” approach</th>
<th>Precautionary principle approach</th>
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<tr>
<td>Industrial research and development</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<td>Pre-market testing by industry, government, and academic scientists</td>
<td><img src="image3.png" alt="Image" /> Limited testing; most products brought to market</td>
<td><img src="image4.png" alt="Image" /> Rigorous testing; only the safest products brought to market</td>
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<tr>
<td>Consumer use of products</td>
<td><img src="image5.png" alt="Image" /> Some products harm human health</td>
<td><img src="image6.png" alt="Image" /> Minimal impact on human health</td>
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<tr>
<td>Post-market testing by industry, government, and academic scientists</td>
<td><img src="image7.png" alt="Image" /> Rigorous testing demanded</td>
<td><img src="image8.png" alt="Image" /> Limited testing required</td>
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<td>Regulations and bans of unsafe products</td>
<td><img src="image9.png" alt="Image" /> Unsafe products recalled</td>
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<tr>
<td>Consumer use of safe products</td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Different nations use different policies; most use a mix between the “innocent until proven guilty” principle and the precautionary principle

- Europe is shifting more towards the precautionary principle
- Industries like the “innocent until proven guilty” approach because it allows them to produce more and make more money
The EPA regulates many substances

- Federal agencies apportion responsibility for tracking and regulating synthetic chemicals
  - FDA: food, food additives, cosmetics, drugs, and medical devices
  - EPA: pesticides
  - Occupational Safety and Health Administration (OSHA): workplace hazards

- Many public health and environmental advocates fear it isn’t enough
  - Many synthetic chemicals are not actually tested
  - Only 10% have been tested for toxicity
  - Fewer than 1% are government regulated
International regulation

- Nations address chemical pollution with international treaties
- **Stockholm Convention on Persistent Organic Pollutants (POPs)** was ratified by 140 nations in 2004
  - Ends the release of the 12 most dangerous POPs
- EU’s Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) Program
  - Aims to evaluate and restrict dangerous chemicals while giving industries a streamlined regulatory system
  - It will cost the chemical industry 2.8 – 5.2 billion euros (U.S. $3.8 – 7.0 billion), but will save more than 10 times that in health benefits