**Chapter 7**

**Human Health and Environmental Toxicology**

**Lecture Outline:**

1. Human Health
   1. Two indicators of human health in a given country are *life expectancy* (how long people are expected to live) and *infant mortality* (how many infants die before the age of one)
   2. Health issues in highly developed countries
      1. Average life expectancy for American women is 80 and 75 for American men
      2. A significant fraction of premature deaths in the United States is caused in part by individual lifestyle habits (poor diet, lack of exercise, smoking)
      3. Healthcare professionals use the *body mass index (BMI)* to determine whether a person is overweight and/or obese
   3. Health issues in developing nations
      1. Malnutrition, unsafe water, poor sanitation, and air pollution still prevail in many less developed countries despite gradual improvements in sanitation and drinking water
      2. Average overall life expectancy for developing countries is 65
      3. Average overall life expectancy for the very poorest developing countries is <45
      4. 18% of the 57 million deaths that occur worldwide each year are children less than 5 years of age
   4. Emerging and reemerging diseases
      1. *Emerging diseases* are infectious diseases that were not previously found in humans; they typically jump from an animal host to the human species (i.e., HIV/AIDS, Lyme disease, West Nile virus, influenza (new strains), SARS, Ebola)
      2. Reemerging diseases are infectious diseases that existed in the past but for a variety of reasons are increasing in incidence or in geographic range (i.e., tuberculosis, yellow fever, malaria, dengue fever)
      3. The main factors involved in the emergence or reemergence of infectious diseases include
         1. Evolution of the infectious organisms
         2. Evolution of antibiotic resistance
         3. Urbanization (overcrowding, poor sanitation)
         4. An increase in elderly who are more susceptible to infection
         5. Pollution, environmental degradation, changing weather patterns
         6. Growth in international travel and commerce
         7. Poverty and social inequality
2. Environmental Pollution and Disease
   1. Persistence, bioaccumulation, and biological magnification of environmental contaminants
      1. *Persistence* is a characteristic of certain chemicals that are extremely stable and may take years to be broken down in to simpler forms by natural processes
      2. *Bioaccumulation* is the buildup of a persistent toxic substance
      3. *Biological magnification* is the increased concentration of toxic chemicals in the tissues of organisms that are at higher levels in food webs
         1. Toxic substances that exhibit all three of these characteristics include certain pesticides (DDT), radioactive isotopes, heavy metals (lead/mercury), flame retardants (PBDEs), and industrial chemicals (PCBs)
         2. Natural decomposers (bacteria) have not yet evolved ways to degrade many synthetic pesticides, therefore leading to the accumulation of pesticides in the environment and food web
   2. *Endocrine disrupters* are chemicals that mimic or interfere with the actions of the endocrine systems in humans and wildlife
      * 1. Examples include chlorine-containing industrial compounds (PCBs and dioxins), heavy metals (lead and mercury), pesticides (DDT, kepone, dieldrin, chlordane, endosulfan), flame retardants (PBDEs), and certain plastics and plastic additives such as phthalates
           1. Phthalates are ingredients in cosmetics, fragrances, nail polish, medications, and common plastics used in food packaging, toys and household products
           2. Phthalates have been implicated in birth defects and reproductive abnormalities
           3. Like hormones, they are active at very low concentrations and appear to alter reproductive development in males and females of various animal species
        2. *Hormones* are chemical messengers produced by organism in minute quantities to regulate growth, reproduction and other important biological functions
3. Determining Health Effects of Environmental Pollution
   1. All chemicals, even “safe” chemicals such as sodium chloride (table salt), are toxic if exposure is high enough
   2. The study of *toxicants*, or toxic chemicals, is called *toxicology*
      1. Toxicity is measured by the extent to which adverse effects are produced by various doses of a toxicant
         1. *Acute toxicity*, which ranges from dizziness and nausea to death, occurs immediately to within several days following a single exposure
         2. *Chronic toxicity* generally produces damage to vital organs, following a long-term, low-level exposure to chemicals
      2. One complication of toxicology is that each individual’s genes largely determine that person’s response to a specific toxicant
         1. *Environmental susceptibility genes* affect how the body metabolizes toxicants
         2. Other gene variations allow certain toxicants to bind strongly – or less so – to DNA
      3. Children and chemical exposure
         1. Children are more susceptible to most chemicals than are adults because their bodies are still developing and are not as effective in dealing with toxicants
         2. Pesticides and children
            1. The EPA estimates that 84% of U.S homes use pesticide products
            2. More than 65,000 reports of exposure and possible poisoning from household pesticides, involving children, occur each year
         3. Identifying cancer-causing substances
            1. *Toxicology* and *epidemiology* are the two most common methods for determining whether a chemical causes cancer
            2. Although epidemiological studies have the advantage that they look at people who were actually exposed to the chemical, several limitations still exist

It is difficult to reconstruct, or estimate, historical doses

Various confounding factors exist (additional exposures)

Individuals respond differently

* + 1. Chemical mixtures interact by additivity, synergy, or antagonism
       1. *Additivity* – the effect is exactly what one would expect, given the individual effects of each component of the mixture (1+1=2)
       2. A *synergistic* chemical mixture has a greater combined effect than expected (1+1=3)
       3. An *antagonistic* interaction in a chemical mixture results in a smaller combined effect than expected (1+1=1.3)

1. Ecotoxicology: Toxicant Effects on Communities and Ecosystems
   1. There has been a *paradigm* shift in the way people think about toxicant effects on communities and ecosystems
      1. People used to think - and some still do – that “the solution to pollution is dilution” (*the dilution paradigm*)
      2. Today virtually all environmental scientists have rejected the dilution paradigm in favor of *the boomerang paradigm* – “what you throw away can come back and hurt you”
   2. *Ecotoxicology* (aka environmental toxicology) studies contaminants in the biosphere, including their harmful effects on ecosystems
      1. Its scope is broad – from molecular interactions to global climate change
      2. It helps policymakers determine the costs and benefits of the many industrial and technological “advances” that affect us and the ecosystems
         1. Obtaining higher-level information is complicated because natural systems are exposed to many *environmental stressors*
         2. Also, natural systems must be evaluated for extended periods to establish trends, and results must be clear enough for evaluation by policymakers and the public
2. Decision Making and Uncertainty: Assessment of Risks
   1. *Risk management* is the process of identifying, assessing, and reducing risks
      1. *Risk* is the probability that a particular adverse effect will result from some exposure or condition
      2. A *hazard* is a condition that has the potential to cause harm
      3. Effective risk management cannot be based on calculated risks alone, but must also account for intuition, trust, and social conditions
   2. *Cost-benefit analysis* of risksanalyzes the estimated cost of some regulation to reduce risk compared with potential benefits associated with that risk reduction
   3. The *precautionary principle* is the idea that no action should be taken or product introduced when the science is inconclusive and unknown risks may exist; it puts the burden of proof on the developers
   4. *Ecological risk assessment* involves hazard identification, dose-response assessment, exposure assessment, and risk characterization