Chapter 13

Food, Soil Conservation, and Pest Management

Chapter Overview Questions

- What is food security?
- How serious are malnutrition and overnutrition?
- How is the world's food produced?
- How are soils being degraded and eroded, and what can be done to reduce these losses?
- What are the advantages and disadvantages of using the green revolution to produce food?

Chapter Overview Questions (cont'd)

- What are the environmental effects of producing food?
- What are the advantages and disadvantages of using genetic engineering to produce food?
- How can we produce more meat, fish, and shellfish?
- How can we protect food resources from pests?
- How do government policies affect food production and food security?
- How can we produce food more sustainably?

Global Human Nutrition

An Activity in Enlightenment

FOOD SECURITY AND NUTRITION

- Global food production has stayed ahead of population growth. However:
  - One of six people in developing countries cannot grow or buy the food they need.
  - Others cannot meet their basic energy needs (undernutrition / hunger) or protein and key nutrients (malnutrition).

FOOD SECURITY AND NUTRITION

- The root cause of hunger and malnutrition is poverty.
- ***Food security*** means that every person in a given area has daily access to enough nutritious food to have an active and healthy life.
  - Need large amounts of ***macronutrients*** (protein, carbohydrates, and fats).
  - Need smaller amounts of ***micronutrients*** (vitamins such as A,C, and E).

FOOD SECURITY AND NUTRITION

- One in three people has a deficiency of one or more vitamins and minerals, especially vitamin A, iodine (causes goiter - enlargement of thyroid gland), and iron.

Figure 13-2

War and the Environment

- Starving children collecting ants to eat in famine-stricken Sudan, Africa which has been involved in civil war since 1983.

Figure 13-3

Solutions: Reducing Childhood Deaths from Hunger and Malnutrition

- There are several ways to reduce childhood deaths from nutrition-related causes:
  - Immunize children.
  - Encourage breast-feeding.
  - Prevent dehydration from diarrhea.
  - Prevent blindness from vitamin A deficiency.
  - Provide family planning.
  - Increase education for women.

Human Nutritional Requirements

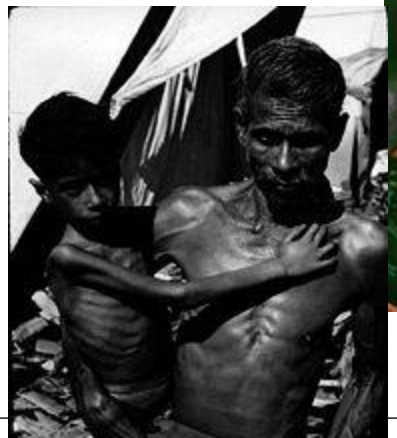
- A balanced diet is essential for human growth, development, metabolism and health.
  - For example, during the developmental years, infants and toddlers need fat for cognitive development. This fat is usually supplied by milk.
- Malnutrition is a lack of a specific nutrient.
- Undernutrition is a deficiency in calories.

Carbohydrates

- Needed for energy. Comes in the form of sugar and starch.
- Supplied by breads, starchy vegetables, cereals and grains.
- Deficiency leads to lack of energy.

Proteins

- Needed for the growth and repair of muscles and other tissue.
- Supplied by beans and animal products.
  - Plant protein is an incomplete source of protein.
- Deficiencies lead to kwashiorkor or marasmus.



Fats

- Needed for energy, storage of energy and the absorption of fat soluble vitamins.
  - Non-polar compound
- Supplied by oils and animal fats.
- Deficiencies lead to incomplete uptake of vital nutrients and vitamins.

Minerals and Vitamins

- Needed for the proper functioning of normal body functions.
- Supplied by fruits and vegetables.
- Deficiencies of specific minerals and vitamins lead to specific health issues.
  - Vitamin C = Scurvy
  - Vitamin B1= Beriberi
  - Vitamin D = Rickets

Overnutrition: Eating Too Much

- Overnutrition and lack of exercise can lead to reduced life quality, poor health, and premature death.
- A 2005 Boston University study found that about 60% of American adults are overweight and 33% are obese (totaling 93%).
- Americans spend $42 billion per year trying to lose weight.
- $24 billion per year is needed to eliminate world hunger.

Activity: Global Human Nutrition

- Choose a country from the list below:
  - United States of America
  - Japan
  - China
  - India
  - Bangledesh
  - Zimbabwe
  - South Africa
  - Australia
  - England
  - Slovakia
  - Australia
  - Peru
  - Iran
  - Italy
  - Portugal
  - Germany
  - Bolivia

- Describe the population of your country.
  - Population size, Demographics, Economic status
- What food and drink make up a typical breakfast? lunch? dinner?
  - Proteins, Carbohydrates, Fats,Minerals
- What foods are grown in your country?
- What foods must be imported? Where are they imported from?
- What are the transportation methods of the imported foods?
- Describe the access to food in your country.
- One of the likely effects of a global fuel crisis would be food shortage. Explain this statement (as if you were a citizen of your chosen country.)

Food Production

Land Use: Agriculture

FOOD PRODUCTION

- Food production from croplands, rangelands, ocean fisheries, and aquaculture has increased dramatically.
- Wheat, rice, and corn provide more than half of the world's consumed calories.
  - Fish and shellfish are an important source of food for about 1 billion people mostly in Asia and in coastal areas of developing countries.

Industrial Food Production: High Input Monocultures

- About 80% of the world's food supply is produced by industrialized agriculture.
  - Uses large amounts of fossil fuel energy, water, commercial fertilizers, and pesticides to produce monocultures.
  - Greenhouses are increasingly being used.
  - Plantations are being used in tropics for cash crops such as coffee, sugarcane, bananas.

FOOD PRODUCTION

© 2007 Thomson Higher Education

© 2007 Thomson Higher Education

- Satellite images of massive and rapid development of greenhouse food production in Spain from 1974 (left) to 2000 (right).

Figure 13-5

Industrial Food Production: High Input Monocultures

- Livestock production in developed countries is industrialized:
  - Feedlots are used to fatten up cattle before slaughter.
  - Most pigs and chickens live in densely populated pens or cages.
  - Most livestock are fed grain grown on cropland.
  - Systems use a lot of energy and water and produce huge amounts of animal waste.

Natural Capital

Croplands

Ecological Services	Economic Services
• Help maintain water flow and soil infiltration	• Food crops
• Provide partial erosion protection	• Fiber crops
• Can build soil organic matter	• Crop genetic resources
• Store atmospheric carbon	• Jobs
• Provide wildlife habitat for some species	

Fig. 13-6, p. 276

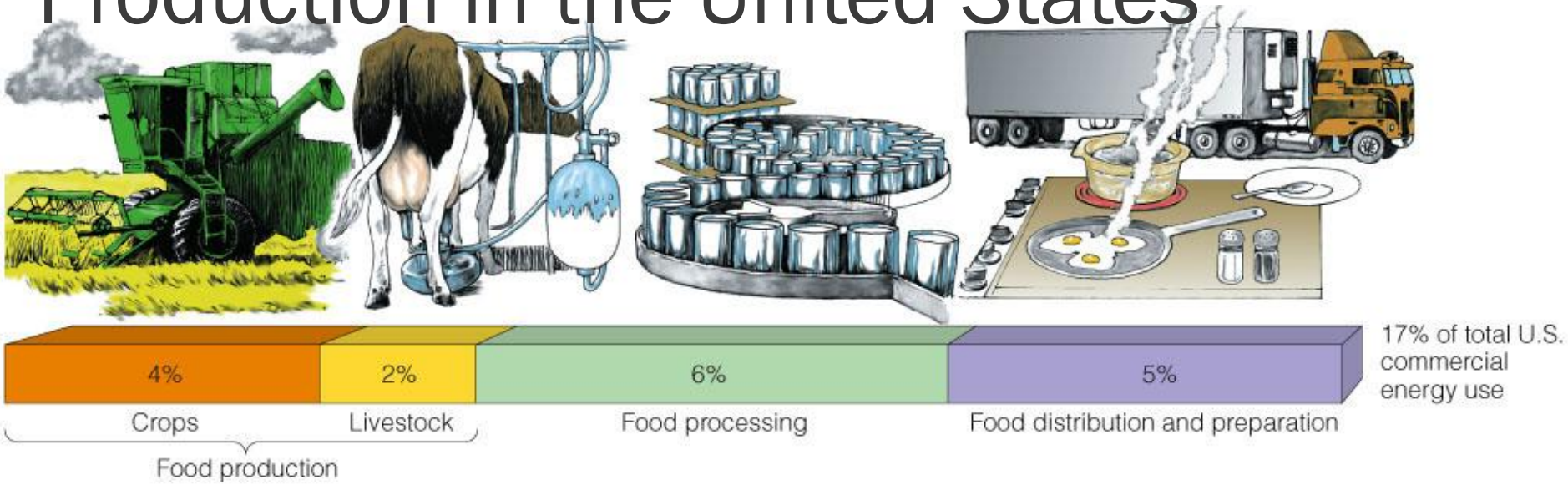
How Many People can the World Support? Food Production and Population

- The number of people the world can support depends mostly on their per capita consumption of grain and meat and how many children couples have.
  - Research has shown that those living very low on the food chain or very high on the food chain do not live as long as those that live somewhere in between.

Case Study: Industrialized Food Production in the United States

- The U.S. uses industrialized agriculture to produce about 17% of the world's grain.
  - Relies on cheap energy to run machinery, process food, produce commercial fertilizer and pesticides.
- About 10 units of nonrenewable fossil fuel energy are needed to put 1 unit of food energy on the table.

Case Study: Industrialized Food Production in the United States



- Industrialized agriculture uses about 17% of all commercial energy in the U.S. and food travels an average 2,400 kilometers from farm to plate.

Figure 13-7

Traditional Agriculture: Low Input Polyculture

- Many farmers in developing countries use low-input agriculture to grow a variety of crops on each plot of land (interplanting) through:
  - ***Polyvarietal cultivation***: planting several genetic varieties.
  - ***Intercropping***: two or more different crops grown at the same time in a plot.
  - ***Agroforestry***: crops and trees are grown together.
  - ***Polyculture***: different plants are planted together.

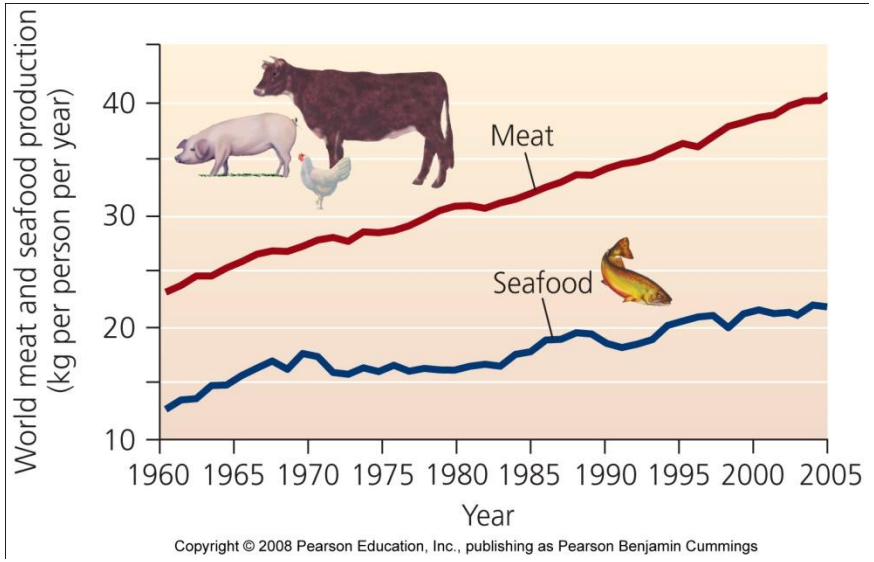
Traditional Agriculture: Low Input Polyculture

- Research has shown that, on average, low input polyculture produces higher yields than high-input monoculture.

Figure 13-8

Eating animal products has significant impacts

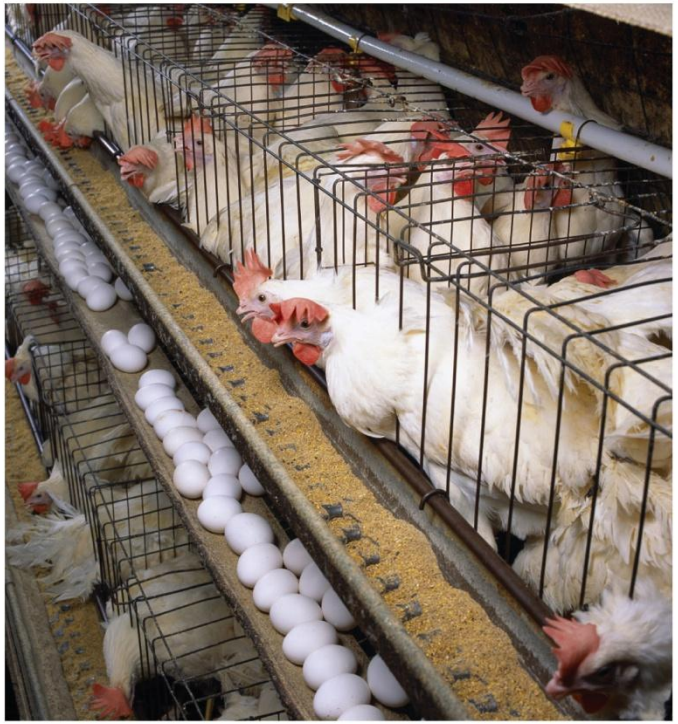
- As wealth and commerce increase, so does consumption of meat, milk, and eggs
  - Global meat production has increased fivefold
  - Per capita meat consumption has doubled



Domestic animal production for food increased from 7.3 billion in 1961 to 20.6 billion in 2000

Feedlot agriculture

- **Feedlots** (**factory farms**) = also called **Concentrated Animal Feeding Operations (CAFOs)**
  - Huge warehouses or pens designed to deliver energy-rich food to animals living at extremely high densities
  - Over ½ of the world's pork and poultry come from feedlots



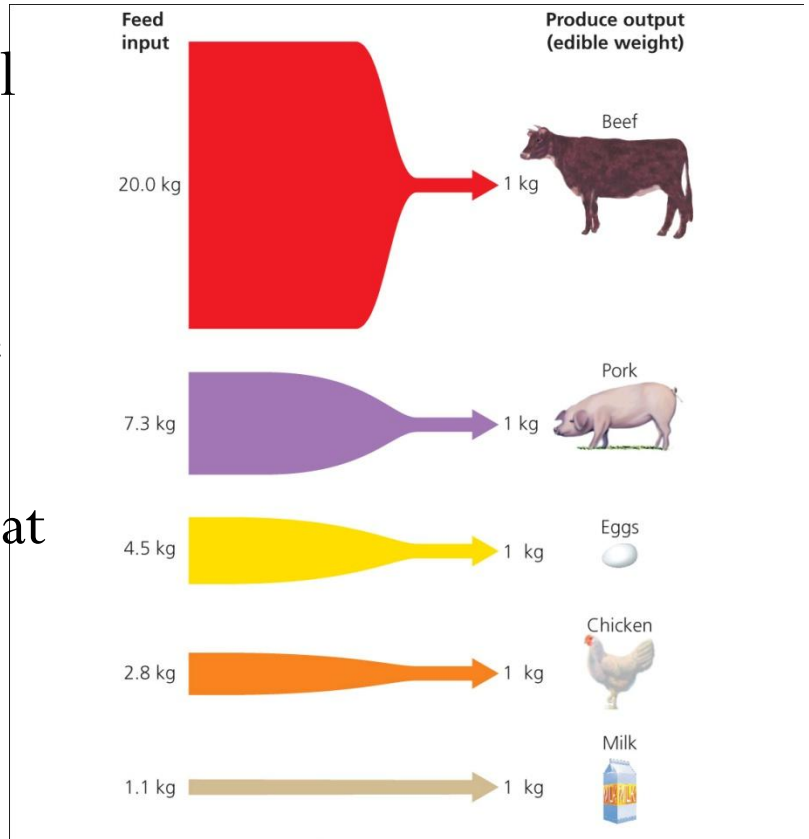
Debeaked chickens spend their lives in cages; U.S. farms can house hundreds of thousands of chickens in such conditions

The benefits and drawbacks of feedlots

- The benefits of feedlots include:
  - Greater production of food
  - Unavoidable in countries with high levels of meat consumption, like the U.S.
  - They take livestock off the land and reduces the impact that they would have on it
- Drawbacks of feedlots include:
  - Contributions to water and air pollution
  - Poor waste containment causes outbreaks in disease
  - Heavy uses of antibiotics to control disease

Energy choices through food choices

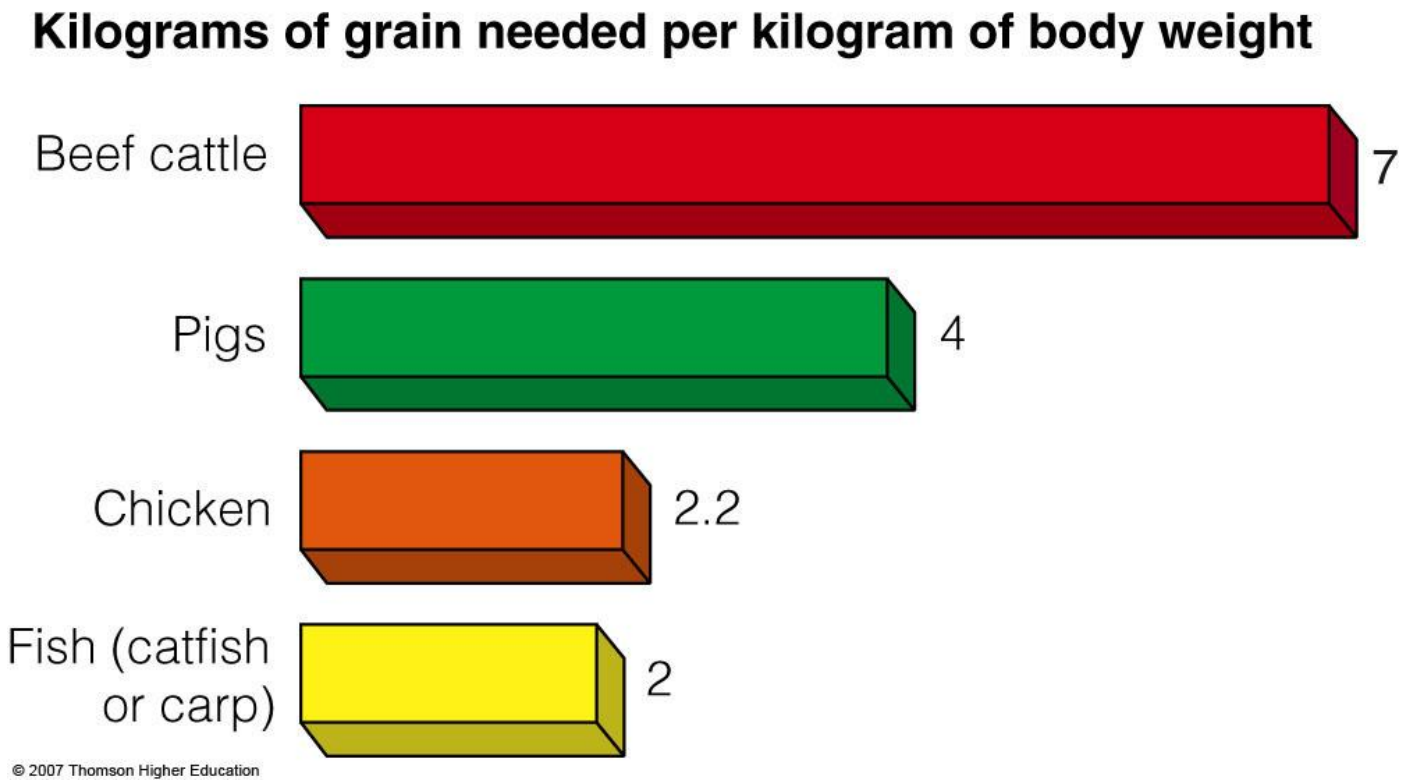
- 90% of energy is lost every time energy moves from one trophic level to the next
- The lower on the food chain from which we take our food sources, the more people the Earth can support.
- Some animals convert grain into meat more efficiently than others



PRODUCING MORE MEAT

- About half of the world's meat is produced by livestock grazing on grass.
- The other half is produced under factory-like conditions (feedlots).
  - Densely packed livestock are fed grain or fish meal.
- Eating more chicken and farm-raised fish and less beef and pork reduces harmful environmental impacts of meat production.

PRODUCING MORE MEAT

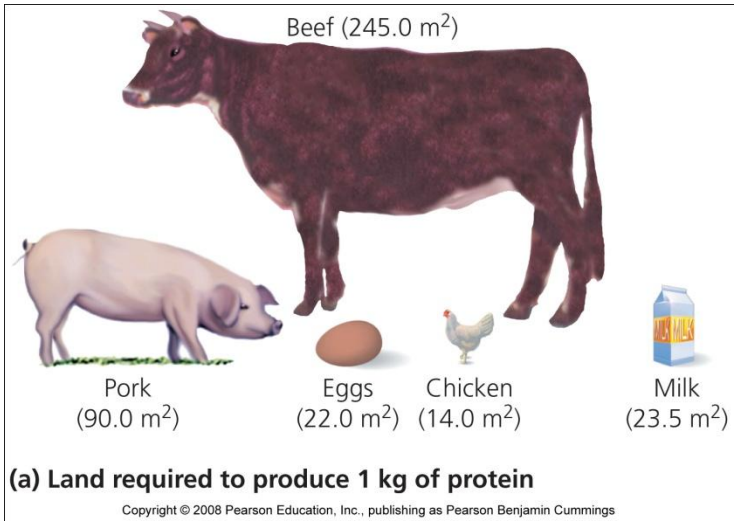


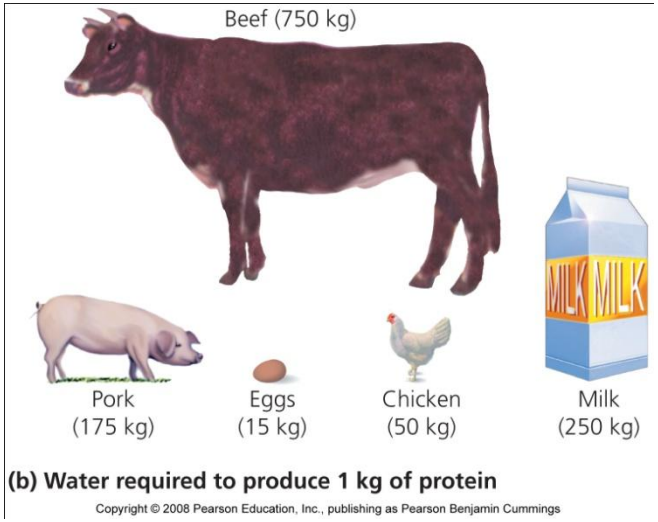
- Efficiency of converting grain into animal protein.

Figure 13-22

Environmental ramifications of eating meat

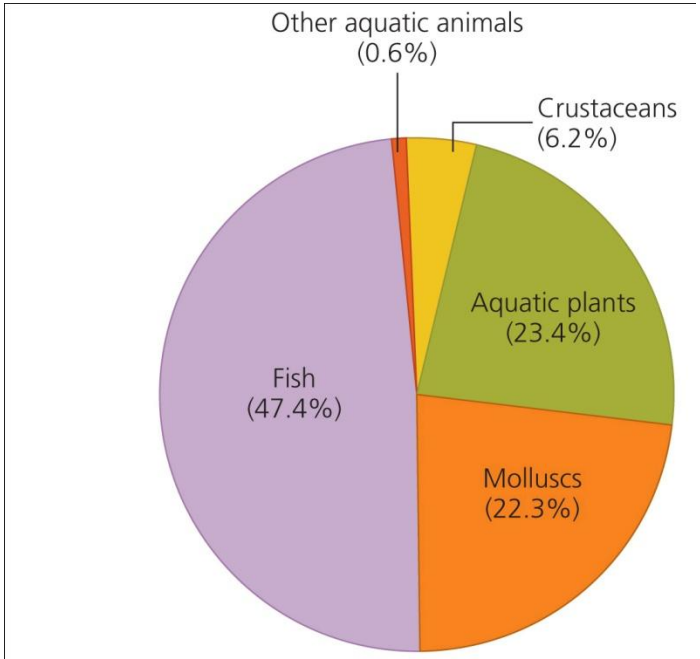
- Land and water are needed to raise food for livestock
- Producing eggs and chicken meat requires the least space and water
  - Producing beef requires the most





When we choose what to eat, we also choose how we use resources

Aquaculture

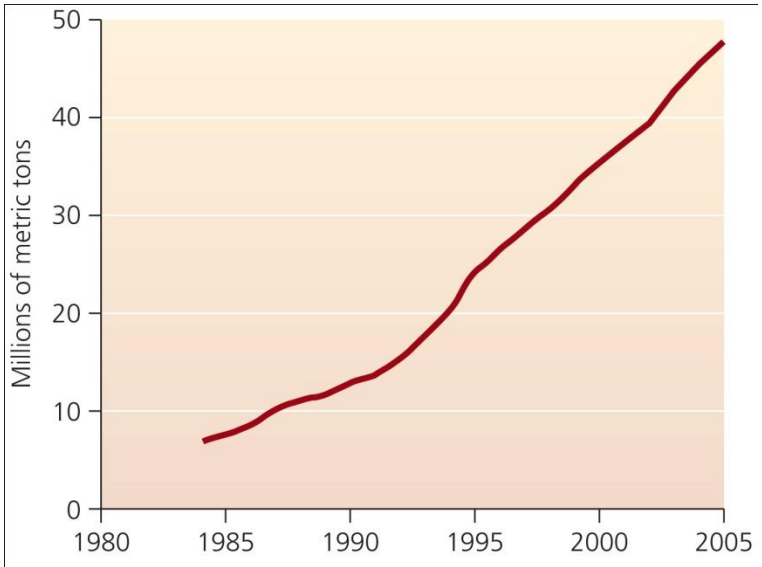


(a) World aquaculture production by groups

- World fish populations are plummeting
  - Technology and increased demand
- **Aquaculture** = raising aquatic organisms for food in a controlled environment
  - Aquatic species are raised in open-water pens or land-based ponds

Aquaculture is growing rapidly

- The fastest-growing type of food production
  - Provides a third of the world's fish for human consumption
  - Most widespread in Asia



(b) World aquaculture production

The benefits and drawbacks of aquaculture

- Benefits:
  - A reliable protein source
  - Sustainable
  - Reduces fishing pressure on overharvested wild fish stocks
  - Energy efficient

- Drawbacks:
  - Diseases can occur, requiring expensive antibiotics
  - Reduces food security
  - Large amounts of waste
  - Farmed fish may escape and introduce disease into the wild

Soil Degradation

The breakdown of our most important resource.

Soil: The Final Frontier

- Soil is a vital part of the natural environment. It influences the distribution of plant species and provides a habitat for a wide range of organisms.
- It controls the flow of water and chemical substances between the atmosphere and the earth, and acts as both a source and store for gases (like oxygen and carbon dioxide) in the atmosphere.

Soil: The Final Frontier

- Soils not only reflect natural processes but also record human activities both at present and in the past.
  - They are therefore part of our cultural heritage.
  - The modification of soils for agriculture and the burial of archaeological remains are good examples of this.

Without it, what would we do?

- Soil helps to provide much of the food that humans consume.
  - Only 25% of the Earth's surface is made up of soil and only 10% of that soil can be used to grow food.
- I.E., without soil, we cannot support primary producers.
  - By the way, they are the base of the trophic levels!

Major Causes of Soil Degradation

- Overgrazing 35%
- Deforestation 30%
- Other Agricultural Activities 27%
- Other Causes 8%

Soil Exhaustion

- Agricultural systems disrupt natural mineral cycling.
  - The soil may become mineral deficient and lose fertility.
  - Plants need minerals to grow and thrive such as nitrates, phosphates and sulfates.

Soil Erosion

- The removal of trees that stabilize slopes result in erosion.
  - Erosion is the removal of the top soil by physical means.
  - Deforestation is one of the major causes of soil erosion.

SOIL EROSION AND DEGRADATION

- Soil erosion lowers soil fertility and can overload nearby bodies of water with eroded sediment.
  - ***Sheet erosion***: surface water or wind peel off thin layers of soil.
  - ***Rill erosion***: fast-flowing little rivulets of surface water make small channels.
  - ***Gully erosion***: fast-flowing water join together to cut wider and deeper ditches or gullies.

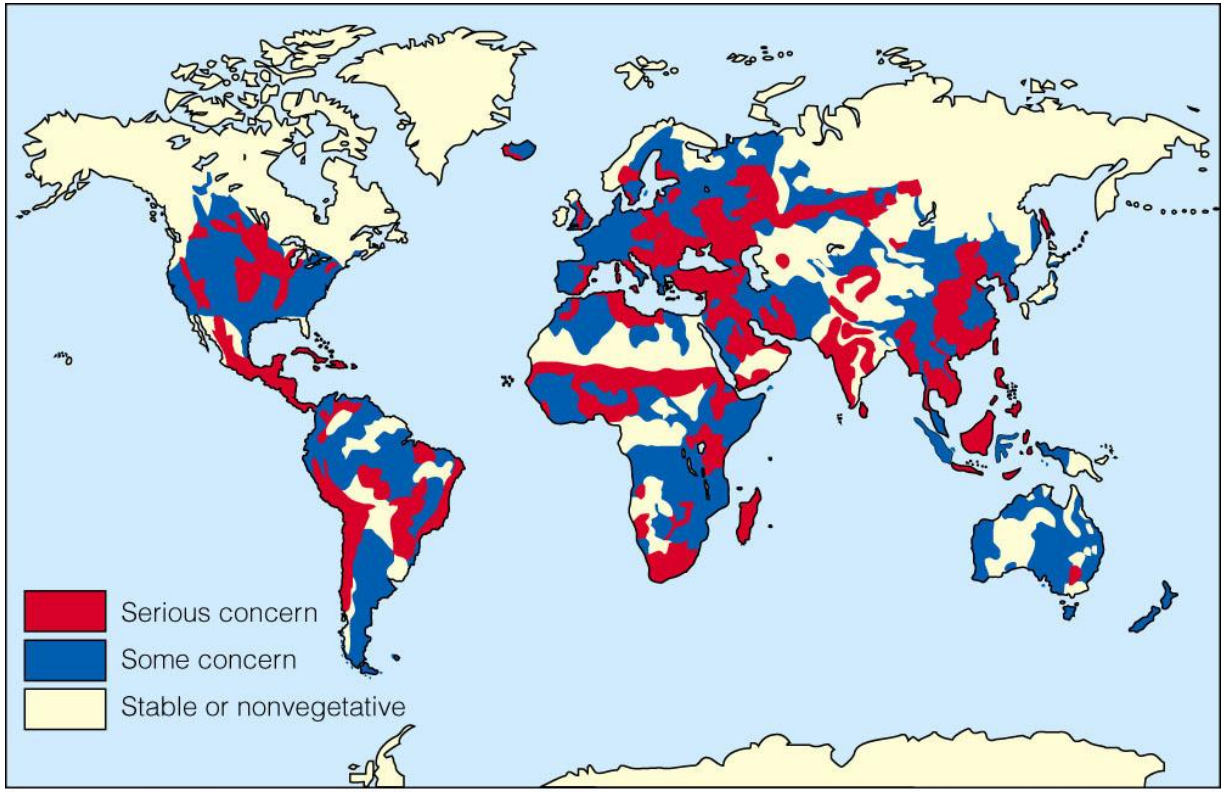
SOIL EROSION AND DEGRADATION

- Soil erosion is the movement of soil components, especially surface litter and topsoil, by wind or water.

- Soil erosion increases through activities such as farming, logging, construction, overgrazing, and off-road vehicles.

Figure 13-9

Global Outlook: Soil Erosion

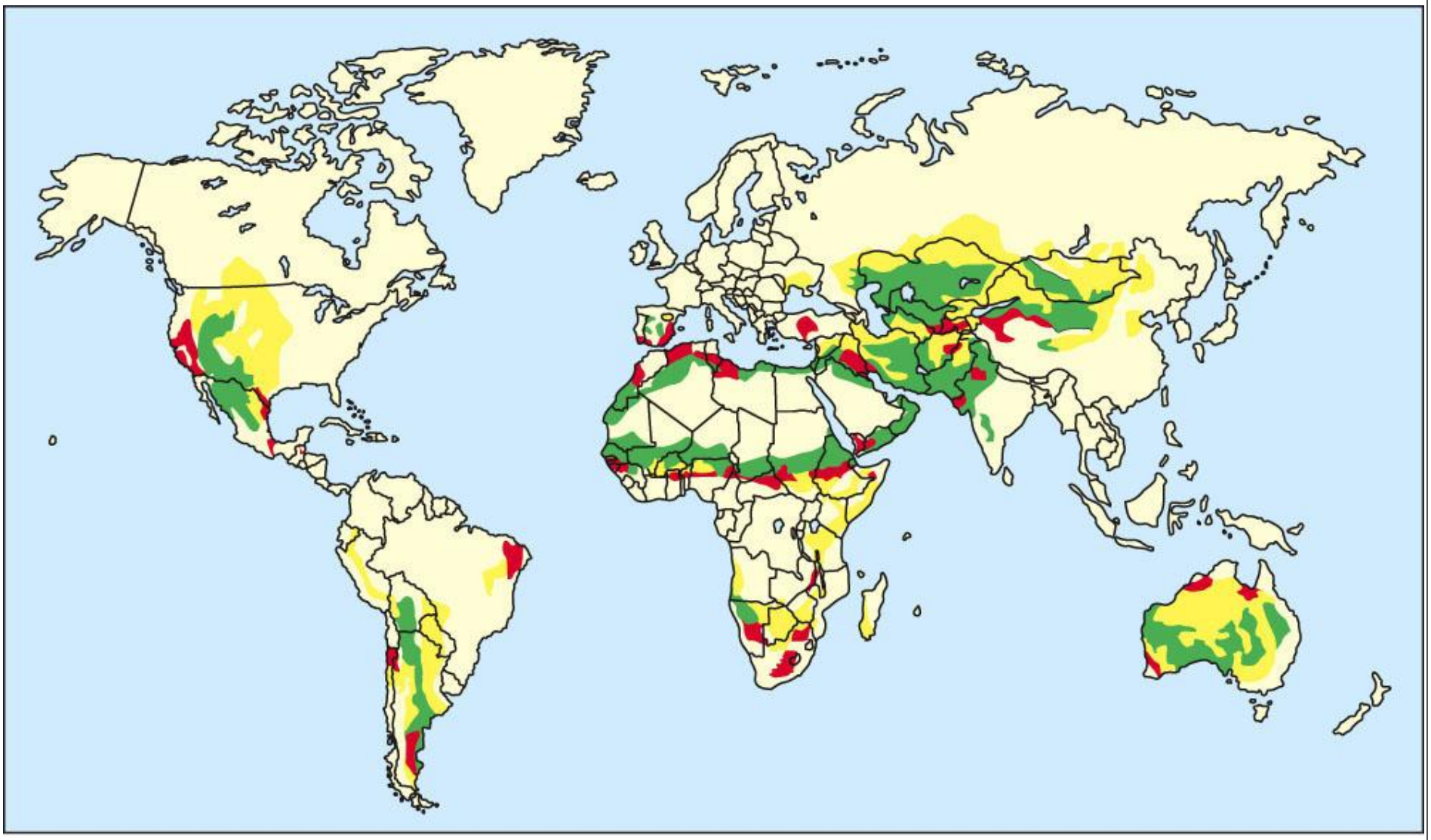


- Soil is eroding faster than it is forming on more than one-third of the world's cropland.

Figure 13-10

Case Study: Soil Erosion in the U.S. – Some Hopeful Signs

- Soil erodes faster than it forms on most U.S. cropland, but since 1985, has been cut by about 40%.
  - 1985 Food Security Act (Farm Act): farmers receive a subsidy for taking highly erodible land out of production and replanting it with soil saving plants for 10-15 years.



Moderate

Severe

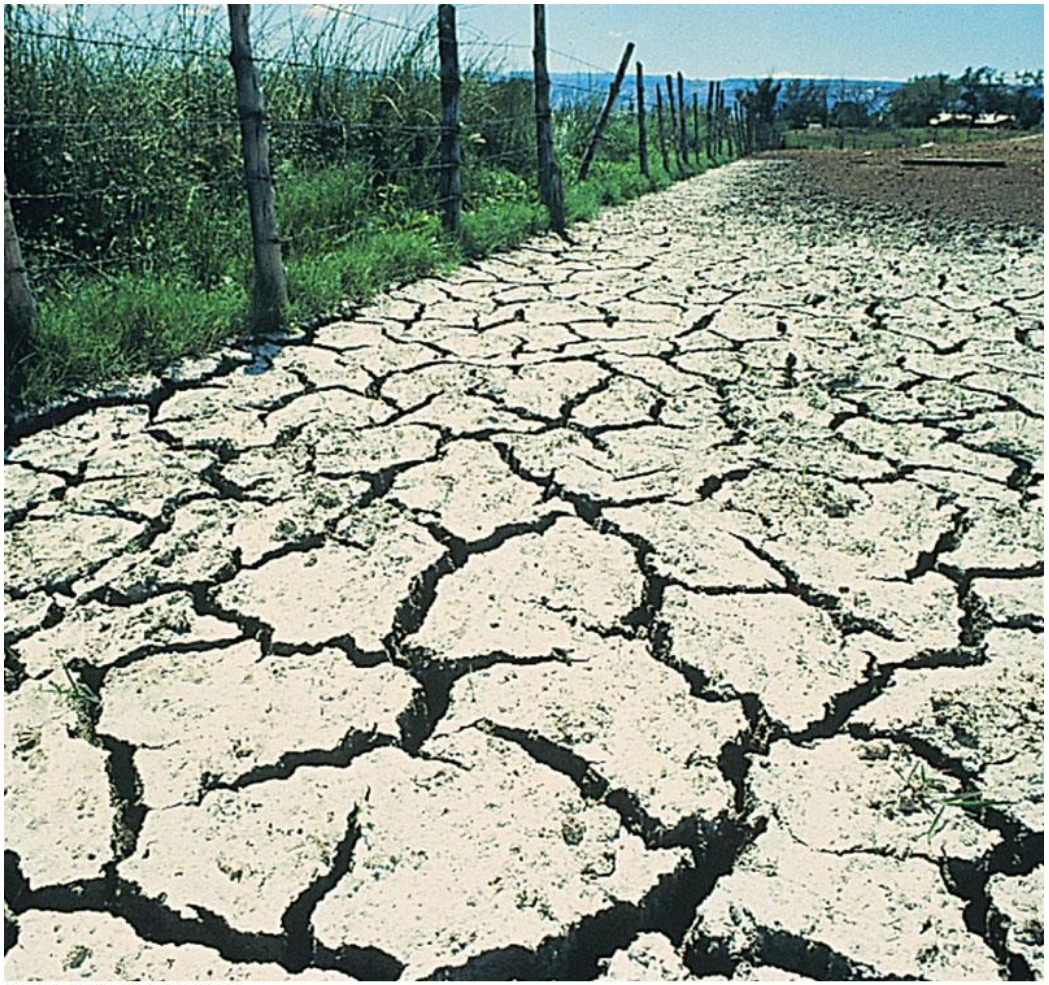
Very severe

Fig. 13-11, p. 280

Salinization

- Salinization is an increase in salt (ionic compounds) in soil. Irrigation in areas where the bedrock contains high salt levels will cause these aqueous salts to be brought to the surface.
  - This problem is compounded by clearing native vegetation.
  - Irrigation of farmland and deforestation has in Western and South Eastern Australia has caused widespread salinization.

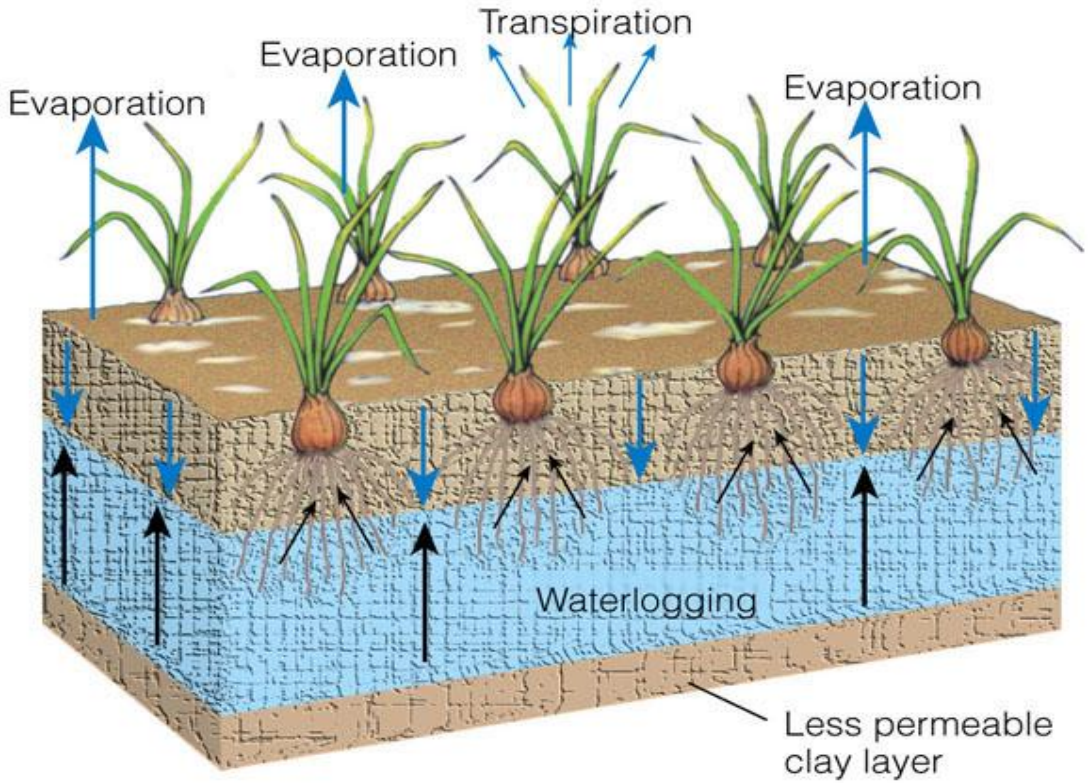
Salinization and Waterlogging of Soils: A Downside of Irrigation



- Example of high evaporation, poor drainage, and severe salinization.
- White alkaline salts have displaced cops.

Figure 13-14

Salinization and Waterlogging



Salinization

1. Irrigation water contains small amounts of dissolved salts.
2. Evaporation and transpiration leave salts behind.
3. Salt builds up in soil.

Waterlogging

1. Precipitation and irrigation water percolate downward.
2. Water table rises.

- Repeated irrigation can reduce crop yields by causing salt buildup in the soil and waterlogging of crop plants.

Figure 13-13

Solutions

Soil Salinization

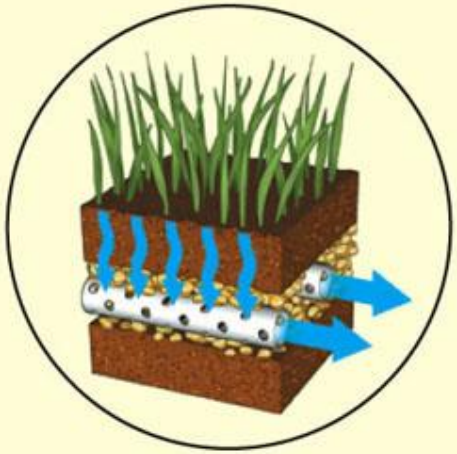
Prevention		Cleanup
Reduce irrigation		Flush soil (expensive and wastes water)
		Stop growing crops for 2–5 years
Switch to salt-tolerant crops (such as barley, cotton, sugarbeet)		Install underground drainage systems (expensive)

Fig. 13-15, p. 281

Chemical Emissions

- Industrial processes and vehicles release toxic substances which are heavier than air and settle on the soil.
  - PCB's, Heavy metals

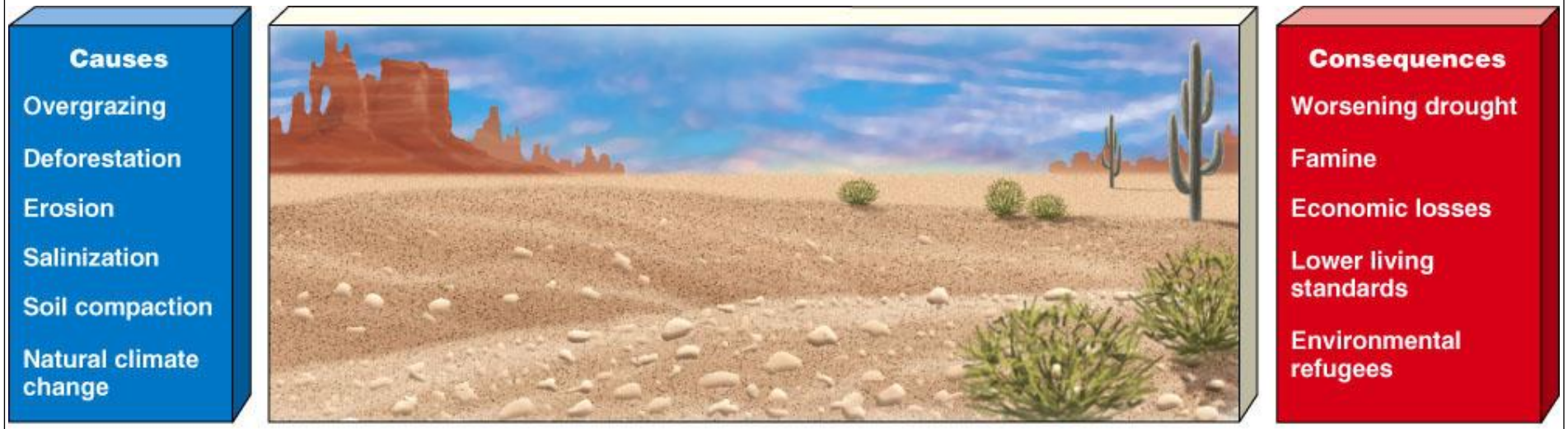
Pesticides

- Pesticides that are applied to fields can also destroy beneficial organisms in the soil.
  - Bacteria that fix nitrogen, organisms that break down soil (worms)
  - Bioaccumulation causes the concentrations of these pesticides to increase up the food chain.
  - In the United States, farmers rely heavily on pesticides to maximize crop output.

Toxic Seepage and Chemical Contamination

- Chemicals released into the environment from industrial discharges or improperly disposed chemicals seep into the soil and migrate or leach.
  - These chemicals can impact the aquifer as well as the soil.

Desertification: Degrading Drylands



- About one-third of the world's land has lost some of its productivity because of drought and human activities that reduce or degrade topsoil.

Figure 13-12

Desertificaion

- **Desertification** is the expansion of dry lands due to poor agricultural practices, improper soil moisture management, salinization and erosion, forest removal, and climate change.
  - Overuse of agricultural lands is the cause.
  - 10% of the world's land has been desertified.
  - 25% is at risk.
  - In Mali, the Sahara desert has expanded more than 650 km in less than 20 years.

Alternatives

- Describe an alternative farming practice that does not use chemical methods for fertilization or pest control.

Remediation

- Discuss the features of desertification, outlining it's causes and ways in which it may be prevented or reversed.

Pest Control

A step toward sustainable agriculture.

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.

Figure 13-27

PROTECTING FOOD RESOURCES: PEST MANAGEMENT

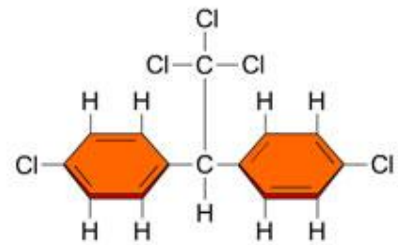
- We use chemicals to repel or kill pest organisms as plants have done for millions of years.
- Chemists have developed hundreds of chemicals (pesticides) that can kill or repel pests.
  - Pesticides vary in their persistence.
  - Each year > 250,000 people in the U.S. become ill from household pesticides.

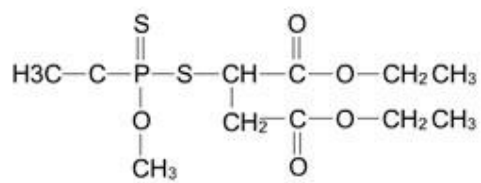
Animation: Pesticide Examples

Atrazine

DDT

Malathion





Reset Animation

PLAY ANIMATION

Individuals Matter: Rachel Carson

- Wrote *Silent Spring* which introduced the U.S. to the dangers of the pesticide DDT and related compounds to the environment.

Figure 13-A

The ideal Pesticide and the Nightmare Insect Pest

- The ideal pest-killing chemical has these qualities:
  - Kill only target pest.
  - Not cause genetic resistance in the target organism.
  - Disappear or break down into harmless chemicals after doing its job.
  - Be more cost-effective than doing nothing.

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.

Figure 13-29

Pesticide Protection Laws in the U.S.

- Government regulation has banned a number of harmful pesticides but some scientists call for strengthening pesticide laws.
  - The Environmental Protection Agency (EPA), the Department of Agriculture (USDA), and the Food and Drug Administration (FDA) regulate the sales of pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).
  - The EPA has only evaluated the health effects of 10% of the active ingredients of all pesticides.

How Would You Vote?

To conduct an instant in-class survey using a classroom response system, access "JoinIn Clicker Content" from the PowerLecture main menu for Living in the Environment.

- Do the advantages of using synthetic chemical pesticides outweigh their disadvantages?
  - a. No. Synthetic pesticides are overused, damage the environment, and increase cancer risks.
  - b. Yes. Pesticides save human lives and protect crops.

Pest Control

- Pest control is the regulation or management of a species that is defined as a pest.
- Pest control can be accomplished through biological or chemical means.

Pesticide Treadmill

- The pests develop a resistance to a particular pesticide.
- Farmers pay more and more for a pest control program which becomes less effective

Chemical Control

- Pesticides are used because they are toxic to specific harmful pests.
  - Unfortunately they are also toxic to helpful organisms and cause contamination to soil, water and crops.
  - Pesticides are persistent in the environment.
  - Biomagnification is a feature of pesticides whereby they become concentrated up the food chain.

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.

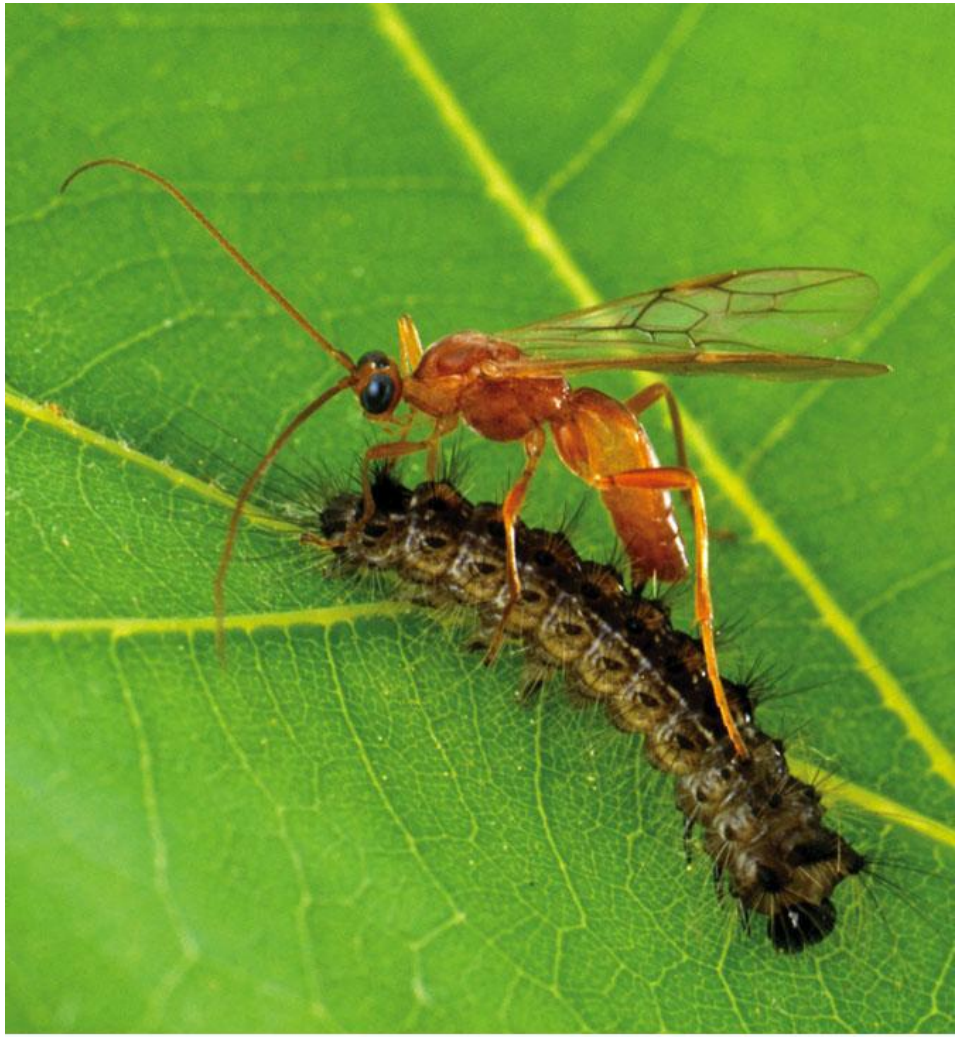
Integrated Pest Management

- IPM programs evaluate crops and pests as part of the ecological system and develop a pest control program that includes crop management, and biological and chemical controls.
  - The program is intended to reduce damage to crops to an economically tolerable level.

Benefits of IPM

- IPM is harder to implement because it requires a great deal of knowledge.
  - Time to realize benefits is much slower.
  - Well designed systems can cut control costs by 50-90%

Other Ways to Control Pests



- ***Biological pest control***: Wasp parasitizing a gypsy moth caterpillar.

Figure 13-31

Other Ways to Control Pests

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

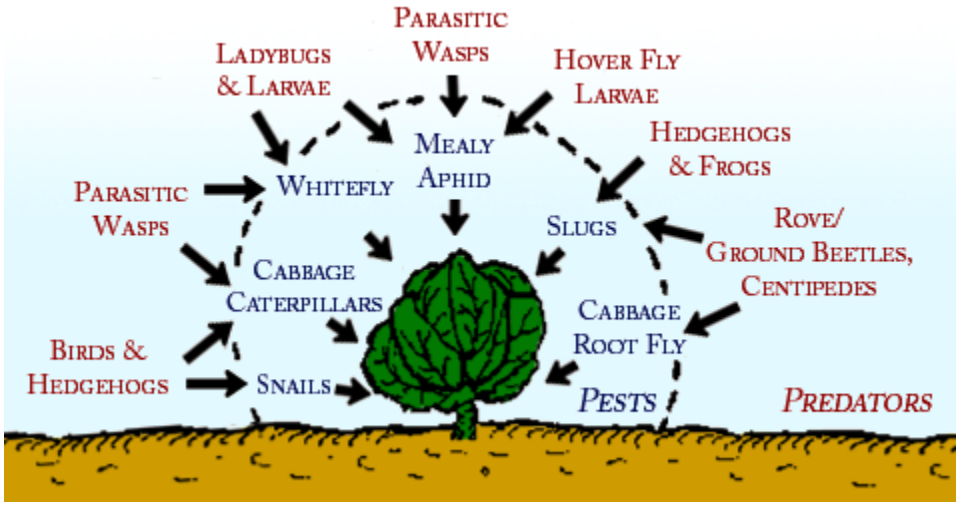
- Both tomato plants were exposed to destructive caterpillars. The genetically altered plant (right) shows little damage.

Figure 13-32

Biological Control

- Control system for parasites, predators, pathogens and weeds.
  - Biopesticides are natural control agents.
  - Biocontrols can also include pheromone traps.
  - Requires farmers to have a better understanding of the ecosystem, the crops and the pests.

Natural Controls



Case Study: integrated Pest Management: A Component of Sustainable Agriculture

- An ecological approach to pest control uses a mix of cultivation and biological methods, and small amounts of selected chemical pesticides as a last resort.
  - Integrated Pest Management (IPM)

Case Study: integrated Pest Management: A Component of Sustainable Agriculture

- Many scientists urge the USDA to use three strategies to promote IPM in the U.S.:
  - Add a 2% sales tax on pesticides.
  - Establish federally supported IPM demonstration project for farmers.
  - Train USDA personnel and county farm agents in IPM.
- The pesticide industry opposes such measures.

It Works!

- In 1986, Indonesia banned the use of 57 of 66 pesticides used on rice and phased out subsidies over 2 years.
  - The money saved was used for an IPM.
  - By 1992, the use of pesticides fell by 65% and rice production grew by 15%.

Staged Process

- Stage 1: Cultivation controls such as weeding by hand.
- Stage 2: Biological controls
- Stage 3: Targeted pesticide use; using narrow spectrum pesticides

Questions

- What is the goal of IPM and it's features?
- Why are top consumers more at risk of bioaccumulation?
- What is the basic principle of biological pest management?

How Would You Vote?

Should governments heavily subsidize a switch to integrated pest management?

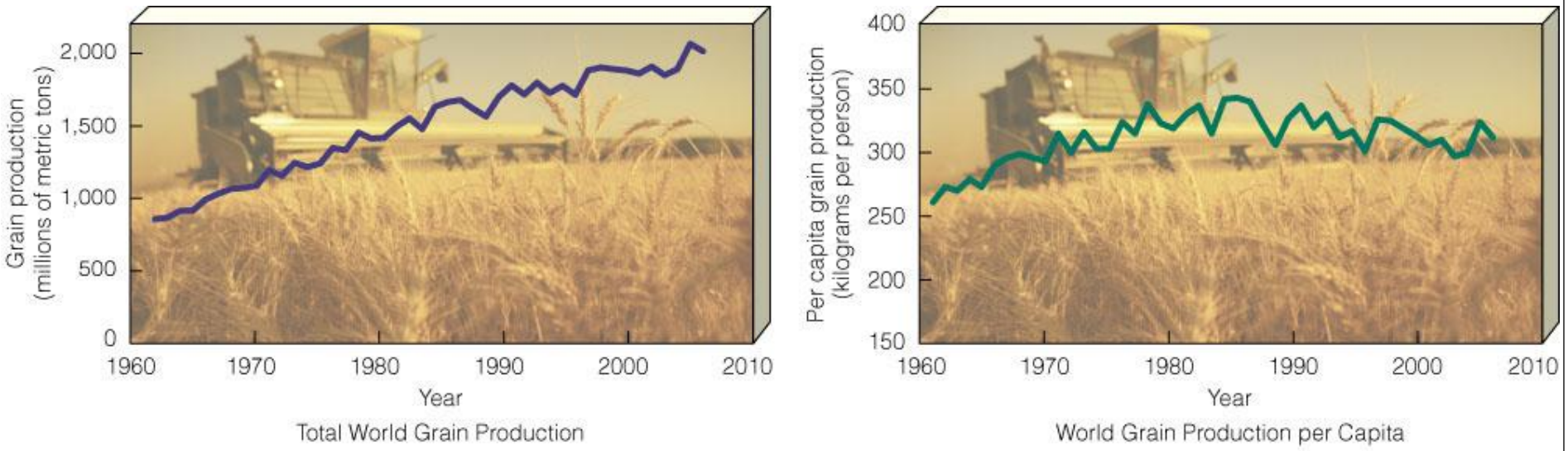
- a. No. Without extensive funding and training, mere subsidies are not enough to successfully promote integrated pest management.
- b. Yes. These subsidies would decrease pollution and exposure to hazardous pesticides.

The Green Revolution

Green means Lean!

- In the 1950's, the first Green Revolution began in developed countries.
- The green revolution strives to maximize crop yields while minimizing pesticides, water and fertilizers.

THE GREEN REVOLUTION AND ITS ENVIRONMENTAL IMPACT



- Since 1950, high-input agriculture has produced more crops per unit of land.
- In 1967, fast growing dwarf varieties of rice and wheat were developed for tropics and subtropics.

Figure 13-17

THE GREEN REVOLUTION AND ITS ENVIRONMENTAL IMPACT

- Lack of water, high costs for small farmers, and physical limits to increasing crop yields hinder expansion of the green revolution.
- Since 1978 the amount of irrigated land per person has declined due to:
  - Depletion of underground water supplies.
  - Inefficient irrigation methods.
  - Salt build-up.
  - Cost of irrigating crops.

Money in the bank!

- Agricultural research centers have put together a seed or gene bank.
- Most of the world's seed banks store one hundred or more seeds representing 90% of world's crops

Money in the bank!

- The Berry Botanic Garden Seed Bank for Rare and Endangered Plants of the Pacific Northwest was established in 1983.
  - dedicated exclusively to conserving rare native plants
  - currently holds more than 14,000 accessions, or packages of seed, representing over 300 of our region's rarest and most vulnerable plants.

Seed Banks

- Seeds are held primarily for use in re-introductions to the wild and rare plant research.
- Seed banking is one form of garden-based conservation. Because such efforts take place away from the plants' natural habitats, they are called off-site, or *ex situ* conservation.

Preserving crop diversity: insurance against failure

- Preserving native variants protects against crop failure
  - Monocultures are vulnerable, so wild relatives contain genes that could provide resistance to disease and pests
- We have already lost a great deal of genetic diversity in crops
  - Wheat varieties in China dropped from 10,000 (1949) to 1,000 (1970s)
- Market forces discourage diversity in food's appearance
  - Consumers prefer uniform, standardized food

Preserving crop diversity: seed banks

- **Seed banks** = institutions that preserve seed types as a kind of living museum of genetic diversity
  - Seeds are collected and preserved, and periodically planted
  - Funding is not adequate for these facilities

(a) Traditional food plants of the Desert Southwest

(b) Pollination by hand

The Royal Botanic Garden's Millennium Seed Bank in Britain holds more than 1 billion seeds

High Input, Low Output

- This type of agriculture uses large amounts of fossil fuels, water, pesticides and fertilizers.
  - They generally only produce a monoculture or single crop.
  - At some point, the soil is degraded and the output diminishes.
  - Machinery to plant, fertilize, irrigate and harvest crops is what uses the fossil fuels.

What crops?

- There are approximately 30,000 plant species that are suitable for human consumption.
  - There are only 3 grain crops (wheat, rice and corn) which provide half of the world's calorie intake.

THE GREEN REVOLUTION AND ITS ENVIRONMENTAL IMPACT

- Modern agriculture has a greater harmful environmental impact than any human activity.
- Loss of a variety of genetically different crop and livestock strains might limit raw material needed for future green and gene revolutions.
  - In the U.S., 97% of the food plant varieties available in the 1940 no longer exist in large quantities.

The Second Revolution

- The second Green Revolution (gene revolution) began in the 1960's and has spread to developing countries.
  - Grain crops are the focus of this revolution.
  - Selective breeding and genetic engineering are used to increase yield.

Genetic Engineering

- Rice is the second most important grain or cereal crop.
  - Genetic engineering has produced faster growing, higher pest resistant crops
- Golden rice is a genetically engineered rice that has higher levels of beta-carotene

Questions

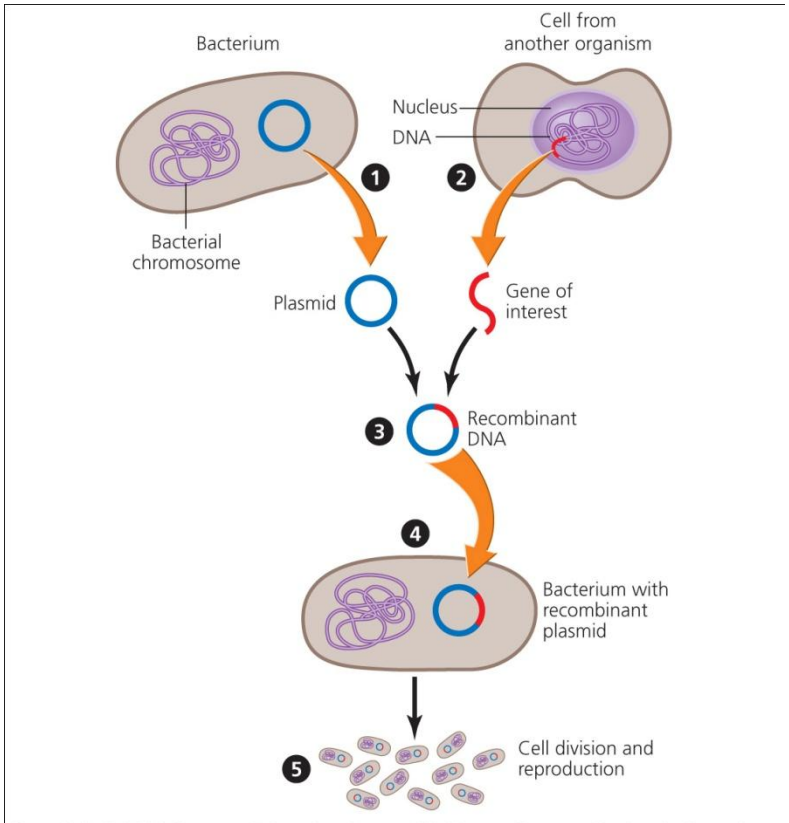
- How is technology being used to improve crop yields and the nutrition of the crops?
- How might countries facing a food shortage benefit from these practices?
- What constraints or resistance will developing countries face?

THE GENE REVOLUTION

- To increase crop yields, we can mix the genes of similar types of organisms and mix the genes of different organisms.
  - Artificial selection has been used for centuries to develop genetically improved varieties of crops.
  - Genetic engineering develops improved strains at an exponential pace compared to artificial selection.
- Controversy has arisen over the use of genetically modified food (GMF).

Genetically modified organisms

- **Genetic engineering =** laboratory manipulation of genetic material
- **Genetically modified organisms** = organisms that have been genetically engineered by …
- **Recombinant DNA** = DNA created from multiple organisms



Genetic engineering has both benefits and risks

- Benefits of genetic engineering:
  - Increased nutritional content
  - Increased agricultural efficiency
  - Rapid growth
  - Disease and pest resistance
- Negatives of genetic engineering:
  - Risks are not yet defined or well understood
  - Protests from environmental activists, small farmers, and consumer advocates

Biotechnology is impacting our lives

- **Biotechnology =** the material application of biological science to create products derived from organisms
- **Transgenic organism** = an organism that contains DNA from another species
  - **Transgenes =** the genes that have moved between organisms
- Biotechnology has created medicines, cleaned up pollution, and dissolves blood clots

Some genetically modified foods

Several Notable Examples of Genetically Modified Food Technology	
Food	**Development**
Golden rice 	Millions of people in the developing world get too little vitamin A in their diets, causing diarrhea, blindness, immune suppression, and even death. The problem is worst with children in east Asia, where the staple grain, white rice, contains no vitamin A. Researchers took genes from plants that produce vitamin A and spliced the genes into rice DNA to create more-nutritious "golden rice" (the vitamin precursor gives it a golden color). Critics charged that biotech companies hyped their product, which contains only small amounts of the nutrient and may not be the best way to combat vitamin A deficiency. India's foremost critic of GM food, Vandana Shiva, charged that "vitamin A rice is a hoax . . . a very effective strategy for corporate takeover of rice production, using the public sector as a Trojan horse." Backers of the technology counter that the nutritive value can be further improved and could enhance the health of millions of people.
Flavr Savr tomato 	By reversing the function of a normal tomato gene, the Calgene Corporation created the Flavr Savr tomato, which Calgene maintained would ripen longer on the vine, taste better, stay firm during shipping, and last longer in the produce department. The U.S. Food and Drug Administration approved the Flavr Savr tomato for sale in the United States in 1994. Calgene stopped selling the Flavr Savr in 1996, however, for several reasons, including problems with the technique and public safety concerns.
Ice-minus strawberries 	University of California–Berkeley researcher Steven Lindow removed a gene that facilitated the formation of ice crystals from the DNA of a particular bacterium, *Pseudomonas syringae*. The modified, frost-resistant bacteria could then serve as a kind of antifreeze when sprayed on the surface of frost-sensitive crops such as strawberries. The multiplying bacteria would coat the berries, protecting them from frost damage. However, early news coverage of this technique showed scientists spraying plants while wearing face masks and protective clothing, an image that caused public alarm.
Bt crops 	By equipping plants with the ability to produce their own pesticides, scientists hoped to boost crop yields by reducing losses to insects. By the late 1980s, scientists working with *Bacillus thuringiensis* (Bt) had pinpointed the genes responsible for producing that bacterium's toxic effects on insects, and had managed to insert the genes into the DNA of crops. The USDA and EPA approved Bt versions of 18 crops for field testing, from apples to broccoli to cranberries. Corn and cotton are the most widely planted Bt crops today. Proponents say Bt crops reduce the need for chemical pesticides. However, critics worry that the continuous presence of Bt in the environment will induce insects to evolve resistance to the toxins and that Bt crops might cause allergic reactions in humans. Another concern is that the crops may harm nontarget species. A 1999 study reported that pollen from Bt corn can kill the larvae of monarch butterflies, a nontarget species, when corn pollen drifts onto milkweed plants monarchs eat. Another study that year showed that the Bt toxin could leach from corn roots and poison the soil.

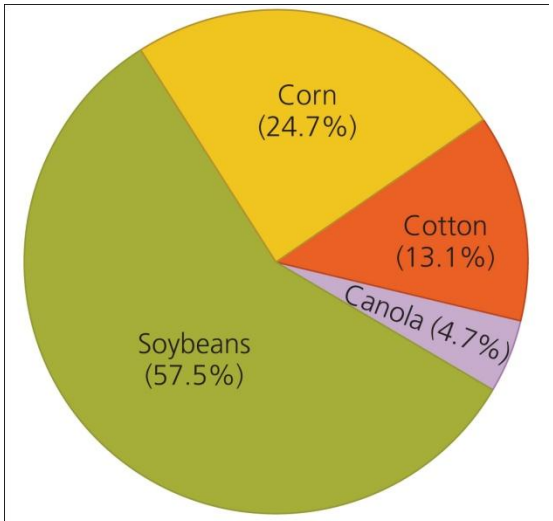
Genetic engineering versus agricultural breeding

- Artificial selection has influenced the genetic makeup of livestock and crops for thousands of years
- Proponents of GM crops say GM foods are safe
- Critics of GM foods say:
  - Traditional breeding uses genes from the same species
  - Selective breeding deals with whole organisms, not just genes
  - In traditional breeding, genes come together on their own

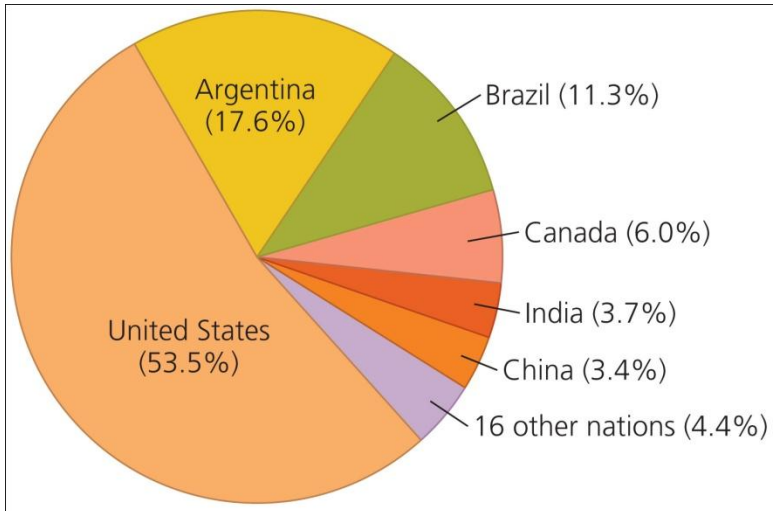
Traditional breeding changes organisms through selection, while genetic engineering is more like the process of mutation

Biotechnology is changing our world

- GM foods become big business
- Most GM crops are herbicide resistant
  - Farmers apply herbicides to kill weeds, and crops survive
  - Most U.S. soybeans, corn, cotton, and canola are genetically modified



(a) GM crops by type



(b) GM crops by nation

Globally, more than 10 million farmers grew GM foods on 102 million ha of farmland, producing $6.15 billion worth of crops

What are the impacts of GM crops?

- As GM crops expanded, scientists and citizens became concerned
  - Dangerous to human health
  - Escaping transgenes could pollute ecosystems and damage nontarget organisms
  - Pests could evolve resistance
  - Could ruin the integrity of native ancestral races
  - Interbreed with closely related wild plants

Supporters maintain that GM crops are safe

- Supporters make the following points:
  - GM crops pose no ill health effects
  - They benefit the environment by using less herbicides
  - Herbicide-resistant crops encourage no-till farming
  - GM crops reduce carbon emissions by needing fewer fuel-burning tractors and sequestering carbon in the soil by no-till farming
- Critics argue that we should adopt the **precautionary principle** = don't do any new action until it's understood

Studies on GM foods show mixed results

- Between 2003 and 2005, the British government commissioned three large-scale studies, which showed
  - GM crops could produce long-term financial benefits
  - Little to no evidence was found of harm to human health, but effects on wildlife and ecosystems are not well known
  - Bird and invertebrate populations in GM fields were mixed; some crops showed more diversity, some less, depending on the crop

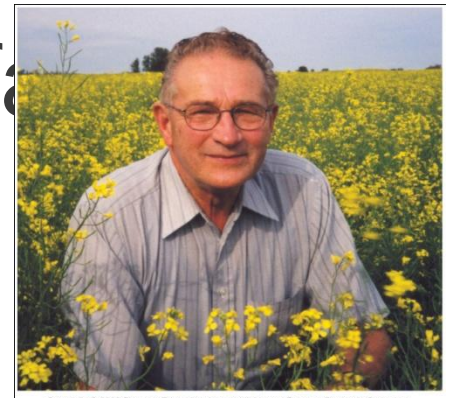
The GM debate involves more than science

- Ethical issues plays a large role
  - People don't like "tinkering" with "natural" foods
  - With increasing use, people are forced to use GM products, or go to special effort to avoid them
  - Multinational corporations threaten the small farmer
  - Research is funded by corporations that will profit if GM foods are approved for use
  - Crops that benefit small, poor farmers are not widely commercialized

The GM industry is driven by market considerations of companies selling proprietary products

GMO producers are suing fa

Farmers say that "[they] are being sued for having GMOs on their property that they did not buy, do not want, will not use, and cannot sell"



- Monsanto has launched 90 lawsuits against 147 farmers, winning an average $412,000 per case
  - Monsanto charged farmer Percy Schmeiser of Canada with using its patented GM seeds without paying for them
  - Schmeiser charged the seeds blew onto his field from the neighbor's adjacent field
  - The courts sided with Monsanto, saying Schmeiser had violated Monsanto's patent

Nations differ in their acceptance of GM foods

- Europe opposed GM foods
  - The U.S. sued the European Union before the World Trade Organization, charging that the European Union was hindering free trade
  - Brazil, India, and China approve GM crops
  - Zambia refused U.S. food aid, even though people were starving, because some seeds were genetically modified

Mixing Genes

- Genetic engineering involves splicing a gene from one species and transplanting the DNA into another species.

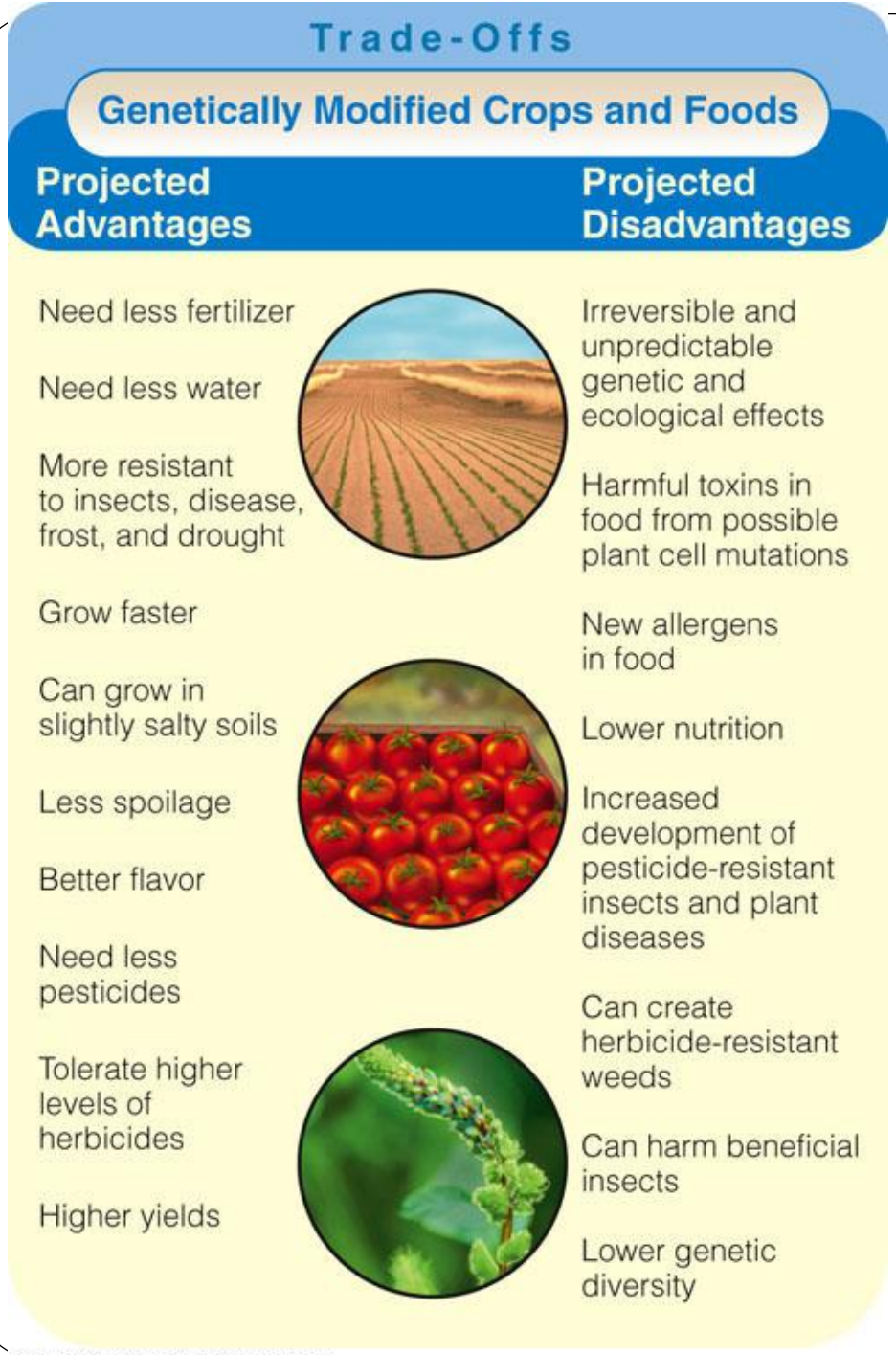


Figure 13-19

THE GENE REVOLUTION

- The winged bean, a GMF, could be grown to help reduce malnutrition and the use of large amounts of inorganic fertilizers.

Figure 13-20

How Would You Vote?

Do the advantages of genetically engineered foods outweigh their disadvantages?

- a. No. The impact of these foods could cause serious harm to the environment or human health.
- b. Yes. These foods are needed to combat world hunger.

THE GENE REVOLUTION

- Controversy has arisen over the use of genetically modified food (GMF).
  - Critics fear that we know too little about the long-term potential harm to human and ecosystem health.
- There is controversy over legal ownership of genetically modified crop varieties and whether GMFs should be labeled.

How Would You Vote?

Should labeling of GMFs be required?

- a. Yes, people have the right to make informed decisions about what they are buying.
- b. No, research shows that GM organisms are safe. Labeling will scare consumers and penalize producers.

Sustainable Agriculture

A step closer to environmental sustainability.

Core Case Study: Golden Rice -Grains of Hope or an Illusion?

- Golden rice is a new genetically engineered strain of rice containing beta-carotene.
- Can inexpensively supply vitamin A to malnourished.

Figure 13-1

Core Case Study: Golden Rice -Grains of Hope or an Illusion?

- Critics contend that there are quicker and cheaper ways to supply vitamin A.
- Scientist call for more evidence that the beta-carotene will be converted to vitamin A by the body.

Figure 13-1

What is sustainable agriculture?

- Sustainable agriculture refers to the long-term ability of a farm to produce food without irreversibly damaging the environment.
  - This is the key to reducing world hunger.

SUSTAINABLE AGRICULTURE THROUGH SOIL CONSERVATION

- Modern farm machinery can plant crops without disturbing soil (no-till and minimum tillage.
  - Conservation-tillage farming:
    - Increases crop yield.
    - Raises soil carbon content.
    - Lowers water use.
    - Lowers pesticides.
    - Uses less tractor fuel.

SUSTAINABLE AGRICULTURE THROUGH SOIL CONSERVATION

- Terracing, contour planting, strip cropping, alley cropping, and windbreaks can reduce soil erosion.

Figure 13-16

SUSTAINABLE AGRICULTURE THROUGH SOIL CONSERVATION

- Fertilizers can help restore soil nutrients, but runoff of inorganic fertilizers can cause water pollution.
  - ***Organic fertilizers***: from plant and animal (fresh, manure, or compost) materials.
  - ***Commercial inorganic fertilizers***: Active ingredients contain nitrogen, phosphorous, and potassium and other trace nutrients.

The Key Issues

- The two key issues in sustainable agriculture are biophysical and socio-economic.
  - Biophysical issues include soil health and the essential biological processes to crops.
  - Socio-economic issues include the ability of farmers to manage their resources like labor and operating costs.

Some more of this . . .

- Sustainable farms involve more
  - high yield polyculture (multiple crops)
  - organic fertilizers
  - biological pest controls (natural predators)
  - integrated pest management
  - irrigation efficiency (to reduce salinization)
  - perennial crops and rotation (5-year plan)
  - water efficient crops
  - soil conservation
  - subsidizing sustainable practices (gov't)

And less of this . . .

- Sustainable farms involve less
  - soil erosion
  - salinization
  - aquifer depletion
  - overgrazing or overfishing
  - loss of biodiversity
  - loss of prime cropland
  - food waste
  - population growth
  - subsidizing unsustainable practices (gov't)

How?

- High value produce sold locally
- organic produce
- use earthworms to aerate soil naturally
- support fungi and bacteria
- plant legumes to allow bacteria to fix N_2
- cycle crops
- use manure for fertilizer

How else?

- Allow plant residue to provide nutrients
- use biological controls to limit pests
- use less pesticides
- less water contamination
- harvest seeds for planting subsequent years

SOLUTIONS: MOVING TOWARD GLOBAL FOOD SECURITY

- People in urban areas could save money by growing more of their food.
  - Urban gardens provide about 15% of the world's food supply.
- Up to 90% of the world's food is wasted.

Figure 13-26

Government Policies and Food Production

- Governments use three main approaches to influence food production:
  - Control prices to keep prices artificially low.
  - Provide subsidies to keep farmers in business.
  - Let the marketplace decide rather that implementing price controls.

How Would You Vote?

Should governments phase out subsidies for conventional industrialized agriculture and phase in subsidies for more sustainable agriculture?

- a. No. Current subsidies maintain critical food supplies that should not be disrupted to Americans and others.
- b. Yes. Agricultural pollution is a serious problem and subsidies should be used to encourage environmentally friendly agriculture.

Solutions: Steps Toward More Sustainable Food Production

- We can increase food security by slowing populations growth, sharply reducing poverty, and slowing environmental degradation of the world's soils and croplands.

SOLUTIONS: SUSTAINABLE AGRICULTURE

- Three main ways to reduce hunger and malnutrition and the harmful effects of agriculture:
  - Slow population growth.
  - Sharply reduce poverty.
  - Develop and phase in systems of more sustainable, low input agriculture over the next few decades.