Ch. 10: Agriculture, Biotechnology, and Future of Food

Central case study

- Genetically modified corn appeared in traditional corn (maize) in 2001.
- These **transgenes** (genes from another species) came from U.S. corn
- **Genetically modified organisms** _____ = organisms whose genes have been directly manipulated

We are producing more food per person

- _____ = 2 more billion ppl to feed
- **Undernutrition** = people receive fewer calories than their minimum requirements
- **Food security** = guarantee of an adequate, safe, nutritious, and reliable food supply
- **Malnutrition**= _____
- **Overnutrition** = receiving too many calories each day
  - Developed countries have abundant, cheap junk food, and people lead sedentary lives
  - In the U.S., 25% of adults are obese

The Green Revolution boosted agricultural production

- Spread to the developing world in the 1940s
  - Wheat, rice, corn
  - Plants produce more and are disease and wind resistant
  - _____won the Nobel Peace Prize for his work
- Developing countries were able to double, triple, or quadruple yields

The Green Revolution brought mixed consequences

- Depended on heavy use of:
  - Synthetic _____ and chemical _____
  - Irrigation
  - Fossil fuel-powered machinery
- Positive effects on the environment
  - Prevented _____
  - Preserved biodiversity and ecosystems
- Negative effects on natural resources
  - _____
  - Loss of _____ and soil quality
- **Monoculture** = large expanses of _____
  - More efficient, increases output
  - Devastates biodiversity
  - Plants are _____ to disease and pests
- Human diet is narrowed: 90% of our food comes from 15 crop and 8 livestock species

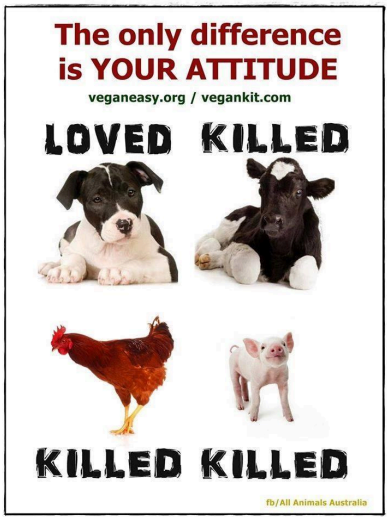
Some biofuels reduce food supplies

- **Biofuels** = fuels derived _____
  - Replace petroleum in engines
- **Ethanol** = a biofuel derived _____
  - 2007 subsidies doubled production
- Food prices increased
  - Farmers sold corn for ethanol, not food
  - Farmers planted biofuels, not food crops

We are moving toward sustainable agriculture

- **Sustainable agriculture** = agriculture that _____ faster than they form. It does not
  - reduce the amount of healthy soil
  - pollute water
  - decrease
  - genetic diversity
  - No-till farming and other soil conservation methods help make agriculture more sustainable

Raising Animals for Food



- Consuming animal products has environmental, social, agricultural, and economic _____
- Since 1950, global meat production has increased fivefold and per capita(per person) meat consumption has doubled
- More wealth = more meat consumption
  - Domestic animals raised for food increased from 7.2 billion in 1961 to _____

Our food choices are also energy choices

- Eating meat is _____ than eating crops
  - 90% of energy is lost from one trophic level to the next
- Eating lower on the food chain feeds _____
- Some animals convert grain into meat more efficiently than others
- Land and water are needed to raise food for livestock
  - Producing eggs and chicken meat requires the least space and water
  - Producing _____
- Foods from different animals have different ecological footprints
- _____

Rising demand led to feedlot agriculture

- **Feedlots** (*factory farms* aka *concentrated animal feeding operations*, or _____) = huge warehouses or pens for animals living at extremely high densities
  - Increases production and lowers costs
  - _____ production goes to livestock
- Environmental benefits:
  - Reduced grazing
  - Manure can be used as fertilizer

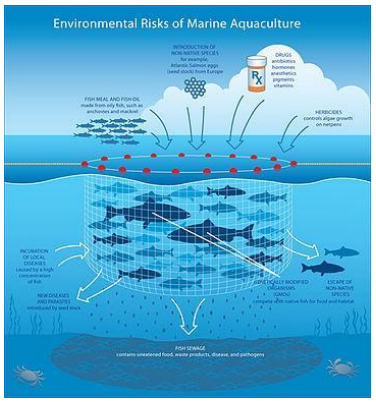
Livestock agriculture pollutes water and air

- Feedlots produce huge amounts of _____
  - Pollute surface and groundwater and can lead to eutrophication
  - Waterborne pathogens can sicken people
- Use of _____ to prevent spread of disease.
  - Microbes evolve resistance to antibiotics
- To spur growth, animals are _____and heavy metals then to ppl
- Feedlots produce odor and _____ (CO_2, methane, nitrous oxides) than automobiles!!!

We raise seafood with aquaculture

- Fish populations are plummeting
  - Technology and increased demand led to overharvesting
- _____ = raising aquatic organisms in a controlled environment
  - Species are raised in open-water pens or land-based ponds

Aquaculture brings benefits and has negative impacts



- Benefits:
  - _____
  - Can be sustainable
  - Reduces pressure on overharvested wild fish
  - Reduces *bycatch* (nontarget organisms)
  - Energy efficient
- Negative impacts:
  - Diseases require expensive _____
  - Lots of waste
  - Sometimes fed wild-caught fish
  - Uses grain that might otherwise go to people
  - Escaped fish may introduce disease or outcompete wild fish

Crop diversity provides insurance against failure

- Preserving native variants protects against crop failure
- _____
  - Wild relatives contain genes that can provide resistance to disease and pests

Seed banks are living museums

- **Seed banks** = institutions that _____ as living museums of genetic diversity
  - Seeds are collected, stored, and periodically planted
  - 1400 seed banks house 1–2 million distinct types of seeds worldwide

We depend on insects to pollinate crops

- The honey bee pollinates over 100 crops that make up one-third of the U.S. diet and contributes $15 billion in services per year
- Populations of pollinators (e.g., bees) have plummeted
- _____= entire beehives have vanished
  - Unknown causes—Insecticides? Parasites? Stress

"Pests" and "weeds" hinder agriculture

- **Pest** = any organism that damages valuable crops
- **Weed** = any plant that competes with crops
- Industrial farming limits natural mechanisms to control pest and weed populations
- _____ = poisons that target pest organisms
  - *Insecticides* kill insects, *herbicides* kill plants, *fungicides* kill fungi

Pests evolve resistance to pesticides

- Some individuals are _____ to a pesticide
- Pesticides also kill nontarget organisms, including predators and parasites of pests

Biological control pits one organism against another

- **Biological control** _____ = strategy that uses a pest's predators or parasites to control the pest
  - Reduces pest populations without chemicals
- ***Bacillus thuringiensis*** _____ = soil bacterium that kills many caterpillars and some fly and beetle larvae

Integrated pest management combines biocontrol and chemical methods

- _____= use of a mix of techniques to suppress pests:
  - Pest population monitoring
  - Biocontrol and mechanical pest removal
  - Chemicals, if necessary
  - Crop rotation and alternative tillage methods
  - Use of transgenic crops

Organic approaches reduce inputs and pollution

- **Organic agriculture** = Using _____but rely on biological approaches such as composting and biocontrol
- Organic Food Production Act (1990) establishes national standards for organic products
  - The USDA issued criteria in 2000 by which food could be labeled organic

Organic agriculture is booming

- Organic farmers can't keep up with demand
  - U.S. consumers pay $29.2 billion in 2011
  - Worldwide _____ from 2000 to 2010
- In the long run, organic farming is at least as profitable as conventional farming

TABLE 10.1 USDA Criteria for Certifying Crops and Livestock as Organic

For crops to be considered organic . . .
• The land must be free of prohibited substances for 3 years.
• Crops must not be genetically engineered.
• Crops must not be irradiated to kill bacteria.
• Sewage sludge cannot be used.
• Organic seeds and planting stock are preferred.
• Farmers must not use synthetic fertilizers. Only crop rotation, cover crops, animal or crop wastes, or approved synthetic materials are allowed.
• Most conventional pesticides are prohibited. Pests, weeds, and diseases should be managed with biocontrol, mechanical practices, or approved synthetic substances.
For livestock to be considered organic . . .
• Mammals must be raised organically from the last third of gestation; poultry, from the second day of life.
• Feed must be 100% organic, although vitamin and mineral supplements are allowed.
• Dairy cows must receive 80% organic feed for 9 months, followed by 3 months of 100% organic feed.
• Hormones and antibiotics are prohibited; vaccines are permitted.
• Animals must have access to the outdoors.

Adapted from the National Organic Program. 2002. Organic production and handling standards. *Washington, DC: U.S. Department of Agriculture.*

Genetically Modified Food

- **Biotechnology** = the application of biological science to create products derived from organisms

- **Genetic engineering** = direct manipulation of genetic material through adding, deleting, modifying DNA
- _____= DNA patched together from multiple organisms

Biotechnology is transforming the products around us

- GM foods are a big business
- Globally in 2012, 17 million farmers grew GM foods on 170 million ha (420 million acres)—11% of all cropland
  - _____ are GM plants
- Most GM crops are herbicide and pesticide resistant
  - Large-scale farmers grow crops more efficiently

What are the benefits/negative impacts of GM foods?

Pros:

- Higher yields & lower costs = _____
- Less irrigation, deforestation, land conversion
- Less GHG through no-till farming
- Less pesticide use

Cons:

- _____
- May be linked to allergies, immune suppression, antibiotic resistance, or cancer.
- New genes = new diseases?
- Lower biodiversity
- Pests can be become resistant
- Could harm non-target animals

- _____ = idea that one shouldn't undertake a new action until the effects of that action are understood
- People don't like "tinkering" with the food supply
- With increasing use, people are forced to use GM products or go to special effort to avoid them

Public debate over GM foods continues

- Still hunger/poverty w/ GM crops. Poor ppl _____
- The "genetic revolution" has been driven by corporate profit.
- Corporations patent transgenes and protect them _____
  - Monsanto has launched 145 lawsuits against several hundred farmers for having transgenes in their fields without buying them from Monsanto

Many nations label GM foods

- Some ppl demand GM Foods labeling.
- USA = _____
- Favoring labeling: Consumers have the right to know what they're eating.
- Opposing labeling: Ppl may think food is dangerous = less demand = less profit.

Sustainable agriculture mimics natural ecosystems

- Ecosystems are naturally sustainable and operate in cycles stabilized by negative feedback loops
- Agriculture can be sustainable _____
- Small-scale Japanese farmers add ducks to rice fields
  - Ducks eat weeds, insects, snails
  - Their waste is fertilizer
  - Their paddling oxygenates the water
  - Fish and ferns provide food and habitat
  - Twice as productive as region's conventional farms

So, "organic"

- So, organic means:

-_____

-No synthetic fertilizers

-No pesticides