

ENVIRONMENT


THE SCIENCE BEHIND THE STORIES
Jay Withgott • Scott Brennan

Ch 10

Agriculture, Biotechnology, and the Future of Food

Part 2: Environmental Issues and the Search for Solutions

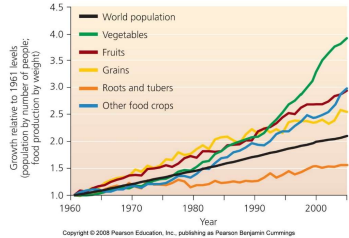
PowerPoint® Slides prepared by Jay Withgott and Heidi Marcum



Third Edition

Production of Food

- Food production currently exceeds population growth

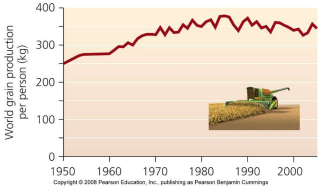



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- We produce food through technology include:
 - Fossil fuels
 - Irrigation
 - Fertilizer
 - Pesticides
 - crossbreeding

Food security




- Food security** = the guarantee of adequate and reliable food supply to all people at all times
- Fewer people today are hungry
- We have reduced hunger by half since 1970
- But, 850 million people still go hungry

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Since 1985, world grain production has fallen by 9%

We face both too little and too much food

- Undernourishment** = people receive less than 90% of their daily caloric needs
 - Mainly from economic reasons in developing countries
 - 31 million Americans are food insecure
- Overnutrition** = receiving too many calories
 - In the U.S., 25% of adults are obese
 - Worldwide, more than 300 million people are obese
- Malnutrition** = a shortage of nutrients the body needs
 - The diet lacks adequate vitamins and minerals

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Quantity and quality of food is important

- **Kwashiorkor** = diets lacking protein or essential amino acids
 - Occurs when children stop breast-feeding
 - Bloated stomach, mental and physical disabilities
- **Marasmus** = protein deficiency and insufficient calories
 - Wasting or shriveling of the body



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Green Revolution

Make sure to know

- Dramatically increased per-acre yields in agriculture
- 1940s with wheat, rice, corn
- From 1900 to 2000, cultivated area increased 33%, while energy inputs increased 80 times!



Depended on large amounts of

- Synthetic fertilizers
- Chemical pesticides
- Irrigation
- Heavy equipment

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Green Revolution

- Positive effects on natural resources
 - Prevented some deforestation
 - Preserved biodiversity
- Negative effects on natural resources
 - Pollution
 - Erosion
 - Salinization
 - Desertification



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Monocultures

- **Monoculture** = a large expanse of a single crop
 - Impact of monoculture:
 - More efficient, increases output
 - Devastates biodiversity
 - Susceptible to disease and pests



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•90% of our food comes from 15 crop species and 8 livestock species



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Pests and pollinators

- **Pest** = any organism that damages valuable crops
- **Weed** = any plant that competes with crops
- **Pesticides** = poisons that target pest organisms
 - **Insecticides** = target insects
 - **Herbicides** = target plants
 - **Fungicides** = target fungi

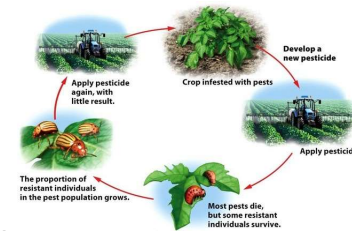


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Pesticides Resistance

- **Evolutionary arms race**: chemists increase chemical toxicity to compete with resistant pests

Rachel Carson predicted the phenomenon called the “**pesticide treadmill**” or the “pesticide trap.” The use of pesticides, by natural selection, will ensure that the most pesticide-resistant insects and weeds flourish, therefore requiring ever greater dosing of pesticides to control.



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Biological control

- **Biological control (Biocontrol)** = uses a pest’s natural predators to control the pest
 - Reduces pest populations without chemicals
 - **Bacillus thuringiensis (Bt)** = soil bacteria that kills many pests



(a) Before cactus moth introduction
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(b) After cactus moth introduction
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Nematodes used to control beetles causing Colony Collapse Disease in Honey Bees

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Biocontrol agents

- May become pests themselves
- The agent may have “nontarget” effects on the environment and surrounding economies
- Removing a biocontrol agent is harder than halting pesticide use
- Due to potential problems, proposed biocontrol use must be carefully planned and regulated



Cane Toads in Australia

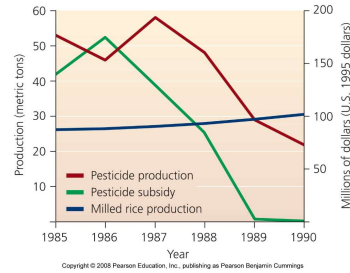
- Introduce to control the native grey-backed cane beetle
- Cane toad become overpopulated.



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Integrated Pest Management (IPM)

- **IPM uses multiple techniques to suppress pests**
 - Biological control
 - Chemicals, when necessary
 - Population monitoring
 - Habitat alteration
 - Crop rotation and transgenic crops
 - Alternative tillage methods
 - Mechanical pest removal



Within 4 years of using IPM in Indonesia, rice yields rose 13%, and \$179 million saved by phasing out subsidies

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Conservation of Pollinators

- Not all insects are pests; some are absolutely vital
 - 800 cultivated plant species rely on insect pollinators
- **Colony Collapse Disorder**
 - phenomenon that occurs when the majority of worker bees in a colony disappear and leave behind a queen, plenty of food and a few nurse bees to care for the remaining immature bees and the queen.
- Native populations of pollinators have plummeted
- Honeybees pollinate more than 100 crops – 1/3 of the U.S. diet.
- To conserve bees:
 - Reduce or eliminate pesticide use
 - Plant flowering plants



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Genetic engineering

- **Genetic engineering** = laboratory manipulation of genetic material
- **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

- Biotechnology has created medicines, cleaned up pollution, and dissolves blood clots
- **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

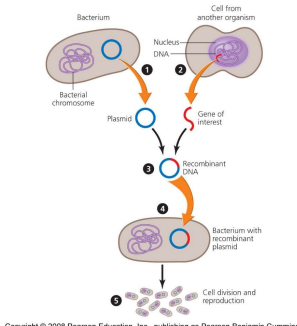


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Genetically Modified Organisms

GMOs

- **Genetically modified organisms** = organisms that have been genetically engineered by ...
- **Recombinant DNA** = DNA created from multiple organisms



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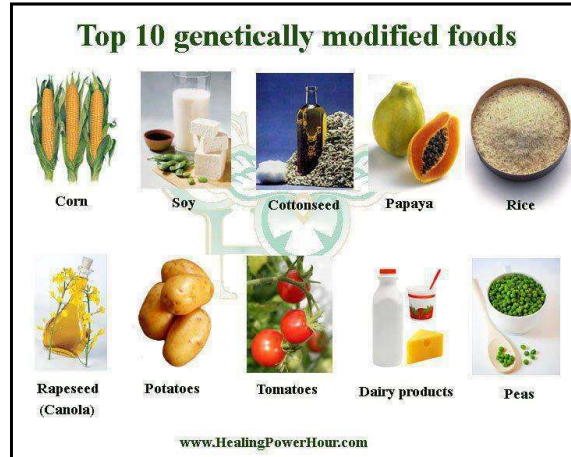


[Ted Talk GMOs](#) [GMO video](#)

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Some genetically modified foods

Top 10 genetically modified foods

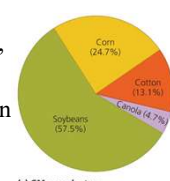


www.HealingPowerHour.com

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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
 - Most U.S. soybeans, corn, cotton, and canola are genetically modified



(a) GM crops by type
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Pesticides and GMOs

- Most GM crops are herbicide resistant
- Farmers apply herbicides to kill weeds, and crops survive

Neonicotinoids

- Are a relatively new class of insecticides that share a common mode of action that affect the central nervous system of insects, resulting in paralysis and death.
- Accumulate in pollen and nectar of treated plants and represent a potential risk to pollinators.

It's no longer a mystery.
We know what's killing the bees.



Tell the EPA to Ban Neonicotinoid Pesticides Before They Devastate the U. S. Bee Population

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What are the impacts of GM crops?

- 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.
 - Lower biodiversity



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GMO Support

- 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

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GMO mixed results

- GM crops could produce long-term financial benefits
- Little to no evidence was found of harm to human health
- 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



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Ethics of GMOs



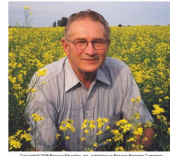
- People don't like "tinkering" with "natural" foods
- With increasing use, people are forced to use GM products, or go to special effort to avoid them
- Multinational corporations threaten the small farmer
- Research is funded by corporations that will profit if GM foods are approved for use
- Crops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

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

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GMO and Monsanto

- 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



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"

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GMOs Worldwide



- **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

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GMO Labeling



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Preserving crop diversity

- 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)
- Ugly food is discouraging
 - Consumers prefer uniform, standardized food

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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
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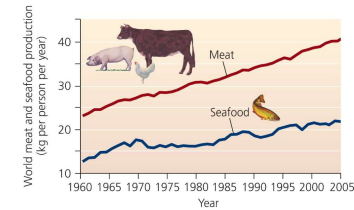
(b) Pollination by hand
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The Royal Botanic Garden's Millennium Seed Bank in Britain holds more than 1 billion seeds

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Feedlot Agriculture

- 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



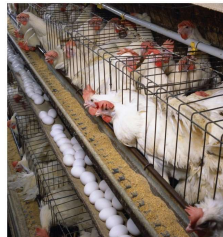
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Domestic animal production for food increased from 7.3 billion in 1961 to 20.6 billion in 2000

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Feedlot agriculture (CAFOs)

- **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



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

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Feedlots= CAFOs

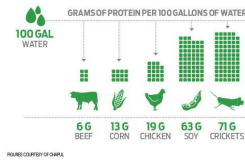
- **The benefits of feedlots include:**
 - Greater production of food
 - Unavoidable in countries with high levels of meat consumption, like the U.S.
 - They take livestock off the land and reduces the impact that they would have on it
- **Drawbacks of feedlots include:**
 - Create a lot of water and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

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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.

1kg Meat	Water	Feed	Emissions
40% = Edible	20,000 litres	25kg	100x more
80% = Edible	8 litres	2kg	



[Article on Insects](#)

[Insect video](#)

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

SAVE 1300 GALLONS OF WATER

DONT FLUSH YOUR TOILET FOR **6 MONTHS**

OR

DONT TAKE A SHOWER FOR **3 MONTHS**

OR

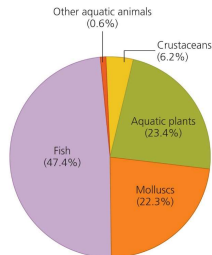
FOR LUNCH TODAY, DONT EAT **1 BURGER**

GOTDROUGHT.COM

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

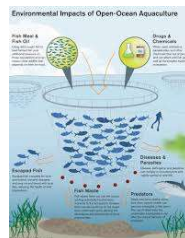
Aquaculture

- **Aquaculture** = raising aquatic organisms for food in a controlled environment
 - Aquatic species are raised in open-water pens or land-based ponds



(a) World aquaculture production by groups
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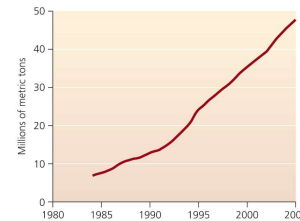
- World fish populations are plummeting
 - Technology and increased demand



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Aquaculture

- 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
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[Paul Greenberg-4 fish Ted talk](#)



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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

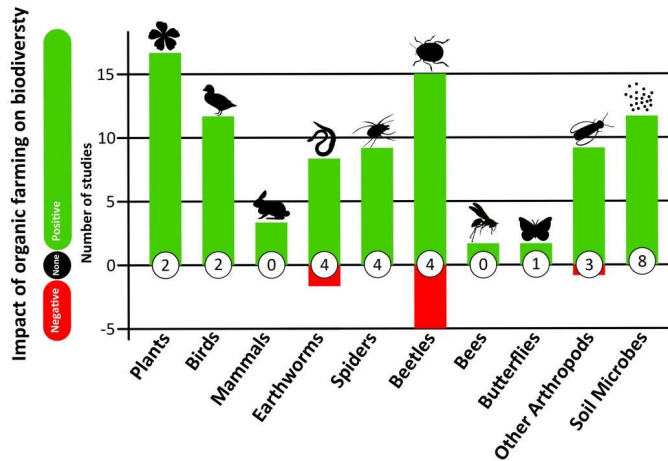
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Sustainable Agriculture

- **Sustainable agriculture** = does not deplete soil, pollute water, or decrease genetic diversity
- **Low-input agriculture** = uses smaller amounts of pesticide, fertilizers, growth hormones, water, and fossil fuel energy than industrial agriculture
- **Organic agriculture** = Uses no synthetic fertilizers, insecticides, fungicides, or herbicides
 - Relies on biological approaches (composting and biocontrol)



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Organic Agriculture

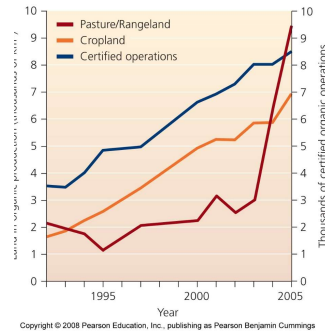
- People debate the meaning of the word “organic”
 - Organic Food Production Act (1990) establishes national standards for organic products
 - The USDA issued criteria in 2000 by which food could be labeled organic
 - Some states pass even stricter guidelines for labeling



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Organic Agriculture

- Sales increased 20% year in Canada and the U.S.
- Expanded by a factor of 40 in Europe
- Amount of land for organic farming is increasing
 - Pasture
 - Cropland



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Organic Agriculture

- **For farmers:**
 - Lower input costs, enhanced income from higher-value products, reduced chemical costs and pollution
 - Obstacles include the risks and costs of switching to new farming methods and less market infrastructure
- **For consumers:**
 - Concern about pesticide's health risks
 - A desire to improve environmental quality
 - Obstacles include the added expense and less aesthetically appealing appearance of the product

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Organic Agriculture in US

- In 1993, the European Union adopted a policy to support farmers financially during conversion to organic farming
- The U.S. offers no such support
 - Organic production lags in the U.S.
 - Farmers can't switch, because they can't afford the temporary loss of income
 - In the long run, organic farming is more profitable

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Organic agriculture succeeds in cities

- **Community gardens** = areas where residents can grow their own food
- In Cuba, over 30,000 people work in Havana's gardens, which cover 30% of the city's land
 - Record yields for 10 crops in 1996-1997



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Community-supported agriculture

- In developed nations, farmers and consumers are supporting local small-scale agriculture
 - Fresh, local produce in season
- **Community-supported agriculture** = consumers pay farmers in advance for a share of their yield
 - Consumers get fresh food
 - Farmers get a guaranteed income



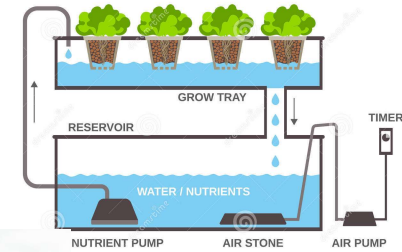
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Hydroponics

A method of growing plants without soil by using mineral nutrient solutions in a water solvent.

HYDROPONICS

infographics elements



Rockwool

- Used as a base
- Inorganic



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Hydroponics



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