Biotechnologies: Agriculture, Food, and Natural Resource Issues
FS 430 (H) / 530
BI 435 (H) / 535

http://www.cof.orst.edu/cof/teach/agbio2009/

- Steve Strauss
  - Forest Science, Genetics, Molecular and Cellular Biology, Biotech Outreach
- David Stone
  - Environmental and Molecular Toxicology

Oregon State University OSU

Today and next two class meetings

- Intros from Profs
- Why this class
  - Toxicology version
  - Biotech version
- Class mechanics
- State of biotech crops and controversy
- Recitation today
  - Finish state of biotech, then gene and genome basics
- Thursday: How crop genetic engineering works

A few Strauss bio facts

- OSU Distinguished Professor
- American Association for the Advancement of Science Fellow
  - "honored for contributions to science in genetics and evolution, for interdisciplinary work on safety and policy in biotechnology, and communicating the challenges of biotechnology in forestry."
- BS Cornell (biology/ecology), MS Yale (forestry/ecology), PhD Berkeley (forestry, genetics)
- Research at OSU on DNA-level genetics and biotechnology of trees
  - Genetic engineering (GE)
- Involved in policy and social debates surrounding field research regulation, ethics, and science of genetically engineered trees
  - Sabbatical study at Oxford on forest certification and GE trees
  - Resources for the Future (DC) Fellowship on effects of regulations on research and commercial development
  - USA and UN Convention on Biodiversity negotiations/presentations

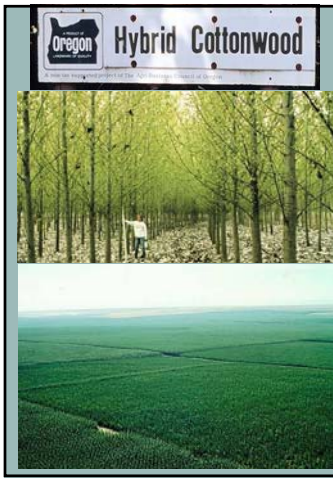
Bradshaw (UW) and Strauss (OSU) "eco"vandalism - 2001

U Wash

Oregon State

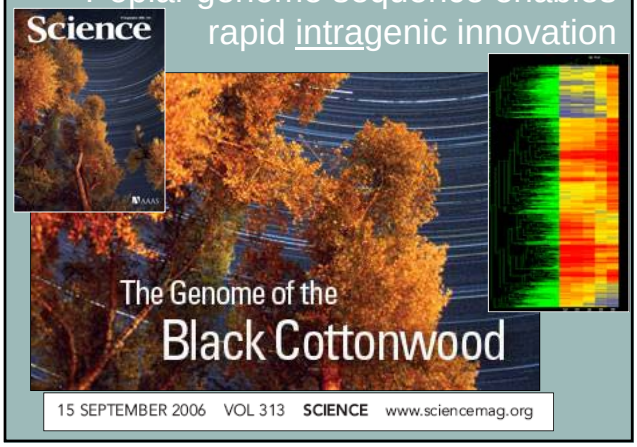
Strauss research

- Genetic modification of poplars for bioenergy/pulp/wood plantations
  - Cottonwoods/aspens
- Research projects
  - Genetic containment / sterility
  - Tree form control
  - Growth rate enhancement
  - Wood quality modification for ethanol production
  - Bioplastics as coproducts
- Publications web site http://www.cof.orst.edu/coops/tbgrc/Staff/strauss/publications.htm



"Wood grass" coppice energy production system

Poplar genome sequence enables rapid intragenic innovation



GE poplar at origin in Petri dish and in the field

Education resources: Outreach in Biotechnology website

http://agsci.oregonstate.edu/orb/

Education resources there: Recent lecture ppts and videos

BIO/FOR 430/530:

Biotechnologies: Agriculture, Food & Resources Issues

Spring 2009

Lecture 1: Introduction

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Environmental & Molecular Toxicology
Oregon State University OSU

Assistant Professor

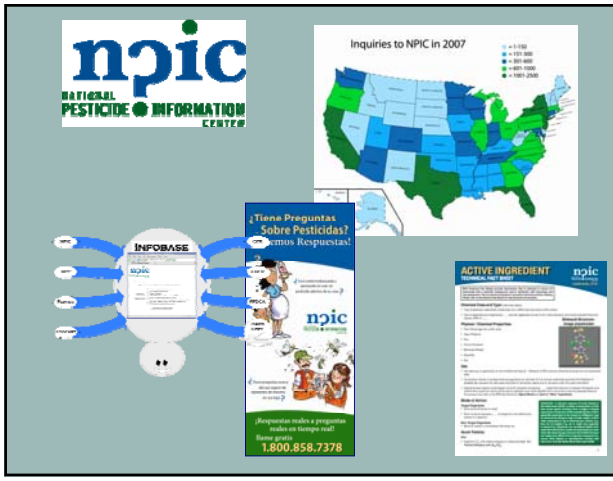
Extension

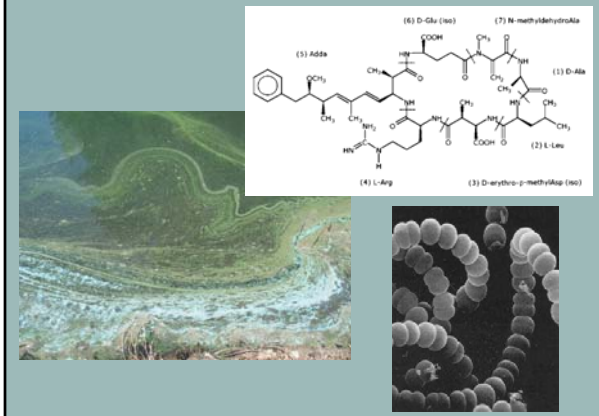
Research

Teaching

NPIC

Hazard vs. Risk

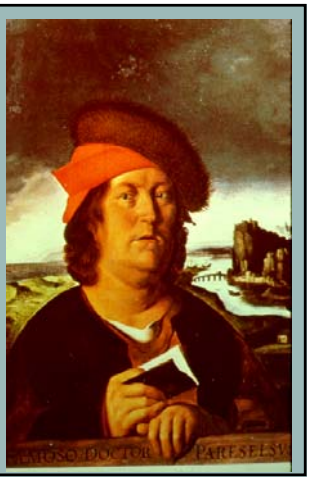




Toxicology Topics:

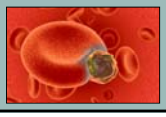
- Basics of Toxicology
- Risk Assessment
- Chemical Regulation
- Natural and Synthetic Toxins
- Risk Perception & Ethics
- Cutting Edge Technologies

"Poison is in everything, and no thing is without poison. The dosage makes it either a poison or a remedy."



What does toxicology do for society?

- Toxicology helps create a "safer" world
- Definition: The study of the negative effects of chemical and physical agents on living organisms
- Modern toxicology uses chemicals as tools to understand molecular/cellular biology



2008 Society of Toxicology

What Do Toxicologists Do?

Most Toxicologists work to assess and understand how chemicals affect living systems

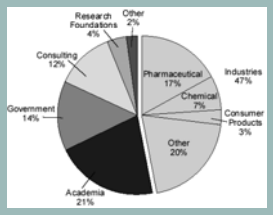
- Develop mechanistic understanding of effects
- Ensure safer chemical products
- Develop safer drugs & medicines
- Determine **risks** from chemical exposures
- Develop treatments for chemical exposures
- Forensics

2008 Society of Toxicology (modified)

Who Are Toxicologists?

Toxicology involves integration of information from many different areas of expertise. People working in toxicology can also be called:

- Biochemists
- Chemists
- Pathologists
- Cancer Researchers
- Veterinarians
- Medical Doctors
- Cell and Molecular Biologists
- Engineers
- Mathematicians
- Statisticians
- Lab Technicians
- Risk Assessors
- Animal Care Providers
- Consultants



2008 Society of Toxicology (modified)

Where do chemicals come from?

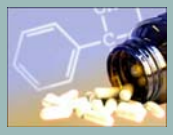
- Chemicals are natural, biological, or synthetic in origin
  - Natural (food, metals, minerals)
  - Biological (toxins from bacteria, spiders, etc…)
  - Synthetic—manufactured through chemical processes (some pesticides, solvents)

- Approximately **100,000** chemicals are currently in use worldwide. **500** new formulations enter the marketplace annually.

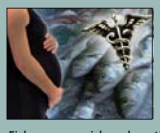
2008 Society of Toxicology

Toxicology and the media…

California Wants to Serve a Warning With Fries (NY Times, Sept 21, 2005)

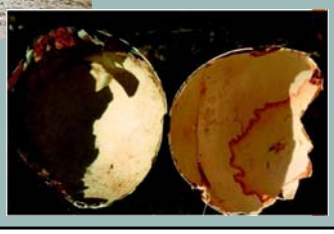


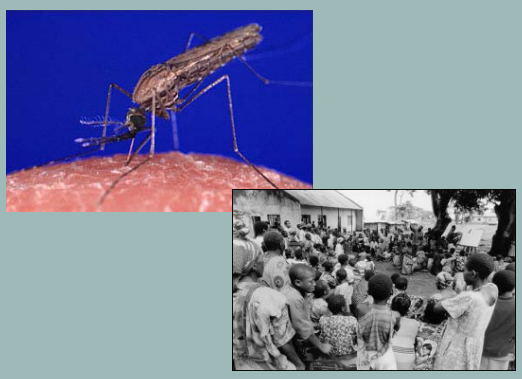
Ephedra Ban: What Took So Long? (CBSNews.com, Dec 30, 2003)



Fish-mercury risk underestimated (CNN.com, Apr 12, 2001)

2008 Society of Toxicology





Biotech: WHY THIS CLASS

Biotechnologies hold huge promise but their novelties also raise very difficult biological and social dilemmas

There is very little public understanding of what they are and are not

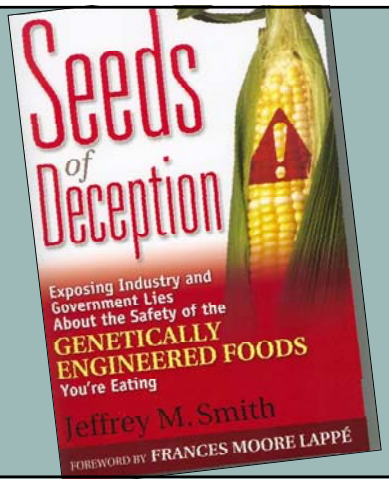
Rutgers survey data - USA (2005) – Prof Bill Hallman, Rutgers University

http://www.foodpolicyinstitute.org/resultpub.php
http://www.foodpolicyinstitute.org/docs/reports/NationalStudy2003.pdf

- Seven in ten (70%) don't believe it is possible to transfer animal genes into plants
- Six in ten (60%) don't realize that ordinary tomatoes contain genes
- More than half (58%) believe that tomatoes modified with genes from a catfish would probably taste fishy
- Fewer than half (45%) understand that eating a genetically modified fruit would not cause their own genes to become modified

Education needs: Gullibility

- "People seem to have a great number of misconceptions about the technology. As a result, they seem to be willing to believe just about anything they hear about GM foods.“



Pseudo-scientific, anti-GMO literature common – science as weapon vs. light

Views on biotech polarized

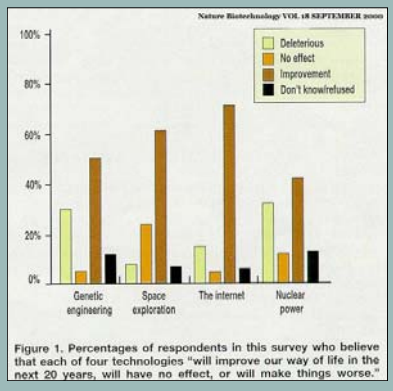


Figure 1. Percentages of respondents in this survey who believe that each of four technologies "will improve our way of life in the next 20 years, will have no effect, or will make things worse."

Spring 2000 survey results

There is discriminating public support for agbiotec in the USA

Are these good or bad reasons to genetically modify plants or animals?

	VERY GOOD	VERY BAD
→ To reduce the need to use pesticides on crops	43%	12%
To reduce the cost of fish, like salmon	21%	27%
→ To produce more affordable pharmaceutical drugs using plants	54%	8%
To produce more affordable pharmaceutical drugs using animals	23%	29%
→ To create peanuts that won't cause allergic reactions	42%	15%
→ To produce less expensive food to reduce hunger in world	52%	12%
To produce more affordable industrial compounds in plants	2%	17%
→ To create new types of grass that don't need to be mowed as often	39%	22%
To create fruits and vegetables that last longer on the store shelves	27%	30%
To produce beef with less fat	27%	32%
→ To expand our understanding of science and nature	46%	10%

SOURCE: Pew Initiative on Food and Biotechnology Sept. 2004

CLASS TOPICS, ORIENTATION

Emphasis on science/scholarly vs. mainly social, public views

Practitioner perspectives

Risks, benefits, fears, laws for chemicals and genes similar

What are the key biotech issues?

- New and rapid science (genes and gene transfer) give many options = technology push
- Breaking of traditional boundaries in moving genes, press ethical views of life
- Poor understanding
  - Science and technology = prone to fear
  - Context of breeding and extensive modification of food crops and products unknown to most
- Strong ideological and political forces
  - Green and organic and natural vs. GMO / NGO roles

Major genetic changes in crops are critical to human health and feeding the world = "domestication"

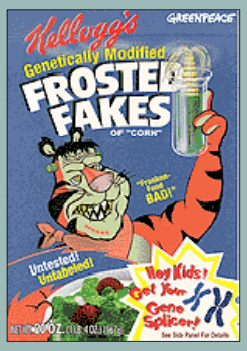
Domestication of *Brassica oleracia*

NGOs as major political forces, at legislative and public opinion levels

GE vs. organic foods

www.soilassociation.org/web/sa/saweb.nsf/

- "GM crops cannot be controlled, and if we are to preserve the integrity of organic food, ... the commercial growing of GM crops must be halted."



What are the issues?

- Patents on life
- Corporate control of seeds and agriculture
- Role of governments in regulation
  - Labeling? Allowance for trade?
  - What is secret vs. public?
  - What is adequate risk assessment for a gene?
    - Environment: How can it be done in containment in the environment? What are standards?
    - Food safety: Allergenicity? Safety? In absence of feeding trials?
- Pollen and seeds move around = contamination. How much is too much?

Social perspectives vary dramatically

Swiss 'dignity' law is threat to plant biology

When it comes to the ethics of experimenting on living subjects, plant biologists have had cause for a certain smugness. But perhaps no longer in Switzerland.

The Swiss federal government's ethics committee on non-human biotechnology has mapped out guidelines to help granting agencies decide which research applications deeply offend the dignity of plants — and hence become unfundable.

Although most people might be bewildered that a discussion on how to define 'plant dignity' should be taking place

NATURE|Vol 452|24 April 2008 NEWS

Science perspectives also vary dramatically

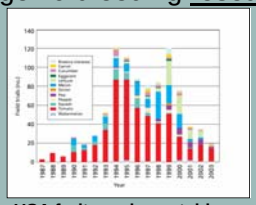
Scrutinized. Perhaps the hottest issue was the role of genetically modified crops in helping poor farmers and making agriculture more sustainable.

14 MARCH 2008 VOL 319 **SCIENCE** www.sciencemag.org

Published by AAAS

Even in USA, for most crops the biotech revolution is ~over, or on hold

DOE and USDA avoid funding even transgenic breeding <u>research</u>



USA fruits and vegetables (California Agriculture 2004, Redenbaugh & McHughen)

Some class mechanics - readings

http://www.cof.orst.edu/cof/teach/agbiotox/index.htm

- Great newish "text book"
  - The book (with recipes) a rare attempt to prove a scientific, thoughtful, integrated, organic <u>and</u> biotech view – marriage of biotech scientist and organic farmer
  - Lecture and video of it on outreach web site
- Many other readings
  - No attempt to closely integrate readings and lectures– two streams of knowledge and perspectives on common issues
  - We, and you, integrate with discussions, essays, and exams
- Readings still evolving – set for this week only so far

Some class mechanics - readings

- There is a lot of reading but you are not responsible for the gory details – read it all but don't memorize the minutiae
  - See past exams on web to help you understand what is gory and what is not!
  - "Peruse only" means read abstract, view figures/tables, be familiar with main points and headings – will be on exams in general way
- Grad and honors students with different requirements and grading – know them
- **Recitations** variable, but often discussions that start with comments from you – <u>do those readings ahead of time</u>
  - Do all readings before exams!

Some class mechanics – writing and presentations

- First essay: A chance to tell us about who you are re. this class, your interests and concerns – due Thursday
  - 2 to 3 other written products
  - Make the essays/labeling piece good, clearly written and organized / quality of organization, writing, grammar **30% for all written products**
- Brief presentations of your second essays in front of class
- No term paper given recitations, reading load
- Most lecture structures include discussion time
  - 50 minute lectures with questions of clarification, then
  - Small group discussions, questions/comments with speakers
  - Rotating reporter/presenter

Other class mechanics

- Email us – we are happy to meet – but no regular office hours
- Grading on web site
  - Note that **attendance and participation count a lot**
- Lecture ppts generally not available ahead of lectures – esp for guest speakers
  - Students are responsible for content of ppts even if lecturers do not finish presenting all of it in class
- Last session on "should we label" and how: A main goal is fun in role playing while exploring that difficult issue

STATE OF BIOTECH-GE CROPS

GE crops have been taken up rapidly by farmers when available

2007 ISAAA Report on Global Status of Biotech/GM Crops

by
Dr. Clive James, Chair, ISAAA Board of Directors

International Service for the Acquisition of Agri-biotech Applications (ISAAA)
http://www.isaaa.org

ISAAA

US registered, Not-for-Profit Charity, co-sponsored by public and private sector organizations

Mission of ISAAA :

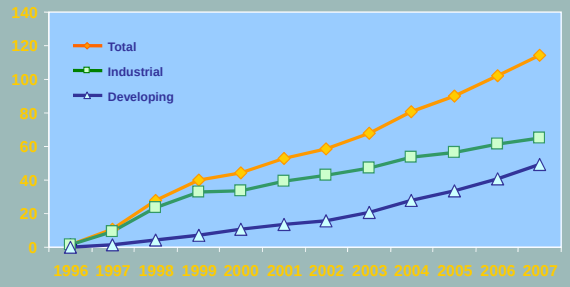
• Share knowledge on crop biotechnology so that the global community is more well informed about the attributes and potential of the new technologies

• Contribute to poverty alleviation by increasing crop productivity and income generation, particularly for resource-poor farmers, and to bring about a safer environment and more sustainable agricultural development, through crop biotechnology.

• For more information, visit http://www.isaaa.org

Global Area of Biotech Crops 1996 to 2007

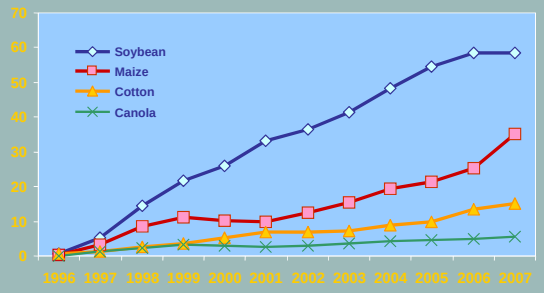
Industrial and Developing Countries (Million Hectares)



Source: Clive James, 2008

Global Area of Biotech Crops 1996 to 2007

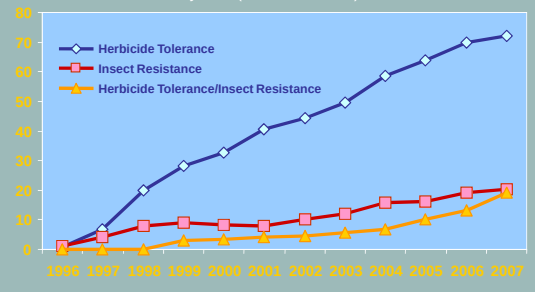
By Crop (Million Hectares)



Source: Clive James, 2008

Global Area of Biotech Crops, 1996 to 2007

By Trait (Million Hectares)

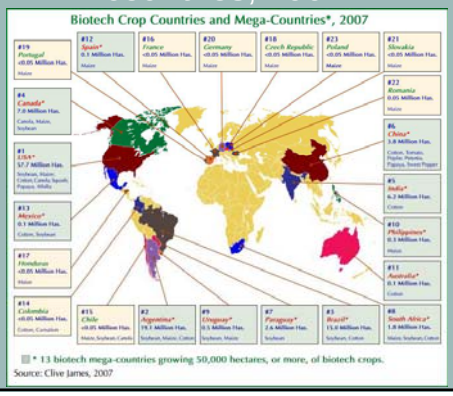


Source: Clive James, 2008

Biological issues of commercialized GE crops

- Herbicide tolerant crops
  - Reliance on one or few herbicides, thus promotion of herbicide resistance by weeds
  - Gene spread to wild relatives, complicating their control by herbicides (canola)
- Insect resistant crops
  - Strong selection for resistance by pests (thus EPA-mandated gene-free refuges and monitoring)
  - Spread to weeds, potentially improving their fitness and spread, and impacting non-target organisms that feed on them

Biotech crop countries and mega-countries, 2007



USDA report on biotech crops in the USA

http://www.ers.usda.gov/publications/eib11/eib11.pdf

United States Department of Agriculture

USDA

Economic Research Service

Economic Information Bulletin Number 11

April 2006

The First Decade of Genetically Engineered Crops in the United States

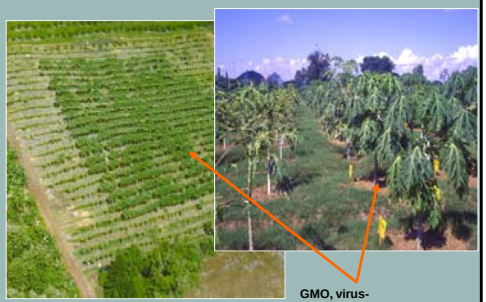
Jorge Fernandez-Cornejo
Margriet Caswell

Its not all mega-crops

Virus-resistant papaya saved the Hawaiian industry in the mid-1990s

"Immunization" via by implanting a viral gene in the papaya genome

Great humanitarian potential, US AID project to help develop it



Courtesy of Denis Gonsalves, formerly of Cornell University

Some products may have large humanitarian benefits

Many different types of GMO crops

"GMO per se means virtually nothing in terms of significance of biological impact/change"

- Can impart new functions as well as modify existing functions

- Herbicide tolerant
- Insect tolerant
- Disease tolerant
- Bioreactors (drugs, industrial chemicals)
- Modified properties (e.g., high lysine corn, high starch potato)
- Improved stress tolerance (salt, heat, cold)
- Modified fertility (hybrids, containment)
- Genomics science provides continuing flow of options, innovations

Discussion questions

- Anything unclear on class mechanics?
- What messages have you mostly heard about biotech and from where did you hear them?
- What are the issues that you heard about today that are of most interest to you and why?