

HOW MUCH **DNA** DO YOU EAT?\*

# SCIENCE BEHIND BIOTECH IN AGRICULTURE

## Resources for Teaching Ag Biotech

*Peggy G. Lemaux*

*<http://ucbiotech.org>*

*<http://pmb.berkeley.edu/~lemaux>*

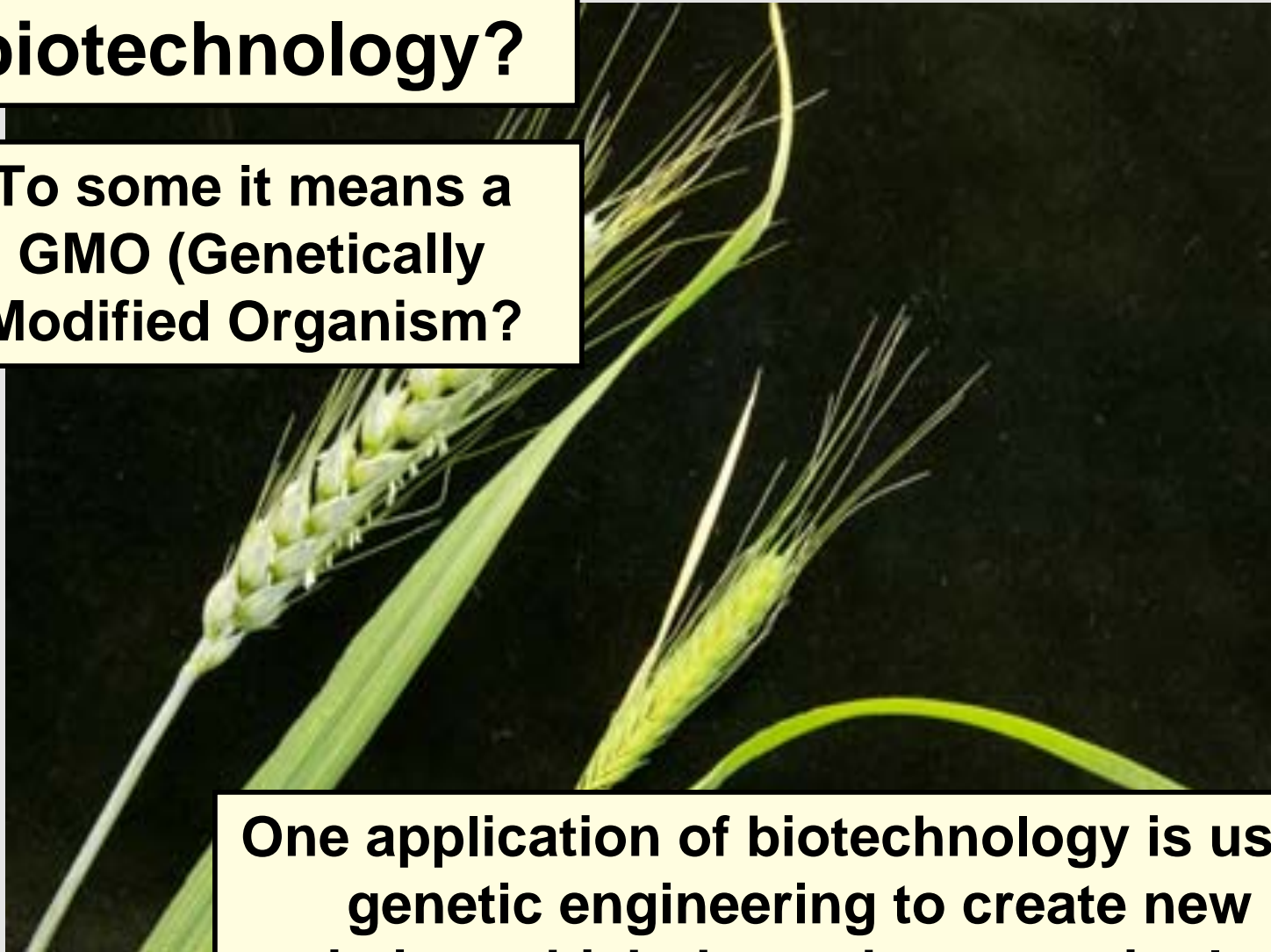
WHOLE TOMATO  
(7mg)

WHOLE BANANA  
(50mg)

All living things have DNA, the chemical that contains all information responsible for the way it looks and how it works. That chemical, a string approximately 5 feet long, can be isolated. The isolated DNA in each food is seen in the tube on the right.

# **What is biotechnology?**

**To some it means a  
GMO (Genetically  
Modified Organism?)**



**One application of biotechnology is using  
genetic engineering to create new  
varieties, which depends on manipulating  
the organism's DNA**

# How have we created new varieties in the past ?



Classical breeding involves mixing DNA of female cells from one wheat variety with DNA from male cells of another...

*Triticum aestivum*

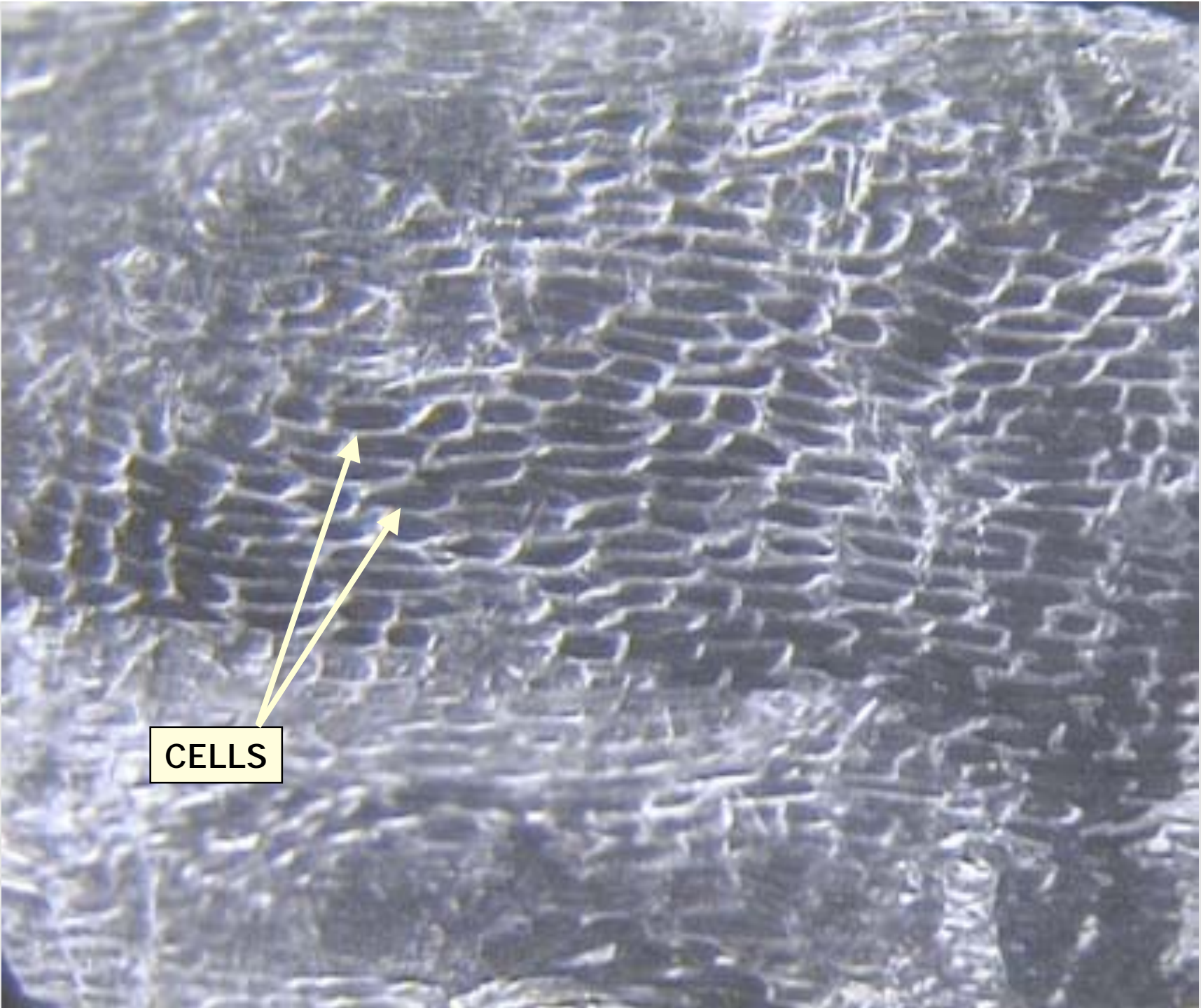
*Triticum monococcum*

**Modern bread variety**   **Ancient variety**

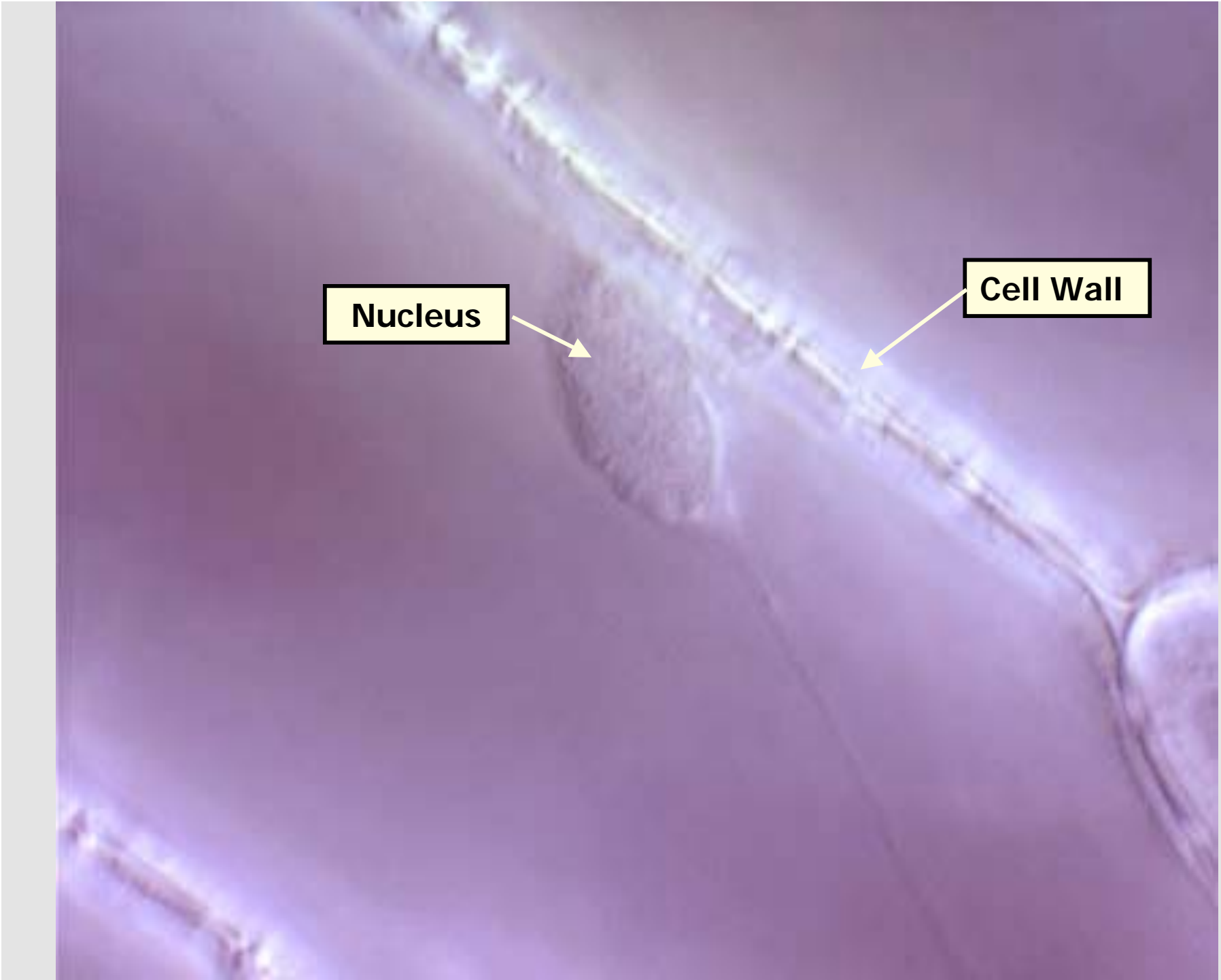
**This results in mixing the genetic information of the two wheat plants?  
What does the DNA look like?**

Peeled tissue

Tweezers

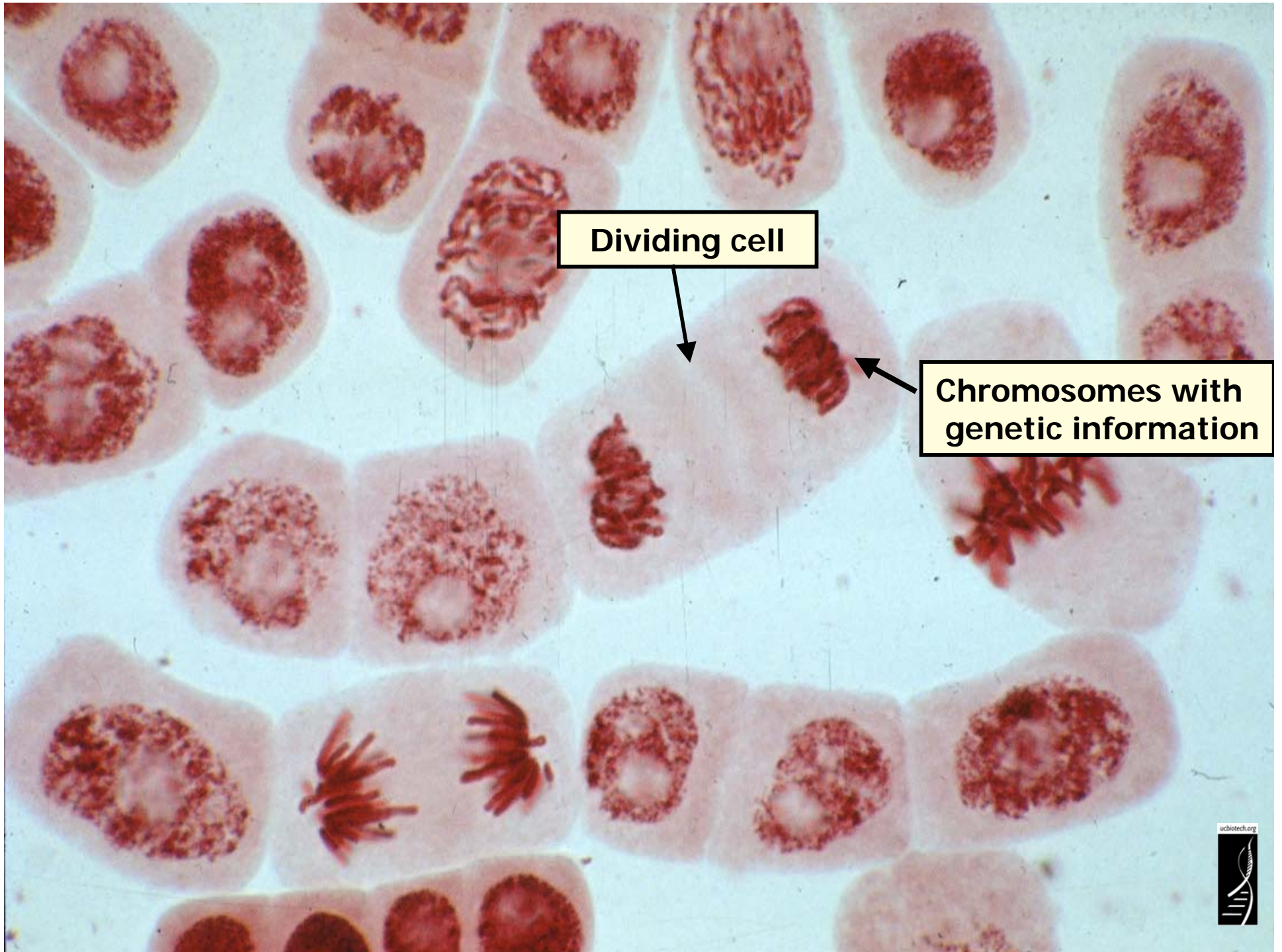


**CELLS**



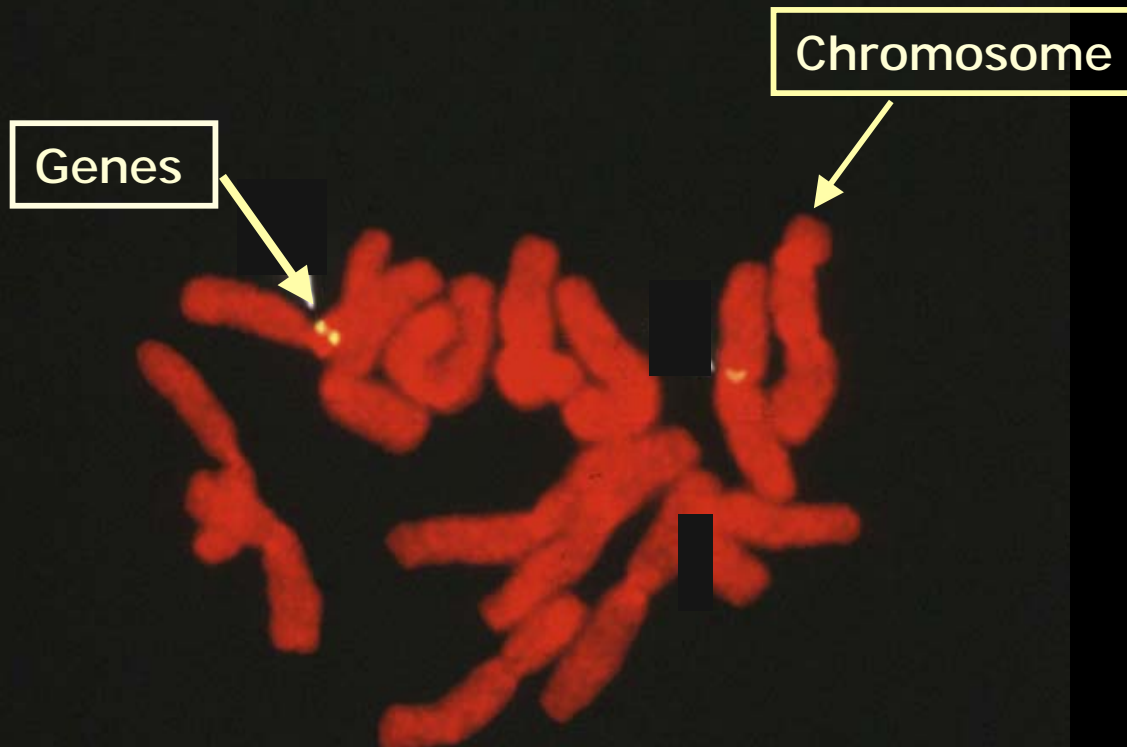
**Nucleus**

**Cell Wall**



**Dividing cell**

**Chromosomes with genetic information**



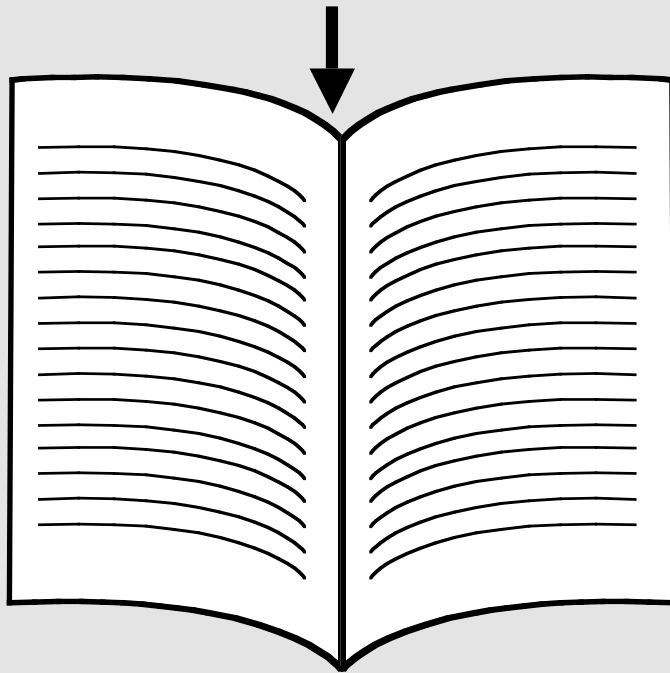
**Now what happens to all of the DNA and genes when we cross two plants?**



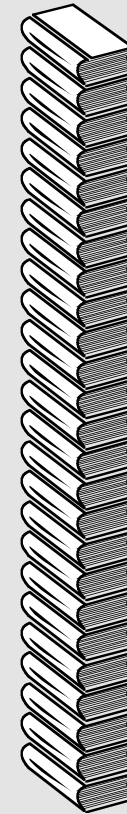
# Genetic information in wheat genome

Made of chemical units represented by alphabetic letters


...CTGACCTAATGCCGTA...



**1700 books**  
**1000 pages each**

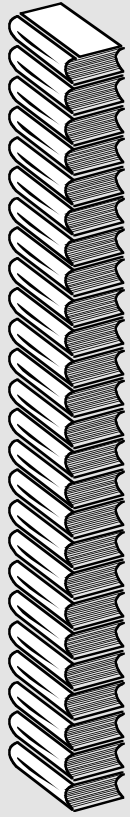


**1700 books**  
**(or 1.7 million pages)**



**How can the genetic information in the cells of the wheat plant be modified to create new varieties?**

# Hybridization or cross breeding of wheat



**X**

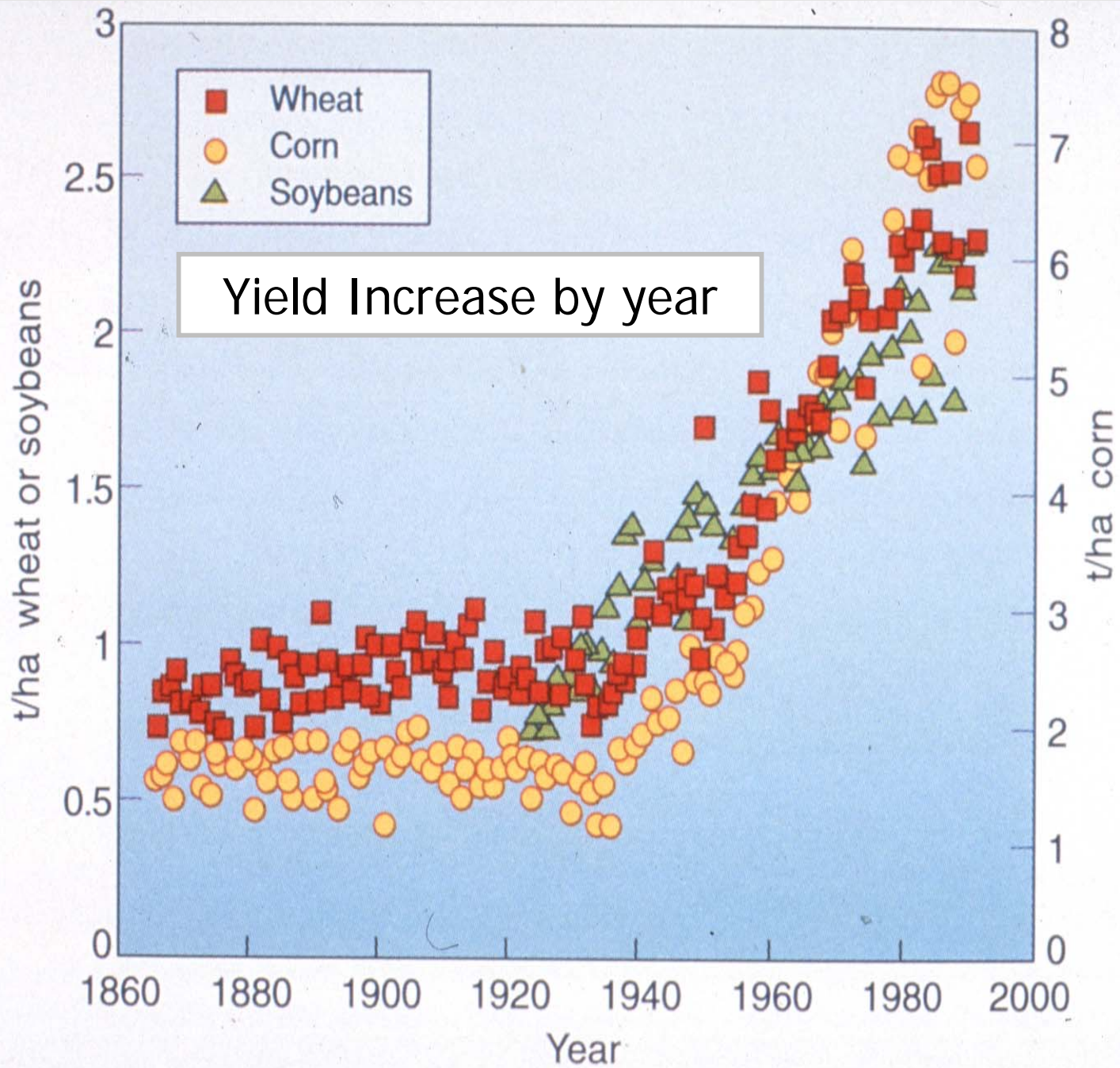


Random  
retention of  
information  
from each  
parent

**1700 books  
(or 1.7 million pages)**

**1700 books  
(or 1.7 million pages)**

**1700 books  
(or 1.7 million pages)**



# Table of contents for genes in wheat

...CTGACCTAATGCCGTA...

TABLE OF CONTENTS	
Introduction	1
Materials & Methods	15
Discussion	23
Section One	41
Section Two	58
Section Three	64
Section Four	70
Conclusion	89

Used for  
Marker-  
Assisted  
Breeding

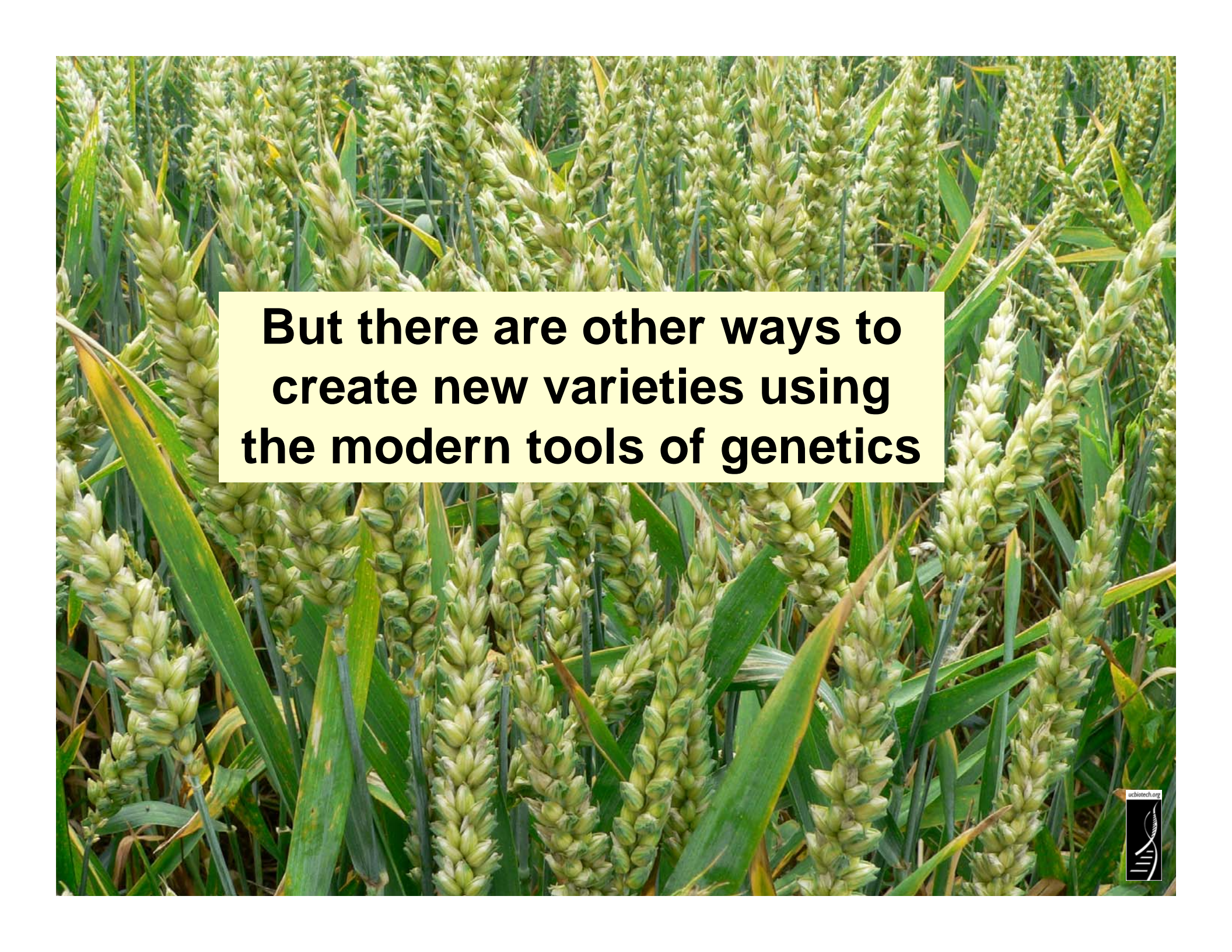
**Genomics**

**1700 books  
(or 1.7 million pages)**



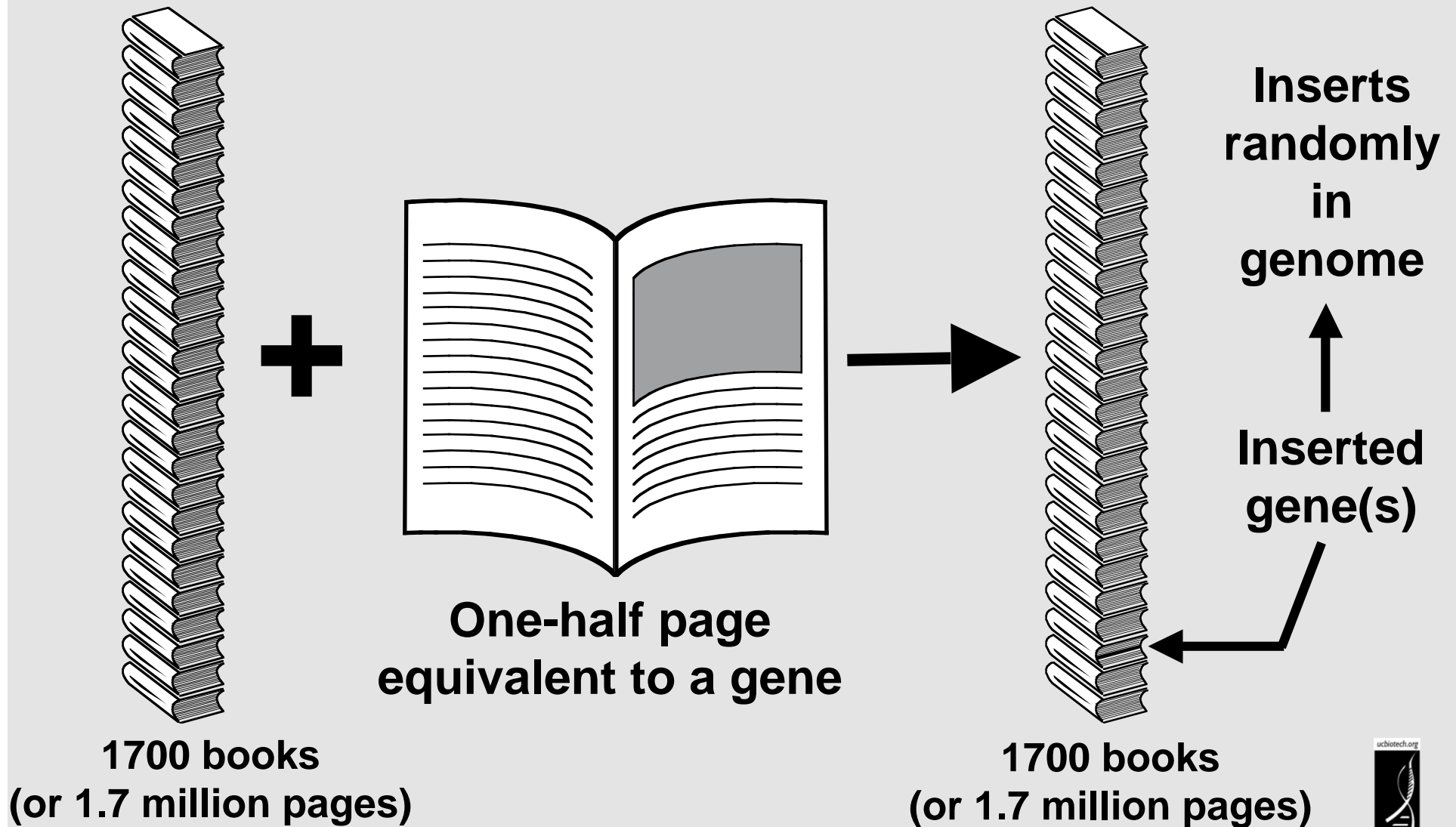
***Marker  
Assisted  
Selection  
for Leaf  
Rust  
Resistance  
in Wheat***

*Plant Protection Science 39: 13-17*




**But there are other ways to  
create new varieties using  
the modern tools of genetics**

# Genetic Engineering Methods







*Creating less allergenic  
wheat varieties through  
genetic engineering*

*Li et al. 2009 Molecular Plant*



# *Classical Breeding*

compared to

# *Genetic Engineering*

Uses plant machinery in  
plant

Gene exchange is  
random involving entire  
genome

Only between closely related  
or within species

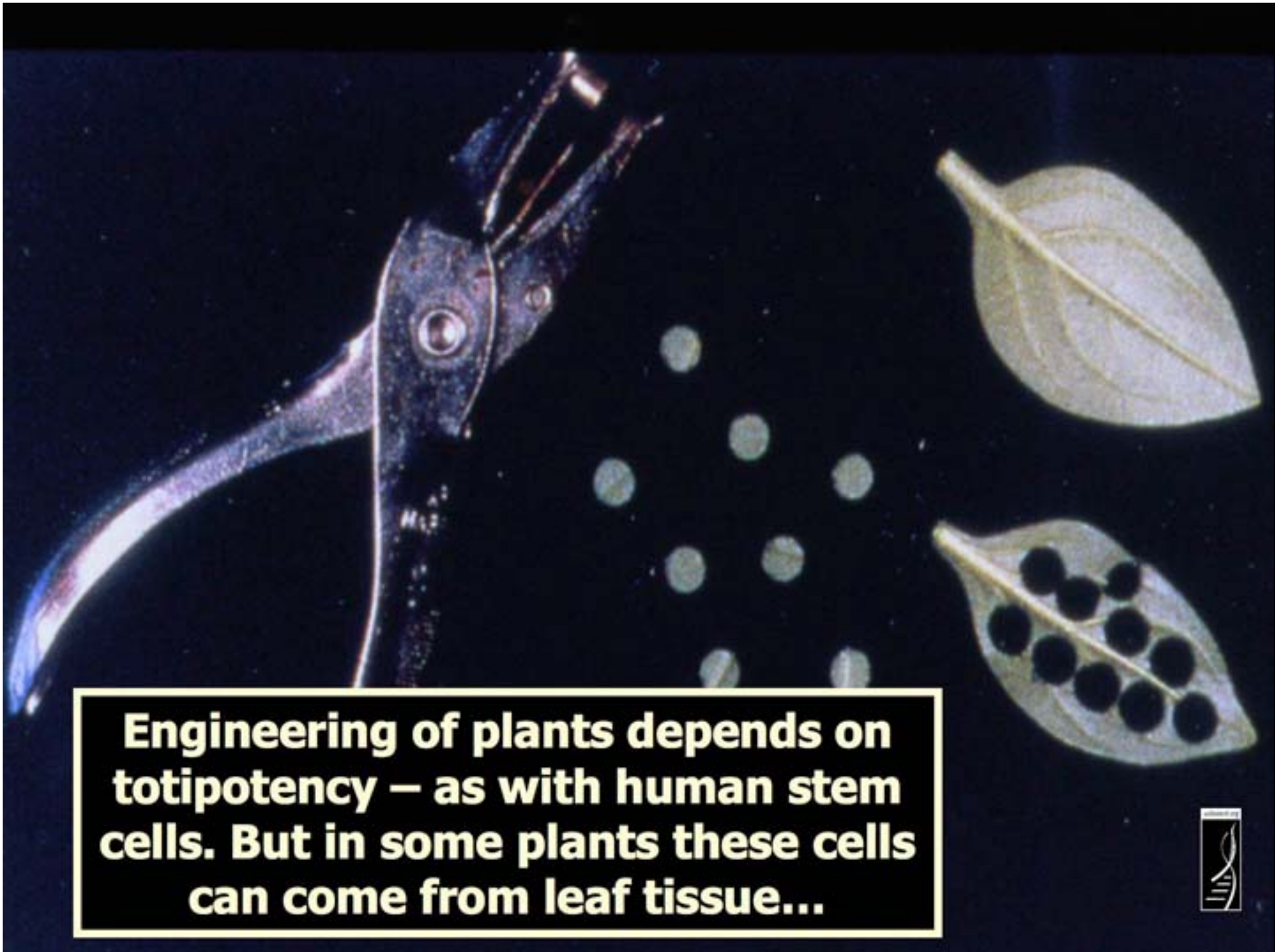
Uses plant machinery in  
laboratory

Gene exchange is  
specific, single or a few  
genes

Source of gene from any  
organism

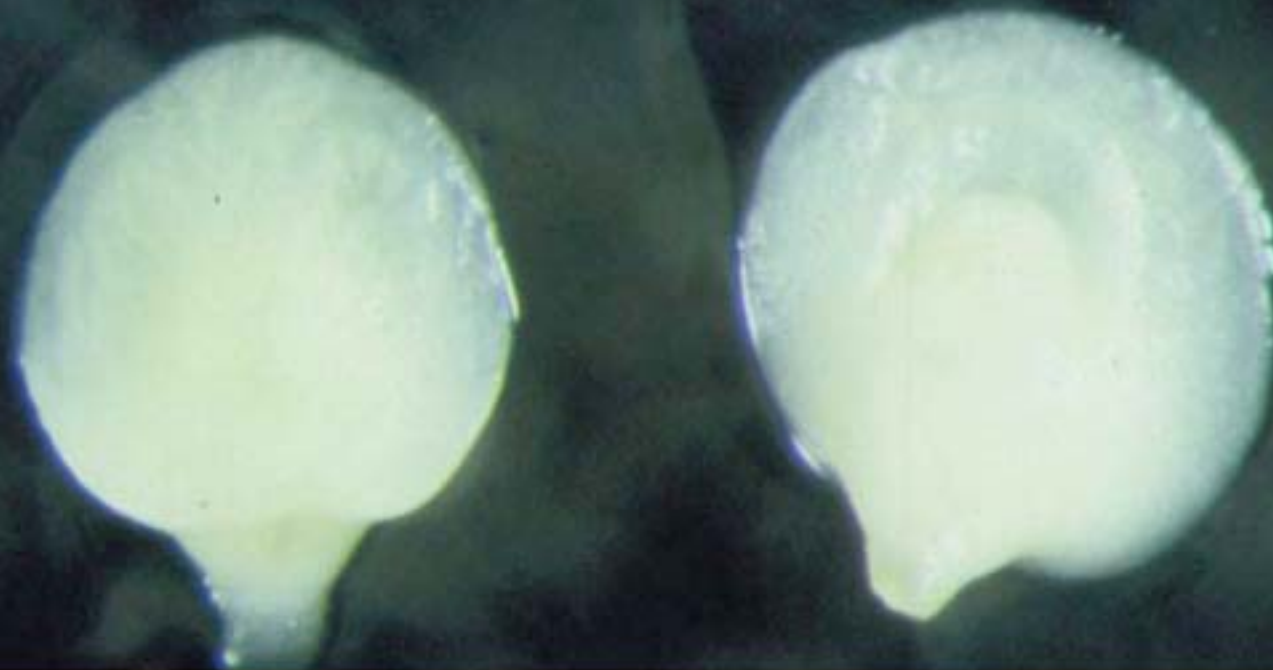


**Exactly how do you perform genetic engineering of crops, like barley, wheat, corn, rice, sorghum...**



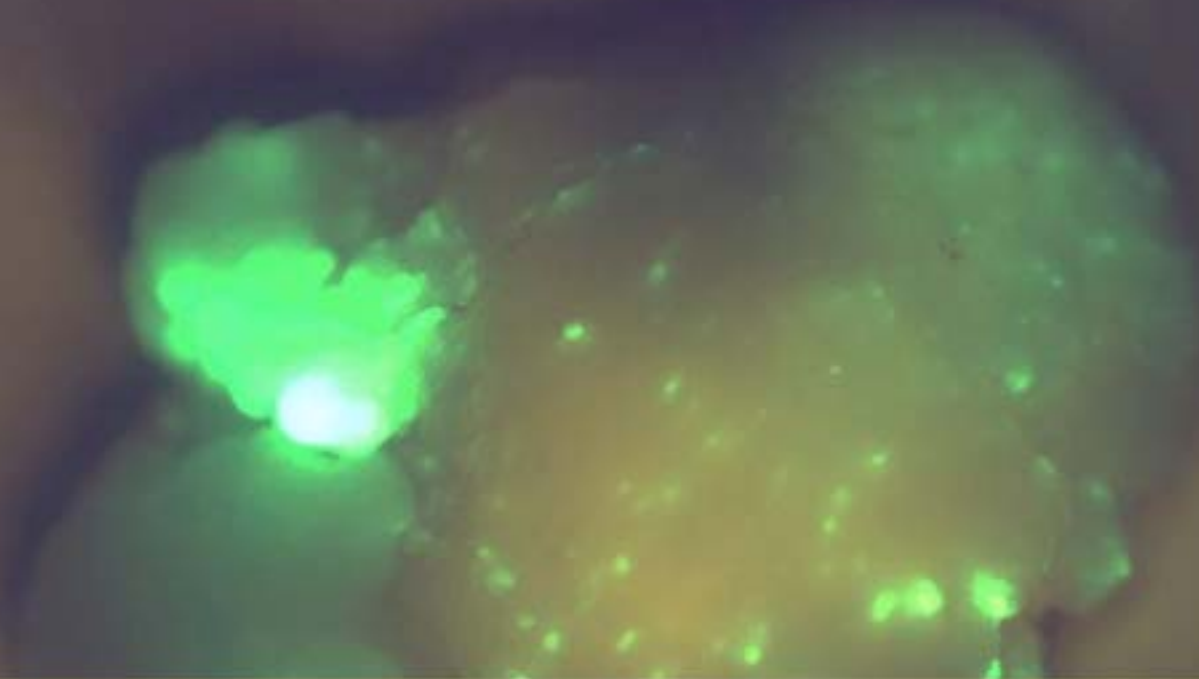
**Engineering of plants depends on totipotency – as with human stem cells. But in some plants these cells can come from leaf tissue...**





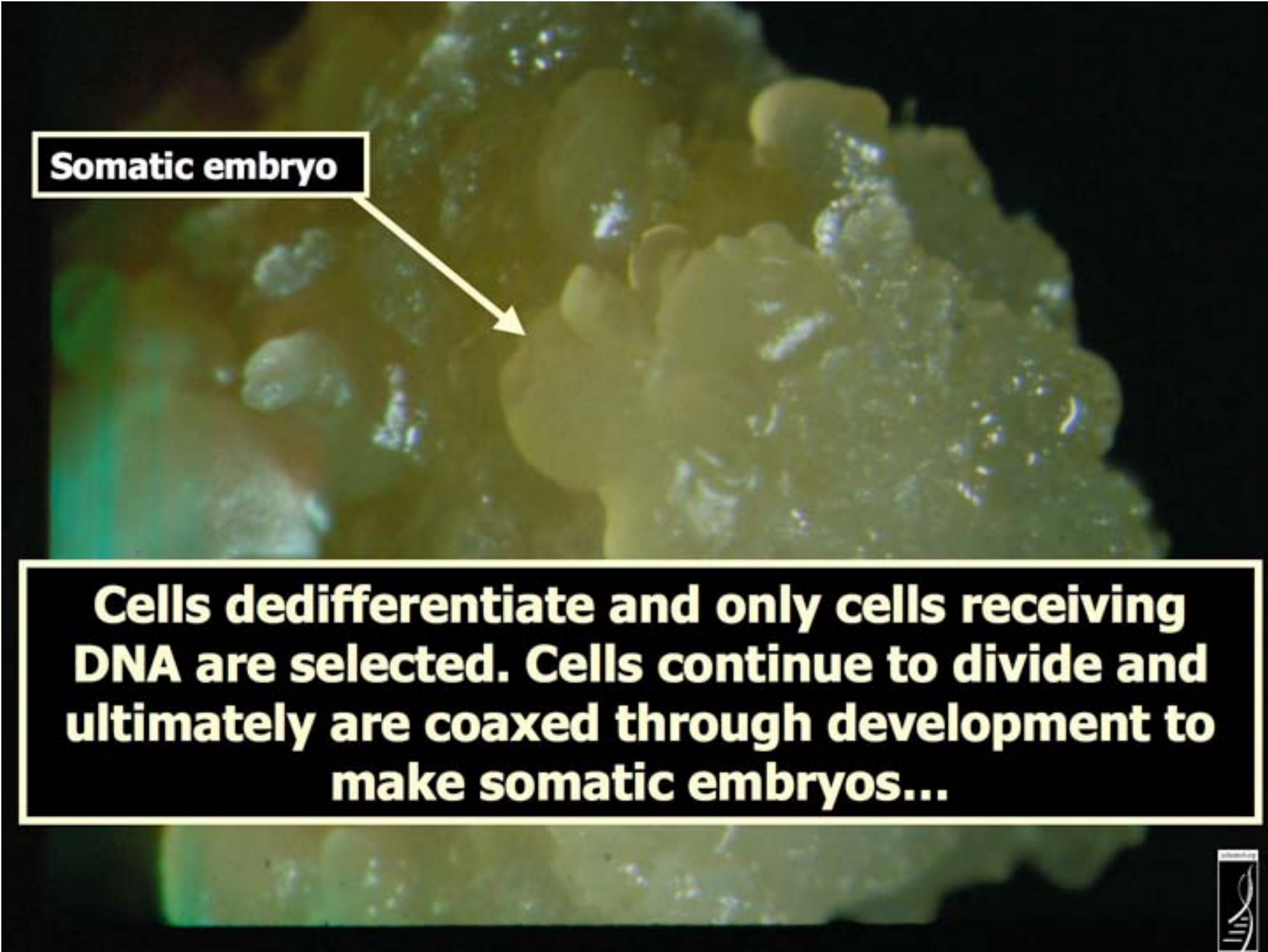
**In cereal crops it is immature embryos that provide totipotent cells ... embryos are placed on medium with plant hormones...**





**DNA with a gene responsible, in this case for green fluorescence, can be introduced using either a bombardment “gun” or a naturally occurring bacterium that injects DNA into the cell; seed germination stops and cells divide...**

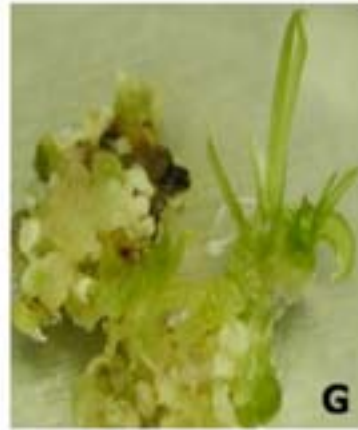
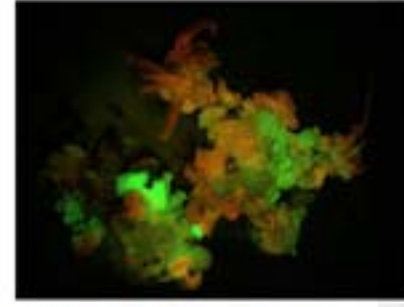
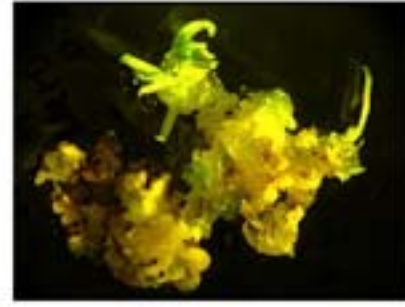
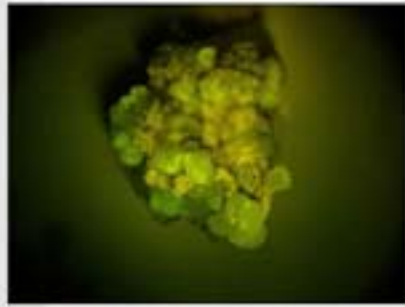


A microscopic image showing a cluster of cells, likely a somatic embryo, with a yellowish-green hue. A white arrow points from a text box to a specific cell within the cluster. The background is dark, making the cells stand out.

**Somatic embryo**

**Cells dedifferentiate and only cells receiving DNA are selected. Cells continue to divide and ultimately are coaxed through development to make somatic embryos...**





**Cells containing your gene of interest and a selectable marker gene are then cued with other hormones to remind cells to form leaves and then roots.**



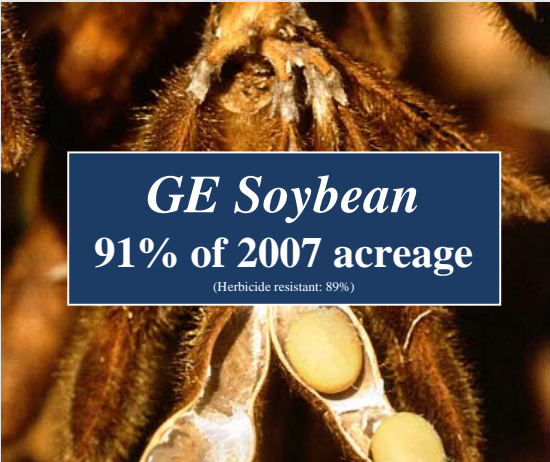




**Now what kind of new traits would you like to introduce?**



**Finally you end up with an engineered plant, every cell of which has the introduced gene(s) and the plant has new characteristics.**



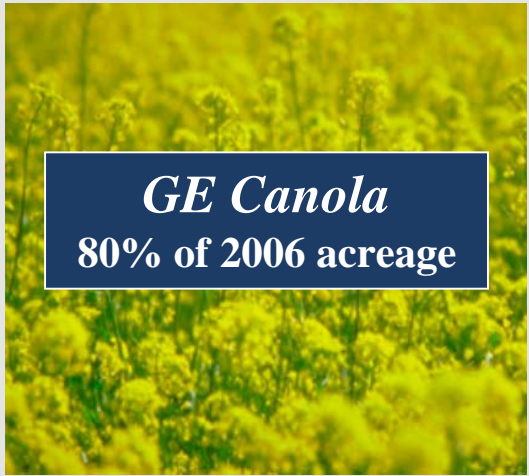
***GE Soybean***  
**91% of 2007 acreage**

(Herbicide resistant: 89%)

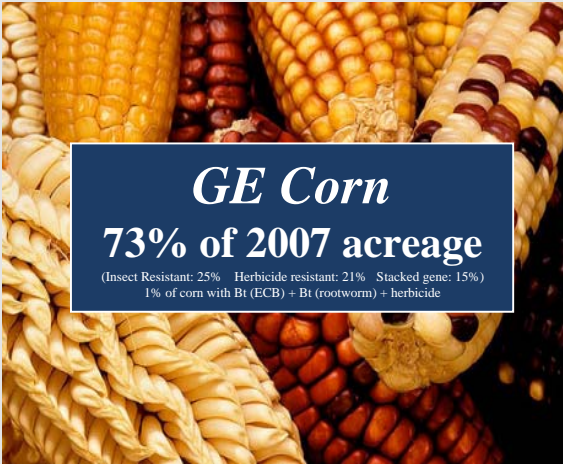


***GE Cotton***  
**87% of 2007 acreage**

(Insect Resistant: 18% Herbicide resistant: 26% Stacked gene: 39%)



***GE Canola***  
**80% of 2006 acreage**



***GE Corn***  
**73% of 2007 acreage**

(Insect Resistant: 25% Herbicide resistant: 21% Stacked gene: 15%)  
1% of corn with Bt (ECB) + Bt (rootworm) + herbicide



***GE Sugar beet***  
**~50% of 2009 acreage**

(Source: SF Chronicle, 9/22/09)



***GE Alfalfa***  
**<0.5% of 2005  
acreage**



**Mainly two traits have been introduced into commercialized crops**

***Bollgard Cotton™***

**Engineered for insect resistance using gene from naturally occurring bacterium**

# *Roundup Ready Soybean*™

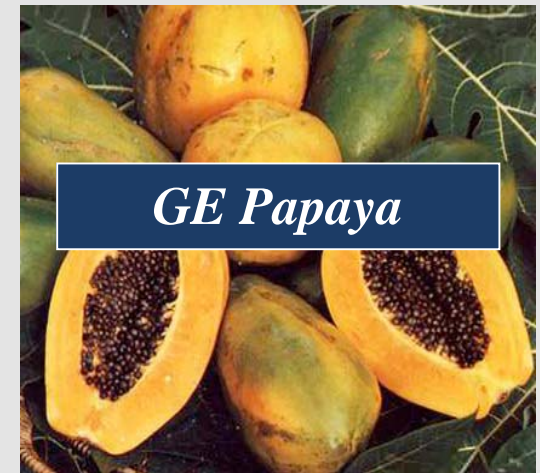


Engineered with bacterial gene to tolerate herbicide application



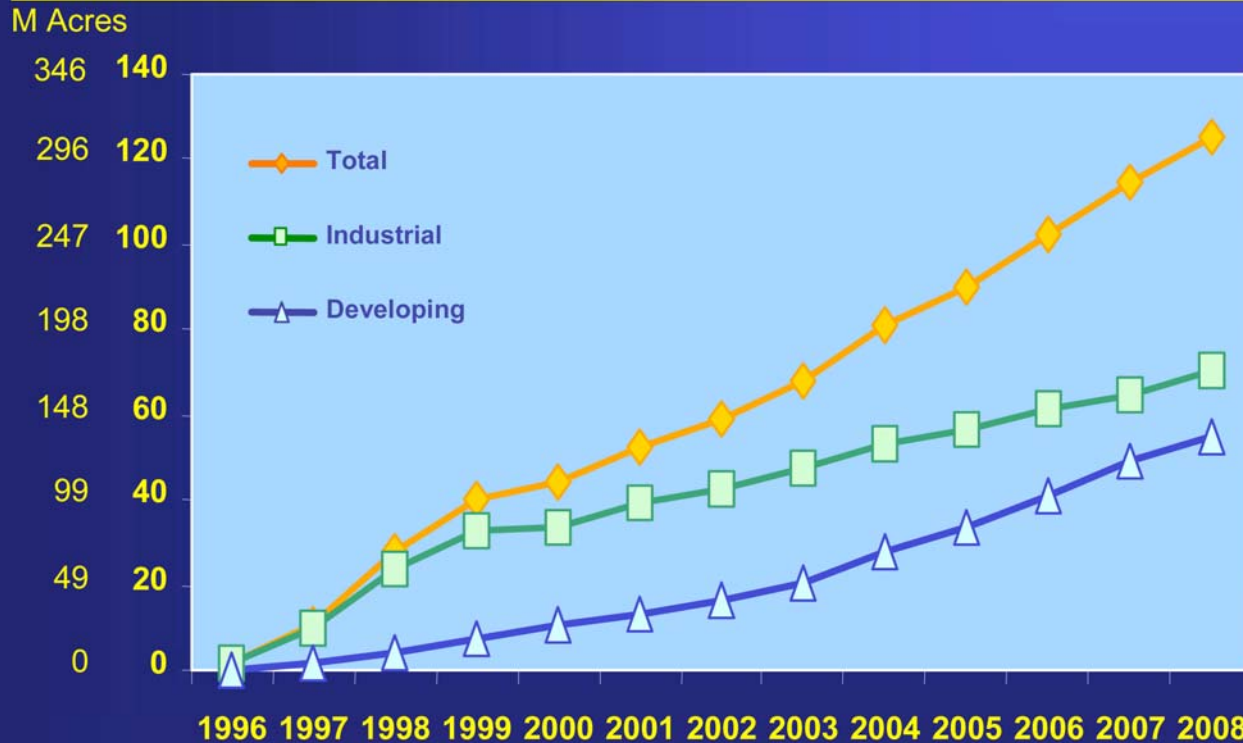
Estimated over 75% of Processed Foods in U.S. Have GE Ingredients

**Only a few whole foods  
on the market are  
genetically engineered**



# Are GE crops being grown?

## Global Area of Biotech Crops, 1996 to 2008: Industrial and Developing Countries (M Has, M Acres)



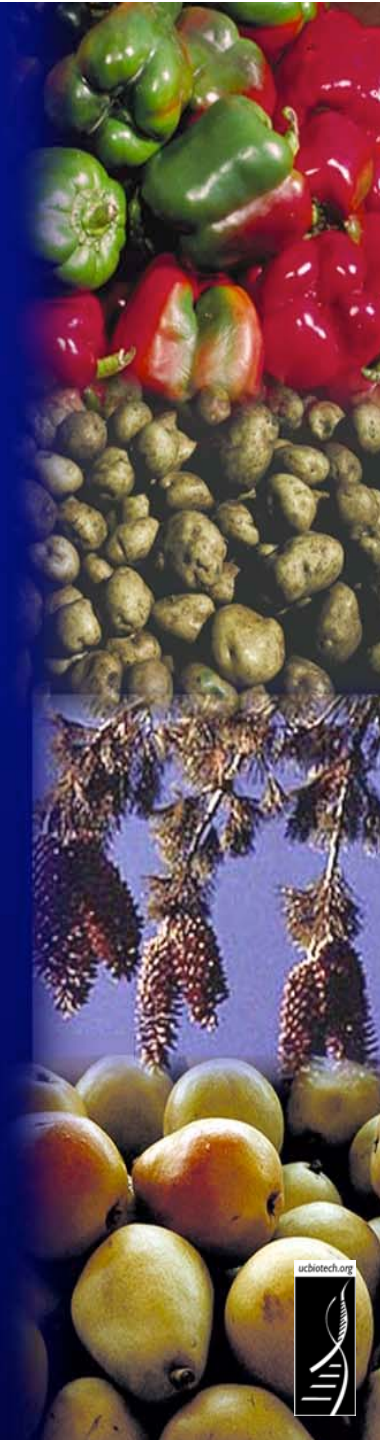
Source: Clive James, 2009

**482,812 square miles worldwide in 2008 (equal to combined areas of CA, TX and NY) in 25 industrial and developing countries**

**Most are in the U.S., Argentina and Brazil**

**But overall there are 25 industrial and developing countries in order of acreage: United States, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Bolivia, Philippines, Australia, Mexico, Spain, Chile, Colombia, Honduras, Burkina Faso, Czech Republic, Romania, Portugal, Germany, Poland, Slovakia, Egypt.**

# *WHAT'S IN THE PIPELINE?*







***Arcadia Biosciences develops canola  
that uses 50% less nitrogen fertilizer***


SOURCE: [http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet\\_april\\_10.htm#story0](http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0)



# *Drought tolerant plants grow vigorously after prolonged drought*



*SOURCE: Rivero, R.M., Kojima, M., Gepstein, A., Sakakibara, H., Mittler, R., Gepstein, S. and Blumwald, E. 2007. Delayed leaf senescence induces extreme drought tolerance in a flowering plant. Proceedings of the National Academy of Sciences USA 104: 19631-19636.*



*Field Trials Conducted in California  
with Grape Root Stocks Engineered  
for Resistance to Fanleaf Virus*

SOURCE: <http://www.democratandchronicle.com/apps/pbcs.dll/article?AID=/20080806/BUSINESS/808060336/1001>





*Genetically engineered pollen  
reduces allergy symptoms*

*SOURCE: Niederberger et al., 2004. Vaccination with genetically engineered allergens prevents progression of allergic disease. PNAS early edition (August 13, 2004)*



# Slow-Mow grass addresses water, maintenance and weed problems



*SOURCE: "Engineering a mow-less lawn", New York Times, 4/22/06  
[http://www.nytimes.com/2006/04/22/business/22offline.html?\\_r=1&oref=slogin](http://www.nytimes.com/2006/04/22/business/22offline.html?_r=1&oref=slogin)*





**Japanese scientists create blue  
rose with blue pigments from  
pansies**

*SOURCE: <http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20040701a2.htm>*

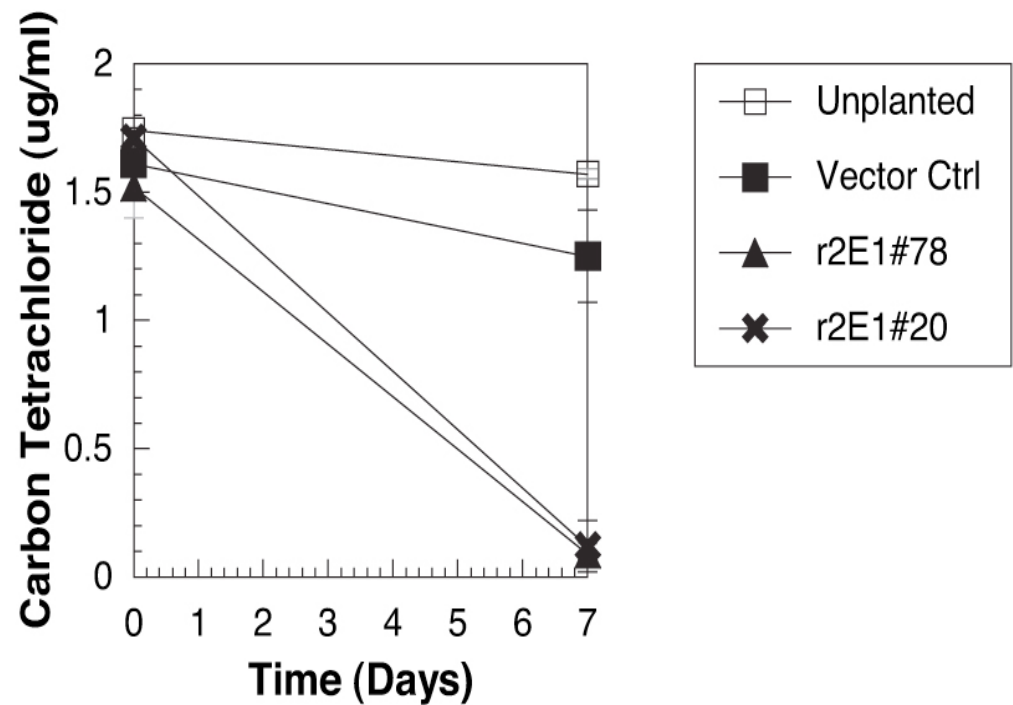




*Production of individual-specific  
vaccines for lymphoma*

*McCormick PNAS 96: 706-708*

# *Engineered poplar removes environmental pollutants through roots and air*



## Removal of carbon tetrachloride

SOURCE: Doty, S.L., James, C.A., Moore, A.L., Vajzovic, A., Singleton, G.L., Ma, C., Khan, Z., Xi, G., Kang, J.W., Park, J.Y., Meilan, R., Strauss, S.H., Wilkerson, J., Farin, F. and Strand. S.E. 2007. Enhanced phytoremediation of volatile environmental pollutants with transgenic trees. *Proceedings of the National Academy of Sciences USA* 104:16816-16821.





# ENERGY FARMS



Green algae can produce hydrogen gas – potentially providing renewable, clean fuel



**ucbiotech.org**

SCIENCE-BASED INFORMATION & RESOURCES  
ON AGRICULTURAL BIOTECHNOLOGY

HOME | **IN THE NEWS** | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACTS



# WHAT EDUCATIONAL RESOURCES ARE AVAILABLE ON THESE TOPICS AND WHERE CAN THEY BE FOUND?



**Review articles:** Focused on food, environmental and socioeconomic issues of GE crops and foods.

**Issues and Responses:** Searchable list of issues related to agriculture, foods, technologies linked to responses.



extensive collection of PP slides on agriculture & biotechnology.

Available on loan:

**Educational displays:** "Genetics and Foods" and Genetic Diversity and Genomics" available with companion educational cards and teacher worksheet in English and Spanish.

**Gene-IE Juice Bar:** Interactive activity to isolate DNA from common fruits and vegetables.

**The Tea Grow:** Educational game to teach what foods come from what crops.



Mobilizes research, education & outreach efforts in partnership with seed & biotechnology industries.

**Animal Genomics & Biotechnology**

**Cooperative Extension Program, UC Davis**

Provides education on use of animal genomics & biotechnology in livestock production.



TheCounter.com  
VISITOR: 74538

Copyright © 1999-2009 ucbiotech.org, all rights reserved

SEARCH - CONTACT - SITE MAP



# ucbiotech.org

SCIENCE-BASED INFORMATION & RESOURCES  
ON AGRICULTURAL BIOTECHNOLOGY

HOME | **IN THE NEWS** | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACTS

## know GMOS

*This website, developed for the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, provides educational resources focused broadly on issues related to agriculture, crops, animals, foods and the technologies used to improve them. Science-based information related to these issues is available, as well as educational tools and information, which can be used to promote informed participation in discussions about these topics.*

## DISPLAY CARDS NOW IN SPANISH!



We now have Spanish cards available to distribute with both educational displays. Click here for more details!

### BIOTECHNOLOGY INFORMATION



#### ANNUAL REVIEWS

Review articles: Focused on food, environmental and socioeconomic issues of GE crops and foods.

Issues and Responses: Searchable list of issues related to agriculture, foods, technologies linked to responses.

### RESOURCES FOR OUTREACH & EXTENSION, RESEARCHERS & TEACHERS



#### Slide Archive:

Extensive collection of PP slides on agriculture & biotechnology.

Available on loan:

Educational displays: "Genetics and Foods" and Genetic Diversity and Genomics" available with companion educational cards and teacher worksheet in English and Spanish.

Gene-IE Juice Bar: Interactive activity to isolate DNA from common fruits and vegetables.

The Tea Grow: Educational game to teach what foods come from what crops.

### HELPFUL SITES



#### Seed Biotechnology Center

Mobilizes research, education & outreach efforts in partnership with seed &

biotechnology industries.

#### Animal Genomics & Biotechnology



#### Cooperative Extension Program, UC Davis

Provides education on use of animal genomics & biotechnology in livestock production.

TheCounter.com  
VISITOR: 74538

Copyright © 1999-2009 ucbiotech.org, all rights reserved

SEARCH - CONTACT - SITE MAP



# ucbiotech.org

SCIENCE-BASED INFORMATION & RESOURCES  
ON AGRICULTURAL BIOTECHNOLOGY

[HOME](#) | [IN THE NEWS](#) | [BIOTECHNOLOGY INFORMATION](#) | [SCIENTIFIC DATABASE](#) | [RESOURCES](#) | [LINKS](#) | [GLOSSARY](#) | [CONTACTS](#)

## SLIDE ARCHIVE

- Acreage
- Cartoons
- Coexistence
- Developing Countries
- Eating Local
- Economics
- Environment
- Food Safety
- Legislation & Regulation
- Miscellaneous
- Organic & Coexistence
- Organic
- Pipeline
- Polls
- Stumbles Along the Way

Available below is an archive of PowerPoint slides on agriculture, food and related topics. They are constantly updated by Peggy G. Lemaux and Barbara Alonso and used in presentations (can be viewed by clicking [here](#)). They are provided as potential resources to be used in others' efforts.

They are organized by topic and are available for download as Powerpoint files. You can preview the slides in each section by clicking on the first slide and watching the slideshow, or click on any slide you wish. You can pause the slideshow at any time.





## ***Cornucopia's Challenge***

30 mins.

6587D

University of California  
Agriculture and Natural Resources  
Communication Services

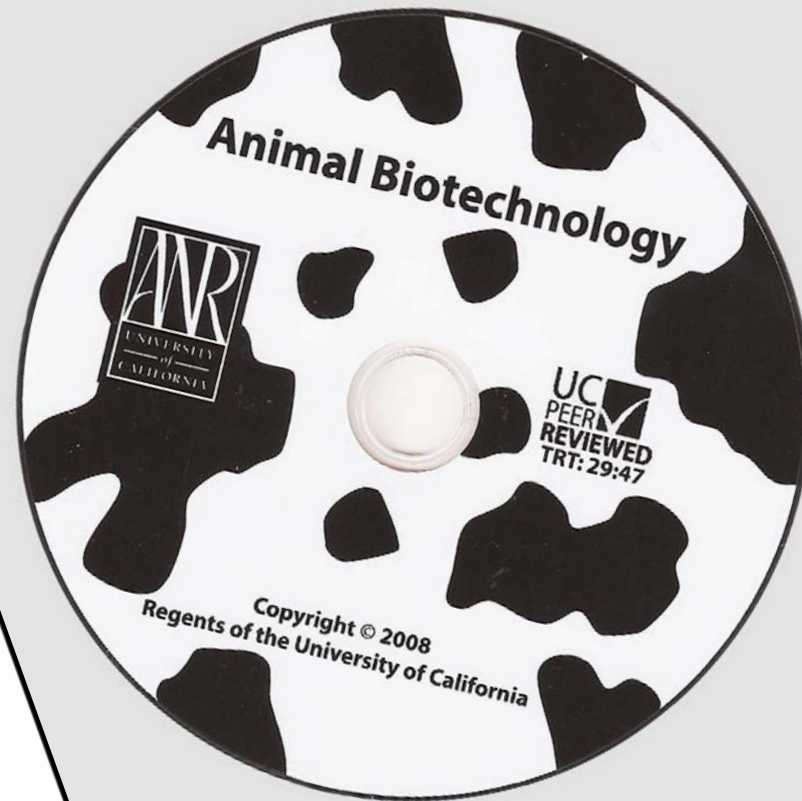
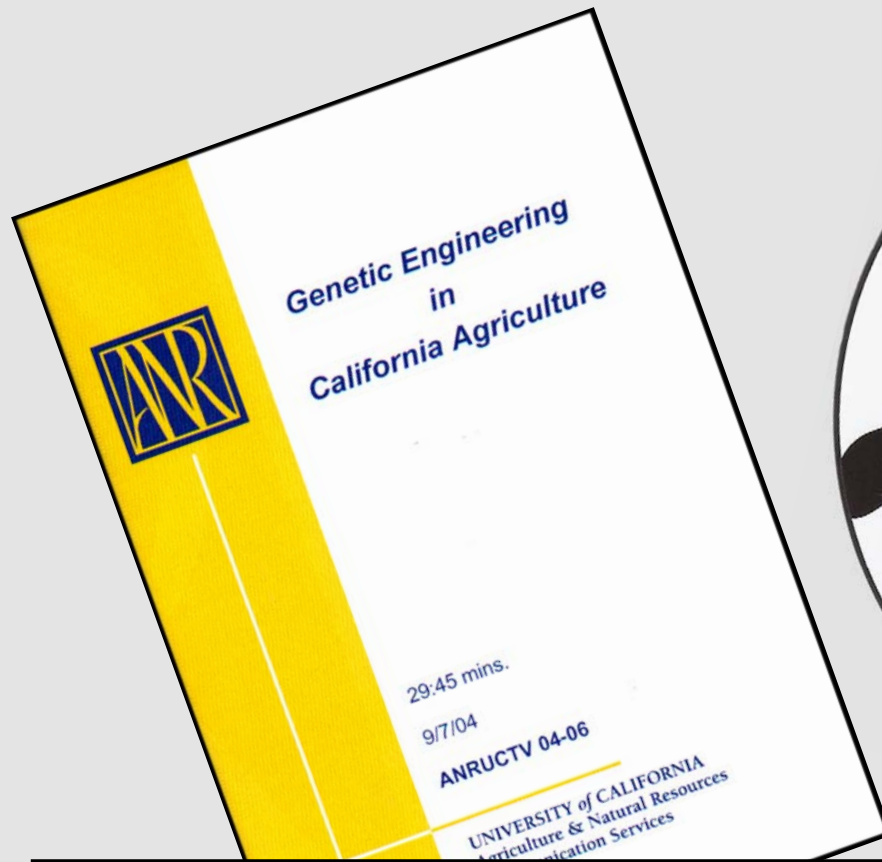


***Cornucopia's Challenge*** is a 30-minute peer-reviewed documentary that follows the journey of three crops - corn, rice and cotton - from seed to market. It looks at the variety of methods that farmers use to meet the challenges of growing, segregating, and marketing these crops to meet differing market requirements and consumer preferences.

DVD



6587



## **30-minute, Peer-reviewed Videos**

**“Genetic Engineering in California Agriculture”**: where and why GE crops and animals are being used in California.

**“Animal Biotechnology”**: addresses biomedical and agricultural applications of animal biotech, history, controversy



Partnership for Plant Genomics and Biotechnology Education

UNIVERSITY OF CALIFORNIA DAVIS

NATIONAL SCIENCE FOUNDATION

## Virtual DNA Fingerprinting Laboratory Program Outline

*Virtual DNA Fingerprinting Laboratory 2.0*<sup>®</sup> involves students in solving a forensic mystery. Over the course of seven episodes, students collect evidence, extract DNA, perform a southern blot, use PCR, and finally solve the crime.

Information about the subject of DNA fingerprinting builds as students progress through the episodes. Please see the *help & info.pdf* file located on the CD-ROM for details about installation, game play, scoring, and teacher options. Teachers may also find the *DNA lab quiz.pdf* file a useful tool to help track student comprehension of material as they complete each episode.

Designed for the secondary level and above, this software addresses the following facets of the National Science Education Standards:

### Science as Inquiry

- Identify questions and concepts that guide scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise scientific explanations and models using logic and evidence
- Recognize and analyze alternative explanations and models
- Understandings about scientific inquiry

### Life Science

- The cell
- Molecular basis of heredity
- Matter, energy, and organization in living systems



Genetics & Foods Display

Genetic Diversity & Genomics

Informational

Teacher Handouts

GENEie Juice Bar

Tic Tac Grow Game

## Genetics & Foods Display



*Click on display to see detailed versions*

Describes the way foods have changed in the past and now in the present using the new genetic tools, using tactile, visually striking and informative modules.



Display and accompanying cards are available on loan. Please click [here](#) to arrange a reservation. Some shipping costs can be provided.

Partial funding provided by the [American Society of Plant Biologists](#). Design by B. Alonso.

## Genetic Diversity & Genomics Display



*Click on display to see detailed versions*

Describes importance of plant variation to the future of foods and how and why plants have changed over time. Composed of tactile, visually attractive interchangeable modules.



Display and accompanying cards are available on loan. Please click [here](#) to arrange a reservation.

Partial funding provided by the [American Society of Plant Biologists](#). Design by B. Alonso.

[TOP](#)



## Informational Cards



Based on educational display on genetics and foods, these “baseball” cards and the displays are available for teachers. Each cards is based on a display module and can be used in the classroom and beyond. Available in both English and Spanish.

### In English



### In Spanish





Click on images to see detailed versions | [Instructions \(PDF file\)](#)

This interactive activity, mimicking contemporary juice bars, stands alone or can accompany the Foods display. It teaches that DNA and genes are a natural part of our every day lives. Bar includes materials needed for DNA isolation: blender, reagents, colorful beakers and tubes, and an educational handout.

Juice bar is available on loan. Please click [here](#) to arrange a reservation. The "How Much DNA Do You Eat" module is also available separately.

An extraction method for strawberry DNA is also available ([Download PDF](#)).

**[Instructional Video - click to watch!](#)**



Additional DNA extraction information:

Steven Ruzin, Biological Imaging Facility, UCB: [Isolating DNA from Veggies \(9MB\)](#)  
(downloadable movie file: [Mac \(hqx: 13.3MB\)](#); [PC \(zip: 9.6MB\)](#)). Strawberry DNA extraction ([PDF](#)).

**Presence of transgenes can be detected with commercial test kits.**

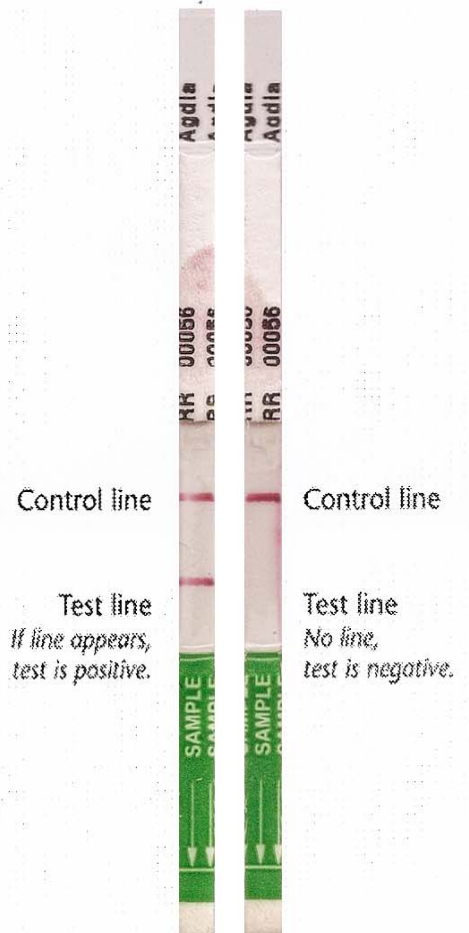


# Roundup Ready<sup>®</sup> (CP4 EPSPS) ImmunoStrip Test

Strip tests for the detection of CP4 EPSPS protein

Catalog no. STX 74000

## Results



Positive (+)

Negative (-)

The control line will appear in 3 to 5 minutes. Maximum reaction occurs in 20 minutes at which time the ImmunoStrip should be removed from the buffer. The control line assures that the test is working properly. If the control line does not appear, the test is invalid.

If the sample is positive, the test line will also appear. If the sample is negative, the test line will not appear.

Do not remove the strip from the sample if control line is not visible. Leave the strip in the sample until the control line is visible and the sample flows into the wicking pad. Depending on the flow characteristics of the sample, the time to develop the signal may vary.

If you wish to keep the strips as permanent records cut off the sample pads and blot the ImmunoStrips<sup>®</sup> between paper towel. This prevents any liquid still in the sample pads from interfering with results.



# ucbiotech.org

SCIENCE-BASED INFORMATION & RESOURCES ON AGRICULTURAL BIOTECHNOLOGY

HOME | IN THE NEWS | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACTS

## FACT SHEETS & HANDOUTS

- Animal Biotechnology
- Coexistence
- Crop-Specific
- General
- Safety & Regulation
- What & How of Biotech Handout



### Animal Biotechnology

- \*Genetic Engineering and Animal Feed  
Alison Van Eenennaam, ANR publication 8183 - [PDF](#)
- \*Genetic Engineering and Animal Agriculture  
Alison Van Eenennaam, ANR publication 8184 - [PDF](#)
- \*Genetic Engineering and Fish  
Alison Van Eenennaam, ANR publication 8185 - [PDF](#)

[TOP OF PAGE](#)

### Coexistence

- \*Genetic Engineering and Pollen Flow  
Norman C. Ellstrand, ANR publication 8182 - [PDF](#)
- \*Genetic Engineering and Organic Production Systems  
Pamela Ronald and Benny Fouche, ANR publication 8188 - [PDF](#)
- \*Methods to Maintain Genetic Purity of Seed Stocks  
Kent Bradford, ANR publication 8189 - [PDF](#)
- \*Methods to Enable Coexistence of Diverse Production Systems Involving Genetically Cotton  
Robert B. Hutmacher, Ron N. Vargas and Steven D. Wright, ANR publication 8191 - [PDF](#)
- \*Methods to Enable to Coexistence of Diverse Corn Production Systems  
Kent Brittan, ANR publication 8192 - [PDF](#)
- \*Methods to Enable Coexistence of Diverse Production Systems Involving Genetically Alfalfa  
Dan Putnam, ANR publication 8193 - [PDF](#) | [Handout \(condensed from alfalfa fact sheet\)](#) / [Publication, "Gene Flow in Alfalfa: Biology, Mitigation, and Potential Impact on Products"](#)

[TOP OF PAGE](#)

AGRICULTURAL BIOTECHNOLOGY IN CALIFORNIA SERIES PUBLICATION #718

## Methods to Enable the Coexistence of Diverse Corn Production Systems

KENT BRITTAN, University of California Cooperative Extension Farm Advisor, Yuba County

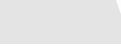
Corn (Zea mays) is produced throughout California as fresh sweet corn, silage corn, and grain. In 2002, California produced 25,000 acres (10,100 ha) of sweet corn, 40,000 acres (17,000 ha) of silage corn, and 100,000 acres (40,500 ha) of grain. The worth of each was \$200 million, \$300 million, and \$52 million, respectively. For an annual total state value of \$500 million (NAAS 2000). People consume approximately 10% of the total corn produced in California as a raw product, with the rest being used for animal, mostly dairy, corn. California is a net importer of corn, with much of this additional grain coming from the midwestern states to feed animals in large poultry houses, cattle feedlots, and to be used in farm soils.

**Does cross-pollination occur in corn?**  
Unlike all other major grain crops such as wheat, rice, and barley, the corn plant has separate male and female flowering parts. The tassel (rod) at the top of the plant is the male flowering structure, producing pollen. During the flowering stage, pollen shed and falling on the silks and female parts, cross-pollination of corn plants occurs. The separation of the male and female parts, cross-pollination of corn plants occurs with high frequency. Under field conditions, 95% or more of the tassel produced by each plant are pollinated by other plants.

Cross-pollination is achieved by wind and gravity dispersal of the shedding pollen. Pollen is lighter and can be carried considerable distances by the wind. However, most conditions, pollen is only viable for 18 to 24 hours, with viability diminishing rapidly from dusk onwards. Over a 7- to 21-day period, tassels at the top of the plant produce 2 to 5 million pollen grains from the silks. This translates into about 2,000 to 3,000 pollen grains shed for each silk. One corn plant (among the largest) shed from the top of the plant facilitates dispersal. Corn pollen (pollinated plants) is approximately 100 microns, compared to most other wind-pollinated plants that have pollen ranging from 17 to 50 microns (Went and Linkers, 1974).

Pollen data, which can make up to 50% of the grain, has become an important member in the GE and organic non-GE markets and has become an important component in the GE and organic non-GE markets. Producers are concerned that pollen data from GE hybrids for nearby non-GE varieties will contaminate their corn by cross-pollination. Farmers growing GE hybrids approved of their crops by the state are growing non-GE varieties, with no approval for GE crops by the state. Labeling of corn that has not received approval for non-GE crops by the European Union, 0.9% tolerance of major import markets for non-GE crops by the European Union, 0.9% Japan, 0% and Mexico, 0%. If the importers receive these levels it must be labeled "Not Contain GE material."

**How far does corn pollen travel?**  
Dispersal of corn pollen has been intensively studied. Some studies measured the distance the pollen traveled from its source as a function of the density of pollen while



AGRICULTURAL BIOTECHNOLOGY IN CALIFORNIA SERIES PUBLICATION #711

## Methods to Enable the Coexistence of Diverse Cotton Production Systems

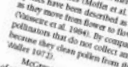
ROBERT B. HUTMACHER, Extension Agronomist, University of California Shafter Research and Extension Center and University of California, Davis, Department of Plant Science, Extension, Madera and Merced Counties; STEVEN D. WRIGHT, Farm Advisor, University of California Cooperative Extension, Yuba and Siskiyou Counties

Upland cotton (*Gossypium hirsutum*) and Pima cotton (*G. barbadense*) are the two types of cotton produced commercially in California. Its average seed as crop value, over the past 5 years cotton has typically ranked in the top three in agricultural field crops grown in California. During that period, plantings of upland cotton in California have ranged from about 400,000 to over 600,000 acres (160,000 to 200,000 ha), while Pima plantings have ranged from about 140,000 to over 200,000 acres (56,000 to 161,000 ha).

**Does cross-pollination occur in cotton?**  
Both upland and Pima cotton are naturally referred to as "largely self-pollinated" or "mostly self-pollinated." These observations acknowledge that these types of cotton are mostly self-pollinated but some cross-pollination can occur, albeit at relatively low incidence rates, through the activity of pollinating insects or by wind dispersal. The pollen of both wild and cultivated *Gossypium* species is large in size and sticky. The pollen grains, typically between 10 and 20 microns in diameter, are typically dispersed by insects, primarily bees, and are often found on the silks and having germinated, the pollen of Pima and upland types are often only for part of a single day. The pollen of cultivated *Gossypium* species has been described as being sticky and clump together in combination with the location of pollen-bearing organs in the anthers, within the flowers, with a method known for groups of pollen grains to be found to be affected by environmental conditions. The duration of pollen-bearing organs on anthesis of male was observed to be 200% to 300% of the duration of the flowers compared with 10 hours for cotton. The duration of pollen-bearing organs is also affected by environmental conditions as well as some characteristics of the flowers.

Higher populations of outside pollen have been shown to increase in incidence when types of bees, including *Megachile* species, are present in the field. Numerous studies have been described in multiple studies as the primary pollinators of cotton (Thomson et al., 1998; 1978; McCreight et al., 1978). Several wild bee species have been described as acting as pollinators, and their pollen stuck on their bodies because they clean pollen from their bodies have been described in an accompanying article (1972).

McCreight (1970) discussed several studies that demonstrated that the number of viable seed per cotton boll could be consistently increased with the introduction of



# Two-part series in *Annual Review of Plant Biology*

## Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I)

Peggy G. Lemaux  
Department of Plant and Microbial Biology, University of California, Berkeley,  
California 94720, emma@remodel.berkeley.edu

### Contents

1. INTRODUCTION .....	773	3.6. Do Genetically Engineered Foods Have Changes in Nutritional Content? .....	783
2. GENERAL ISSUES .....	773	3.7. Is the Bt Protein Safe for Human Consumption? .....	784
2.1. Terminology .....	773	3.8. Have Allergens Been Introduced into Foods Through Genetic Engineering? .....	786
2.2. Besides Genetically Engineered Crops, Does Genetic Engineering Play a Role in Producing Food? ..	774	3.9. Were Foods Made From Bt Corn Removed from the Market Because of Allergenicity Concerns? .....	786
2.3. How Does the Creation of Genetically Engineered Crops Differ from That of a Classically Bred Crop? .....	774	3.10. Do Only Genetically Engineered Foods Cause Food Allergies? .....	787
2.4. Can Marker-Assisted Selection Be Used Instead of Genetic Engineering to Improve Crops? .....	774	3.11. Can Genetically Engineered Foods Have Fewer Allergens than Non-GE Foods? .....	788
2.5. Does the Use of rDNA Always Involve Moving Genes from One Organism to Another? .....	775	3.12. Do Viral Sequences Used in Plant Genetic Engineering Create a Human Health Risk? .....	788
2.6. Which U.S. Agencies Have Regulatory Authority Over Genetically Engineered and ... ..	776		
3.1. Do Foods Consumed by Humans Contain Genetically Engineered Bacteria? .....	779		
3.2. Were Potatoes Engineered with a Lectin Protein Unsafe to Eat? .....	780		
3.3. Were Fish Genes Introduced into Strawberries? .....	780		
3.4. Are Food Safety Studies Conducted on GE Foods? ..	780		
3.5. What Happens to the DNA in Foods When They Are Eaten? .....	782		

**Food and food safety issues**

### Key Words

benefits, biotechnology, crops, food safety, genetic engineering, risks

### Abstract

Through the use of the new tools of genetic engineering, genes can be introduced into the same plant or animal that already exists with classical breeding. This technology has been used to produce genetically engineered crops and animals. These crops and animals are not sexually compatible with their wild counterparts. These crops and animals are produced in large numbers (over 250 million acres worldwide). These crops and animals are pest tolerant, but other GE crops and animals are not. For some farmers and consumers, the benefits of these crops and animals are acceptable; for others, the risks are not. The general and food issues raised by these crops and animals need to be addressed. Responses to these issues will be covered. Responses to these reviewed scientific literature related to environmental and food safety issues will be covered.

**Environmental and socioeconomic issues**

### TABLE OF CONTENTS

ABSTRACT	
1. INTRODUCTION	
2. ENVIRONMENTAL ISSUES	
2.1. Will the widespread use of Bt crops lead to insects' developing resistance to Bt?	
2.2. Can GE crops cause adverse effects on nontarget organisms?	
2.3. Could the use of GE crops result in a loss of biodiversity of plants?	
2.4. Will the use of GE crops result in population decline of other organisms?	
2.5. Will use of herbicide tolerant GE crops lead to "superweeds"?	
2.6. What methods are used to help plants protect themselves against pests?	
2.7. Does the use of GE crops result in increased use of pesticides?	
2.8. Is it true that Bt crops protect themselves against pests?	
2.9. Can introduction of virus-resistant GE crops lead to new or mutated viruses?	
2.10. Can GE plants and microbes have a positive impact on the environment?	
2.11. Can genes from GE plants move to bacteria in the field?	
2.12. Is the loss of honeybees due to GE crops?	
2.13. Can federal regulatory agencies stop planting of GE crops?	
2.14. How does the Cartagena biosafety protocol affect the planting of GE crops?	
2.15. What happens to the DNA in foods when they are eaten?	
3. REFERENCES	





**ucbiotech.org**

SCIENCE-BASED INFORMATION & RESOURCES  
ON AGRICULTURAL BIOTECHNOLOGY

HOME | **IN THE NEWS** | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACTS

## know GMOS

*This website, developed for the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, provides educational resources focused broadly on issues related to agriculture, crops, animals, foods and the technologies used to improve them. Science-based information related to these issues is available, as well as educational tools and information, which can be used to promote informed*

**DISPLAY CARDS  
NOW IN  
SPANISH!**

We now have Spanish cards available to distribute with both educational displays. Click here for more details!

**VISIT [ucbiotech.org](http://ucbiotech.org) TO SEE WHAT EDUCATIONAL RESOURCES YOU CAN USE IN YOUR CLASSROOM.**

CONTACT BARBARA [balonso@berkeley.edu](mailto:balonso@berkeley.edu) OR

PEGGY [lemauxpg@berkeley.edu](mailto:lemauxpg@berkeley.edu)

The Tea Grow: Educational game to teach what foods come from what crops.

TheCounter.com  
VISITOR: 74538

Copyright © 1999-2009 [ucbiotech.org](http://ucbiotech.org), all rights reserved

SEARCH - CONTACT - SITE MAP