Brainstorm:

What do you think the “Green Revolution” might be?

Chapter 14
Agricultural Methods

Manipulating the environment to produce the kinds of foods humans want

Green Revolution

a large increase in crop production in developing countries achieved by the use of fertilizers, pesticides, and high-yield crop varieties.

Shifting Agriculture

"Slash and Burn"

- Cutting down and burning trees and other vegetation in a small area of forest
- Releases nutrients that can be used for a few crops until nutrients are depleted (2-3 years)

- Useful on thin, nutrient-poor soil (tropical rain forests and steep slopes with low population)

Polyculture

Mixture of plants

Advantages: shade, nitrogen-fixing plants, natural pest control (plant chemicals)

Shifting agriculture (slash and burn) and polyculture used in Tropical Rainforests and by Native American cultures

Labor-Intensive Agriculture

1) The growing site does not allow for mechanization
2) The kind of crop requires much hand labor
3) The economic condition of the people does not allow them to purchase tools and machines for mechanized agriculture

Often fruits, vegetables and nuts
Practiced in much of the developing world



Mechanized Monoculture Agriculture

- Large expanses of level land
- Same crop

***Issues*:**

1. Soil erosion
2. Loss of genetic diversity
3. Reliance on fertilizer and pesticides

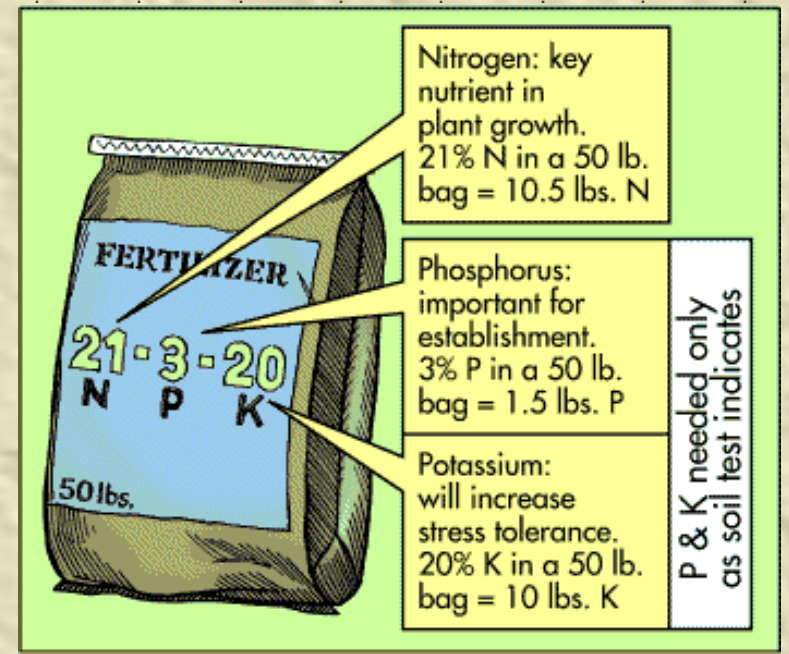
Fertilizer and Agriculture

Macronutrients: primary soil nutrients often in short supply

- Nitrogen (N), Phosphorus (P) and Potassium (K)

Micronutrients: elements necessary in very small amounts.

- Ex.: boron, zinc and manganese

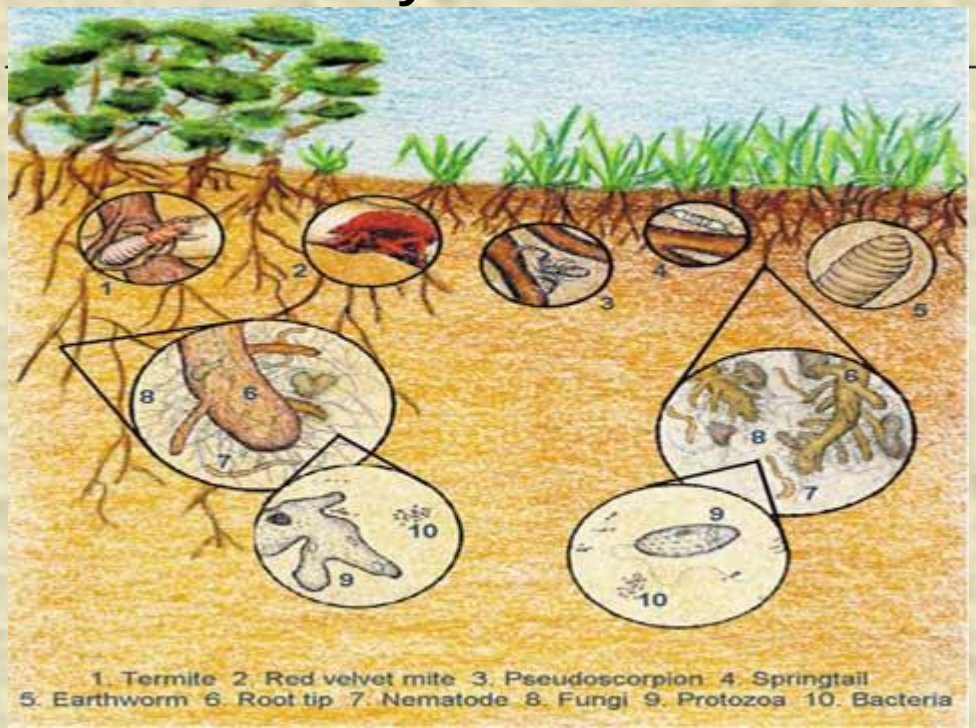


Organic Material

Modifies structure of soil, maintains pore space allowing water and air to reach roots

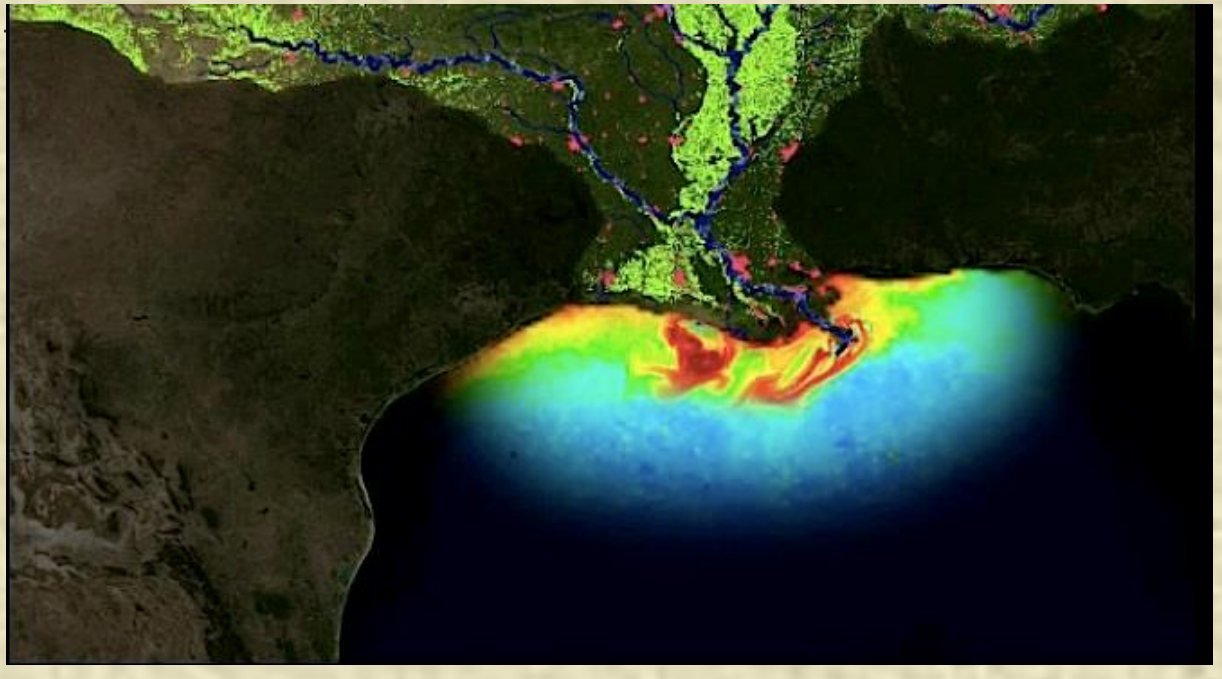
Humus: decomposed organic matter helps maintain soil chemistry

Soil bacteria: rely on organic matter for role in Nitrogen and Carbon cycle



Problems with Fertilizer use

- Production relies on energy from fossil fuels so price and availability is strongly influenced by world energy prices.
- Water dissolves soil nutrients and carries them into streams and lakes encouraging growth of unwanted plants and algae.



Pest Management

Pests: Any organism that interferes in some way with human welfare or activities

PROTECTING FOOD RESOURCES: PEST MANAGEMENT

- Organisms found in nature (such as spiders) control populations of most pest species as part of the earth's free ecological services.

PROTECTING FOOD RESOURCES: PEST MANAGEMENT

- We use chemicals to repel or kill pest organisms as plants have done for millions of years.
- Chemists have developed hundreds of chemicals (pesticides) that can kill or repel pests.
  - Pesticides vary in their persistence.
  - Each year > 250,000 people in the U.S. become ill from household pesticides.

PROTECTING FOOD RESOURCES: PEST MANAGEMENT

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- Advantages and disadvantages of conventional chemical pesticides.

Figure 13-28

Classification of Pesticides

Any chemical with the goal to kill or control populations of unwanted pests (target organisms)

[Most kill nontarget organisms also]

Herbicides

- A toxic chemical that kills plants

Insecticides

- A toxic chemical that kills insects

Rodenticides

- A toxic chemical that kills rodents

Fungicides

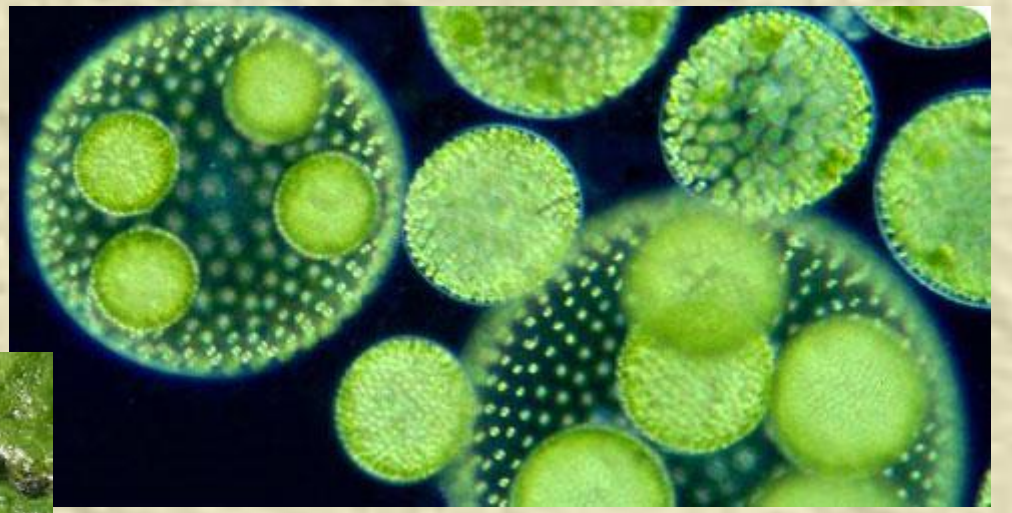
- A toxic chemical that kills fungi

Nematicides

- A toxic chemical that kills nematodes (roundworms)

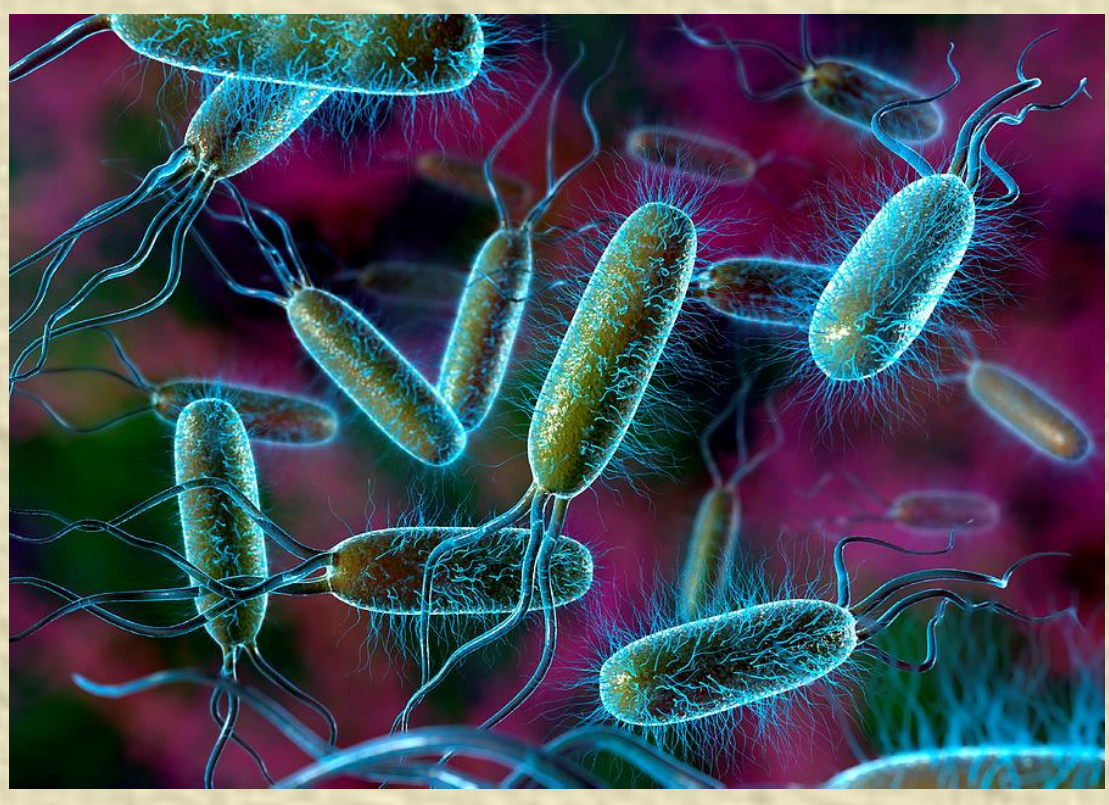
Algaecides

- A toxic chemical that kills algae



Bactericides

- A toxic chemical that kills bacteria



Piscicides

- A toxic chemical that kills fish

Hard/Persistent Pesticides

Characteristics:

- Composed of compounds that retain their toxicity for long periods of time. They work their way up the food chain through animals and may accumulate in their fatty tissues and stay indefinitely.

Examples

DDT and many other chlorinated hydrocarbons.

Soft Pesticides
(Nonpersistent)

Characteristics

- Reduced-risk pesticides. They are short-term and don't harm the environment or man.

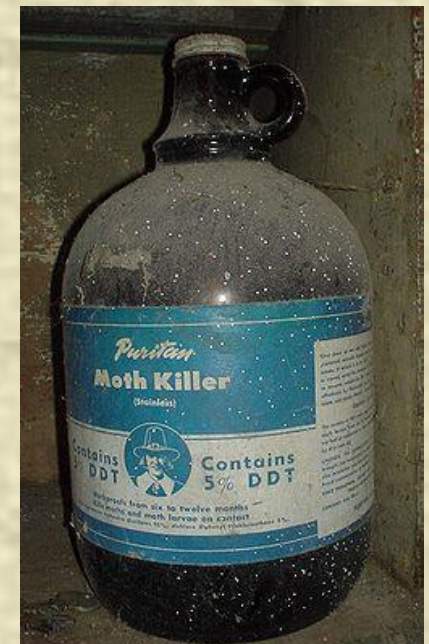
Examples

soaps, oils, plant extracts, baking soda, and dish liquid.

Chemical Classes of Pesticides

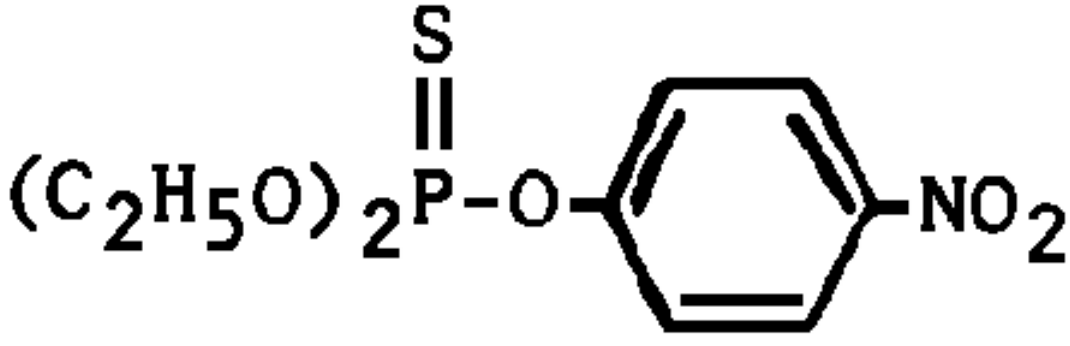
Organochlorines (chlorides)

- Hard/persistent
- Toxic in the long term
- Not very toxic in the short-term
- Ex. DDT



Organophosphates

- Soft/not persistent
- Highly toxic in the short term (affect nervous system)
- They require very specific safety equipment for application.
- Ex. Parathion



Carbamates

- Soft/not persistent
- Not as toxic as the other two (affects nervous system)
- Most of the over-the-counter pesticides.
- Ex. Sevin Dust

Characteristics of an Ideal Pesticide

1. Inexpensive
2. Affects only target organism
3. Short half-life
4. Break down into harmless materials

Historical Use of Pesticides

- Natural Pesticides – pyrethrins (from chrysanthemums, sulfur and garlic

- Synthetic Pesticides – Used during and after WWII and today.

Benefits of Pesticide Usage

Disease Control

- Save human lives
- Prevent insect-transmitted diseases, such as malaria (*Anopheles* mosquito), bubonic plague (rat fleas), typhus (body lice & fleas), & sleeping sickness (Tsetse fly).

Food Production

- Increase food supplies and lower food costs.
- About 55% of the world's food supply is lost to pests before (35%) and after (20%) harvest.
- These losses would be worse and food prices would rise.

Fiber Production

- Crops such as cotton
- Kills pests like the cotton boll weevil.

Efficiency When Compared to Alternatives

- Pesticides control most pests quickly and at a reasonable cost
- They have a long shelf life
- Easily shipped and applied
- Are generally safe when handled properly
- When genetic resistance occurs, farmers can use stronger doses or switch to other pesticides.
- Proponents feel they are safer than the alternative

Development of Safer Pesticides

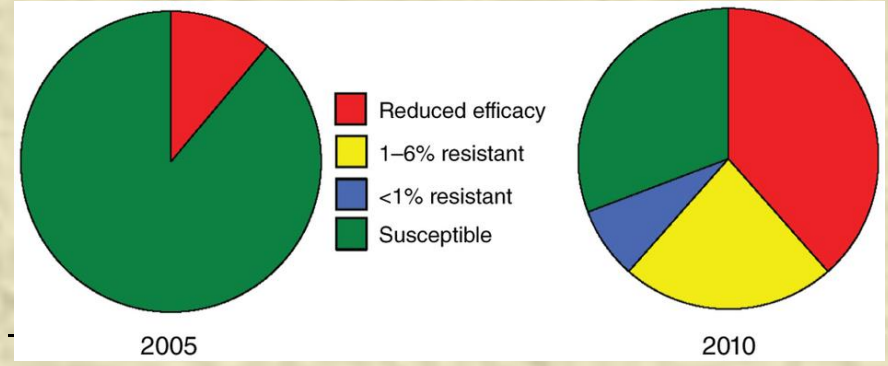
- such as botanicals and micro-botanicals
- safer to users and less damaging to the environment.
- Genetic engineering holds promise in developing pest-resistant crop strains.
- It is very expensive to develop these, so they are only doing it for large-market crops like wheat, corn, and soybeans.

Problems Associated with Pesticide Usage

Impact on Non-target Organisms

- The USDA says that only 2% of the insecticides from aerial or ground spraying actually reaches the target pests
- Only 5% of herbicides applied to crops reaches the target weeds.
- They end up in the environment

Superbugs



- Genetic resistance to pesticides.
- Insects breed rapidly; within 5-10 years (sooner in tropics) they can develop immunity to pesticides and come back stronger than before.
- Weeds and plant-disease organisms also become resistant.
- 520 insect and mite species, 273 weed species, 150 plant diseases, and 10 rodent species (mostly rats) have developed genetic resistance to pesticides.
- At least 17 insect pest species are resistant to all major classes of insecticides

Superpests

- Superpests are resistant to pesticides.
- Superpests like the *silver whitefly* (left) challenge farmers as they cause > $200 million per year in U.S. crop losses.

Case Study: Growing Germ Resistance to Antibiotics

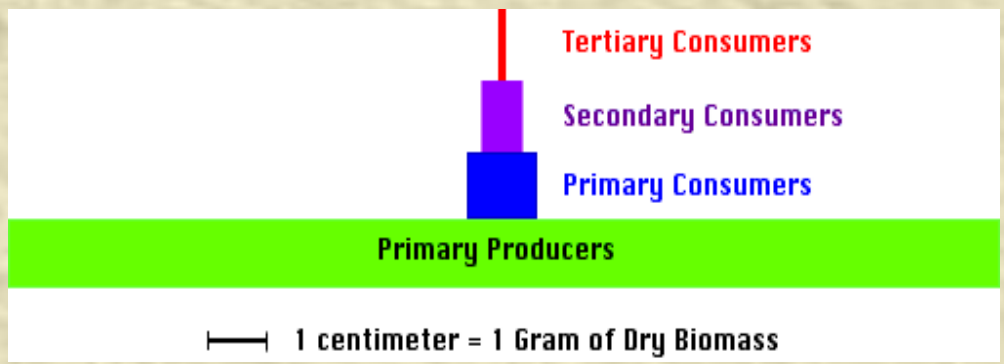
- Rabidly producing infectious bacteria are becoming genetically resistant to widely used antibiotics due to:
  - ***Genetic resistance***: Spread of bacteria around the globe by humans, overuse of pesticides which produce pesticide resistant insects that carry bacteria.
  - ***Overuse of antibiotics***: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

Persistence

- Many pesticides stay in the environment for a very long time. Ex. DDT

Bioaccumulation

- Increase in the concentration of a chemical in specific organs or tissues at a level higher than normal.
- Stored in body fat and can be passed along to offspring.
- Usually a concern to organisms higher on the food chain.



Formation of New Pests

- Turning of minor pest into major pests.
- The natural predators, parasites, & competitors of a pest may be killed by a pesticide it allows the pest population to rebound.
- EX. DDT to control insect pests on lemon trees caused an outbreak of a scale insect (a sucking insect that attacks plants) that had not been a problem.

Food/Water Contamination

- Pesticides run off into our water as we spray for bugs and can stay on our food.

Pesticide Poisoning

- Short-term exposure to high levels of pesticides can result in harm to organs and even death (usually improper use)
- Long-term exposure to lower levels of pesticides can cause cancer.
- Children are at a greater risk than adults.

Pesticide Poisoning

Symptoms

- Nausea, vomiting, and headaches.
- More serious can result in damage to the nervous system & other body organs.

Examples

•The W.H.O. estimates that more than 3 million people are poisoned by pesticides each year, & about 220,000 die.

National Cancer Institute

- Pesticides have been shown to cause lymphomas, leukemia, brain, lung, and testicular cancers.
- The issue of whether certain pesticides cause breast cancer remains unresolved
- Researchers have noted a correlation between a high level of pesticides in the breast's fatty tissue and cancer.

How Pesticides Function

LD-50 (Median Lethal Dose)

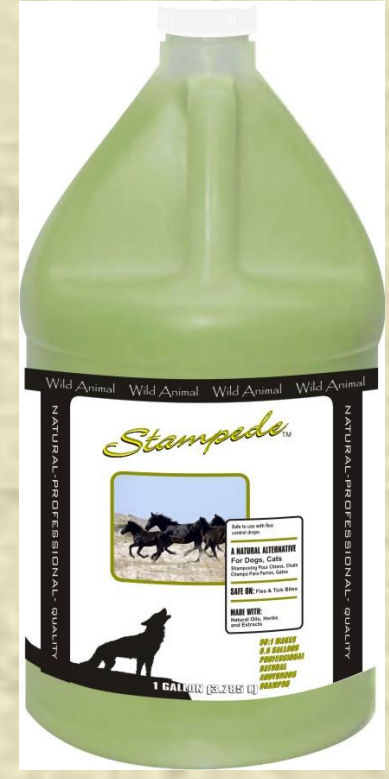
- The LD-50 is the amount of pesticide it will take, in one dose, to kill ½ of all the target organisms.
- It is usually referring to rats & mice in a laboratory experiment.

Nervous System

- Some interfere with the nervous system, cause uncontrollable muscle twitching or paralysis.
- Some are nervous system poisons.
  Ex. Spectracide, Nicotine, DDT, Dursban, & Diazinon.

Photosynthesis

- Some pesticides inhibit photosynthesis and prevent chlorophyll formation.
- Ex. Stampede, Pyrazon.

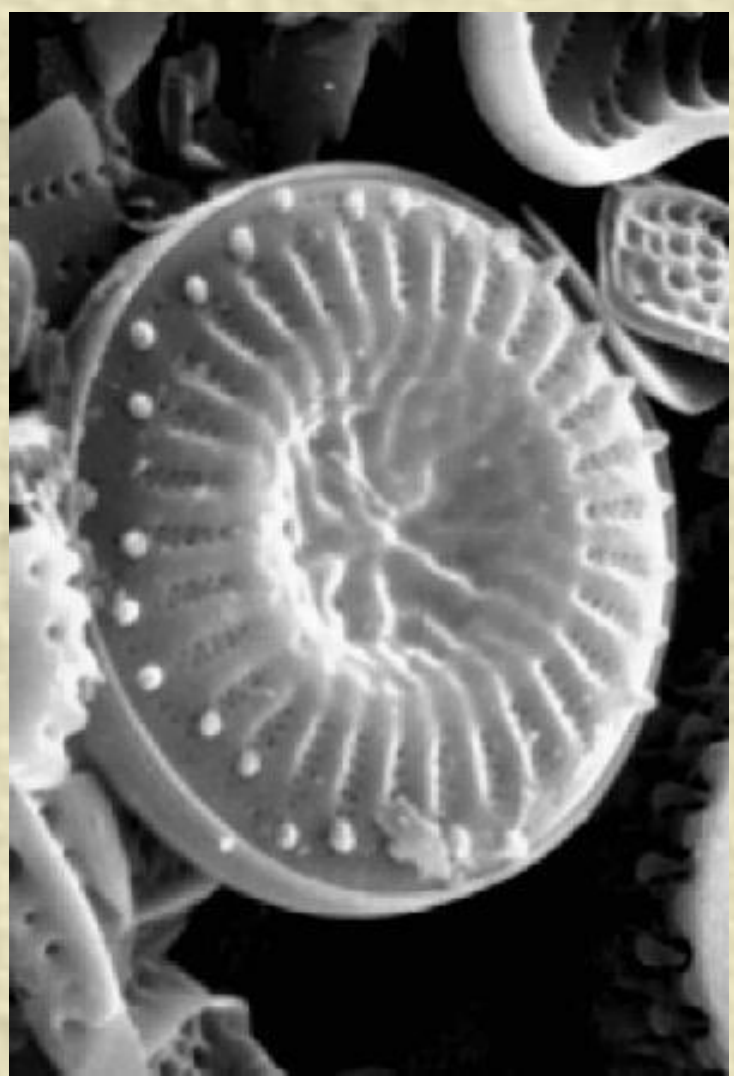


Smothering

- The vapors kill the pest by suffocating the animal. Soap can smother soft bodies of insects.
- Ex. flea collars, pest strip, and soap.

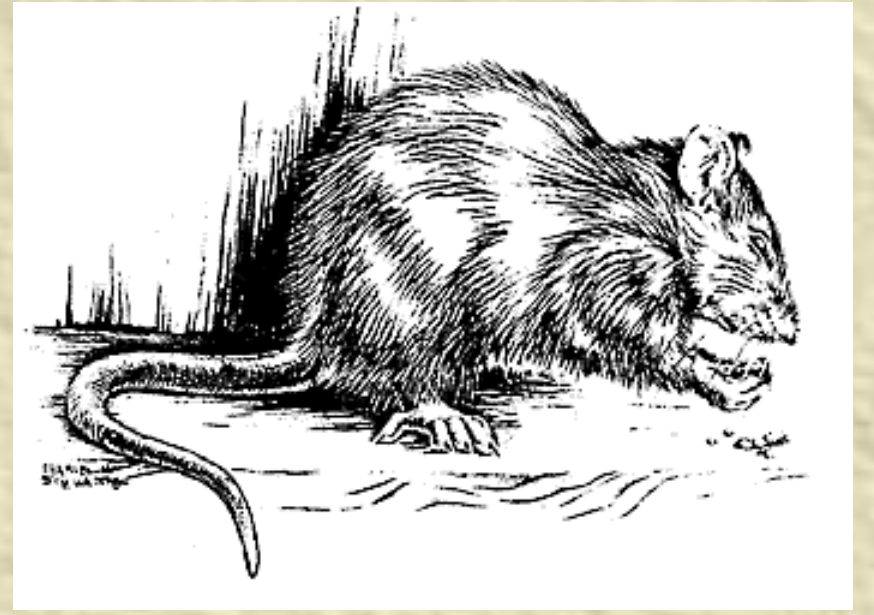
Dehydration

- Dehydration uses the fossilized remains of tiny, one-celled organisms called diatoms. It kills insects by scratching their wax outer covering and causing them to dehydrate. This is a soft pesticide.



Inhibition of Blood Clotting

- Other types of pesticides cause animals (especially rats) to bleed to death by preventing their blood from clotting.



Pesticides and the Law

EPA

- The EPA & USDA are responsible for the overseeing the laws.

Research

- Pesticide companies must use 3 methods to determine pesticides health threats:
  - Case Reports – (made to physicians) about people suffering from adverse health effects
  - Laboratory Investigations – (usually on animals) to determine toxicity, residence time, what parts of the body are affected and how the harm takes place.
  - Epidemiology – (in populations of humans exposed) used to find why some people get sick while others do not

Days to Harvest

- The last day you can spray crops before you harvest them for human consumption.

Restrictions

- The EPA sets a tolerance level specifying the amount of toxic pesticide residue that can legally remain on the crop when the consumer eats it.

FFDCA

- Federal Food, Drug, and Cosmetic Act
- Strengthened in 1996
- Sets pesticide tolerance levels

Label Requirements

- Brand name
- Ingredient statement
- Percentage or amount of active ingredient(s) by weight
- Net contents of the container
- Name and address of the manufacturer
- Registration and establishment numbers
- Signal words and symbols
- Precautionary statement
- Statement of practical treatment
- Environmental hazard statement
- Classification statement
- Directions for use
- Re-entry statement
- Harvesting and/or grazing restrictions
- Storage and disposal statement.

FIFRA

- The Federal Insecticide, Fungicide & Rodenticide Act
- It was first established in 1947 & revised as recently as 1996.
- States what must be on a pesticide label & requires registration of all pesticides.

FQPA

- Food Quality Protection Act
- Established in 1996
- Amends both FIFRA and FFDCA.

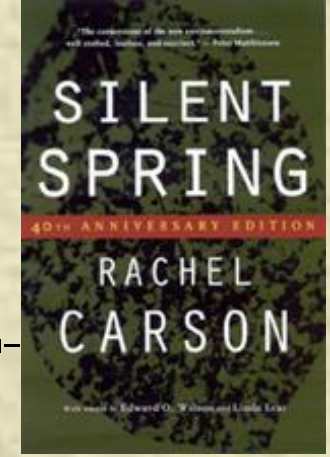
Rachel Carson

- Rachel Carson 1907 to 1964.
- She published her famous work *Silent Spring* in 1962.

Contributions

- “Pesticide sprays, dusts, and aerosols are now applied almost universally to farms, gardens, forests, and homes - non selective chemicals that have the power to kill every insect, the good and the bad, to still the song of birds and the leaping of fish in the streams, to coat the leaves with a deadly film and to linger on soil - all this though the intended target may be only a few weeds or insects. Can anyone believe . . .

Contributions



. . . it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for life? They should not be called insecticides, but biocides."

- *Silent Spring* heightened public awareness and concern about the dangers of uncontrolled use of DDT and other pesticides, including poisoning wildlife and contaminating human food supplies.

Integrated Pest Management (IPM)

Definition:

- A limited use of pesticides along with other practices.

Other Ways to Control Pests

- There are cultivation, biological, and ecological alternatives to conventional chemical pesticides.
  - Fool the pest through cultivation practices.
  - Provide homes for the pest enemies.
  - Implant genetic resistance.
  - Bring in natural enemies.
  - Use pheromones to lure pests into traps.
  - Use hormones to disrupt life cycles.

Cultural Methods

Physical

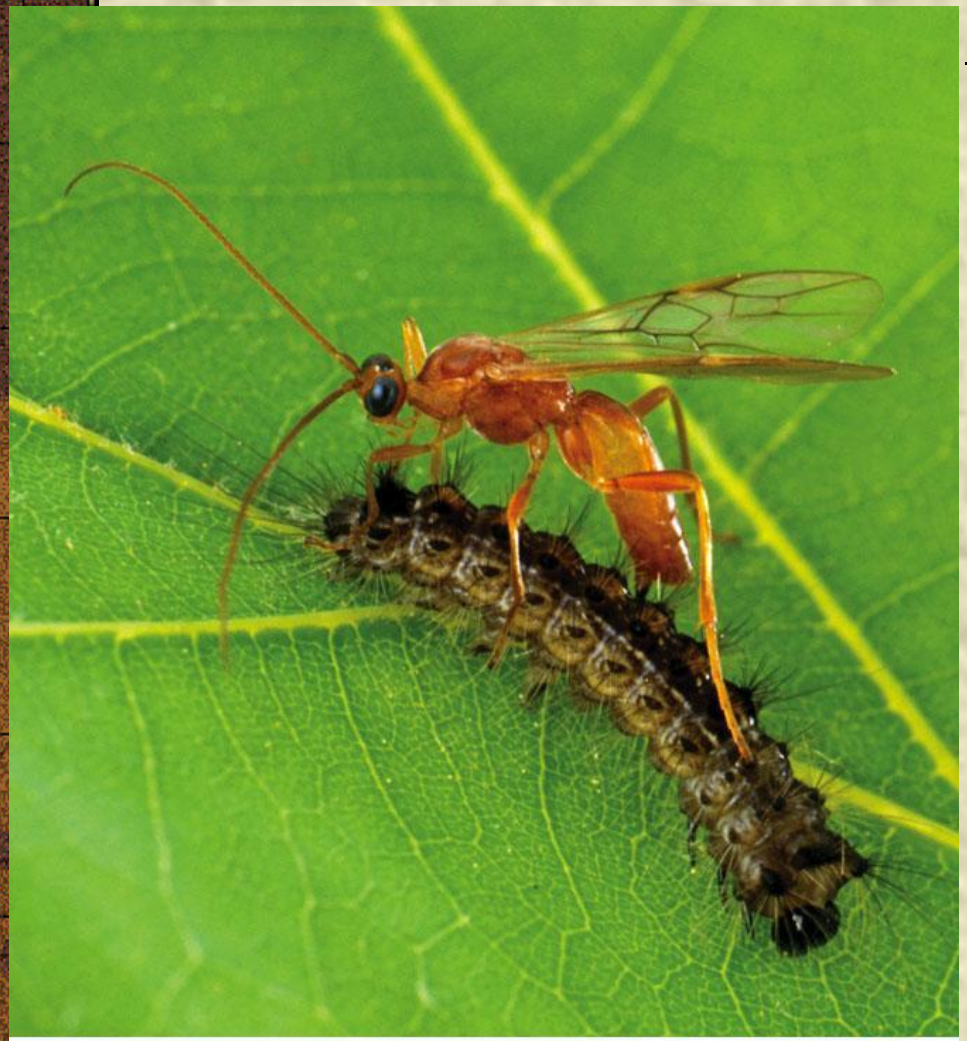
- This includes rotating between different crops, selecting pest-resistant varieties, planting pest-free rootstock, and vacuuming up harmful bugs.

Traditional "EcoFarmer"

- Each crop is evaluated as parts of an ecological system.
- A control program is developed that includes a mix of cultivation, biological, and chemical methods applied in proper sequence with the proper timing.

Biological Methods

Other Ways to Control Pests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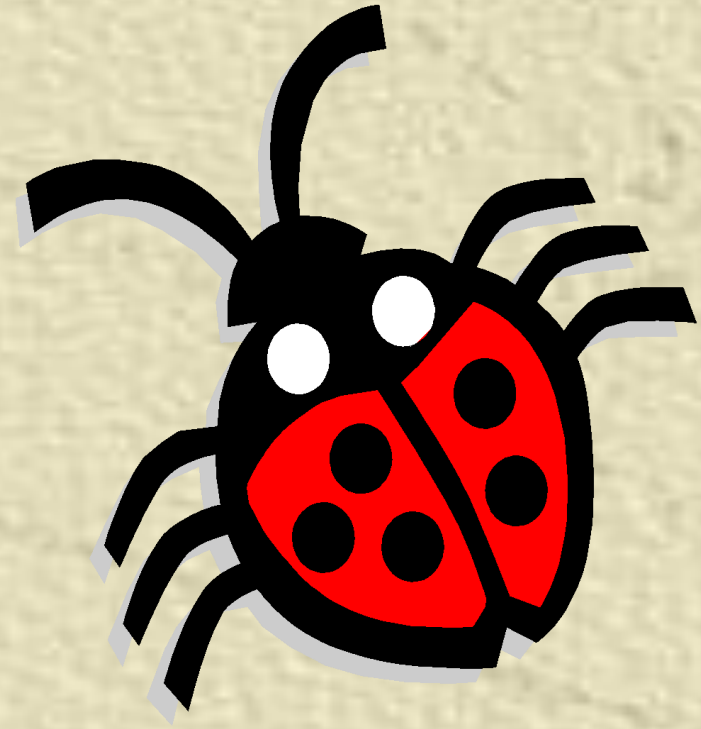
- ***Biological pest control***: Wasp parasitizing a gypsy moth caterpillar.

Figure 13-31

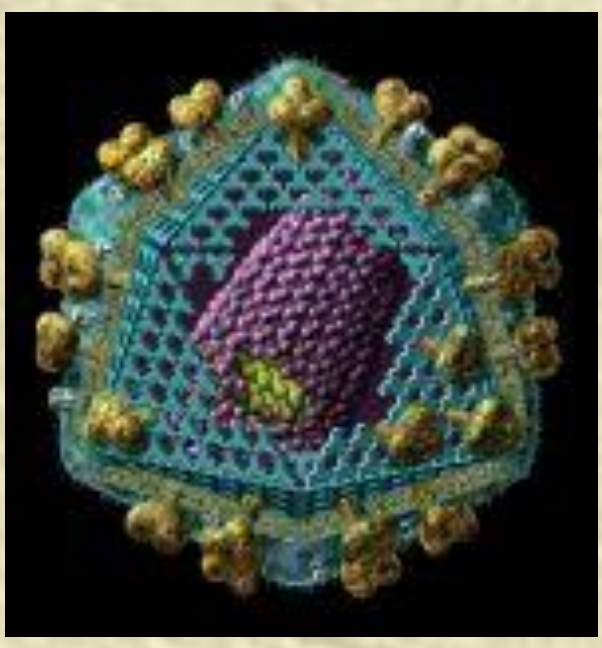
Predators/Parasites

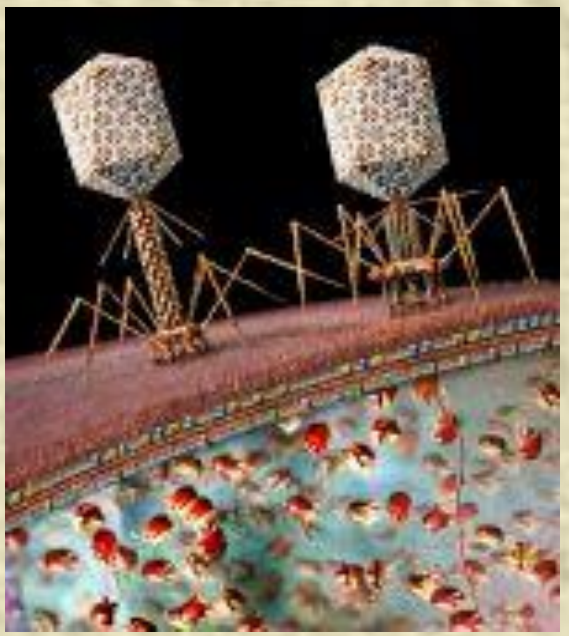
- Using natural predators & parasites to control population of pests.



Diseases

- Using disease organisms (bacteria and viruses) to control pests.





Natural Repellants

- Garlic, sulfur, pyrethrins (from chrysanthemums) to help control pests.

Microbials

- Used for insect wars, especially by organic farmers.
- EX. The Bacillus thruingensis (Bt) toxin is a registered pesticide sold commercially as a dry powder.
- Each of the thousands of strains of this common soil bacteria kills a specific pest.

Timing of Application

- Adjusting planting times so that major insect pests either starve or get eaten by their natural predators.

Type of Crops

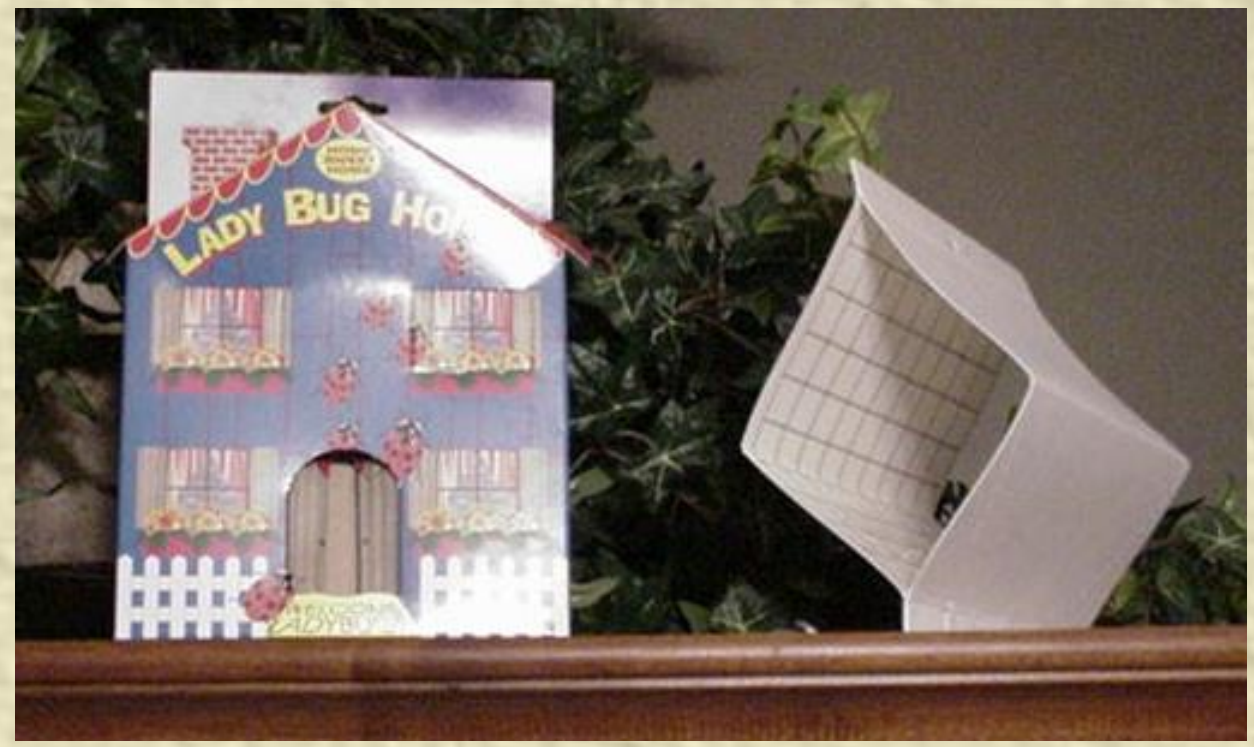
- Switching from vulnerable monocultures to intercropping, agroforestry, and polyculture, which use plant diversity to reduce losses to pests.

Photodegradable Plastics

- Using plastic that degrades slowly in sunlight to keep weeds from sprouting between crops.

Pheromones

- Synthesized bug sex attractant used to lure pests into traps or attract their predators.



Genetic Methods

Other Ways to Control Pests

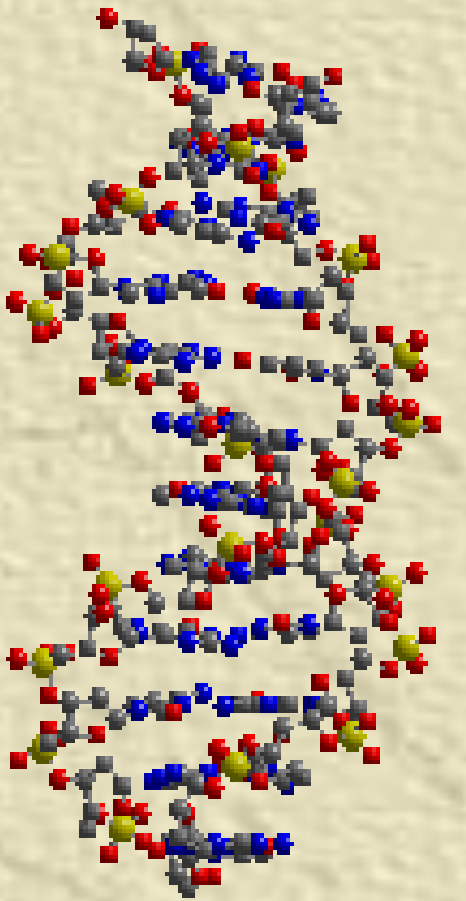
- Genetic engineering can be used to develop pest and disease resistant crop strains.

- Both tomato plants were exposed to destructive caterpillars. The genetically altered plant (right) shows little damage.

Figure 13-32

Resistant Crops

- Plants and animals that are resistant to certain pest insects, fungi, and diseases can be developed.
- This can take 10 to 20 years.
- Genetic engineering is now helping to speed up this process through the development of transgenic crops.



Sterilization

- Males of some insect species can be raised in the laboratory, sterilized by radiation or chemicals, and released into an infested area to mate **unsuccessfully** with fertile wild females.
- Males are sterilized rather than females because the male insects mate several times, whereas the females only mate once.

What Can You Do?

Reducing Exposure to Pesticides

- Grow some of your food using organic methods.
- Buy organic food.
- Wash and scrub all fresh fruits, vegetables, and wild foods you pick.
- Eat less or no meat.
- Trim the fat from meat.

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Fig. 13-30, p.

Agriculture Summary

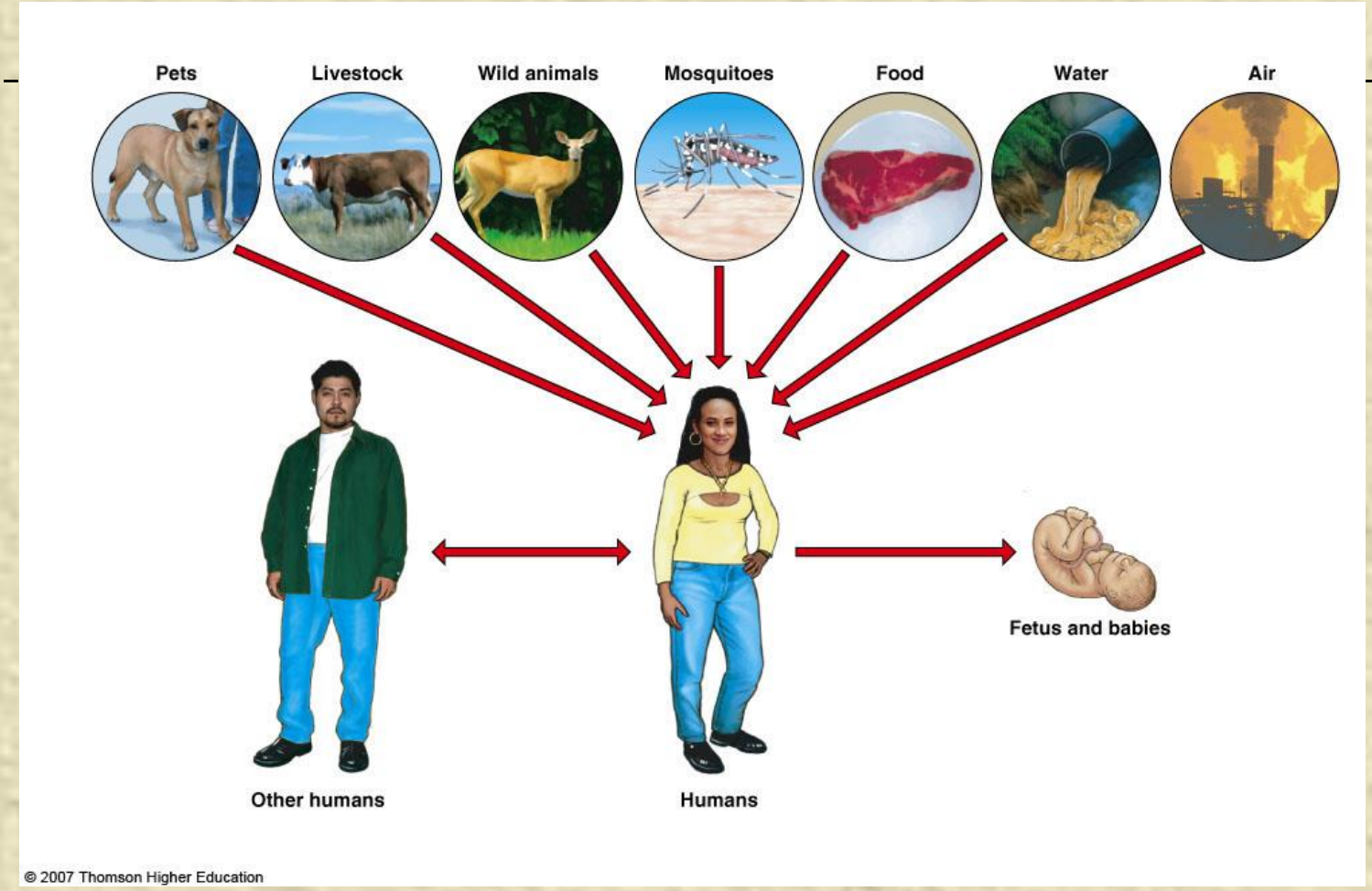
RISKS AND HAZARDS

- Risk is a measure of the likelihood that you will suffer harm from a hazard.
- We can suffer from:
  - ***Biological hazards***: from more than 1,400 pathogens.
  - ***Chemical hazards***: in air, water, soil, and food.
  - ***Physical hazards***: such as fire, earthquake, volcanic eruption…
  - ***Cultural hazards***: such as smoking, poor diet, unsafe sex, drugs, unsafe working conditions, and poverty.

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***)

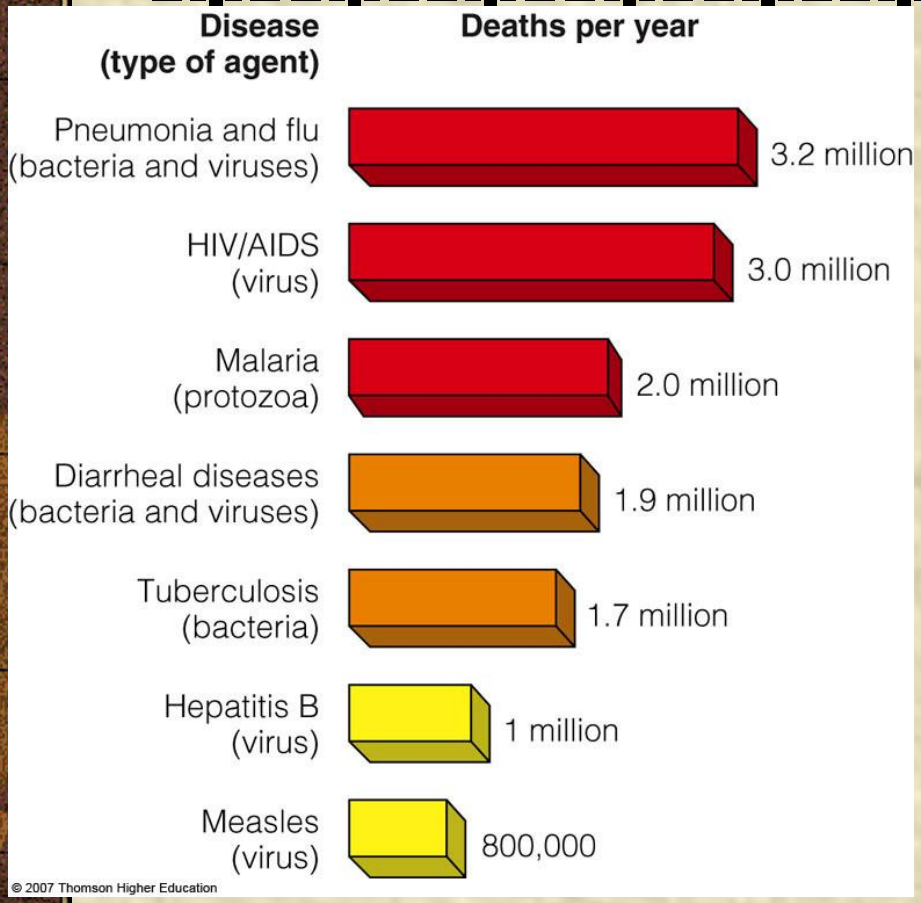
Transmissible Disease



- Pathway for infectious disease in humans.

Figure 18-4

Transmissible Disease

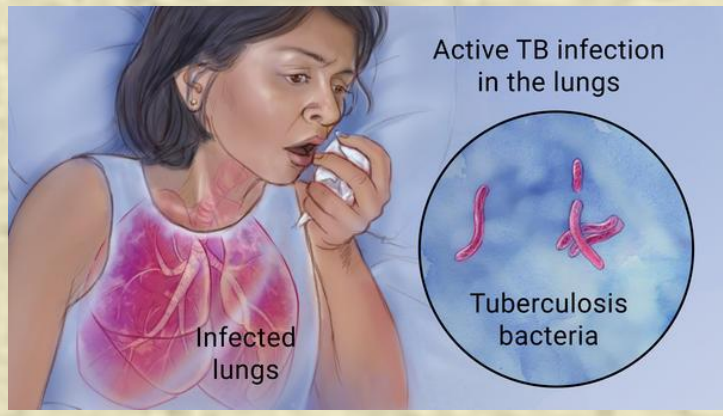


- WHO estimates that each year the world's seven deadliest infections kill 13.6 million people – most of them the poor in developing countries.

Figure 18-5

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.



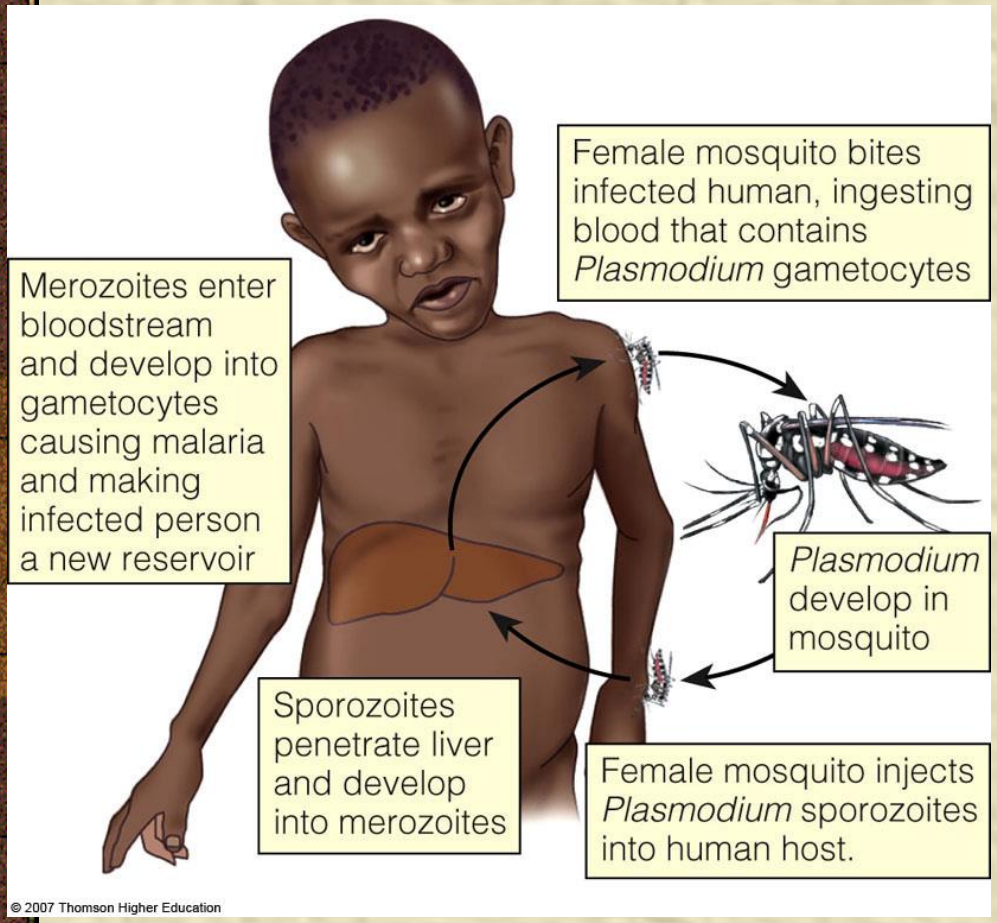
Viral Diseases

- Flu, HIV, and hepatitis B viruses infect and kill many more people each year then 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.

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.

Case Study:
Malaria – Death by Mosquito



- Malaria kills about 2 million people per year and has probably killed more than all of the wars ever fought.

Figure 18-7

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.

Ecological Medicine and Infectious Diseases

- 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.

CHEMICAL HAZARDS

- A toxic chemical can cause temporary or permanent harm or death.
  - ***Mutagens*** are chemicals or forms of radiation that cause or increase the frequency of mutations in DNA.
  - ***Teratogens*** are chemicals that cause harm or birth defects to a fetus or embryo.
  - ***Carcinogens*** are chemicals or types of radiation that can cause or promote cancer.

CHEMICAL HAZARDS

- A hazardous chemical can harm humans or other animals because it:
  - Is flammable
  - Is explosive
  - An irritant
  - Interferes with oxygen uptake
  - Induce allergic reactions.

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.

Ebola

- Transmitted from wild animals and spreads from human-to-human transmission.
- Average case fatality is 50%
- Community engagement is key to successfully controlling outbreaks.
- Early supportive care with rehydration, symptomatic treatment improves survival.
- There are currently no licensed Ebola vaccines but 2 potential candidates are undergoing evaluation.

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.

TOXICOLOGY: ASSESSING CHEMICAL HAZARDS

- Factors determining the harm caused by exposure to a chemical include:
  - The amount of exposure (dose).
  - The frequency of exposure.
  - The person who is exposed.
  - The effectiveness of the body's detoxification systems.
  - One's genetic makeup.

TOXICOLOGY: ASSESSING CHEMICAL HAZARDS

- Children are more susceptible to the effects of toxic substances because:
  - Children breathe more air, drink more water, and eat more food per unit of body weight than adults.
  - They are exposed to toxins when they put their fingers or other objects in their mouths.
  - Children usually have less well-developed immune systems and detoxification processes than adults.

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