ENVIRONMENTAL HEALTH,

POLLUTION AND TOXICOLOGY

Disease —impairment of an individual's well-being and ability to function—is often due to poor adjustment between the individual and the environment.

- Disease occurs on a continuum—between a state of health and a state of disease is a gray zone of suboptimal health, a state of imbalance. In the gray zone, a person may not be diagnosed with a specific disease but may not be healthy.

- There are many gray zones in environmental health resulting from exposure to man-made chemicals, including pesticides; food additives, such as coloring, preservatives, and artificial saturated fat, some of which alter the chemical structure of food; exposure to tobacco smoke; exposure to air pollutants, such as ozone; exposure to chemicals in gasoline and in many household cleaners; and exposure to heavy metals, such as mercury or lead. As a result of exposure to chemicals in the environment from human activity, we may be in the midst of an epidemic of chronic disease that is unprecedented in human history.

- Many people believe that soil, water, and air in a so called natural state must be good, and that if human activities have changed or modified them, they have become contaminated, polluted, and therefore bad. BUT; many natural processes—including dust storms, floods, and volcanic processes—can introduce materials harmful to people and other living things into the soil, water, and air.

- the night of August 21, 1986
- there was a massive natural release of CO2 from Lake Nyos in Cameroon, Africa.
- it was probably initially released from volcanic vents at the bottom of the lake and accumulated there over time.
- water keep the dissolved gas down at the bottom, but the water was evidently agitated by a slide or small earthquake, and the bottom water moved upward.
- CO2 reached the surface of the lake, it was released quickly into the air.
- CO2 gas is heavier than air, it flowed downhill from the lake and settled in nearby villages, killing many animals and more than 1,800 people by asphyxiation

- A polluted environment is one that is impure, dirty, or otherwise unclean. The term **pollution** refers to an unwanted change in the environment caused by the introduction of harmful materials or the production of harmful conditions (heat, cold, sound).

- **Contamination** has a meaning similar to that of pollution and implies making something unfit for a particular use through the introduction of undesirable materials—for example, the contamination of water by hazardous waste.

- The term **toxin** refers to substances (pollutants) that are poisonous to living things.
- **Toxicology** is the science that studies toxins or suspected toxins, and toxicologists are scientists in this field.
- A **carcinogen** is a toxin that increases the risk of cancer.

- Pollutants are commonly introduced into the environment by way of **point sources**, such as smokestacks, pipes discharging into waterways, a small stream entering the ocean, or accidental spills.
- **Area sources -nonpoint sources**, are more diffused over the land and include urban runoff and mobile sources, such as automobile exhaust. Area sources are difficult to isolate and correct because the problem is often widely dispersed over a region, as in agricultural runoff that contains pesticides.

Categories of Pollutants

Infectious Agents

- Infectious diseases spread by the interactions between individuals and by the food, water, air, soil, and animals we come in contact with
- constitute some of the oldest health problems
- infectious diseases have the potential to pose rapid threats, both local and global, by spreading in hours via airplane travelers.
- terrorist activity may also spread diseases.
- new diseases are emerging, and previous ones may emerge again. Although we have cured many diseases, we have no known reliable vaccines for others, such as HIV, hantavirus, and dengue fever.

- The H1N1 flu pandemic (widespread outbreak of a disease) that became apparent in 2009 started in Mexico and has spread around the world.
- The complete origin remains unknown, but it has genetic markers of two swine flues, a human flu, and an avian (bird) flu. As we live closer together, nearer large numbers of animals such as chickens and pigs in large industrial farms and tightly confined animals in smaller farms, the probability of a disease crossing from animals to humans increases.

Environmentally Transmitted Infectious Disease

- Diseases that can be controlled by manipulating the environment such as by improving sanitation or treating water are classified as environmental health concerns. Although there is great concern about the toxins and carcinogens produced in industrial society today, the greatest mortality in developing countries is caused by environmentally transmitted infectious disease.

- In the United States thousands of cases of waterborne illness and food poisoning occur each year. These diseases can be spread by people, by mosquitoes and fleas or by contact with contaminated food, water or soil. They can also be transmitted through ventilation systems in buildings.

Some examples of environmentally transmitted infectious diseases.

- Legionellosis or legionnaires disease which often occurs where air conditioning systems have been contaminated by disease causing organisms.
- Giardiasis a protozoan infection of the small intestine spread via food, water or person to person contact
- Salmonella a food poisoning bacterial infection that is spread via water or food
- Malaria a protozoan infection transmitted by mosquitoes
- Lyme borreliosis (Lyme disease) transmitted by ticks
- Cryptosporidiosis a protozoan infection transmitted via water or person to person contact
- Anthrax spread by terrorist activity

Toxic Heavy Metals

- The major heavy metals that pose health hazards to people and ecosystems include **mercury, lead, cadmium, nickel, gold, platinum, silver, bismuth, arsenic, selenium, vanadium, chromium, and thallium.**
- Each of these elements may be found in soil or water not contaminated by people, each has uses in our modern industrial society, and each is also a by-product of the mining, refining, and use of other elements.
- Heavy metals often have direct physiological toxic effects.

- **Some are stored or incorporated in living tissue, sometimes permanently.**
- **Heavy metals tend to be stored (accumulating with time) in fatty body tissue. A little arsenic each day may eventually result in a fatal dose—the subject of more than one murder mystery.**

- The quantity of heavy metals in our bodies is referred to as the **body burden**.
- The body burden of toxic heavy elements for an average human body (70 kg) is about 8 mg of antimony, 13 mg of mercury, 18 mg of arsenic, 30 mg of cadmium, and 150 mg of lead. Mercury, thallium, and lead are very toxic to people. They have long been mined and used, and their toxic properties are well known.

Mercury, for example, is the “Mad Hatter” element. At one time, mercury was used to stiffen felt hats, and because mercury damages the brain, hatters in Victorian England were known to act peculiarly. Thus, the Mad Hatter in Lewis Carroll’s Alice in Wonderland had real antecedents in history.

Toxlc Pathways

- Chemical elements released from rocks or human processes can become concentrated in people through many pathways (Figure 10.4). These pathways may involve what is known as **biomagnification** —the accumulation or increasing concentration of a substance in living tissue as it moves through a food web (also known as **bioaccumulation**).

- For example, cadmium, which increases the risk of heart disease, may enter the environment via ash from burning coal. The cadmium in coal is in very low concentrations (less than 0.05 ppm). However, after coal is burned in a power plant, the ash is collected in a solid form and disposed of in a landfill. The landfill is covered with soil and revegetated. The low concentration of cadmium in the ash and soil is taken into the plants as they grow, but the **concentration of cadmium in the plants is three to five times greater than the concentration in the ash**. As the cadmium moves through the food chain, it becomes more and more concentrated. By the time it is incorporated **into the tissue of people and other carnivores, the concentration is approximately 50 to 60 times the original concentration in the coal**.

Organic Compounds

- Organic compounds are carbon compounds produced naturally by living organisms or synthetically by industrial processes. It is difficult to generalize about the environmental and health effects of artificially produced organic compounds because there are so many of them, they have so many uses, and they can produce so many different kinds of effects.

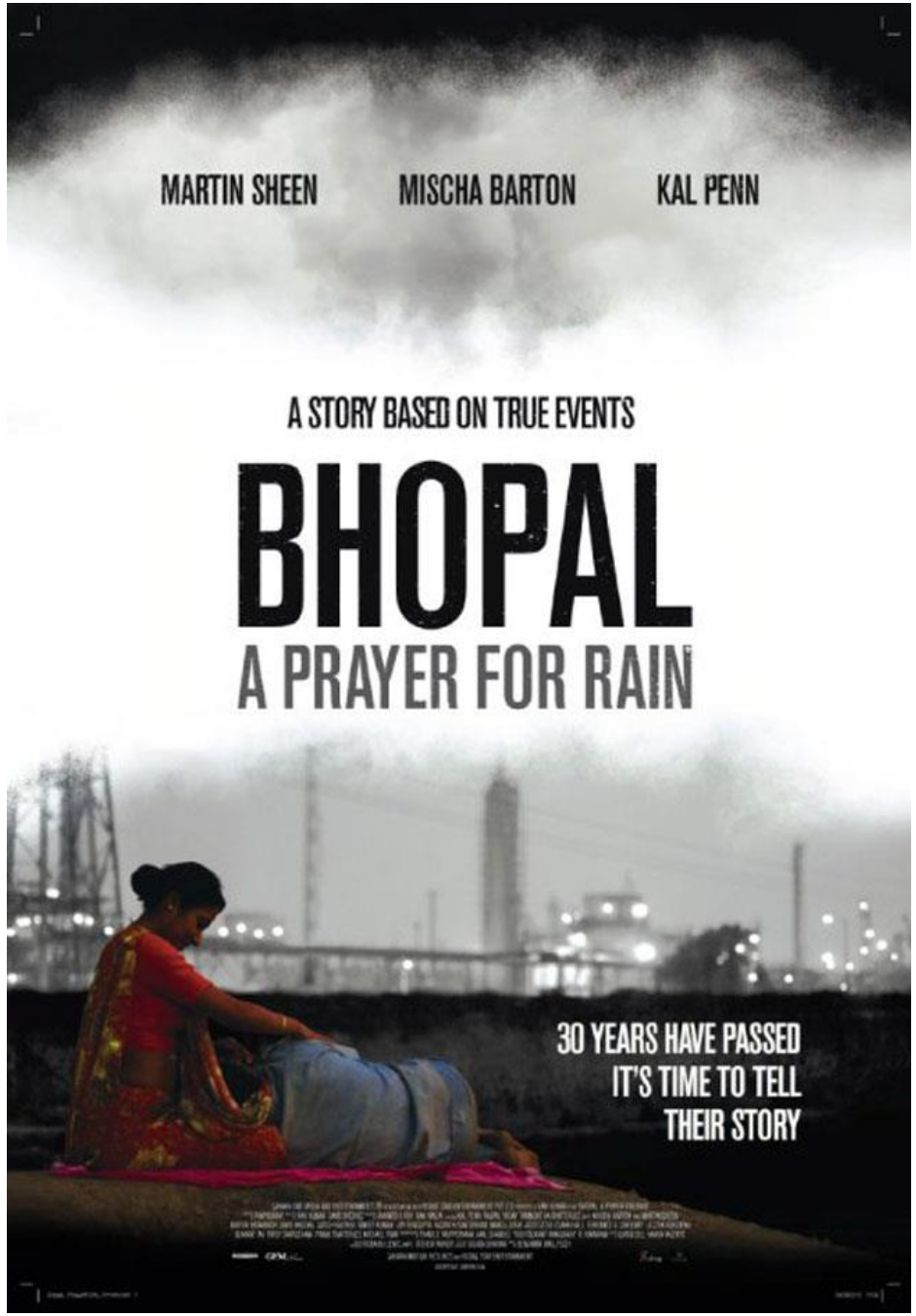
- Synthetic organic compounds are used in industrial processes, pest control, pharmaceuticals, and food additives.
- over 20 million synthetic chemicals, and new ones are appearing at a rate of about 1 million per year!
- Most are not produced commercially, but up to 100,000 chemicals are now being used, or have been used in the past.
- Once used and dispersed in the environment, they may become a hazard for decades or even hundreds of years.

Persistent Organic Pollutants

- Some synthetic compounds are called persistent organic pollutants, or POPs. Many were first produced decades ago, when their harm to the environment was not known, and they are now banned or restricted. POPs have several properties that define them:

- They have a carbon-based molecular structure, often containing highly reactive chlorine.
- Most are manufactured by people—that is, they are synthetic chemicals.
- They are persistent in the environment—they do not easily break down in the environment.
- They are polluting and toxic.
- They are soluble in fat and likely to accumulate in living tissue.
- They occur in forms that allow them to be transported by wind, water, and sediments for long distances.

- The **Bhopal disaster**, also referred to as the **Bhopal gas tragedy**, was a gas leak incident on the night of 2–3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh, India. It is considered to be the world's worst industrial disaster. Over 500,000 people were exposed to methyl isocyanate (MIC) gas. The highly toxic substance made its way into and around the small towns located near the plant.
- The government of Madhya Pradesh confirmed a total of 3,787 deaths related to the gas release. A government affidavit in 2006 stated that the leak caused 558,125 injuries, including 38,478 temporary partial injuries and approximately 3,900 severely and permanently disabling injuries. Others estimate that 8,000 died within two weeks, and another 8,000 or more have since died from gas-related diseases.
- Union Carbide Corporation (UCC) argues water entered the tank through an act of sabotage.


MARTIN SHEEN
MISCHA BARTON
KAL PENN
A STORY BASED ON TRUE EVENTS
BHOPAL
A PRAYER FOR RAIN
30 YEARS HAVE PASSED
IT'S TIME TO TELL
THEIR STORY

Hormonally active agents (HAAs)

- HAAs are also POPs. An increasing body of scientific evidence indicates that certain chemicals in the environment, (HAAs), may cause developmental and reproductive abnormalities in animals, including humans.
- HAAs include a wide variety of chemicals, such as some herbicides, pesticides, phthalates (compounds found in many chlorine-based plastics), and PCBs (Polychlorinated biphenyl). Evidence in support of the hypothesis that HAAs are interfering with the growth and development of organisms comes from studies of wildlife in the field and laboratory studies of human diseases, such as breast, prostate, and ovarian cancer, as well as abnormal testicular development and thyroid-related abnormalities.

Nuclear Radiation

- Nuclear radiation is introduced here as a category of pollution, excessive exposure is linked to serious health problems, including cancer.

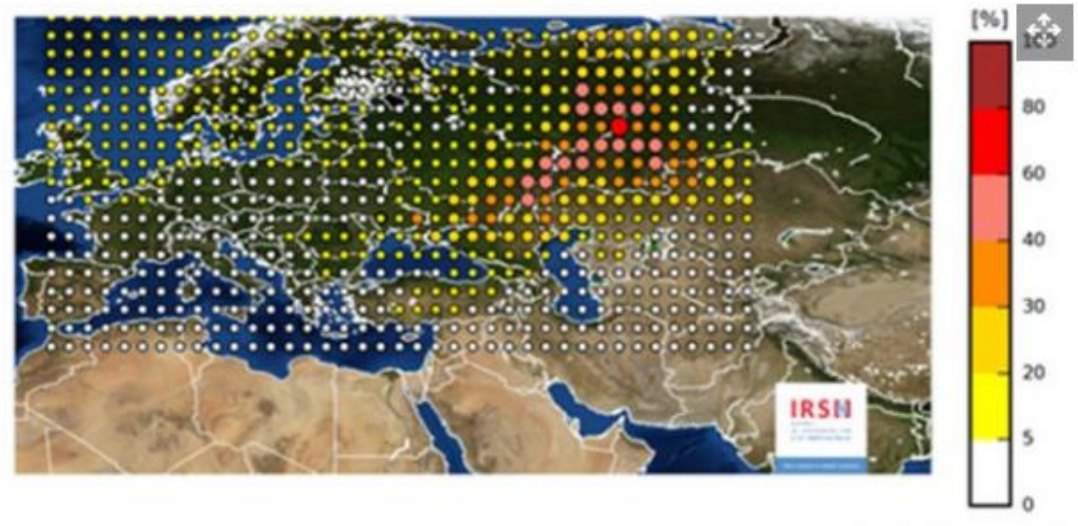
Mysterious Radiation Cloud Over Europe Traced to Secret Russian Nuclear Accident

By Tom Metcalfe July 29, 2019 Strange News

Russia has never acknowledged that any nuclear accident took place at the Mayak facility in the Chelyabinsk region in 2017.
(Image: © U.S. Army/Carl Anderson)

A vast cloud of nuclear radiation that spreadover continental Europe in 2017 has been traced to an unacknowledged nuclear accident in southern Russia, according to an international team of scientists.

The lead author of the new research, nuclear chemist Georg Steinhauser of Leibniz University in Hanover, Germany, said that more than 1,300 atmospheric measurements from around the world showed that between 250 and 400 terabecquerels of radioactive ruthenium-106 had been released during that time.



In early October 2017, several European countries detected elevated levels of ruthenium-106 above the continent. Based on concentration levels, the likely source of contamination was located around the Ural Mountains.
(Image credit: ISRN)

Ruthenium-106 is a radioactive isotope of ruthenium, meaning that it has a different number of neutrons in its nucleus than the naturally occurring element has. The isotope can be produced as a byproduct during nuclear fission of uranium-235 atoms.

Although the resulting cloud of nuclear radiation was diluted enough that it caused no harm to people beneath it, the total radioactivity was between 30 and 100 times the level of radiation released after the Fukushima accident in Japan in 2011, Steinhauser told Live Science.

Thermal Pollution

Thermal pollution, also called heat pollution, occurs when heat released into water or air produces undesirable effects.

Heat pollution can occur as a sudden, acute event or as a long-term, chronic release.

Sudden heat releases may result from natural events, such as brush or forest fires and volcanic eruptions, or from human activities, such as agricultural burning.

The major sources of chronic heat pollution are electric power plants that produce electricity in steam generators and release large amounts of heated water into rivers.

Average water temperature and the concentration of dissolved oxygen (warm water holds less oxygen than cooler water)

change

Optimum temperature for each organism

- Heating river water can change its natural conditions and disturb the ecosystem in several ways.
- Fish spawning cycles may be disrupted, and the fish may have a heightened susceptibility to disease.
- Warmer water also causes physical stress in some fish, making them easier for predators to catch, and warmer water may change the type and abundance of food available for fish at various times of the year.

- There are several solutions to chronic thermal discharge into bodies of water. The heat can be released into the air by cooling towers, or the heated water can be cools down to normal temperatures. Some attempts have been made to use the heated water to grow organisms of commercial value that require warmer water. Waste heat from a power plant can also be captured and used for a variety of purposes, such as warming buildings.

Particulates

Small particles of dust (including soot and asbestos fibers) released into the atmosphere by many natural processes and human activities. Modern farming and the burning of oil and coal add considerable amounts of particulates to the atmosphere, as do dust storms, fires, and volcanic eruptions.

- The 1991 eruptions of Mount Pinatubo in the Philippines explosively hurling huge amounts of volcanic ash, sulfur dioxide, and other volcanic material and gases as high as 30 km into the atmosphere. Eruptions can have a significant impact on the global environment and are linked to global climate change and stratospheric ozone depletion. In addition, many chemical toxins, such as heavy metals, enter the biosphere as particulates. Sometimes, nontoxic particulates link with toxic substances, creating a synergetic threat.

Active volcano on Luzon Island Philippines

Second largest eruption of 20th century

On June 15 1991

Eruption of Eyjafjallajokull (Iceland)

Caused enormous disruption to air travel across western and northern Europe

Asbestos

Asbestos is a term for several minerals that take the form of small, elongated particles, or fibers.

Industrial use of asbestos;

- to fire prevention
- protection from the overheating of materials
- insulation for a variety of other purposes.

Unfortunately, however, excessive contact with asbestos has led to asbestosis (a lung disease caused by inhaling asbestos) and to cancer in some industrial workers. Experiments with animals have demonstrated that asbestos can cause tumors if the fibers are embedded in lung tissue.

Electromagnetic Fields

Electromagnetic fields (EMFs) are part of everyday urban life. Cell phones, electric motors, electric transmission lines for utilities, and our electrical appliances— toasters, electric blankets, computers, and so forth—all produce magnetic fields. There is currently a controversy over whether these fields produce a health risk.

- Early on, investigators did not believe that magnetic fields were harmful, because fields drop off quickly with distance from the source, and the strengths of the fields that most people come into contact with are relatively weak. For example, the magnetic fields generated by power transmission lines or by a computer terminal are normally only about 1% of Earth's magnetic field; directly below power lines, the electric field induced in the body is about what the body naturally produces within cells.

- Several early studies, however, concluded that children exposed to EMFs from power lines have an increased risk of contracting leukemia, lymphomas, and nervous-system cancers. Investigators concluded that children exposed are about one and a half to three times more likely to develop cancer than children with very low exposure to EMFs, but the results were questioned because of perceived problems with the research design (problems of sampling, tracking children, and estimating exposure to EMFs).

- A later study analyzed more than 1,200 children, approximately half of them suffering from acute leukemia. It was necessary to estimate residential exposure to magnetic fields generated by power lines near the children’s present and former homes. That study, the largest such investigation to date, found no association between childhood leukemia and measured exposure to magnetic fields.

- In sum, despite the many studies that have evaluated relationships between cancer (brain, leukemia, and breast) and exposure to magnetic fields in our modern urban environment, the jury is still out. There seems to be some indication that magnetic fields cause health problems for children, but the risks to adults (with the exception of utility workers) appear relatively small and difficult to quantify.

Noise Pollution

- Noise pollution is unwanted sound.
- Sound is a form of energy that travels as waves. We hear sound because our ears respond to sound waves through vibrations of the eardrum. The sensation of loudness is related to the intensity of the energy carried by the sound waves and is measured in decibels (dB).

- The threshold for human hearing is 0 dB; the average sound level in the interior of a home is about 45 dB; the sound of an automobile, about 70 dB; and the sound of a jet aircraft taking off, about 120 dB. A tenfold increase in the strength of a particular sound adds 10 dB units on the scale. An increase of 100 times adds 20 units. The decibel scale is logarithmic—it increases exponentially as a power of 10. For example, 50 dB is 10 times louder than 40 dB and 100 times louder than 30 dB.

- Environmental effects of noise depend not only on the total energy but also on the sound's pitch, frequency, and time pattern and length of exposure to the sound. Very loud noises (more than 140 dB) cause pain, and high levels can cause permanent hearing loss. Human ears can take sound up to about 60 dB without damage or hearing loss. Any sound above 80 dB is potentially dangerous. The noise of a lawn mower or motorcycle will begin to damage hearing after about eight hours of exposure.

LIGHT POLLUTION

Light pollution is any artificial light that spills into the environment.

https://www.darkskytravels.com/newarticles

Consequences of light pollution

Light pollution degrades night landscapes. It increases the brigtness of the night sky and gives it unnatural yellow tint. It also changes night ecosystems.

Plants: light impacts photosynthesis, regulates blooming, growth and rest periods. Artificial light can drastically change this natural rhytm. Too short nights can reduce or totally stop blooming.

Insects: massive victims of light pollution

Birds:

- desorientation.
- changes of migration patterns, ending the migration and staying over winter in a wrong place.
- blinding and death by collisions with buildings or light sources.
- all night activity (gulls).

https://www.cbsnews.com/news/more-than-4000-birds-crash-land-in-parking-lot/

More than 4,000 birds crash-land in parking lot

BY MICHELLE CASTILLO
DECEMBER 14, 2011 / 2:12 PM / CBS NEWS

CEDAR CITY, Utah - Authorities were shocked to find more than 4,000 birds scattered across a local Utah Wal-Mart parking lot on Monday night.

According to CBS affiliate KUTV in Salt Lake City, Utah, witnesses claimed thousands of the creatures had crash-landed in the parking area. At least 1,500 Eared Grebes, a duck-like aquatic bird, which slammed into the pavement were dead. Fortunately, Utah Department of Wildlife Resource officials and volunteers were able to rescue up to 3,000 of the large flock.

A Utah Division of Wildlife Resources employee frees some surviving grebes on Dec. 13, 2011 at Stratton Pond in Hurricane, Utah.
LYNN CHAMBERLAIN,UTAH DIVISION OF WILDLIFE SERVICES

According to The Spectrum, officials think the birds were migrating to Mexico and decided to take a rest in the Wal-Mart parking lot, which they mistook for a large body of water since the Eared Grebes can only take off from water surfaces. Officials suspect the birds didn't compensate for landing on the hard pavement.

Animals:

- LP impacts orientation.
- LP affects attraction/repulsion and changes mating habits and cycles.
- LP changes or blocs biological rhythms and causes complex long-term consequences
- LP changes habitat quality.

Humans: - LP changes diurnal rhythms (sleep, feed periods, awakens, perpetual exhaustion, etc.).

- LP impacts the melatonin cycles, esp. hits women.
- LP changes seasonal rhythms due to artificially long days in winter.
- children myopia due to sleeping in lighted rooms. – and….

Voluntary Exposure

- Voluntary exposure to toxins and potentially harmful chemicals is sometimes referred to as exposure to personal pollutants.
- The most common of these are tobacco, alcohol, and other drugs. Use and abuse of these substances have led to a variety of human ills, including death and chronic disease; criminal activity, such as reckless driving and manslaughter; loss of careers; street crime; and the straining of human relations at all levels.

General Effects of Pollutants

- Almost every part of the human body is affected by one pollutant or another, as shown in Figure 10.11a. For example, lead and mercury affect the brain; arsenic, the skin; carbon monoxide, the heart; and fluoride, the bones.
- Wildlife is affected as well.
- Locations in the body where pollutants may affect humans and wildlife are shown in Figure 10.11b; effects of pollutants on wildlife populations are listed in Table 10.3.

Concept of Dose and Response

- Five centuries ago, the physician and alchemist Paracelsus wrote that "**everything is poisonous, yet nothing is poisonous.**" By this he meant, essentially, that too much of any substance can be dangerous, yet in an extremely small amount can be relatively harmless. Every chemical element has a spectrum of possible effects on a particular organism. For example, selenium is required in small amounts by living things but may be toxic or increase the probability of cancer in cattle and wildlife when it is present in high concentrations in the soil. Copper, chromium, and manganese are other chemical elements required in small amounts by animals but toxic in higher amounts.

- It was recognized many years ago that the effect of a certain chemical on an individual depends on the dose. This concept, termed dose response, can be represented by a generalized dose-response curve.

Dose-Response Curve (LD-50, ED-50, and TD-50)

Individuals differ in their response to chemicals, so it is difficult to predict the dose that will cause a response in a particular individual. It is more practical to predict instead what percentage of a population will respond to a specific dose of a chemical. For example, the dose at which 50% of the population dies is called the **lethal dose 50**, or LD-50. The LD-50 is a crude approximation of a chemical's toxicity. It is a gruesome index that does not adequately convey the sophistication of modern toxicology and is of little use in setting a standard for toxicity. However, the LD-50 determination is required for new synthetic chemicals as a way of estimating their toxic potential. Table 10.4 lists, as examples, LD-50 values in rodents for selected chemicals.

- The ED-50 (effective dose 50%) is the dose that causes an effect in 50% of the observed subjects. For example, the ED-50 of aspirin would be the dose that relieves headaches in 50% of the people observed. The TD-50 (toxic dose 50%) is defined as the dose that is toxic to 50% of the observed subjects. TD-50 is often used to indicate responses such as reduced enzyme activity, decreased reproductive success, or the onset of specific symptoms, such as hearing loss, nausea, or slurred speech.

Threshold Effects

A threshold is a level below which no effect occurs and above which effects begin to occur. If a threshold dose of a chemical exists, then a concentration of that chemical in the environment below the threshold is safe. If there is no threshold dose, then even the smallest amount of the chemical has some negative effect.

Ecological Gradients

- Dose response differs among species. For example, the kinds of vegetation that can live nearest to a toxic source are often small plants with relatively short lifetimes (grasses, sedges, and weedy species usually regarded as pests) that are adapted to harsh and highly variable environments. Farther from the toxic source, trees may be able to survive. Changes in vegetation with distance from a toxic source define the ecological gradient. Ecological gradients may be found around smelters and other industrial plants that discharge pollutants into the atmosphere from smokestacks.

Tolerance

- The ability to resist or withstand stress from exposure to a pollutant or harmful condition is referred to as tolerance. Tolerance can develop for some pollutants in some populations, but not for all pollutants in all populations. Tolerance may result from behavioral, physiological, or genetic adaptation.

- **Behavioral tolerance** results from changes in behavior. For example, mice learn to avoid traps.
- **Physiological tolerance** results when the body of an individual adjusts to tolerate a higher level of pollutant. There are many mechanisms for physiological tolerance, including detoxification, in which the toxic chemical is converted to a nontoxic form, and internal transport of the toxin to a part of the body where it is not harmful, such as fat cells.

- **Genetic tolerance**, or adaptation, results when some individuals in a population are naturally more resistant to a toxin than others. They are less damaged by exposure and more successful in breeding. Resistant individuals pass on the resistance to future generations, who are also more successful at breeding. Adaptation has been observed among some insect pests following exposure to some chemical pesticides. For example, certain strains of malaria-causing mosquitoes are now resistant to DDT, and some organisms that cause deadly infectious diseases have become resistant to common antibiotic drugs, such as penicillin.

Acute and Chronic Effects

- Pollutants can have acute and chronic effects.
- An **acute effect** is one that occurs soon after exposure, usually to large amounts of a pollutant.
- A **chronic effect** occurs over a long period, often from exposure to low levels of a pollutant.
- For example, a person exposed all at once to a high dose of radiation may be killed by radiation sickness soon after exposure (an acute effect). However, that same total dose received slowly in small amounts over an entire lifetime may instead cause mutations and lead to disease or affect the person's DNA and offspring (a chronic effect).