Risk, Toxicology & Human Health

Chapter 11

What is risk?

- Possibility of suffering harm from a hazard
- HAZARD - Something that can cause injury, disease, economic loss or environmental damage

What is probability?

- How likely it is that some event or effect will occur.
  - Can range from 0 - no risk to 1 (absolute certainty of a risk)
  - Risk is defined as probability of exposure times the probability of harm

    RISK = EXPOSURE X HARM

What is risk assessment?

- Uses data, etc. to estimate the probability that harm will occur as a result of exposure to specific hazards.
  - IDENTIFY REAL OR POTENTIAL HAZARD
  - DETERMINE PROBABILITY OF IT HAPPENING
  - ASSESS SEVERITY ON HEALTH, ENVIRONMENT, ECONOMY, OR SOCIAL IMPACT

What is risk management?

- Decide what risks face society and try to manage them
- Decide how reliable the risk assessment is
- Decide how much risk is acceptable
- Decide how much money is needed to reduce the risk
- If funds aren’t available, than what?
- How to communicate plan to the public

What are the types of hazards?

- Cultural hazards - drugs, drinking, unsafe sex, smoking, working conditions, & poverty
- Chemical hazards - harmful chemicals in our environment - about 500 whose effects are not known.
- Physical hazards - natural disasters - radiation, fire, earthquakes
- Biological hazards - pathogens, pollen, animals, etc.

What is toxicology?

- The adverse effects of chemicals on health
- Toxicity
  - A measure of how harmful a substance is
- What is dose?
  - Amount exposed to
    - How does it get into the body?
      - Inhaled
      - Injected
      - Absorbed
      - Injested

How harmful a chemical is depends on:

- Size of dosage over a period of time
- How often exposure occurs
- Who is exposed
- How well the body's detoxification system works (liver, lungs, kidneys)
- Genetic makeup that determines an individuals sensitivity to a particular toxin.
- Also: solubility - does it get into water supply? Persistence - how long does it last?

Variations in sensitivity

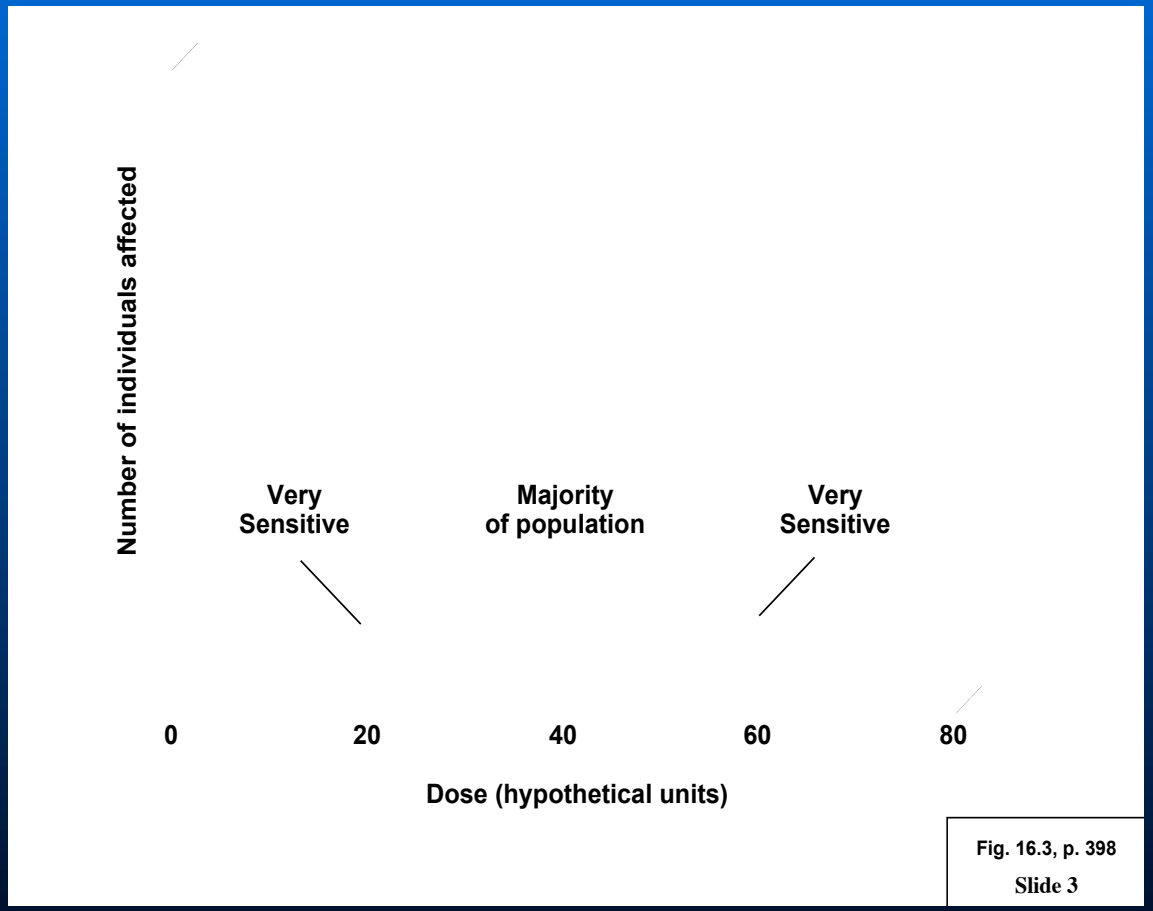


Fig. 16.3, p. 398

Slide 3

What is response?

- The resulting type and amount of damage to health
  - Size of dose over a certain period of time
  - How often exposure occurs
  - Who is exposed?
  - How well the body systems work

- Acute effect - immediate reaction -
  - Dizziness, rash, etc.
- Chronic effect - permanent damage - liver or kidney damage, etc.

What is bioaccumulation?

- Increase in the concentration of a chemical in specific organs or tissues at a higher level than is normally expected.
  - Water soluble toxic chemical are usually excreted in urine
  - Oil or fat-soluble toxins accumulate in fat deposits and remain in the body (residence time) - have a biological half-life

What is Biomagnification?

- Toxins are magnified as they pass through the food chain
  - DDT, PCB's
  - Are stored in body fat and affect during gestation or egg laying and during nursing stages.

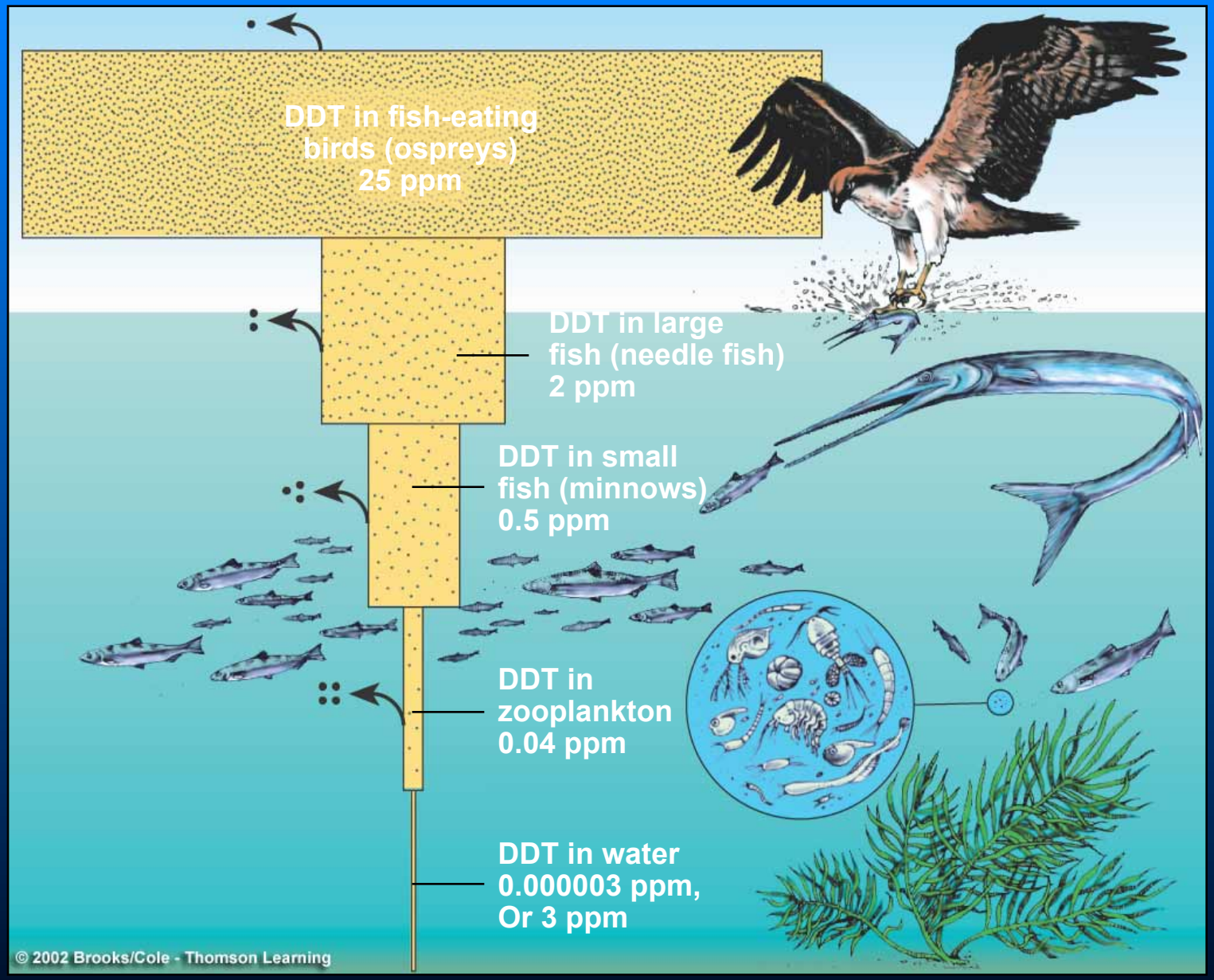

DDT in fish-eating birds (ospreys) 25 ppm
DDT in large fish (needle fish) 2 ppm
DDT in small fish (minnows) 0.5 ppm
DDT in zooplankton 0.04 ppm
DDT in water 0.000003 ppm, Or 3 ppm
© 2002 Brooks/Cole - Thomson Learning

Fig. 16.4, p. 399

- Chemical interactions can DECREASE or MULTIPLY the harmful effects of a toxin.
  - ANTAGONISTIC INTERACTION –reduce the harmful response
  - SYNERGISTIC INTERACTION – multiplies harmful effects.

Why should we care?

- It depends on the chemical and the concentration
  - Detection of trace elements does not mean it is harmful
- A basic concept of toxicology is that any synthetic or natural substance can be harmful if ingested in a large enough quantity.
- Most chemicals have a safe or THRESHOLD LEVEL of exposure below which harmful effects are insignificant

What is a poison?

- A chemical with an LD_{50} of 50 mg or less/kg of body weight.
- LD_{50} -median lethal dose - amount of chemical received in one dose that kills exactly 50% of the test animals within a 14 day period.

How is toxicity determined since chemicals vary in toxicity?

- Case reports - from physicians
- Laboratory investigations - usually on lab animals
- Epidemiology - studies of populations of humans exposed to certain chemicals or diseases.

Some Toxicity ratings

Toxicity Rating	LD_{50}	Average Lethal Dose	Examples
super toxic	< 0.01	less than 1 drop	nerve gases, botulism, mushroom toxins, dioxin
extremely toxic	< 5	less than 7 drops	potassium cyanide, heroin, atropine, parathion, nicotine
very toxic	5–50	7 drop to 1 teaspoon	mercury salts, morphine, codeine
toxic	50–500	1 teaspoon to 1 ounce	lead salts, DDT, sodium hydroxide, fluoride, sulfuric acid, caffeine, carbon tetrachloride
moderately toxic	500–5,000	1 ounce to 1 pint	methyl alcohol, ether, pehobarbital, amphetamines, kerosine, aspirin
slightly toxic	5,000–15,000	1 pint to 1 quart	ethyl alcohol, lysol, soaps
essentially nontoxic	> 15,000	more than 1 quart	water, glycerin, table sugar

What are dose response curves?

- Acute toxicity tests - show effects on test organisms
  - Control group - not exposed
  - Test group - exposed
- Some things have no threshold level – called a non threshold dose response model- ionizing radiation or chemicals that cause cancer of birth defects

Dose-response curve

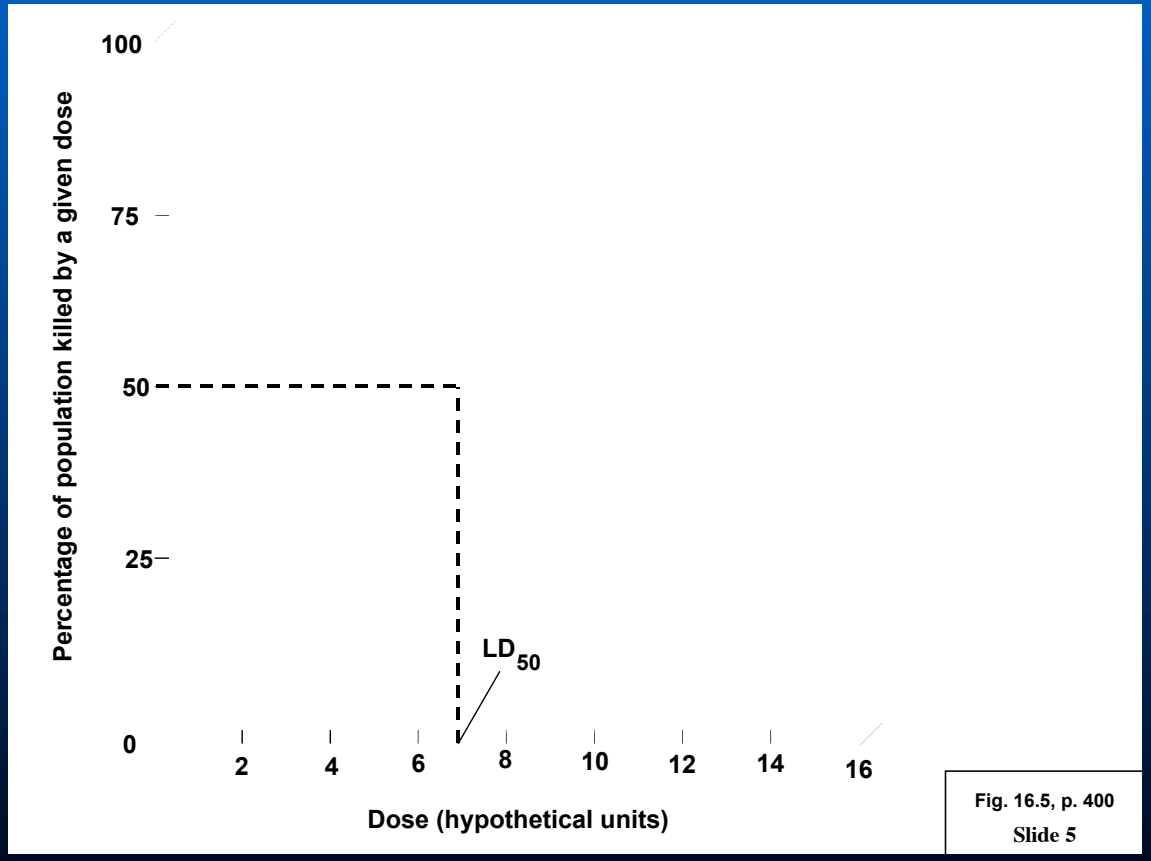
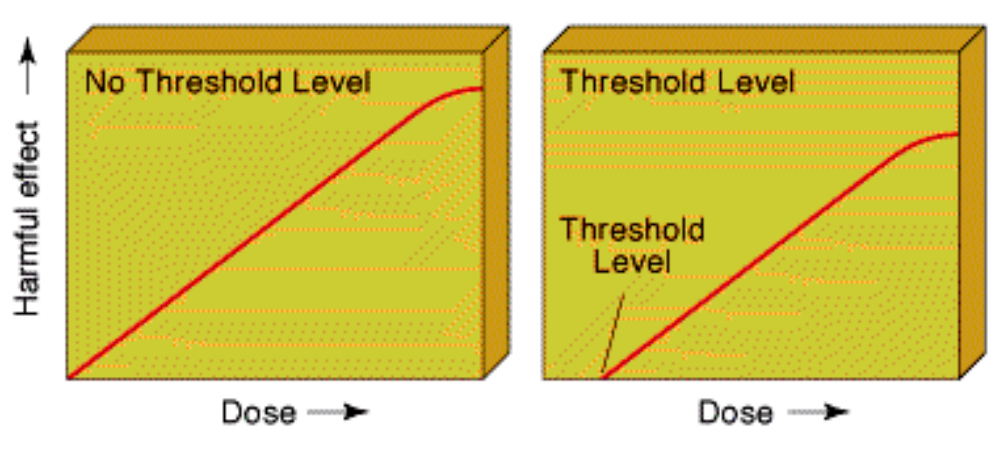


Fig. 16.5, p. 400

Slide 5

Dose - response curve



What are toxic chemicals?

- Generally defined as fatal to over 50% of test animals at given concentrations -LD-$_{50}$
- Hazardous chemicals cause harm by:
  - Being flammable or explosive
  - Irritate skin or lungs
  - Interfere with oxygen intake
  - Induce allergic reactions

What are mutagens?

- Cause mutations or changes in DNA molecules - chemicals & radiation
  - If in reproductive cells can be passed on to future generations
  - In other cells, can result in tumors
  - Most mutations are harmless
  - There is no agreement on how to test substances for genetic damage in humans

What are teratogens?

- Cause birth defects while embryo is developing during pregnancy - especially the first three months
  - PCBs
  - Thalidomide
  - Steroids, hormones
  - Heavy metals such as arsenic, cadmium, lead and mercury

Thalidomide babies - teratogen

What are carcinogens?

- Cause cancer
  - Metastasis - gets into the body fluids and travels to other parts
  - Major sources are: smoking, diet, occupational exposure, environmental pollutants
  - Some are inherited
  - Typically 10 - 40 years passes between initial exposure to a carcinogen and appearance of detectable symptoms.

What is the immune system?

- Cells and tissues that protect the body against disease and harmful substances
  - Antibodies - attack alien invaders and mark them for attack from other immune cells
  - Cellular defenses - kill invaders
- Some synthetic chemicals, viruses, etc. weaken the immune system and leave it open to attack by invaders
  - Example: pesticides

What is the nervous system? Brain, spinal cord, and nerves

- Many poisons are neurotoxins – attack nerve cells
  - Chlorinated hydrocarbons - PCB'S & DDT
  - Organophosphate pesticides
  - Formaldehyde
  - Some heavy metals
  - Some industrial solvents

What is the endocrine system?

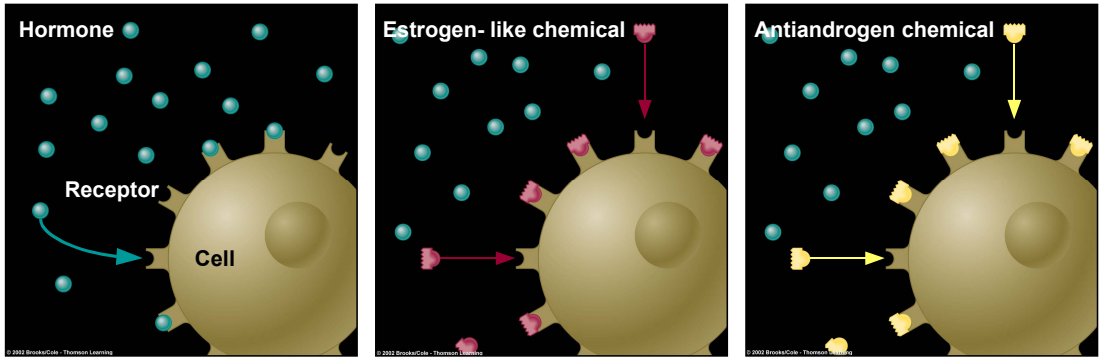
- Hormones - produced by organs and tissues
  - Are chemical messengers
  - Are excreted into the bloodstream at very low levels
  - Control sexual reproduction, growth, development and behavior in humans
  - Each hormone has a special molecular shape which allows it to attach only to certain cell receptors - then they move into cell nucleus to sent chemical messages

What are hormonally active agents? HAA's

- Human made chemicals – called hormone disrupters
  - More than 60 are known
- Hormone mimics - estrogen like
- Hormone blockers - prevent natural hormones such as androgens from attaching to their receptors.
- Can be at extremely low levels
- Thyroid disrupters - affect growth, weight, brain development, etc.

- Examples: dioxins
- PCB’s - biomagnify
- Some chemicals in plastics
- some pesticides
- Lead

Hormone disruptors



Normal Hormone Process | Normal Mimic | Hormone Blocker

Fig. 16.7, p. 403

Slide 7

How much do we know?

- Of the 75,000 chemicals in commercial use, only about 10% have been screened for toxicity and only 2 % have been tested to see if they are carcinogens, teratogens,or mutagens
- Each year about 1000 new chemicals come on the market.
- 99.5% of all commercially used chemicals are not regulated by federal and state governments.

What are the reasons for this?

- Under present laws chemicals are considered innocent until proven guilty.
- There aren't enough funds, facilities and test animals to provide such information
- We know little about the interactions of chemicals and how they affect human health.

Precautionary approach

- Emphasis should be more on pollution prevention
- we don’t really know the effects of so many chemicals.
- “look before you leap”!

What are biological hazards?

- Nontransmissible diseases: not caused by living organisms
  - Cardiovascular disease, cancer, diabetes, bronchitis, emphysema, and malnutrition
- Transmissible diseases - caused by living organisms - can be spread from person to person
  - Pathogens – infectious agents
  - Vectors – insects and non human carriers

What factors affect spread of disease?

- Migration to urban areas
- Reducing biodiversity by destroying forests and wiping out species that control vectors
- Increased cultivation of rice - causes mosquito populations to increase
- Increased international air travel
- Climate change
- Natural disasters such as floods
- Some bacteria are becoming resistant to antibiotics
- Virulent strains of influenza may develop
- Bioterrorism

What is risk analysis?

- Identify hazards
- Risk assessment - evaluate associated risks
- Comparative risk analysis - rank risks
- Risk communication - make public aware of the risks
- Poverty is the greatest risk people face

Figure 11-15

Page 246

Scientists (Not in rank order in each category)	Citizens (In rank order)
High-Risk Health Problems • Indoor air pollution • Outdoor air pollution • Worker exposure to industrial or farm chemicals • Pollutants in drinking water • Pesticide residues on food • Toxic chemicals in consumer products **High-Risk Ecological Problems** • Global climate change • Stratospheric ozone depletion • Wildlife habitat alteration and destruction • Species extinction and loss of biodiversity	**High-Risk Problems** • Hazardous waste sites • Industrial water pollution • Occupational exposure to chemicals • Oil spills • Stratospheric ozone depletion • Nuclear power-plant accidents • Industrial accidents releasing pollutants • Radioactive wastes • Air pollution from factories • Leaking underground tanks
Medium-Risk Ecological Problems • Acid deposition • Pesticides • Airborne toxic chemicals • Toxic chemicals, nutrients, and sediment in surface waters	**Medium-Risk Problems** • Coastal water contamination • Solid waste and litter • Pesticide risks to farm workers • Water pollution from sewage plants
Low-Risk Ecological Problems • Oil spills • Groundwater pollution • Radioactive isotopes • Acid runoff to surface waters • Thermal pollution	**Low-Risk Problems** • Air pollution from vehicles • Pesticide residues in foods • Global climate change • Drinking water contamination