

Risk, Toxicology and Human Health

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AP Environmental Science
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Human Health

- **Health is a state of complete physical, mental, social and spiritual well-being and not merely the absence of disease or infirmity**

or

- **The ability to lead a socially and economically productive life**

Holistic Concept of Health

- This concept recognizes the strength of social, economic, political and environmental influences on health
- Determinants
 - Heredity
 - Health and family welfare services
 - Environment
 - Life-style
 - Socio-economic conditions

Disease

- Disease results from the complex interaction between man, an agent and the environment
- Ecological point of view –
“maladjustment of the human organism to the environment”

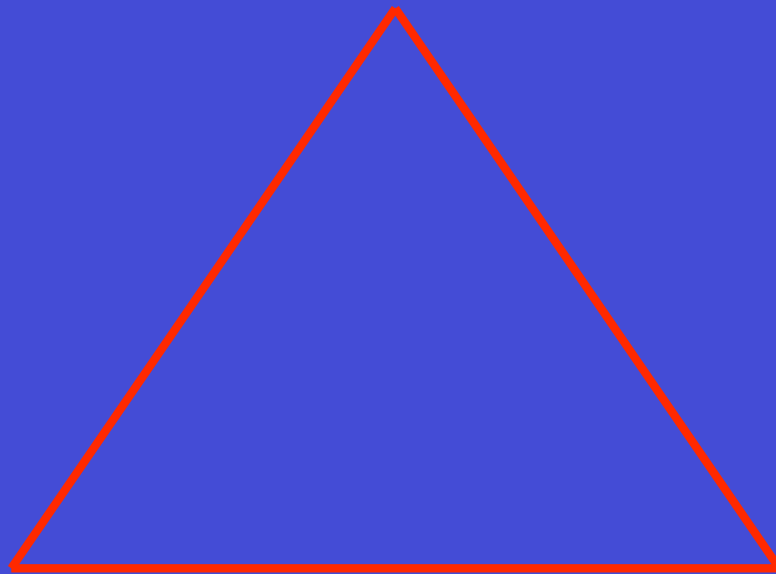
Epidemiological Triad

Environment

Vector

Agent

Host



Key Concepts

- **Types of Hazards**
- **Exposure Assessment**
- **Risk estimation, management, and reduction**

Types of Hazards

- **Biological Hazards**

- These are living organisms or their products that are harmful to humans

Biological Hazards

- **Water-borne diseases**
 - Transmitted in drinking water
 - Disease organisms shed into water in feces
 - Can produce illness in those who consume untreated, contaminated water

Biological Hazards

- **Water-borne diseases**
 - municipal water treatment facilities are usually able to purify water
 - removing these agents by filtration
 - killing them by disinfection

Biological Hazards

- **Water-borne diseases**
 - **Examples**
 - Polio virus
 - Hepatitis A virus
 - Salmonella
 - Shigella
 - Cholera
 - Amoebic dysentery
 - Giardia
 - Cryptosporidium

E. coli outbreak in Walkerton

- In May 2000 the small community of Walkerton, Ontario was laid waste by a toxic strain of **E. coli:0157**.
 - The contamination came from the public water supply.
 - Six people died in the first week including a two year old daughter of a local medical doctor.
 - Four new cases surfaced in late July, all very young children.
 - Over a thousand innocent people were infected.

Waterborne Bacteria

- Disease symptoms usually are explosive emissions from either end of the digestive tract



Escherichia coli



Vibrio sp.

Waterborne Protozoans

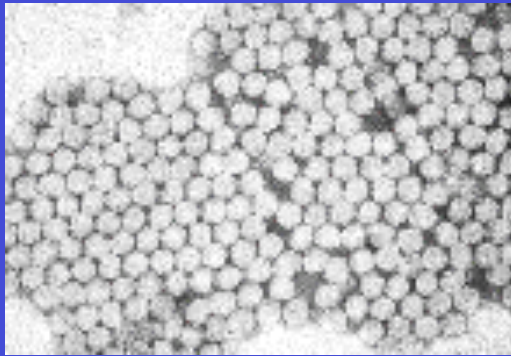
- Disease symptoms are usually explosive emissions from either end of the digestive tract



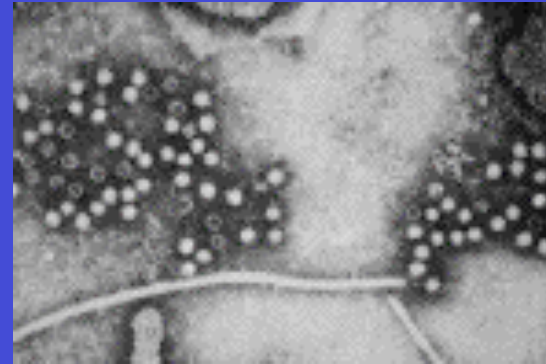
*P. Darben

Giardia sp.*

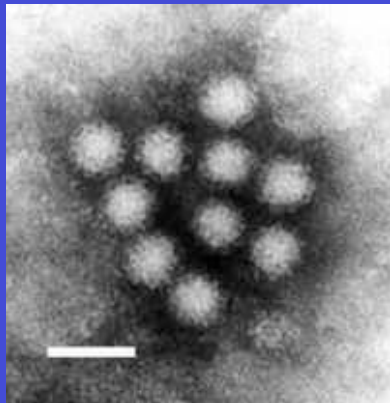
Waterborne Human Viruses



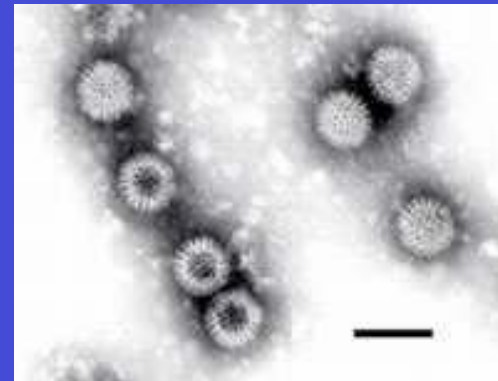
Hepatitis A virus



Hepatitis E virus



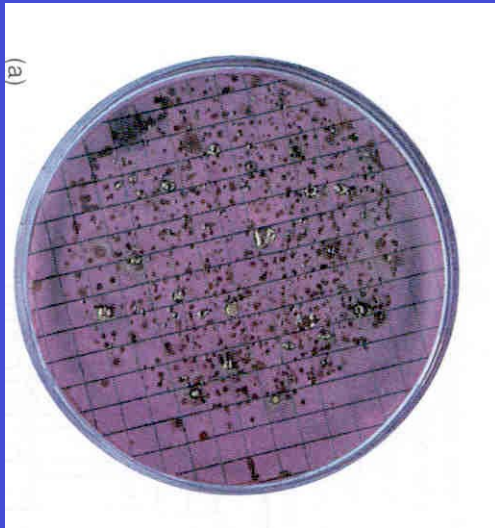
Norwalk virus*



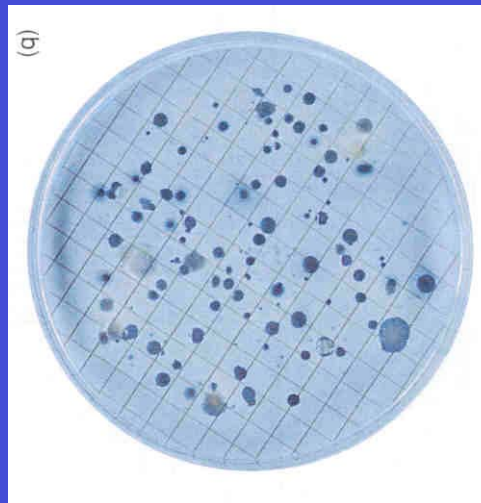
Rotavirus*

*F. Williams

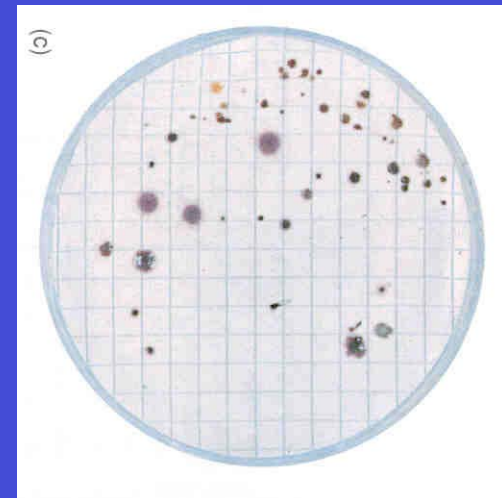
Indicator Tests



Total coliform
[Endo agar]



Fecal coliform
[m-FC agar]



Fecal streptococci
[M-enterococcus]

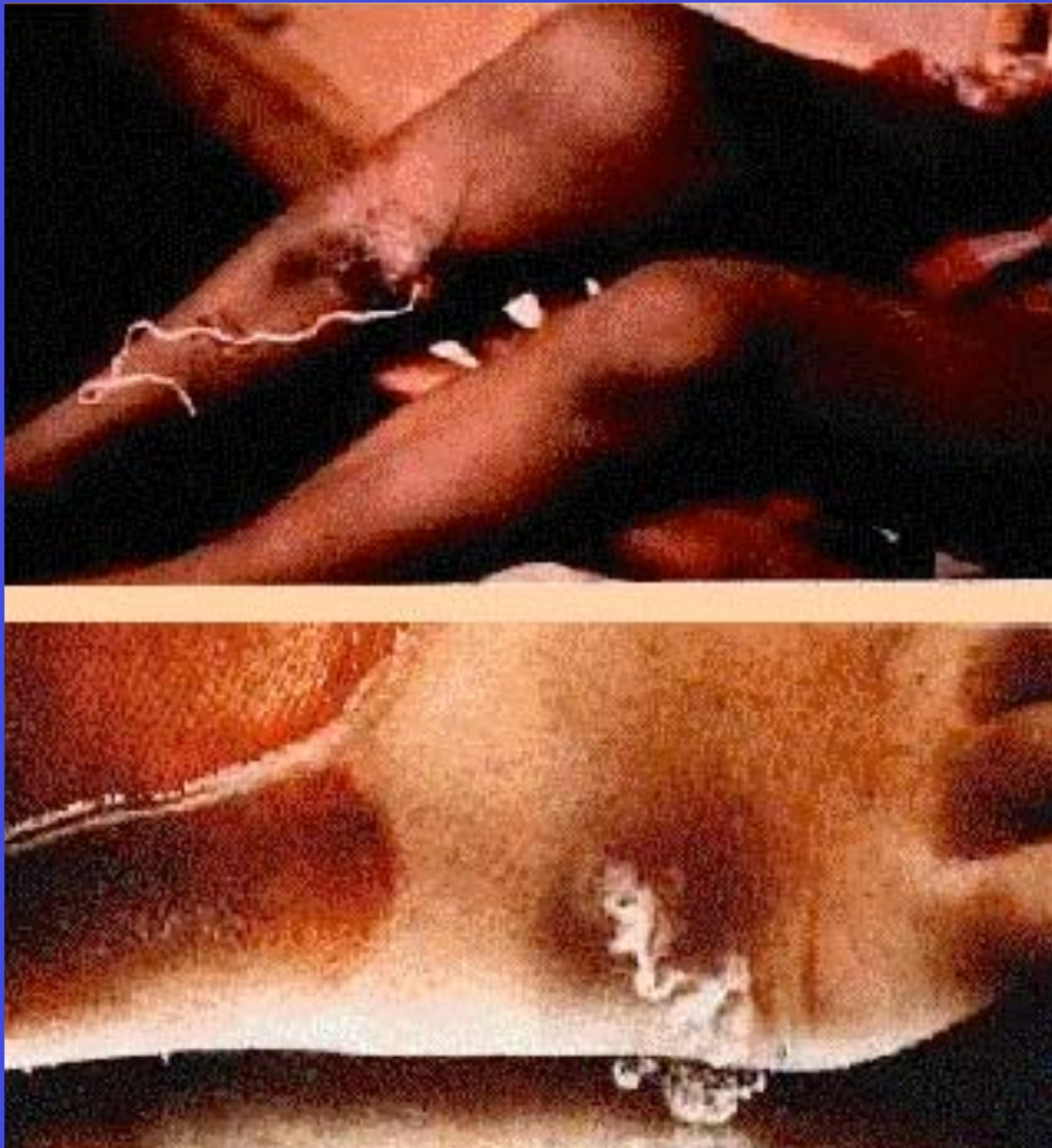
Prescott et al., Microbiology

Case Study on Eradicating Dracunculiasis



Guinea Worm Disease

- People have suffered from Guinea Worms for centuries – the “fiery serpent” was mentioned in the bible
- People are infected by drinking water that contain the larvae in a tiny freshwater crustacean called Cyclops
- A year later, larvae mature into 3 feet worms that emerge through skin blisters
- This is such a *painful process* that men and women can't work, children can't attend school



**The Guinea
Worm grows
down the leg
and its sex
organs appear
at the ankle or
on the foot
usually,
bursting when
it senses water,
releasing ova.**

<http://www.pmech.uiowa.edu/fuortes/63111/GUINEA/>



- No vaccine for Guinea worm is available.
- People do not seem to build up any resistance and the disease can be reinfected over and over.
- No research is being conducted for any vaccine or cure.
- Worms are removed slowly each day by winding around a stick.

Biological Hazards

- **Food-borne diseases**
 - To protect against food-borne disease
 - local health departments
 - inspect
 - » food service establishments (restaurants)
 - » retail food outlets (supermarkets)
 - » processing plants
 - verify that food
 - » stored
 - » handled properly

Biological Hazards

- **Food-borne diseases**
 - **Examples**
 - **Salmonella, serotype enteritidis**
 - Eggs or undercooked chicken
 - Reptiles
 - **Escherichia coli 0157:H7**
 - Spinach
 - Undercooked meat
 - » Jack in the Box

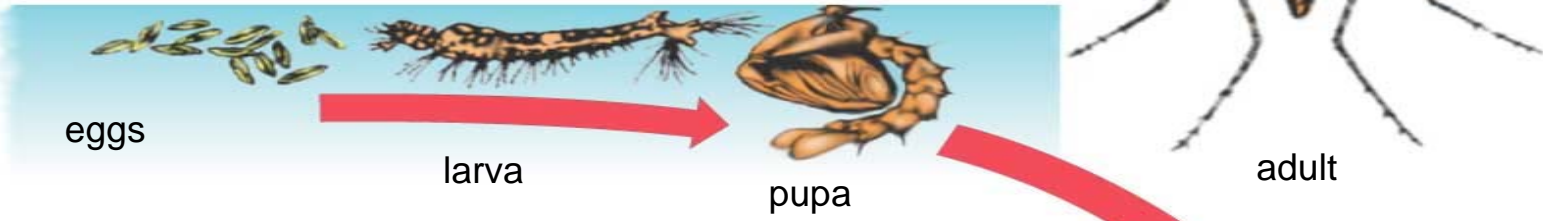
Biological Hazards

- **Vector-borne diseases**
 - Transmitted by insects, other arthropods and other animals including humans
 - Improper environmental management can cause vector-borne disease outbreaks

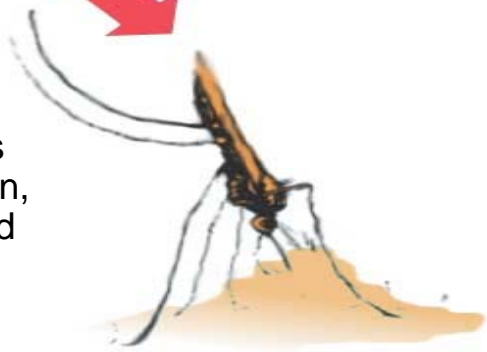
Biological Hazards

- **Vector-borne diseases**
 - **Examples**
 - **Mosquitoes**
 - Malaria
 - St. Louis encephalitis
 - La Crosse encephalitis
 - West Nile Virus
 - **Fleas**
 - Bubonic plague
 - Murine typhus

Anopheles mosquito (vector)
in aquatic breeding area



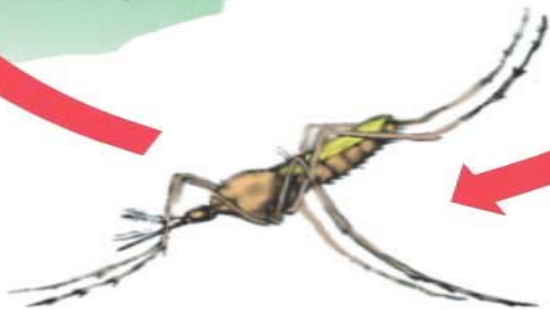
1. Female mosquito bites infected human, ingesting blood that contains *Plasmodium* gametocytes



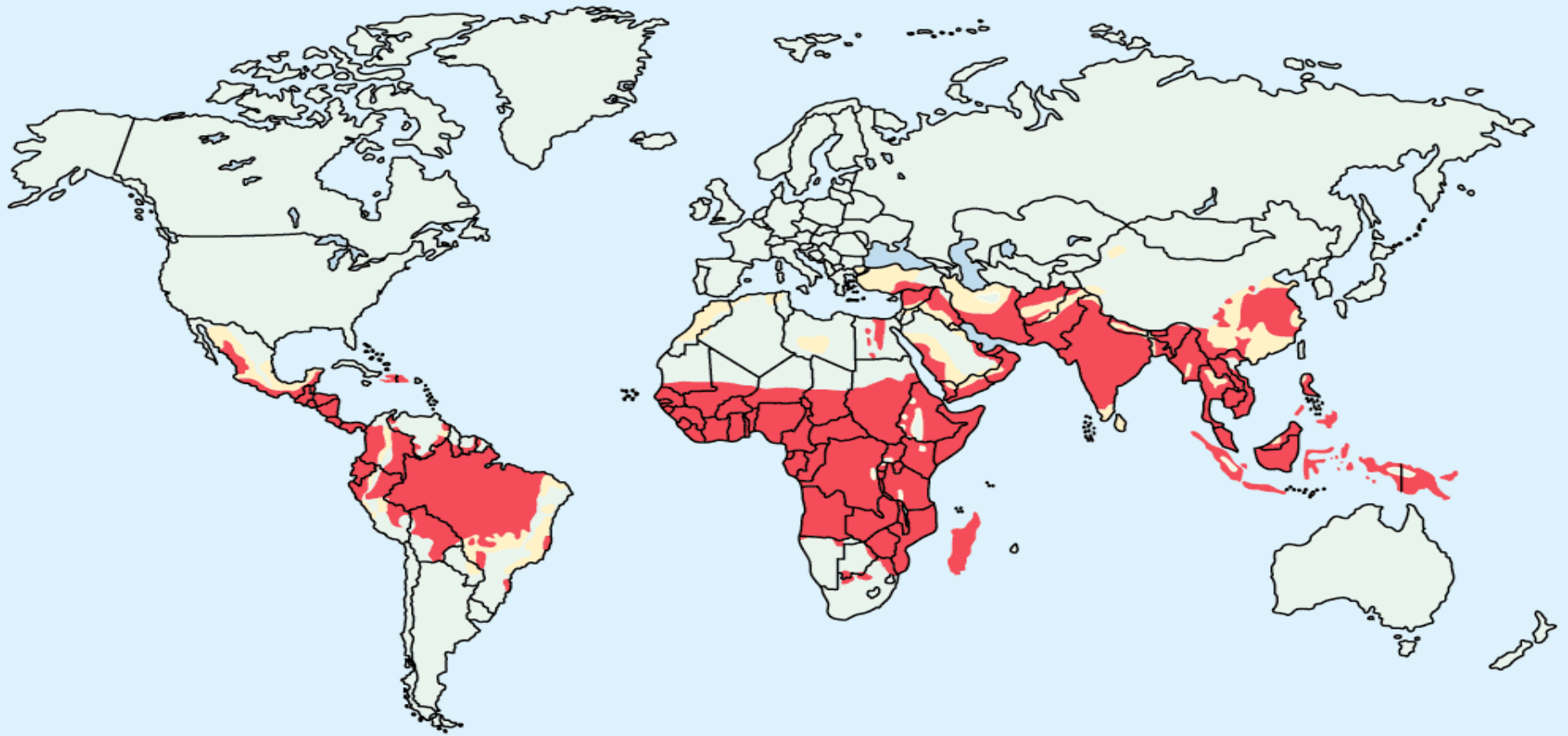
2. *Plasmodium* develops in mosquito



3. Mosquito injects *Plasmodium* sporozoites into human host



4. Parasite invades blood cells, causing malaria and making infected person a new reservoir



Areas in which malaria has disappeared, been eradicated, or never existed



Areas with limited risk

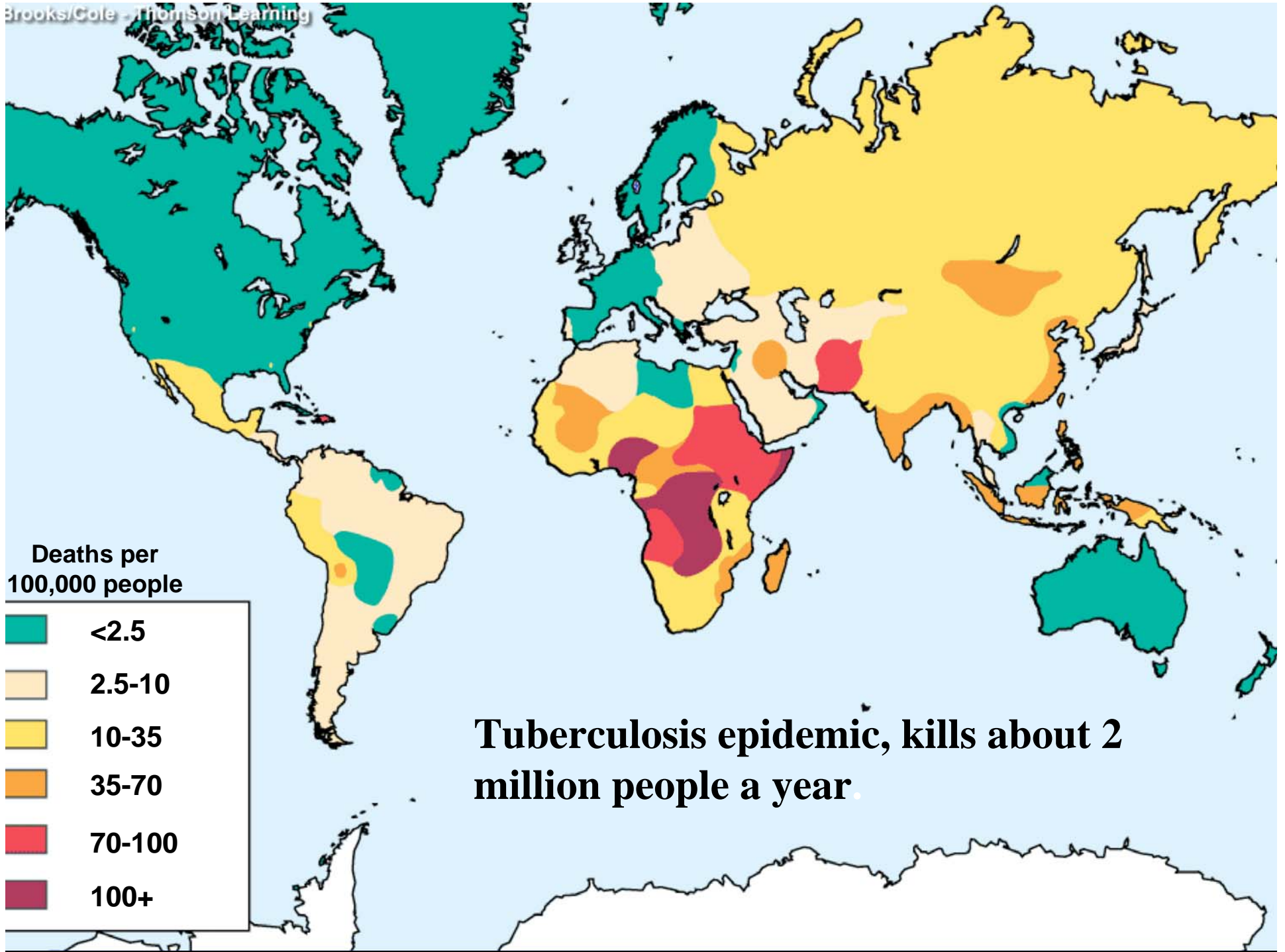


Areas where malaria Transmission occurs

Fig. 16.10, p. 409

Biological Hazards

- **Vector-borne diseases**
 - **Examples**
 - **Humans**
 - SARS
 - Tuberculosis
 - HIV
 - Gonorrhoea
 - Syphilis
 - Chlamydia
 - Etc.



Tuberculosis epidemic, kills about 2 million people a year.

Biological Hazards

- **Vector-borne diseases**
 - Greatest viral health threat to human life are virulent flu strain
 - 1918 Swine Flu
 - Killed 20 – 30 million
 - Today flu kills
 - 1 million per year worldwide
 - 20,000 in the U.S.

Spread of Diseases

- Increases international travel
- Migration to urban areas
- Migration to uninhabited areas and deforestation
- Hunger and malnutrition
- Increased rice cultivation
- Global warming
- Hurricanes and high winds
- Accidental introduction of insect vectors
- Flooding

Reducing Spread of Diseases

- Increase research on tropical diseases and vaccines
- Reduce poverty and malnutrition
- Improve drinking water
- Reduce unnecessary use of antibiotics
- Educate people on taking antibiotics
- Reduce antibiotic use in livestock
- Careful hand washing by medical staff
- Slow global warming
- Increase preventative health care

Types of Hazards

- **Biological Hazards**
- **Chemical Hazards**
 - Harmful chemicals in the air, water, soil, and food
 - Most human have small amounts of about 500 synthetic chemicals

Hazardous Chemicals

- Methods to determine threat
 - **Case Studies**
 - MD with actual patient record

Case Studies

In-depth, longitudinal examination of a single instance or event

- 18 year- old, 5-8, 145 pound healthy male
 - Circumstances
 - Collapsed on 2/4/07 at 4:30 PM while in the kitchen
 - Ambulance rushed him to VHH where he died of cardiac arrest a little after 5 PM
 - Toxicology results – negative
 - Brain Aneurysm
 - History
 - Broken neck at age 7
 - Hit by car June of 2005

Hazardous Chemicals

- Methods to determine threat
 - Case Studies
 - MD with actual patient record
 - **Epidemiology**
 - Health officials investigating case studies

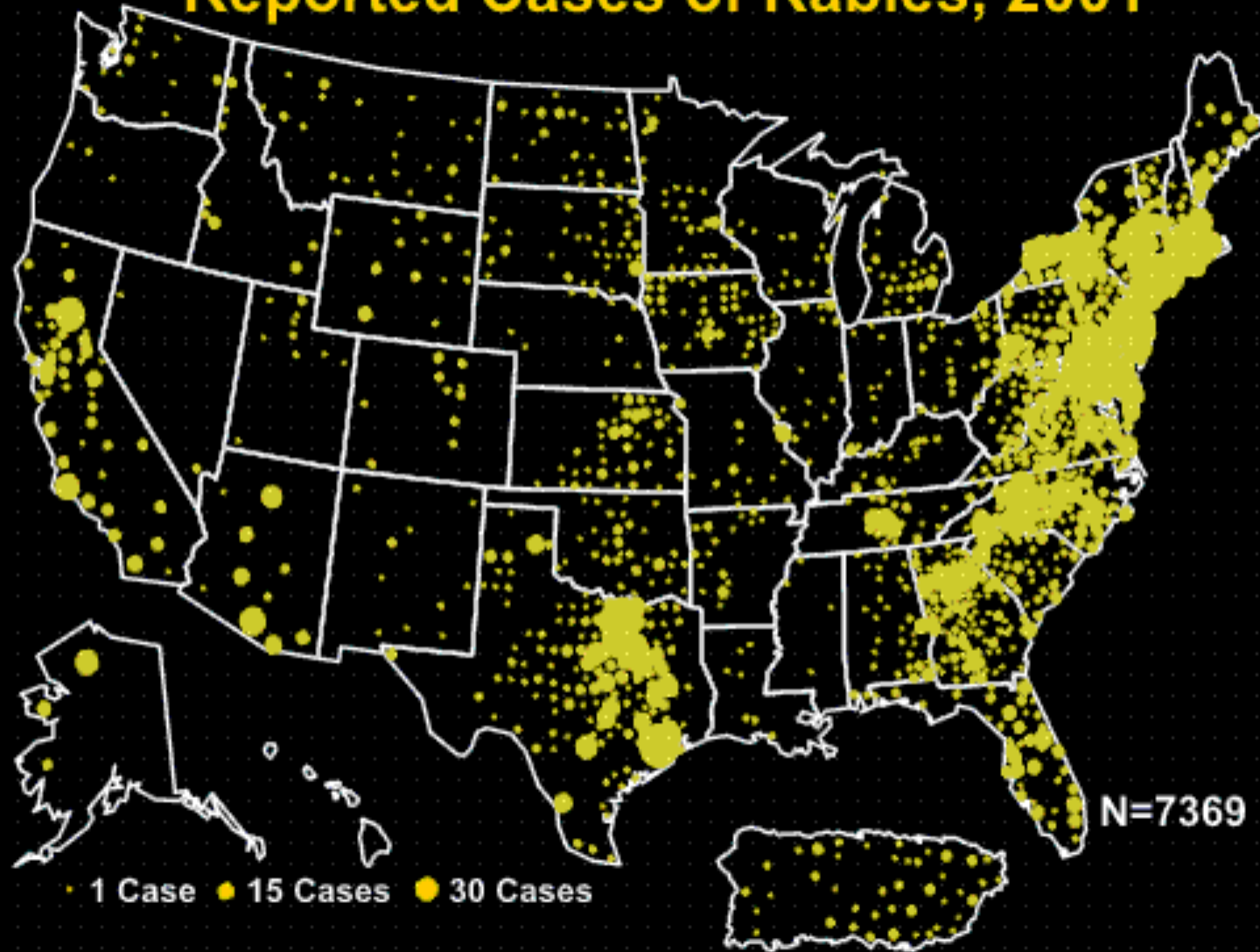
Epidemiology

- Study of the distribution and causes of disease in populations
 - how many people or animals have a disease
 - the outcome of the disease (recovery, death, disability, etc.)
 - the factors that influence the distribution and outcome of the disease

Epidemiology of Rabies

- In 2001, 49 states, the District of Columbia, and Puerto Rico reported 7,437 cases of rabies in animals and no cases in humans to CDC
- The total number of reported cases increased by 0.92% from those reported in 2000 (7,369 cases)

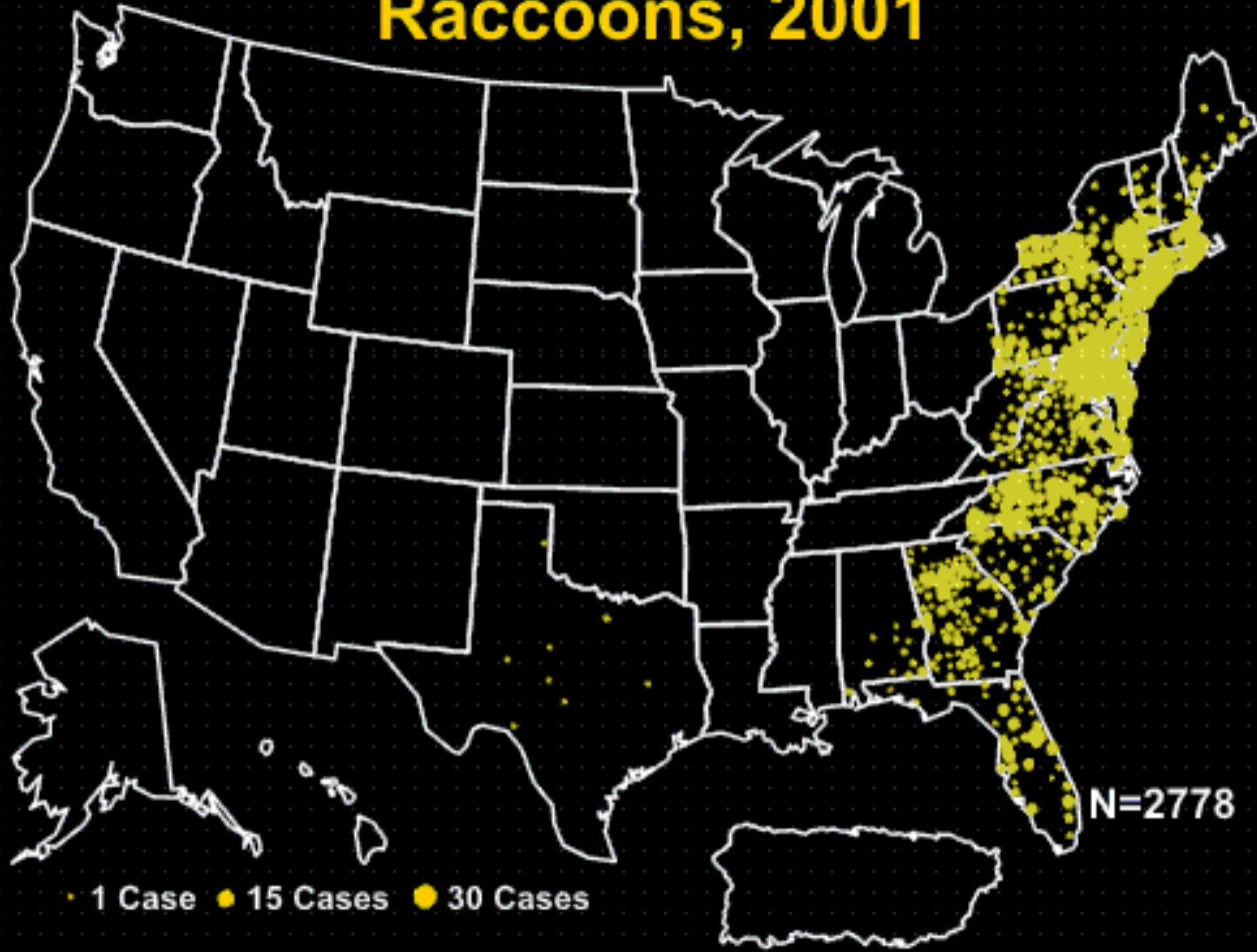
Reported Cases of Rabies, 2001



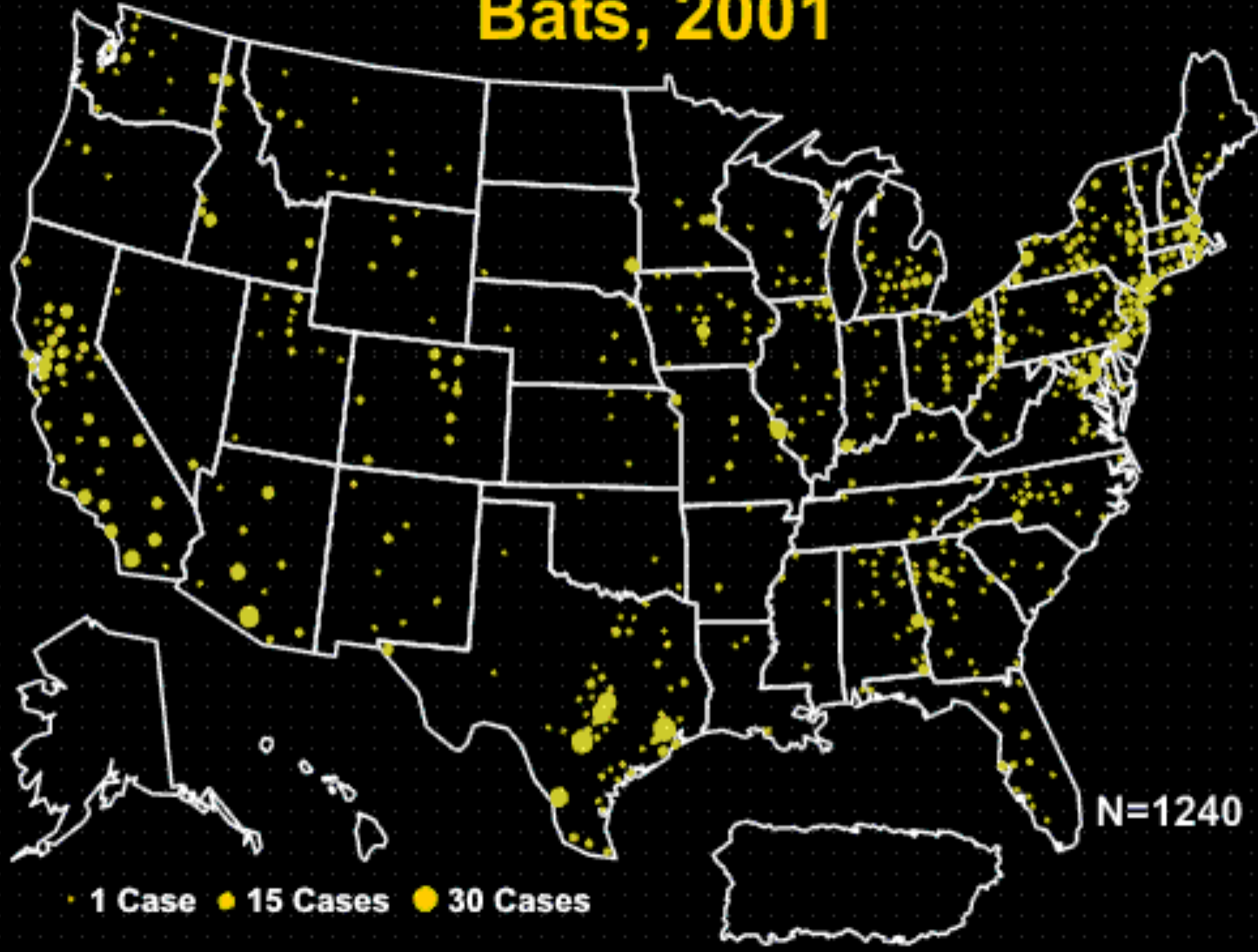
Epidemiology of Rabies

- Wild animals accounted for 93% of reported cases of rabies in 2001
- Outbreaks of rabies infections in terrestrial mammals like raccoons, skunks, foxes, and coyotes are found in broad geographic regions across the United States

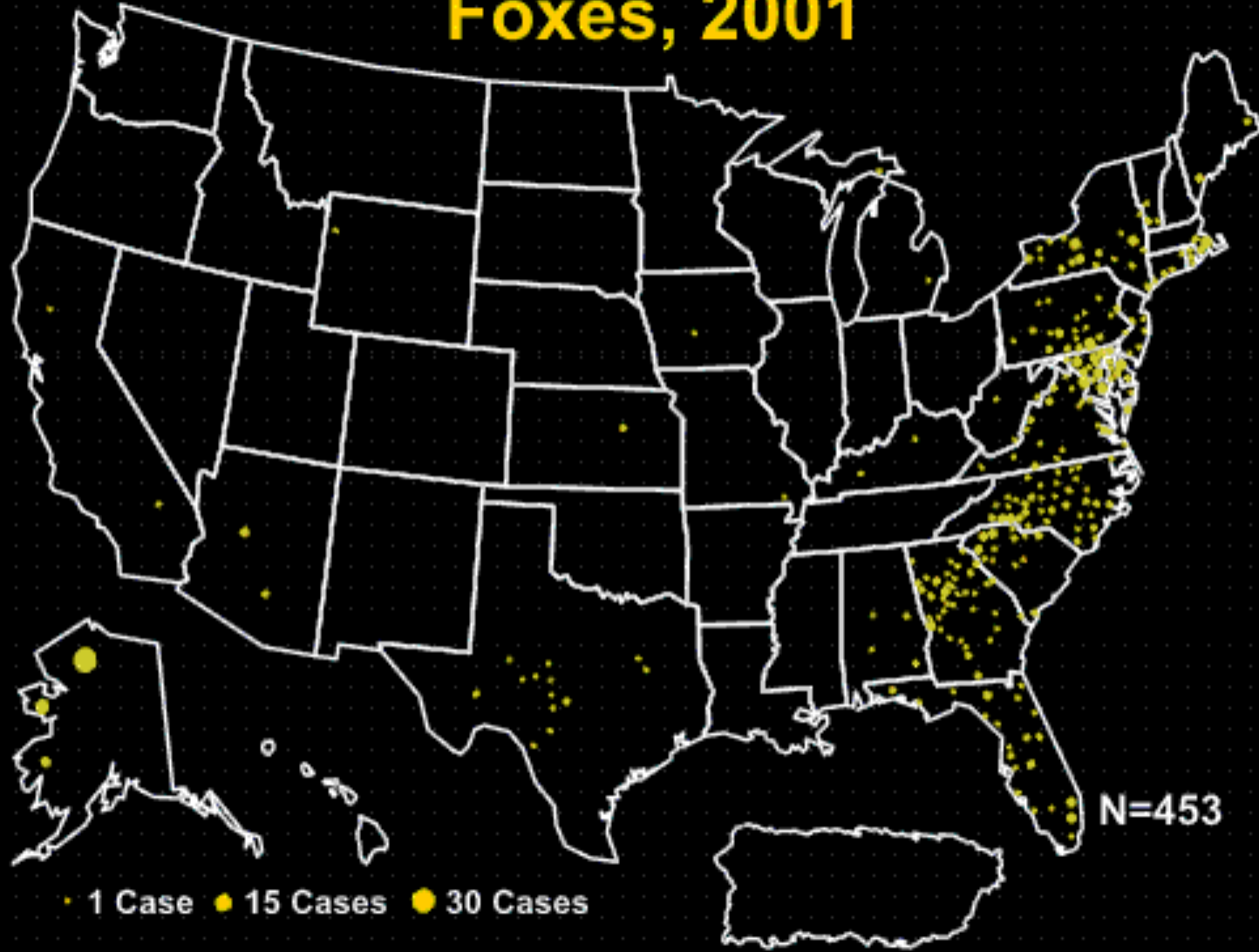
Raccoons, 2001



Bats, 2001



Foxes, 2001



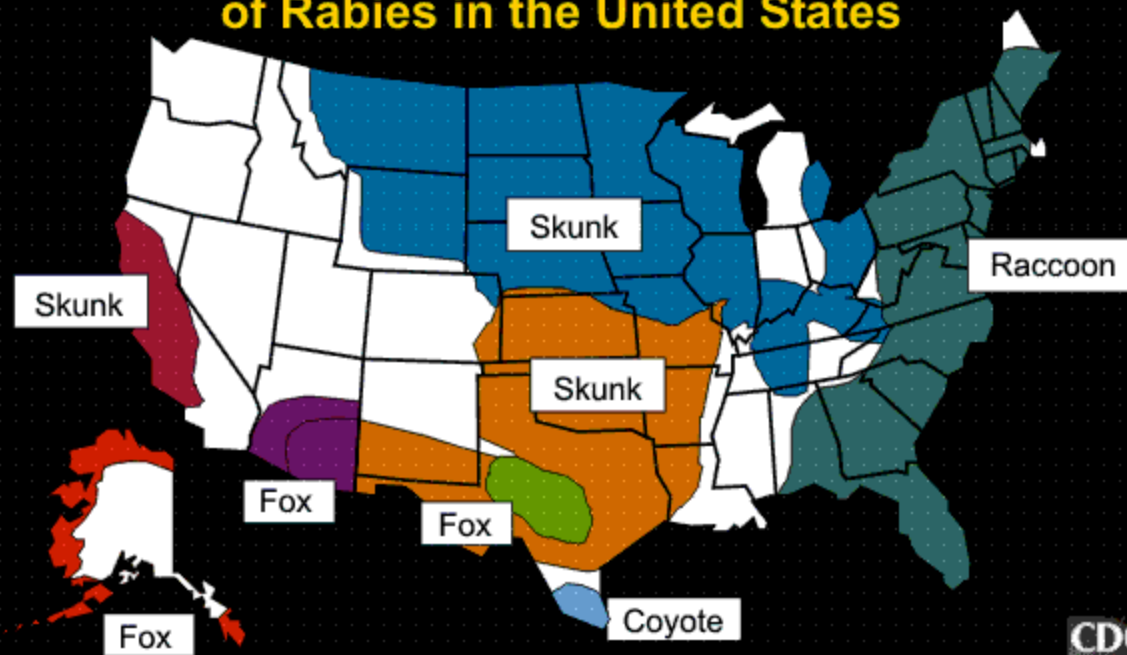
Coyote, 2001



Epidemiology of Rabies

Geographic boundaries of currently recognized reservoirs for rabies in terrestrial mammals

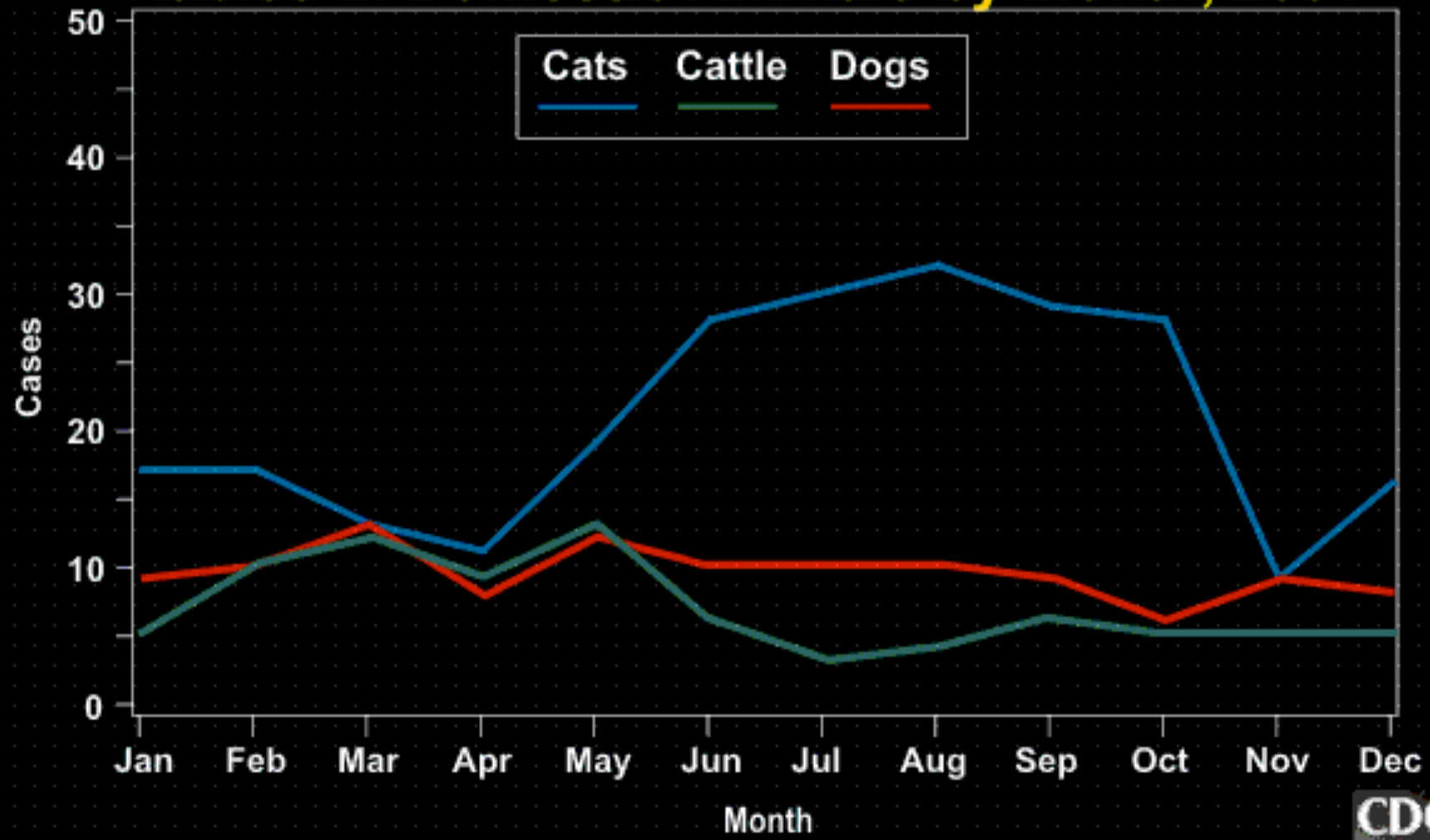
Distribution of Major Terrestrial Reservoirs of Rabies in the United States



Epidemiology of Rabies

- Domestic species accounted for 6.8% of all rabid animals reported in the United States in 2001
- The number of reported rabid domestic animals decreased 2.4% from the 509 cases reported in 2000 to 497 in 2001

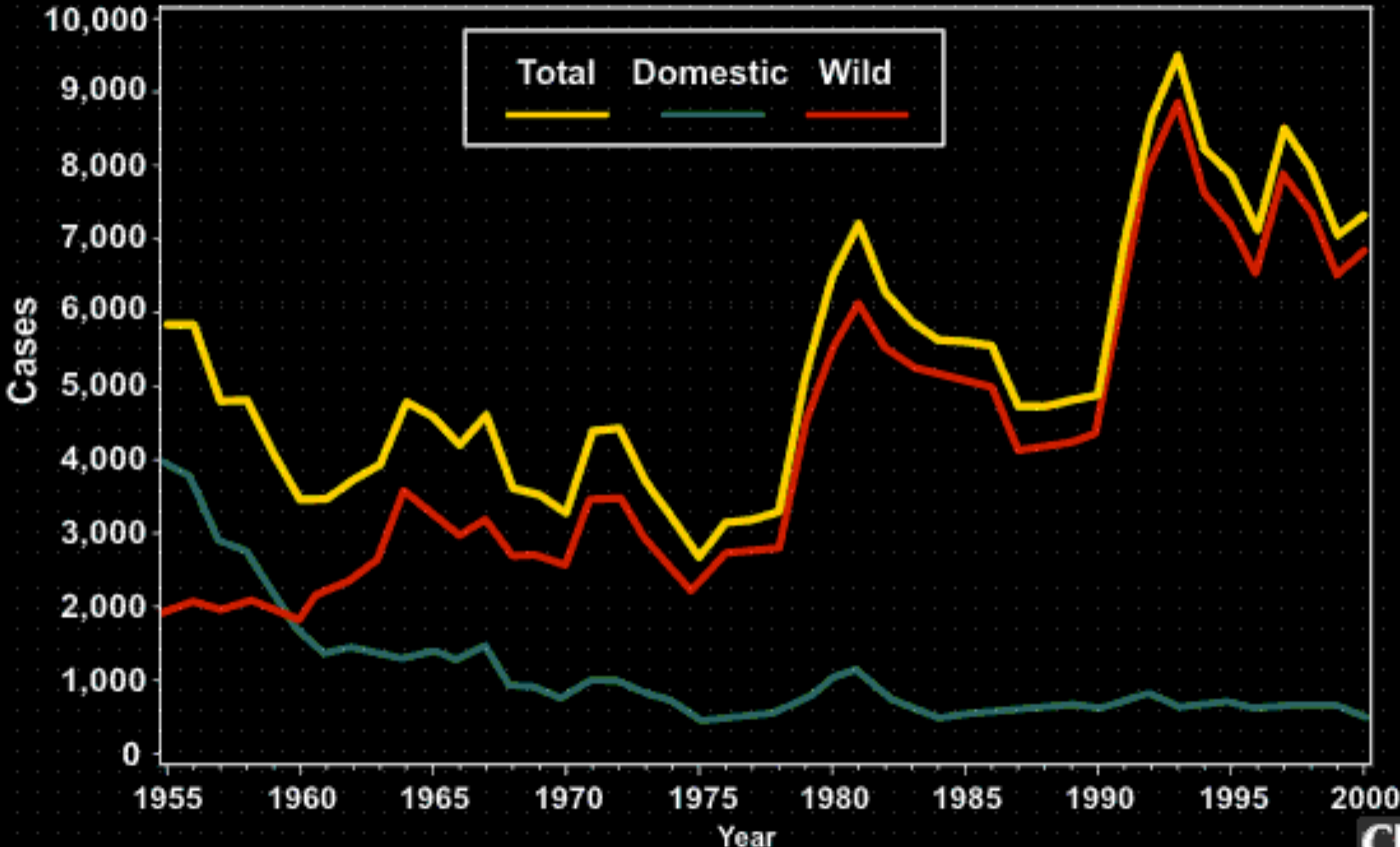
Rabies in Domestic Animals by Month, 2001



Epidemiology of Rabies

- Successful vaccination programs that began in the 1940s caused a decline in dog rabies in this country
- But, as the number of cases of rabies in dogs decreased, rabies in wild animals increased

Cases of Animal Rabies, 1955-2001



Epidemiology of Rabies

Human rabies

- Declined from 100 or more each year to an average of 1 or 2 each year
- Programs
 - Animal control and vaccination programs begun in the 1940's have practically eliminated domestic dogs as reservoirs of rabies in the United States
 - Effective human rabies vaccines and immunoglobins have been developed

Hazardous Chemicals

- Methods to determine threat
 - Case Studies
 - MD with actual patient record
 - Epidemiology
 - Health officials investigating case studies
 - **Laboratory Investigations**
 - Substances that are fatal to more than 50% of the test animals (LD50) at a given concentration

Laboratory Investigations

- Animal Studies
 - Populations of lab animals usually rodents
 - Measured doses under controlled conditions
 - Takes two to five years
 - Costs \$200,000 to \$2,000,000 per substance
- Newer methods

Laboratory Investigations

- Newer methods
 - Bacteria
 - Cell and tissue culture
 - Appropriate tissue
 - Stem cells
 - Chicken egg membrane

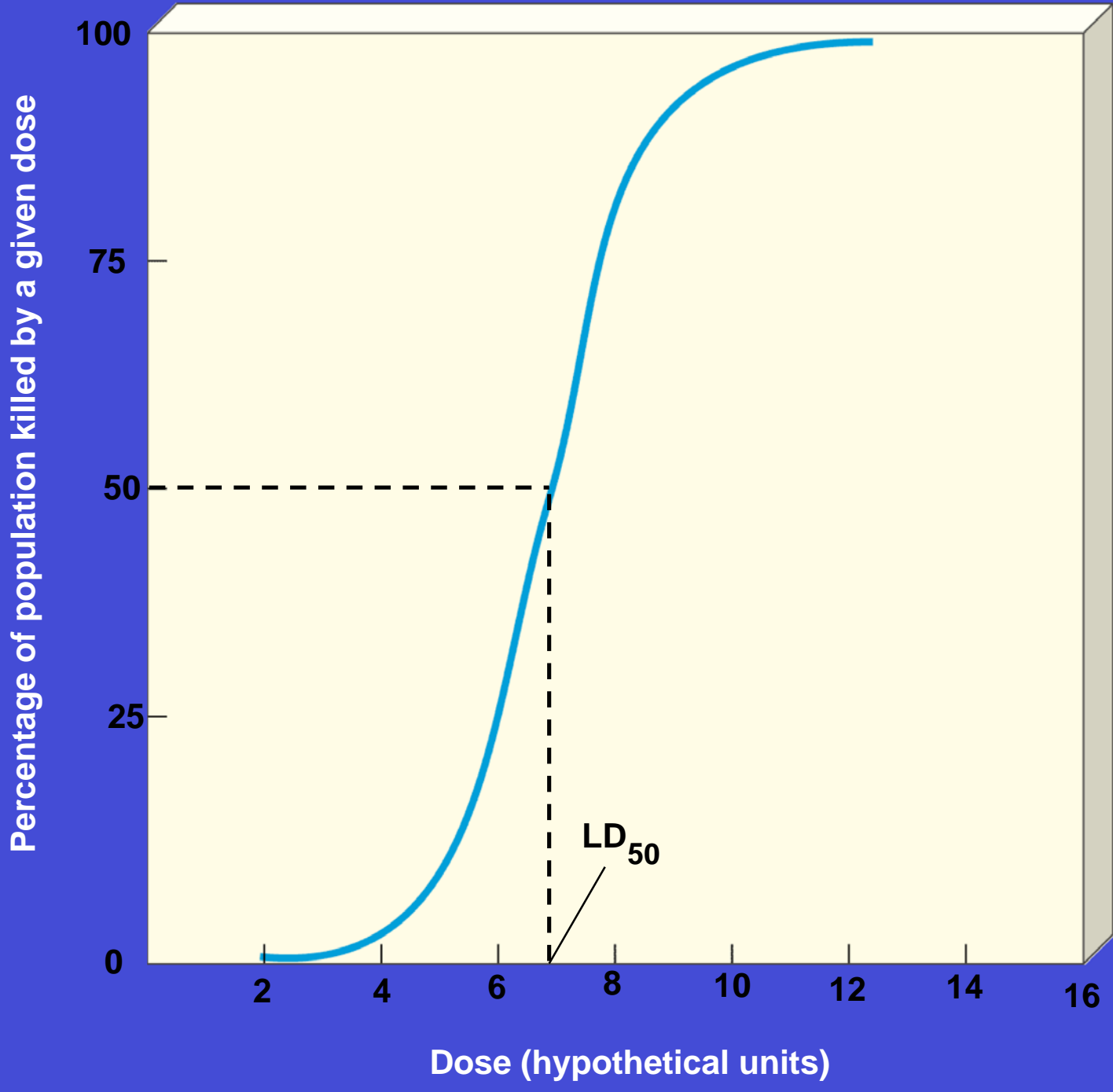


Fig. 16.5, p. 400

Why?

Number of individuals affected

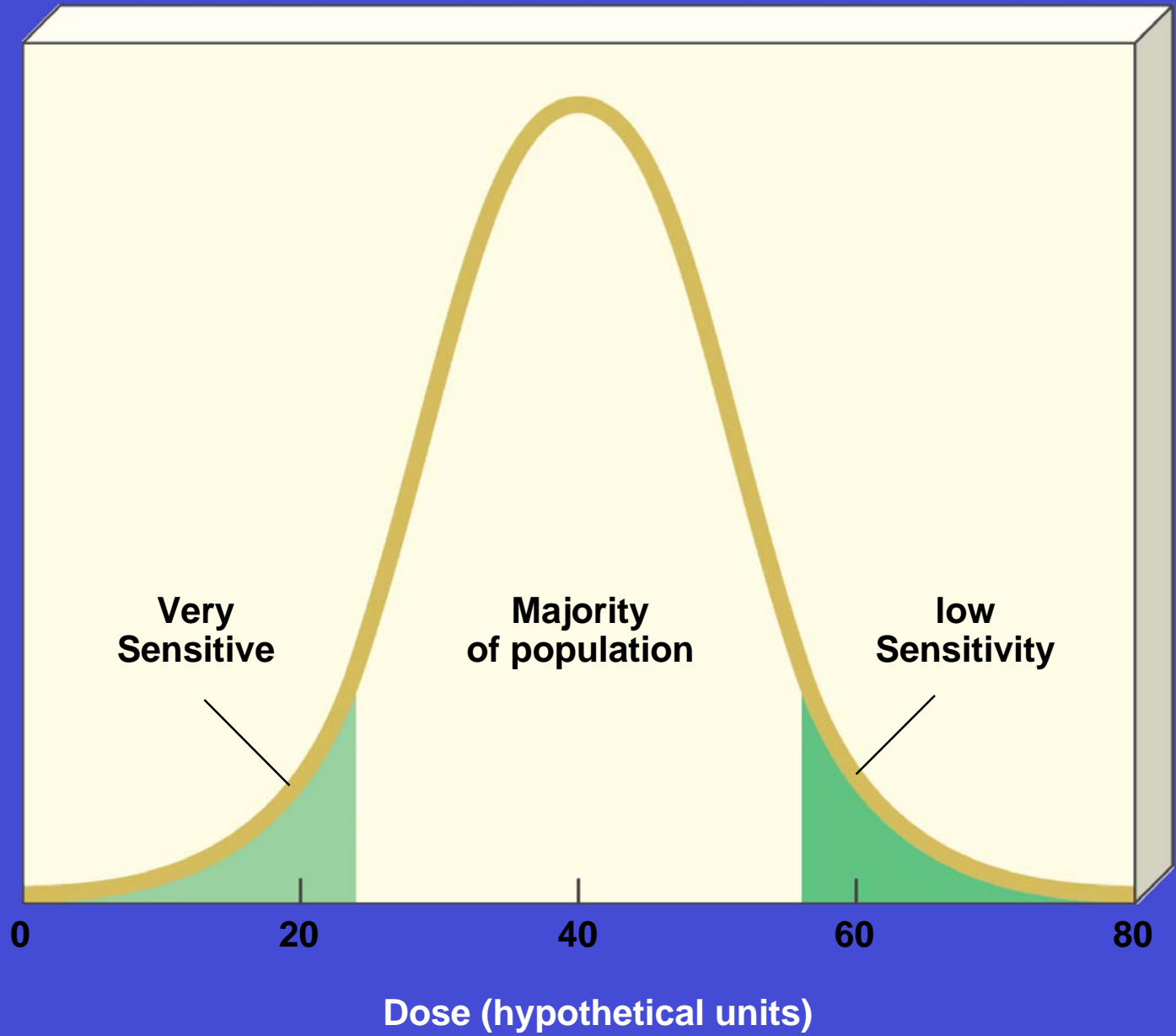


Fig. 16.3, p. 398

Laboratory Investigations

- Validity Challenged
 - Human physiology is different
 - Different species react different to same toxins
 - Mice die with aspirin
 - Species can be selected depending on physiological area
 - Pigs circulatory very similar to humans

Toxicity

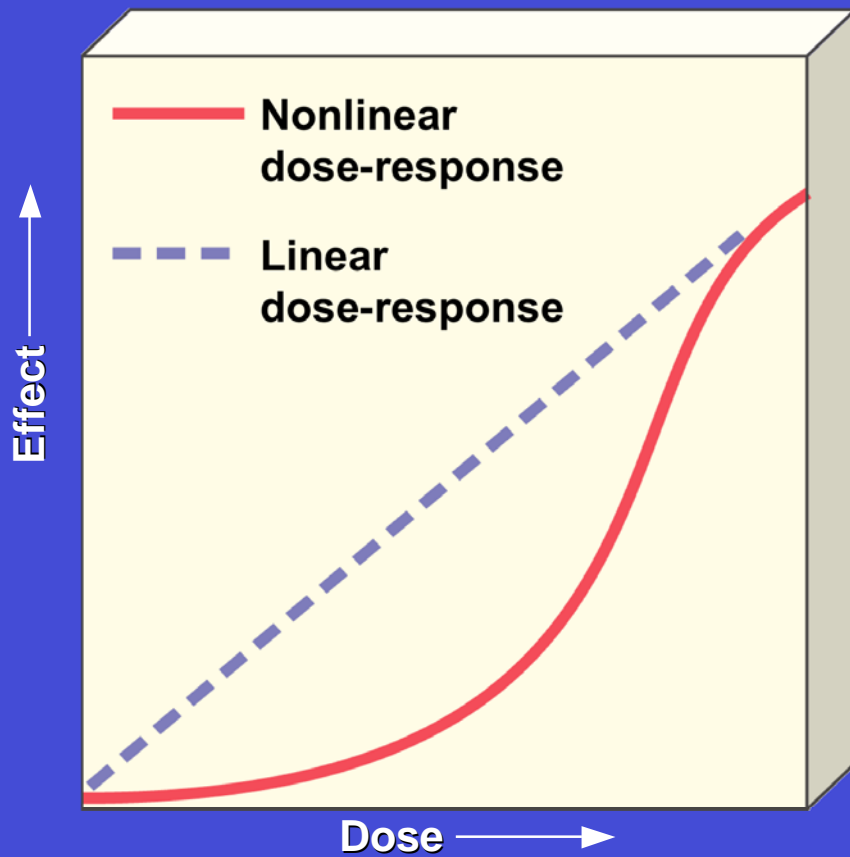
<u>Toxicity</u>	<u>LD50</u>	<u>Lethal Dose</u>	<u>Examples</u>
Super	< 0.01	less than 1 drop	dioxin, botulism mushrooms
Extreme	<5	less than 7 drops	heroin, nicotine
Very	5-50	7 drops to 1 tsp.	morphine, codeine
Toxic	50-500	1 tsp.	DDT, H ₂ SO ₄ , Caffeine
Moderate	500-5K	1 oz.-1 pt.	aspirin, wood alcohol
Slightly	5K-15K	1 pt.	ethyl alcohol, soaps
Non-Toxic	>15K	>1qt.	water, table sugar

(LD50 measured in mg/kg of body weight)

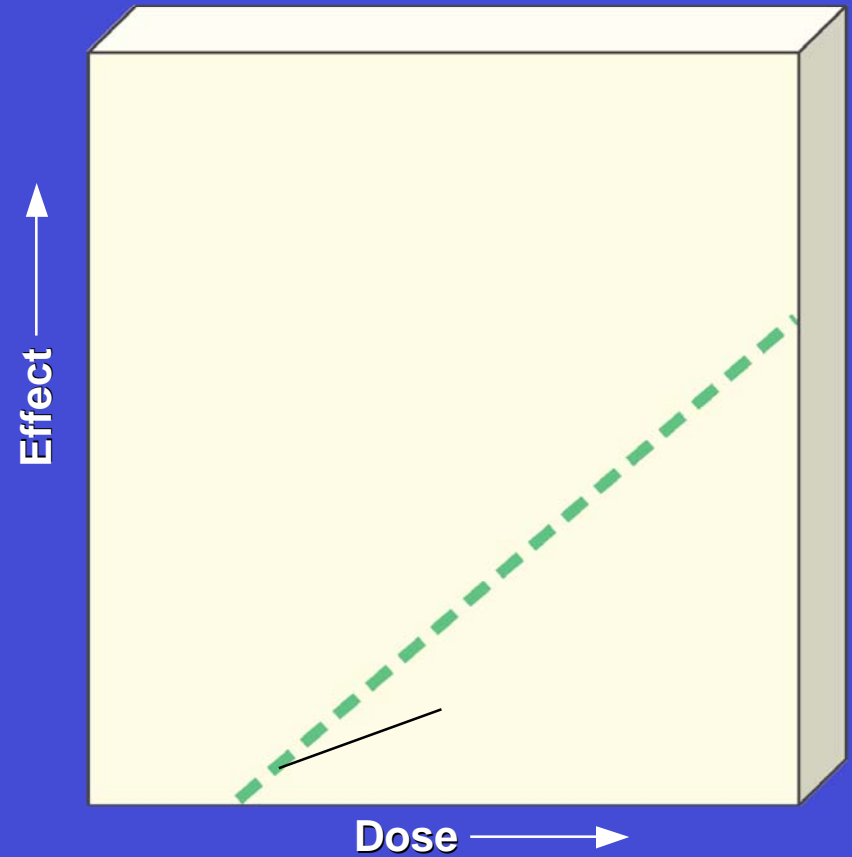
Hazardous Chemicals

- Why so little is known of toxicity
 - Only 10% of at least 75,000 commercial chemicals have been screened
 - ~2% determined to be carcinogen, teratogen or mutagen
 - >1000 new synthetic chemicals added per year
 - >99.5% of US commercial chemicals are NOT regulated

Dose-Response Curves



No threshold



Threshold

Chemical Hazards

- Hazardous Chemicals
- **Mutagens**
 - Chemicals (and ionizing radiation) that changes DNA or RNA in cells

Chemical Hazards

- Hazardous Chemicals
- Mutagens
 - **Teratogens**
 - Chemicals, radiation, or viruses that cause birth defects while the human embryo is gestating, especially in the first three months

Teratogens

- Examples:
 - Rubella
 - Mercury in water
 - Fetal alcohol syndrome
 - Crack babies
 - Methamphetamine

Ocean Pollution: Mercury and Minamata Disease

- Mercury has many industrial uses but is extremely toxic
- A chemical plant released large quantities of mercury into Minamata Bay, Japan
- Residents who ate highly contaminated fish suffered neurological disease and birth disorders



Chemical Hazards

- Hazardous Chemicals
- Mutagens
 - Teratogens
 - **Carcinogens**

Carcinogens

- Causative agents
 - Chemicals – Tobacco smoke
 - Radiation – Pilots and cosmic radiation
 - Viruses – HPV and cervical cancer
 - Texas Governor mandated vaccination of all School females with Merck's HPV vaccine
- Promote growth of malignant tumors

Carcinogens

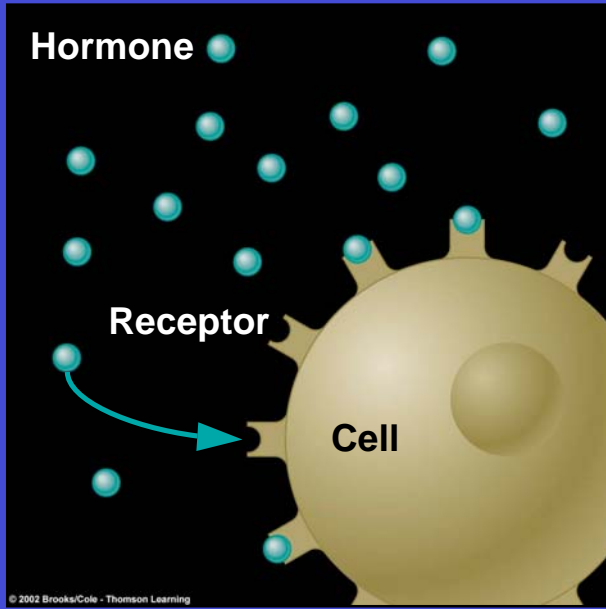
- Latent Period
 - Long time lapse between exposure
 - Smoking
 - Eating
 - Lifestyle choices – laying in sun
 - Symptoms
 - Lung cancer
 - AIDS
 - Melanoma

Chemical Hazards

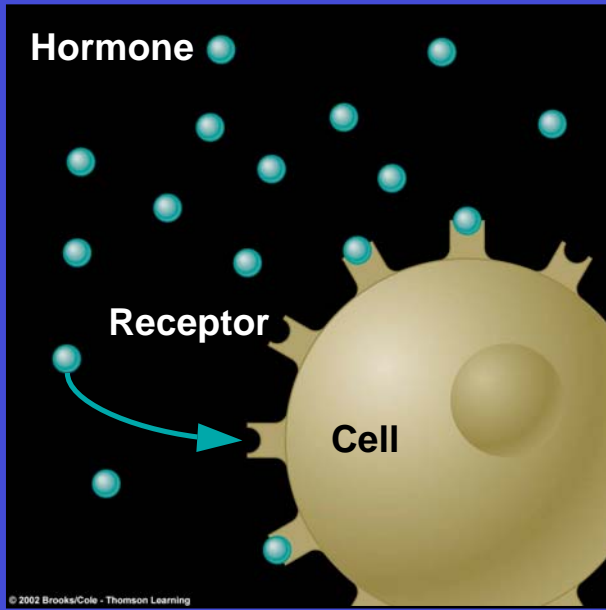
- Hazardous Chemicals
- Mutagens
 - Teratogens
 - Carcinogens
- **Hormonally Active Agents**

Hormonally Active Agents

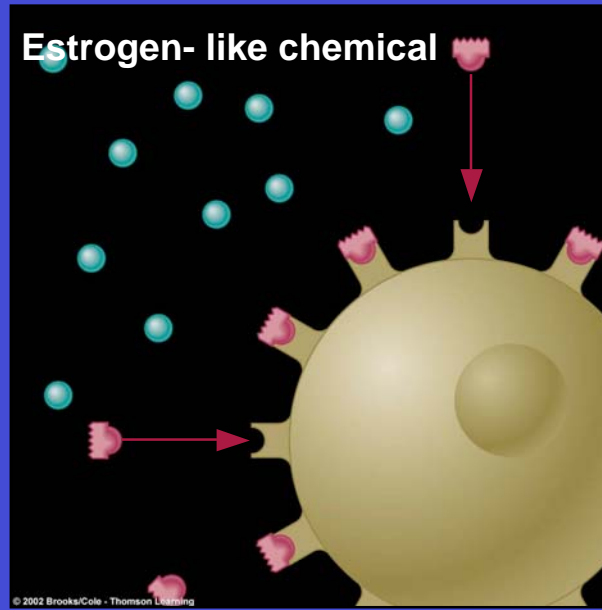
- Estrogen-like chemicals
 - Alter development
 - Early pubescence
 - Low sperm count
 - Runts in wildlife
 - Examples of hormone mimics
 - PCB
 - Organophosphates pesticides
 - Industrial solvents



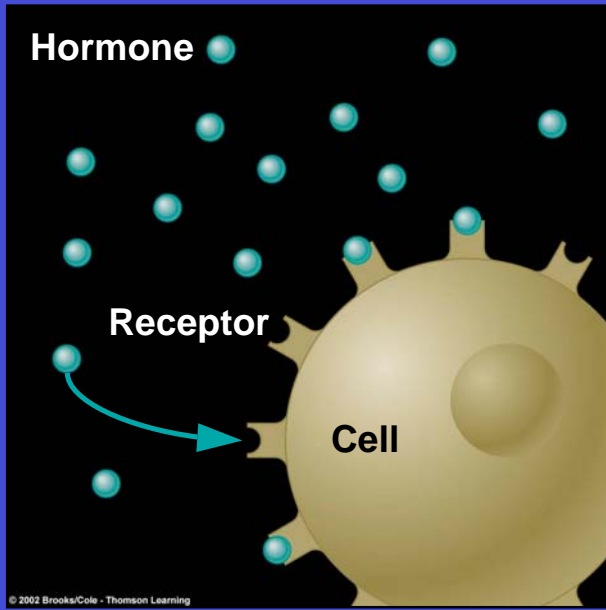
Normal Hormone Process



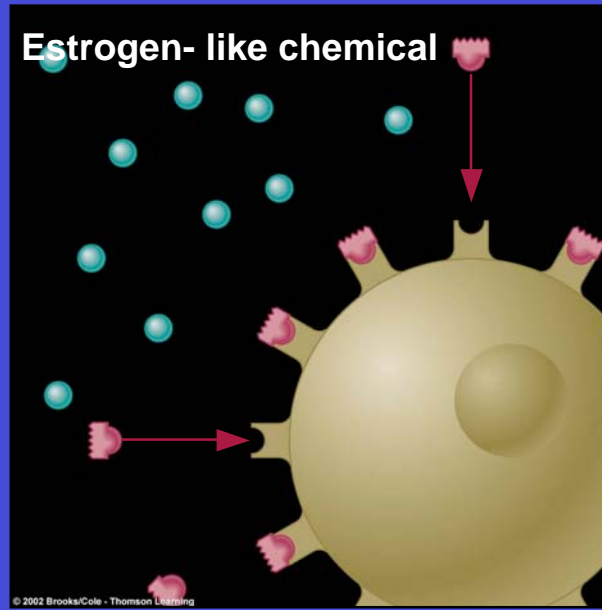
**Normal Hormone
Process**



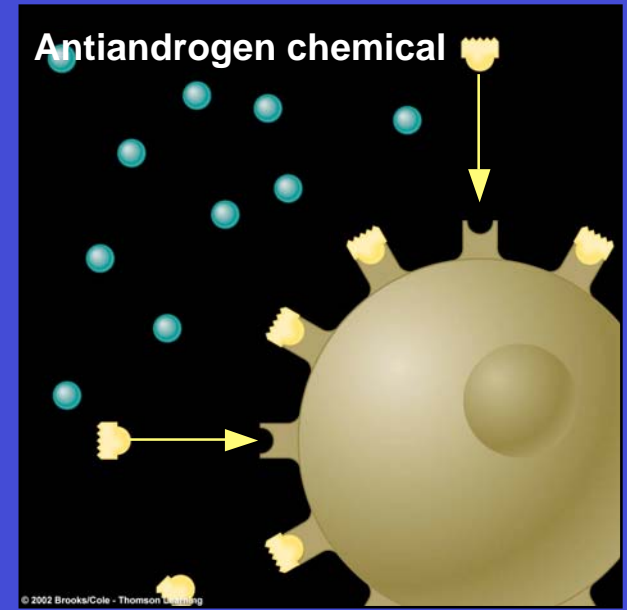
Normal Mimic



Normal Hormone Process



Normal Mimic



Hormone Blocker

Chemical Hazards

- Hazardous Chemicals
- Mutagens
 - Teratogens
 - Carcinogens
- Hormonally Active Agents
- **Precautionary Principles**

Precautionary Principle

- **Better safe than sorry**
 - **Two scenarios**
 - **Assume new chemicals guilty – Humans are not guinea pigs**
 - **Most Chemicals not toxic and too expensive to test**

Precautionary Principle

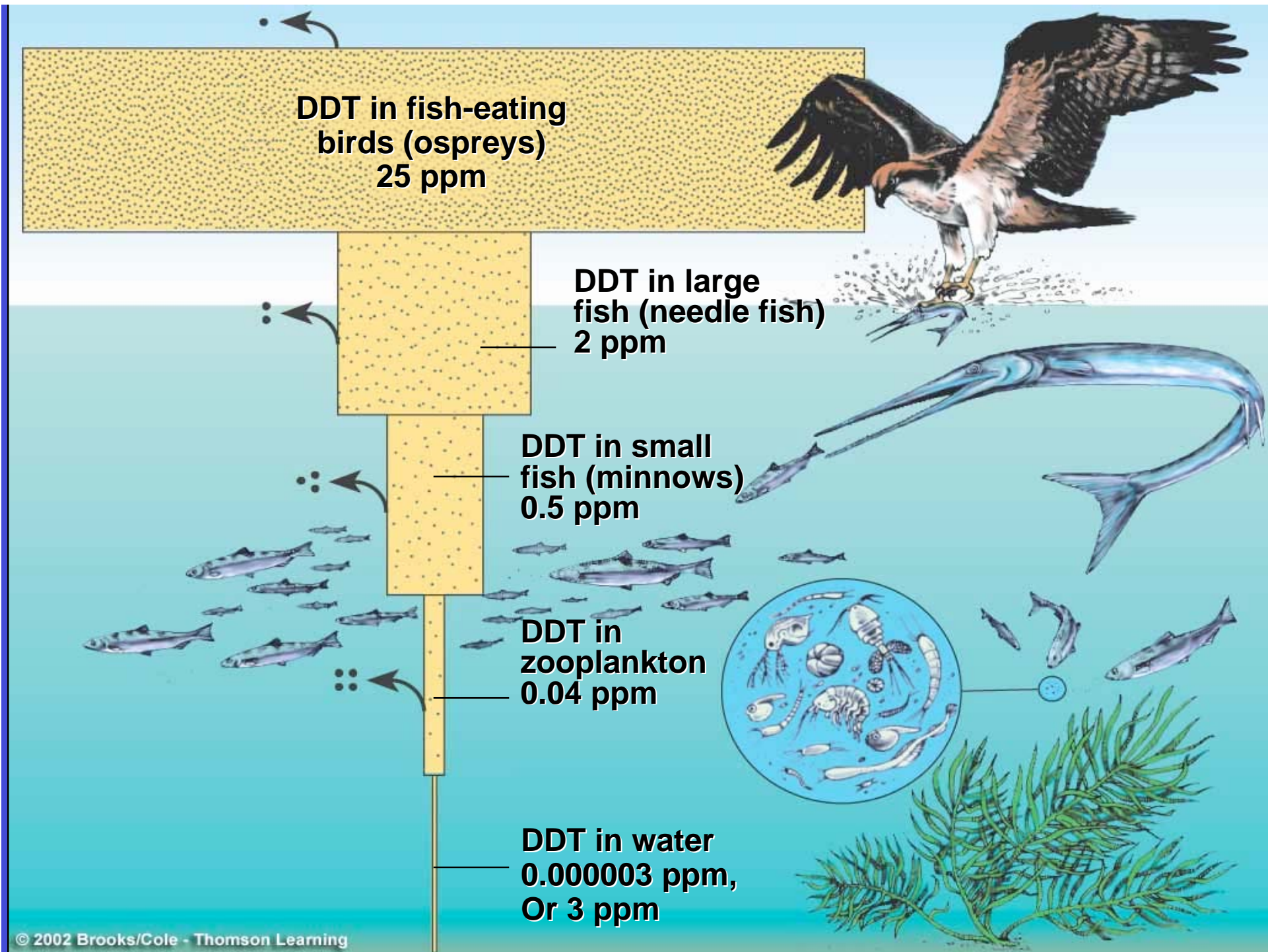
- **Better safe than sorry**
 - **Two scenarios**
 - **Assume new chemicals guilty – Humans are not guinea pigs**
 - **Most Chemicals not toxic and too expensive to test**

Precautionary Principle

- **Bioaccumulation**
 - **An increase in concentration of a chemicals in specific organs or tissues in organisms**

Precautionary Principle

- **Biomagnification**
 - **Increase in concentration in organisms**
 - DDT
 - PCB
 - **Slowly degradable, fat-soluble chemicals**
 - **At successively higher trophic levels of food chains or in fatty tissue**



Types of Hazards

- **Biological Hazards**
- **Chemical Hazards**
- **Physical Hazards**
 - Ionizing radiation, airborne particles, equipment design, fire, earthquake, volcanic eruptions, flood, tornadoes, and hurricanes

Physical Hazards

- **Example: Radon**
 - **Source:**
 - **Arises naturally from decomposition of uranium in the earth**
 - **Occurs at dangerous levels in some buildings and homes**
 - **Can cause lung cancer**
 - **Test kits available for under \$20**

Types of Hazards

- Biological Hazards
- Chemical Hazards
- Physical Hazards
- **Cultural Hazards**
 - Sociological
 - Psychological

Cultural Hazards

- **Sociological**

- result from living in a society where one experiences noise, lack of privacy and overcrowding

- **Population growth**

- Beyond carrying capacity when environmental resources can support no further growth

Cultural Hazards

- Psychological
 - Environmental factors that produce psychological changes expressed as stress, depression, hysteria

Key Concepts

- Types of Hazards
- **Exposure Assessment**
- Methods of toxicology
- Risk estimation, management, and reduction

Exposure Assessment

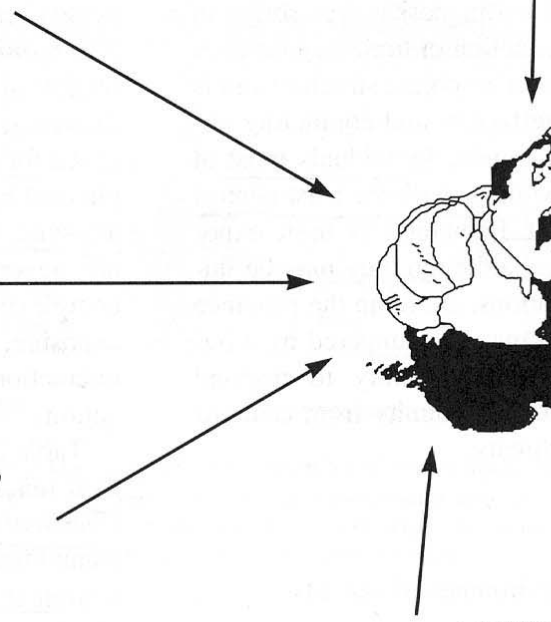
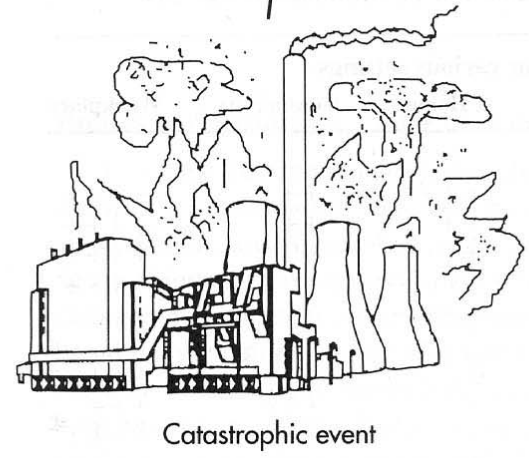
4 important considerations

1. Route

2. Magnitude

3. Duration of exposure

4. Frequency



Key Concepts

- Types of Hazards
- Exposure Assessment
- Risk estimation, management, and reduction

Risk Analysis

- **How can risks be estimated, managed and reduced?**

Risk Analysis involves...

- Identifying hazards
- Evaluate risks
- Ranking risks
- Determining options and deciding course of action
- Informing policy makers and public about risks

Risk Analysis

➤ Risk

The possibility of suffering harm from a hazard that can cause injury, disease, economic loss, or environmental damage. Risk is Expressed in terms of probability, a mathematical statement about How likely it is that some event or effect will occur.

$$\text{Risk} = \text{Exposure} \times \text{Harm}$$

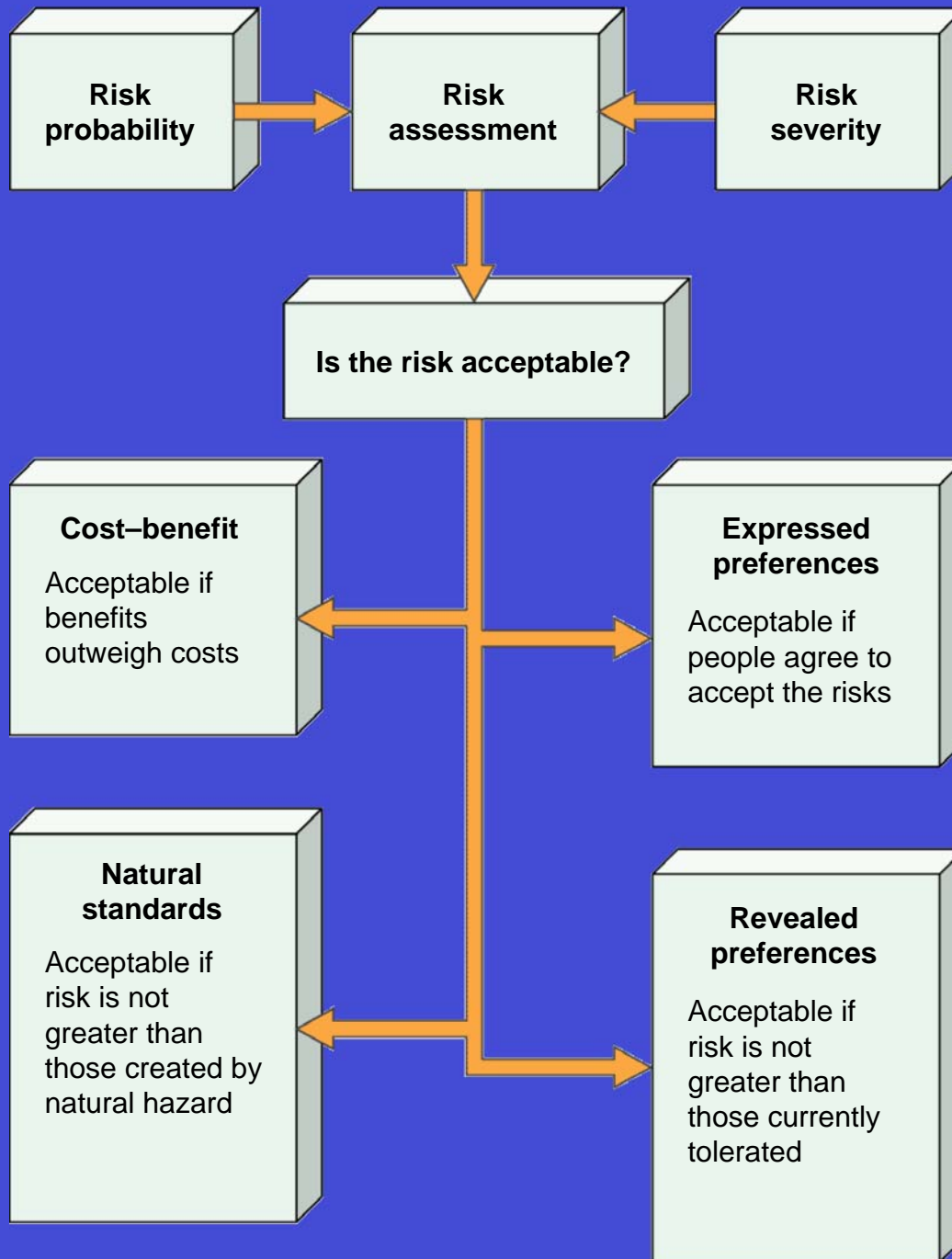


Fig. 16.14, p. 412

Risk Analysis Usefulness

- Organize and analyze available scientific information
- Identify significant hazards
- Focus on areas that warrant more research

Risk Analysis Usefulness

- Help regulators decide how money for reducing risks should be allocated,
- Stimulate people to make more informed decisions about health and environmental goals and priorities.

Risk Perception

- If chance of death is 1 in 100,000 people are not likely to be worried or change behavior.
- Most of us do a poor job of assessing relative risks from hazards around us.

Risk Perception

- Most people deny the high-risk activities they voluntarily enjoy
 - Motorcycles (1 in 50)
 - Smoking (1 in 300 pack a day smokers, by 65)
 - Hang-gliding (1 in 2,500)

What do you think
are the highest risk
hazards in the U.S.?

Cause of Death

Deaths

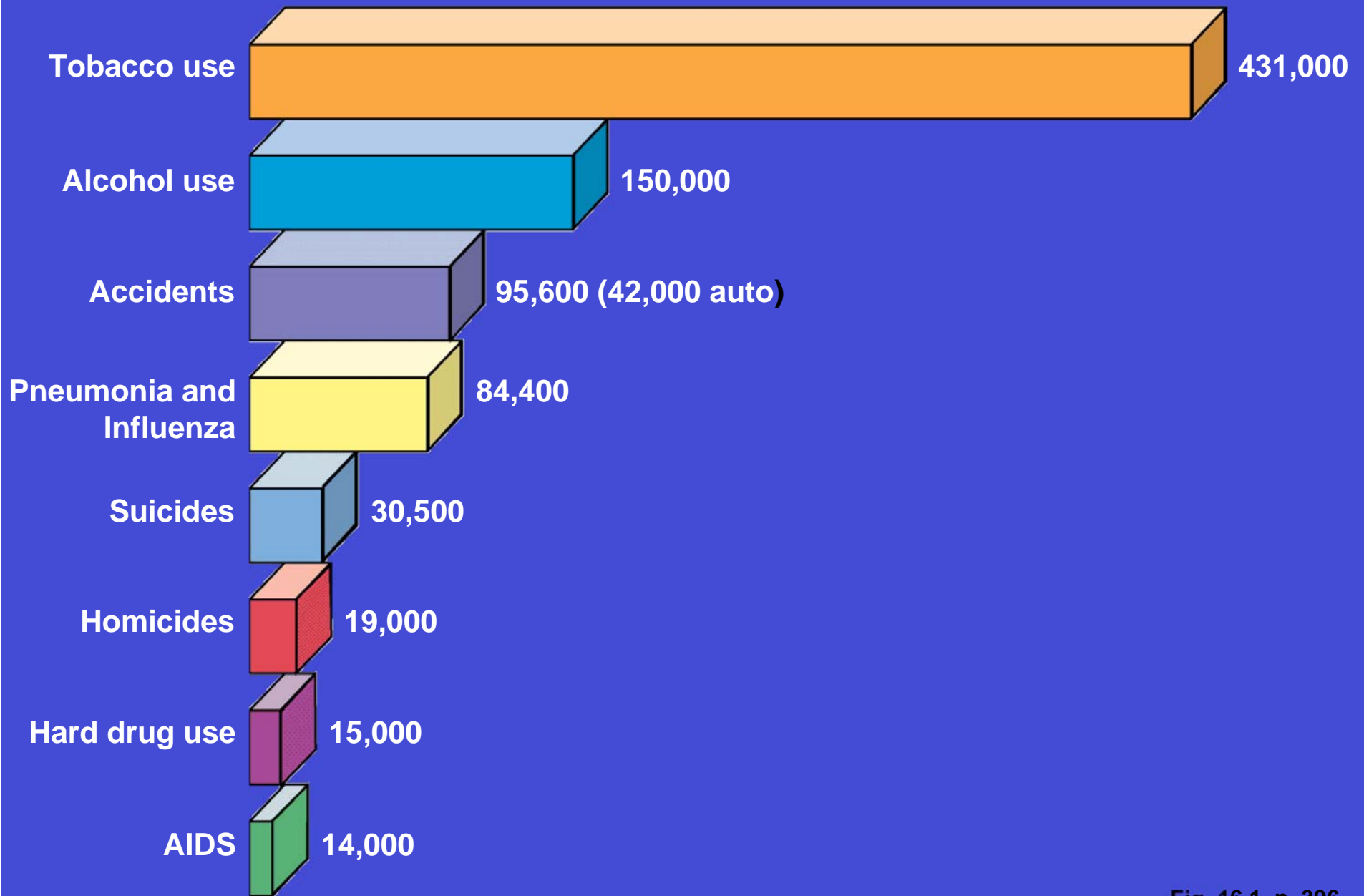


Fig. 16.1, p. 396

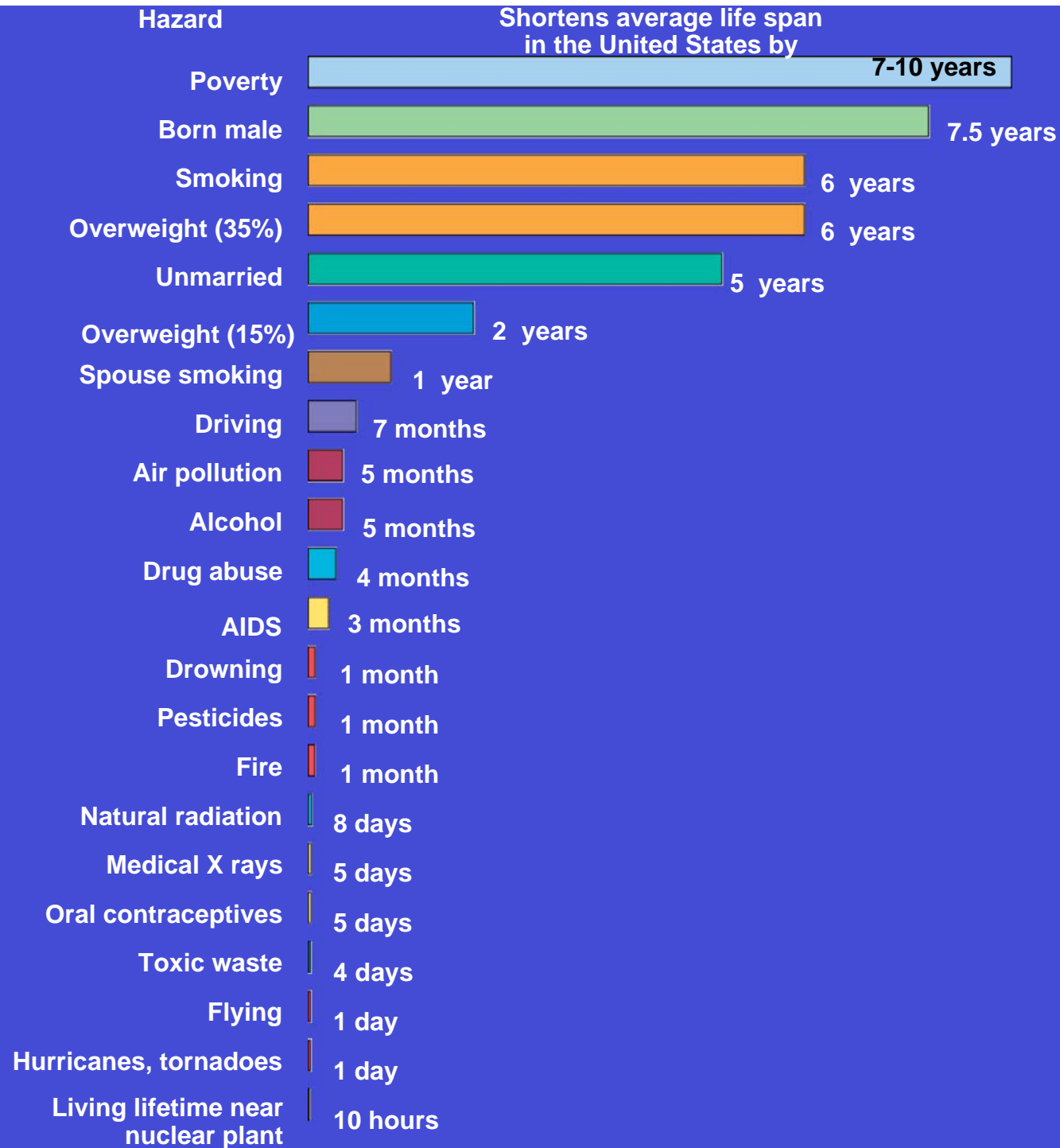


Fig. 16.15, p. 414

Yet some of these people are terrified of dying from...

- Commercial plane crash
 - 1 in 4.6 million
- Train crash
 - 1 in 20 million
- Snakebite
 - 1 in 36 million
- Shark attack
 - 1 in 300 million



Each year 99.1% of the
people on Earth do not
die.

Average life expectancy
continues to increase.

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5. Barbara E. Moore, Ph.D., Department of Biology, University of Texas at San Antonio @ [http://www.texastmdl.org/presentations/Pathogen Issues I final.ppt](http://www.texastmdl.org/presentations/Pathogen%20Issues%20I%20final.ppt)
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