Foods: Past, Present and Future

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Each year Americans eat an average of 210 pounds of meat per capita, more than double the global average.

Only 3% of Americans are vegetarians

INDUSTRY STATS

capita in the U.S. each year.

3%

Percentage of Americans who are **vegetarians.**

SOURCES: OECD; HARRIS POLL

What do we know about what makes a fruit or vegetable look, taste and smell like it does?

versus

Fortune March 2017

HOW MUCH DNA DO YOU EAT?*

First we'll start with some basics about genetics…

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.

MICHIGAN STATE UNIVERSITY
FOOD LITERACY AND ENGAGEMENT POLL
September 2017

Please tell me whether you think the following statement is true or false: Genetically modified foods have genes and non-genetically modified foods do not.

SOURCE: Michigan State University Food Literacy and Engagement Poll, September 2017
http://food.msu.edu/articles/msu-food-literacy-and-engagement-poll

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All living things contain DNA – including the foods we eat

Tour d'Onion

Or what makes an onion, an onion?

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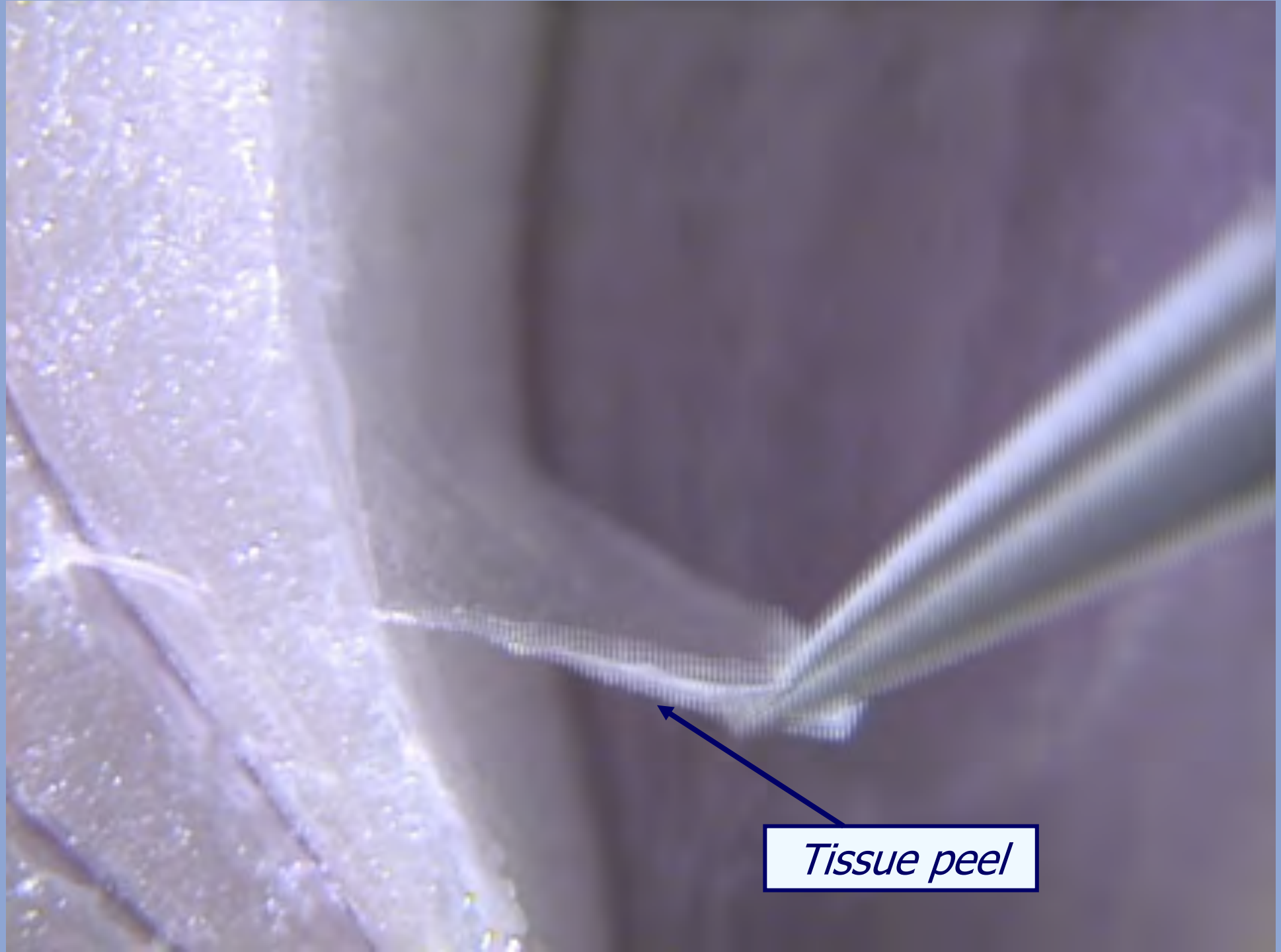
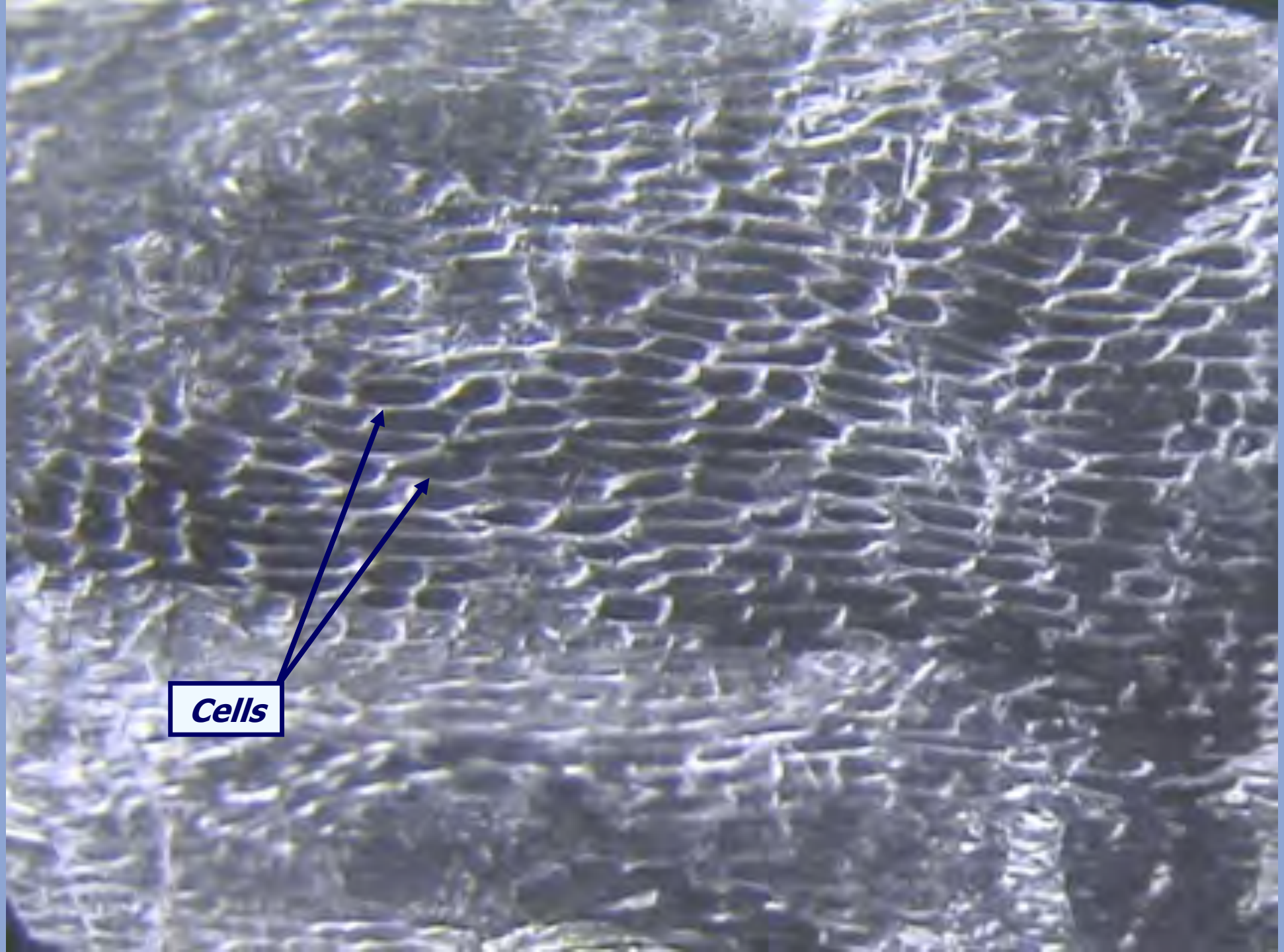
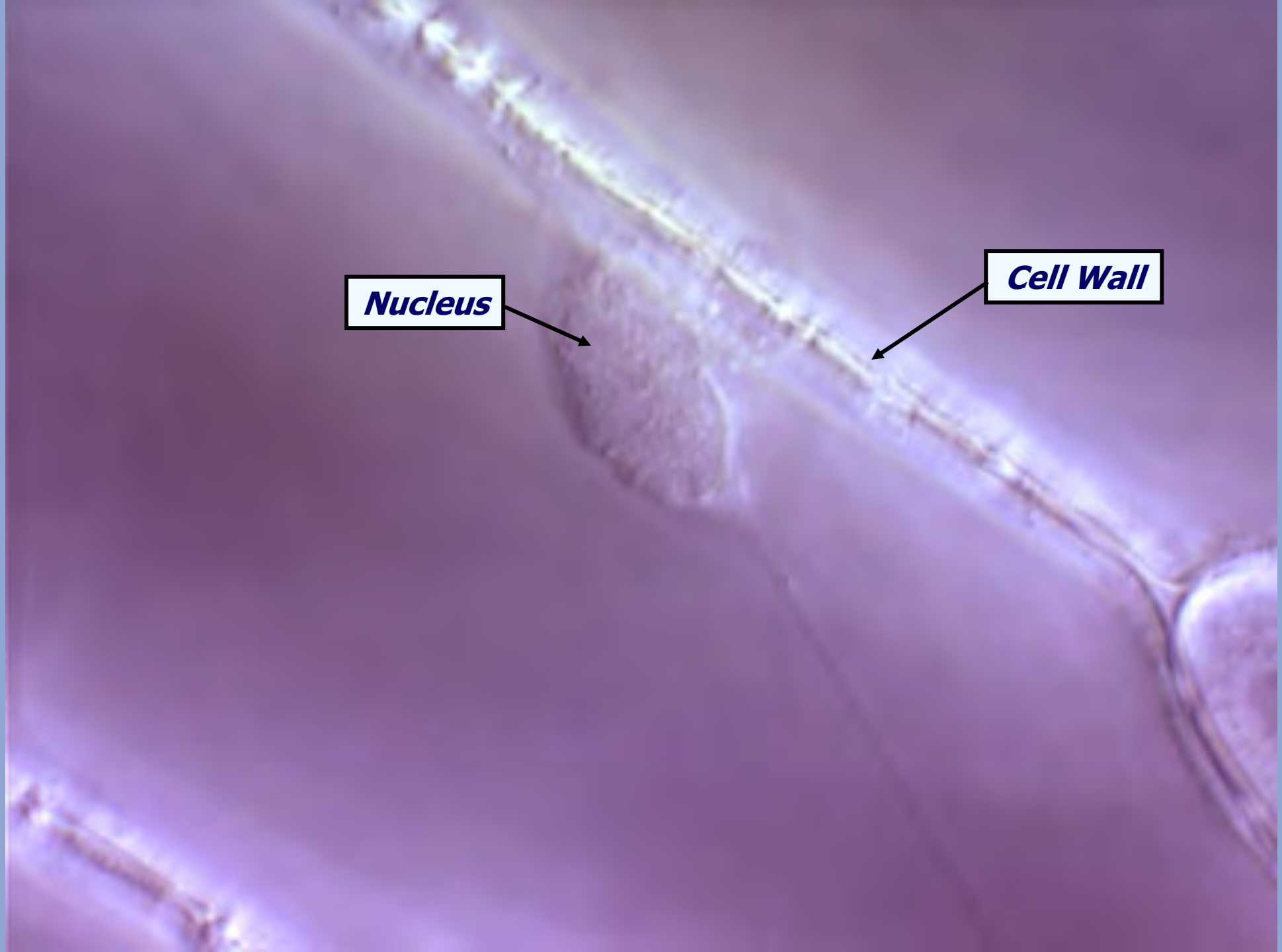
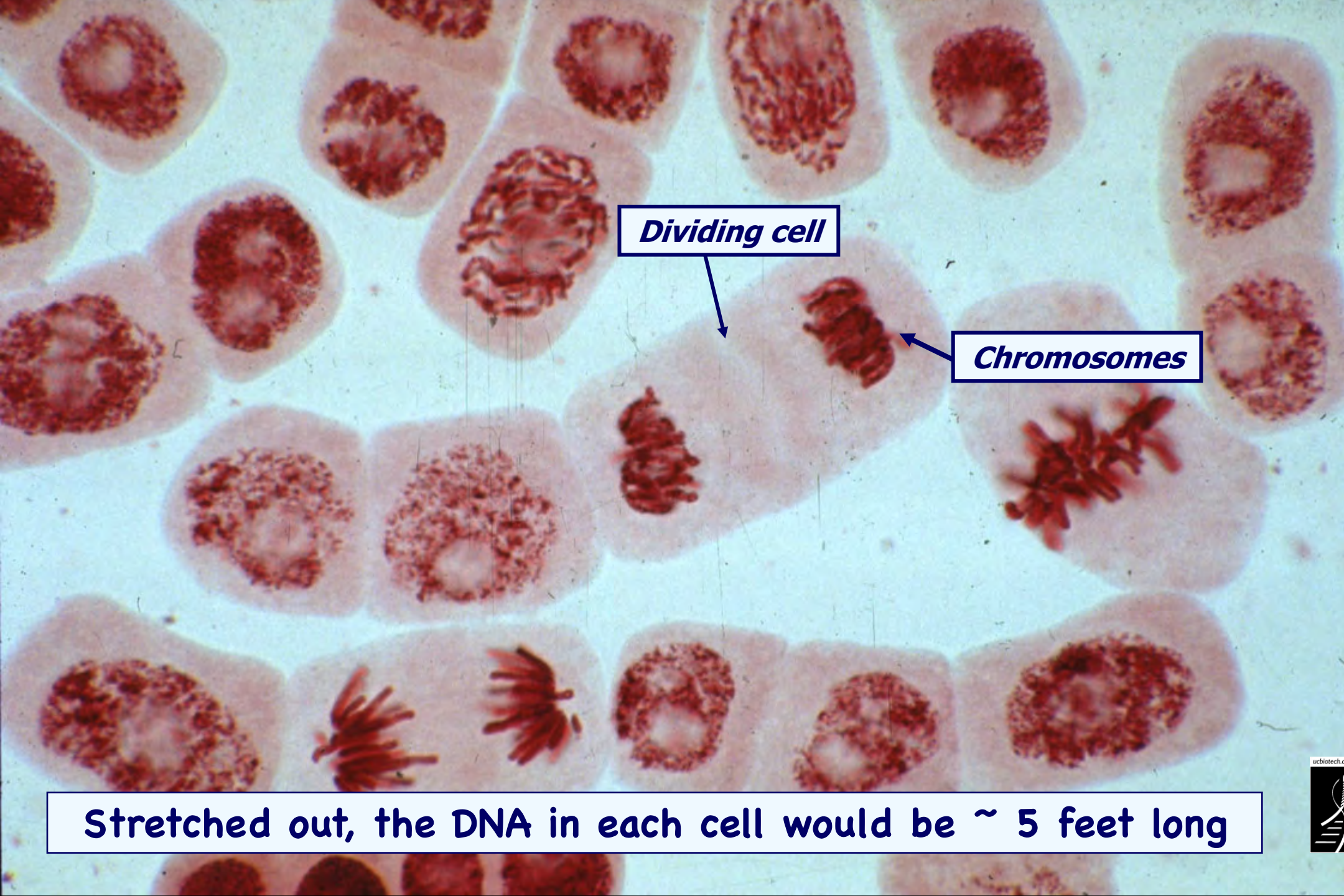

Tissue peel


Cells


Nucleus
Cell Wall



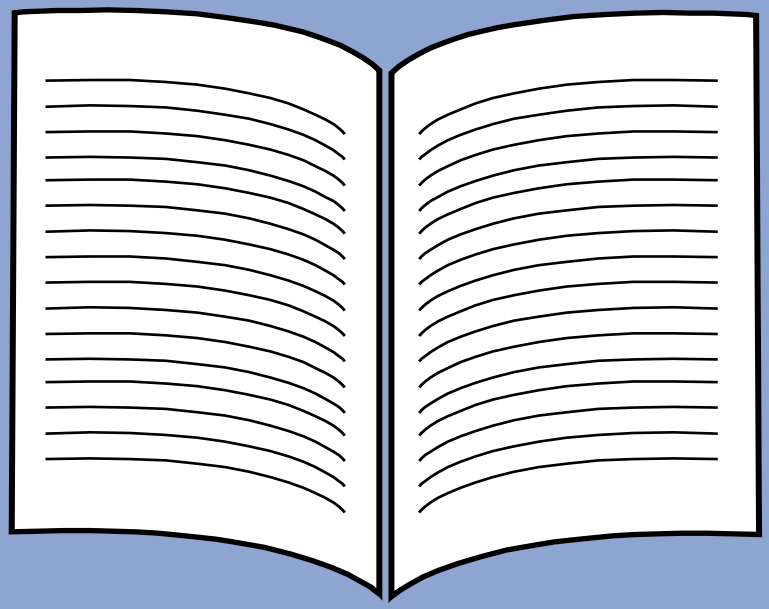
Stretched out, the DNA in each cell would be ~ 5 feet long

Chromosome
Genes

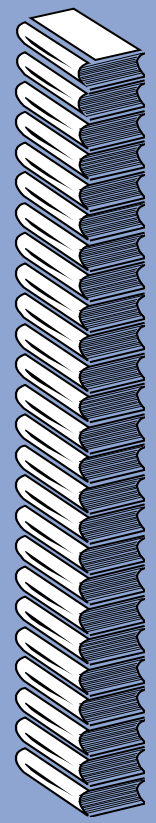
Genetic information in the genome is responsible for traits

Represent chemical units in genome by alphabetic letters

...CTGA**C**CTAATGCC**G**TA...



...CTGA**A**CTAATGCC**T**TA...



Sometimes mistakes happen when copying information in books (genome) → creating changes, called mutations

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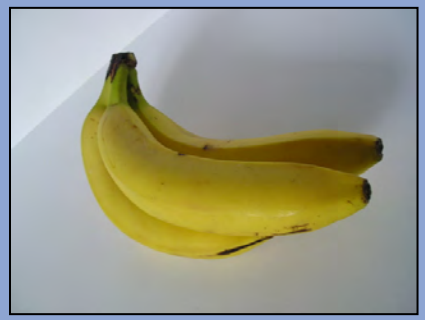
Mutations Have Gotten These Plants from Looking Like This...

To Looking Like They Are Now

Carrot

Eggplant



Banana

Broccoli, Kale, Cabbage

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Mutation breeding intentionally makes changes in a crop's DNA – >3200 officially released crops – like 600 maize, rice, wheat varieties, released since 1950's.

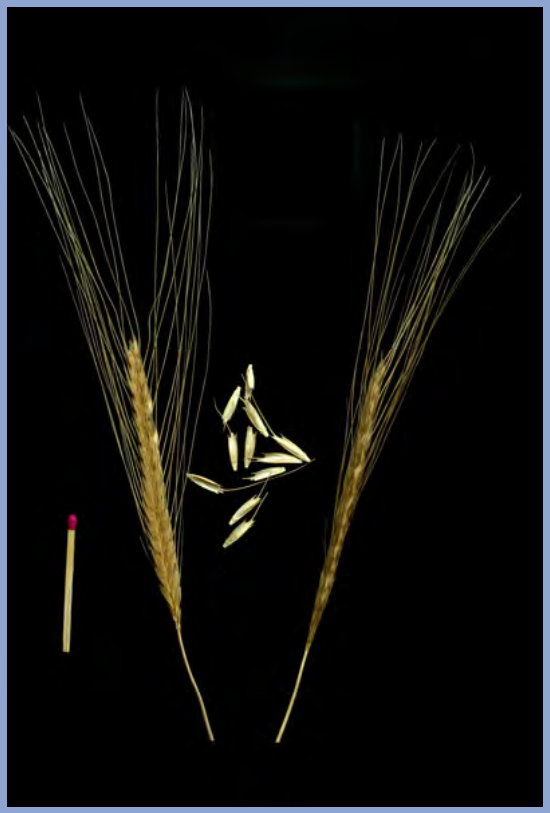
Photo by Stephen Ausmus, USDA

Modern Example

Japanese Farmer Creates Mongee Banana With Softer, Digestible Skin

2/22/2018 A-peeling? Japanese farmers invent edible banana skin | World news | The Guardian

How can genetics be used to create a wheat variety with better nutrition – using ancient wheat?



X

Triticum monococcum *Triticum aestivum*

Ancient variety Modern bread variety

What happens to the genetic information from the two parents?

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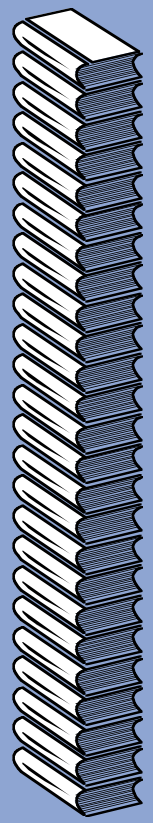
Information in the wheat genome

Chemical units represented by alphabetic letters

...CTGACCTAATGCCGTA...



1700 books
1000 pages each

1700 books
(or 1.7 million pages)

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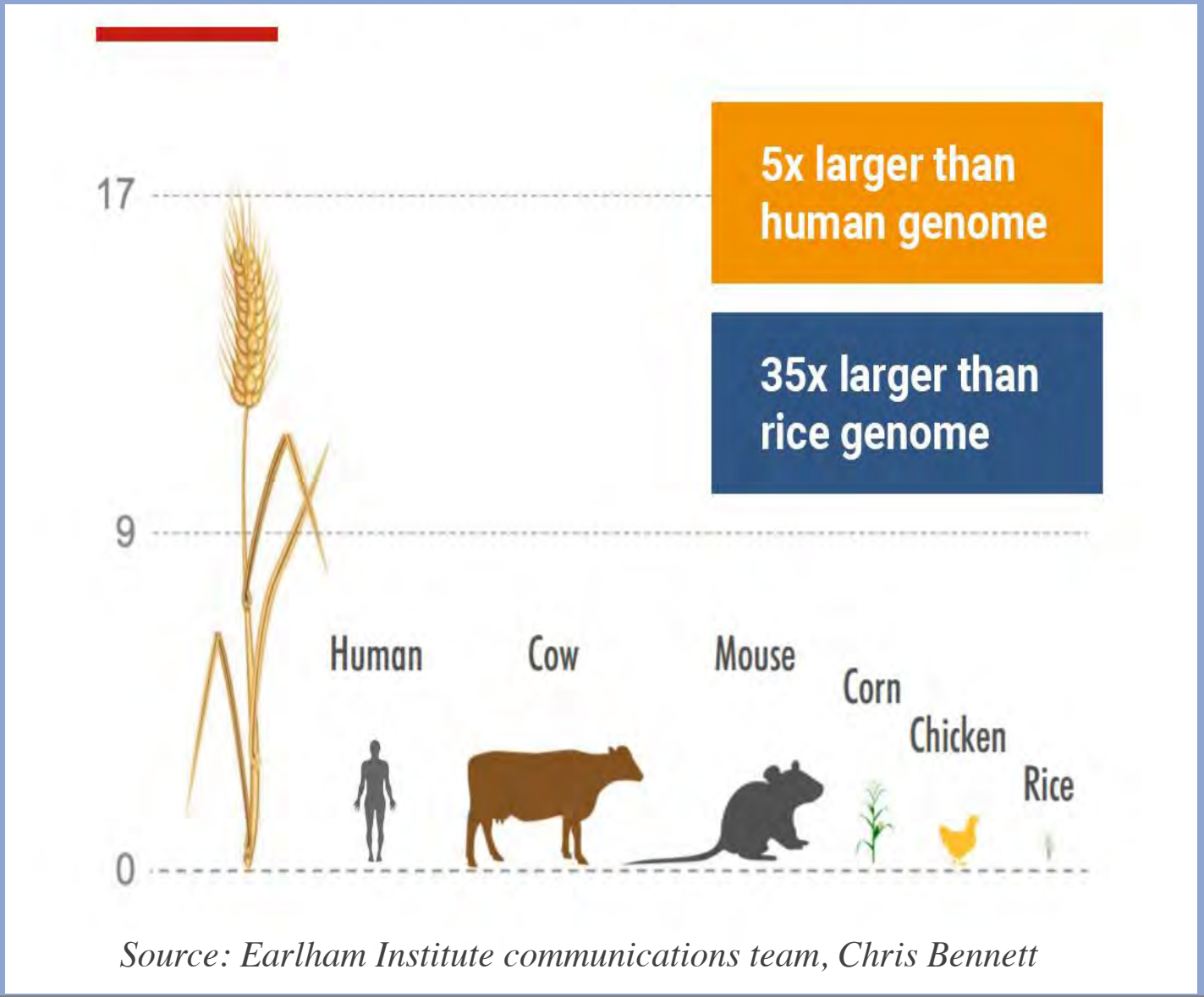
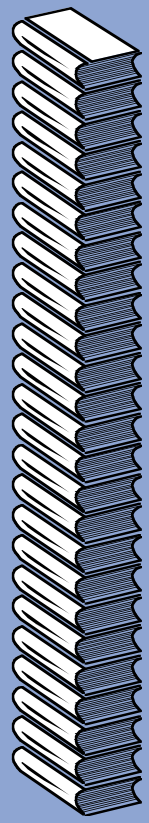
How does the genetic information (genome) in wheat compare to what's in a human?



Source: Earlham Institute communications team, Chris Bennett

Hybridization or cross breeding of wheat



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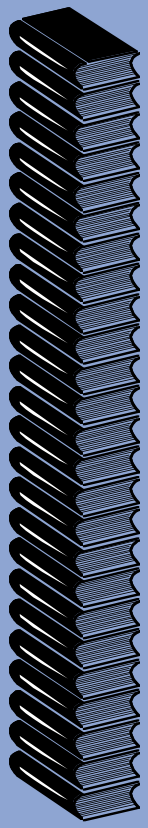

Random retention of information from each parent

1700 books (or 1.7 million pages)

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1700 books (or 1.7 million pages)

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Genetic modification by hybridization <u>is not</u> GEn or GMO

SOURCE: "Triple Null: New Genetically Modified Soybean A Big Benefit For Food Allergies", Science 2.0, 5/4/15.
http://www.science20.com/news_articles/triple_null_new_genetically_modified_soybean_a_big_benefit_for_food_allergies-155306

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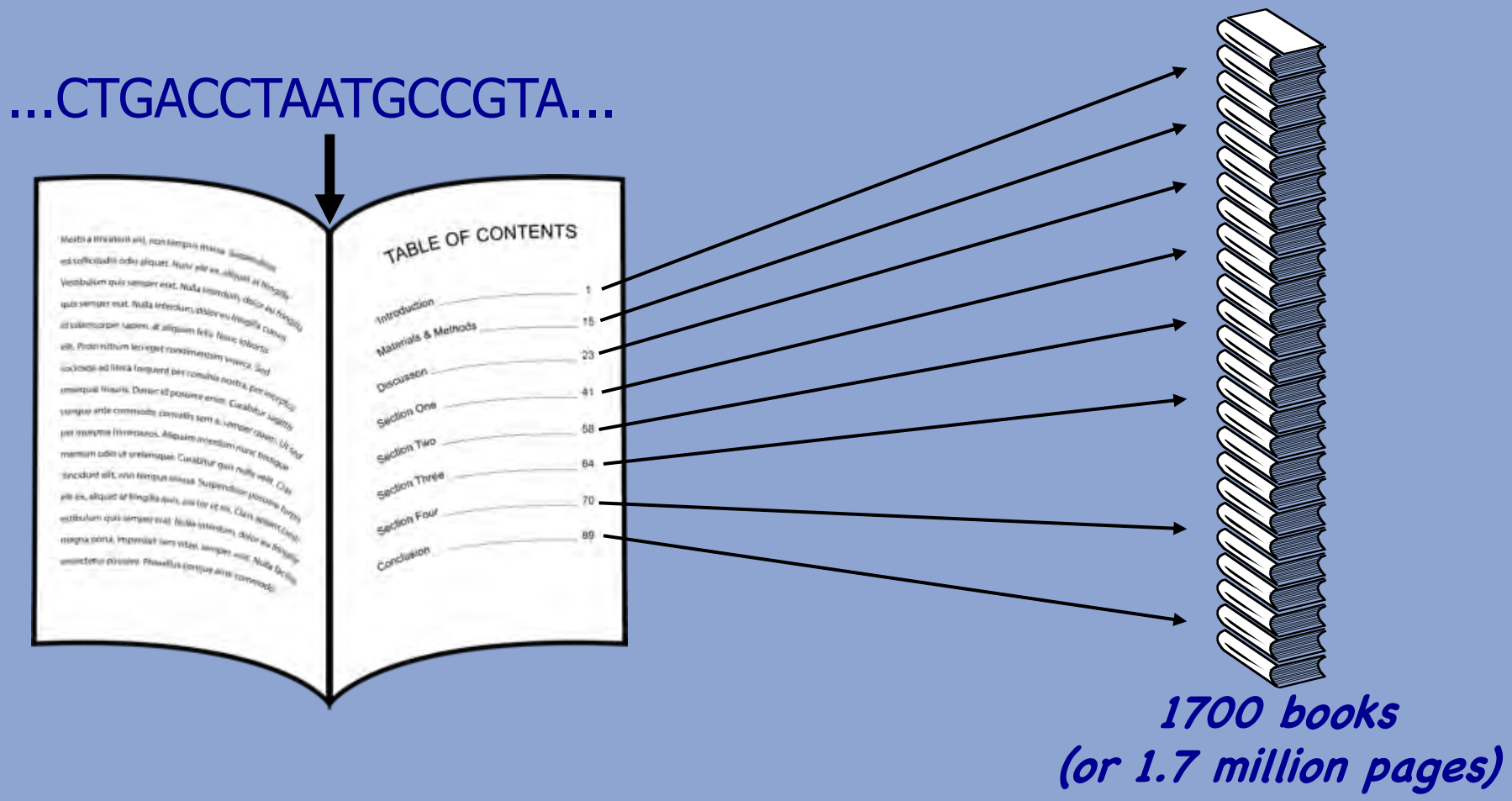
Putting this in context, these breeding efforts were critical to increasing crop production…

Product	2014 total production	2014 acreage	Acreage needed at 1950's rate	Additional Resources needed
Soybeans	3.927.090,000 bu 235,562,540,000 lb	82,591,000 acres	180,971,889 acres	~98 million acres (= size CA)
Corn	14,215,532,000 bu	83,136,000 acres	372,134,346 acres	~289 million acres (= 3X size CA)
Broiler Chickens	51,373,100,000 lbs	8,544,100,000 head	16,679,545,455 head	~8 billion head requiring 81.5 billion lbs feed

New breeding methods

Uses table of contents of genes for marker assisted selection



Genetic modification that is not GEn or GMO

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Can't we just do all modifications this way?

Marker-assisted selection used to protect rice against bacterial blight and blast disease

Limited to diversity in crop and compatible relatives

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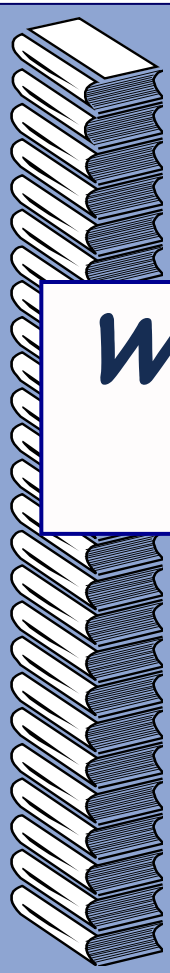
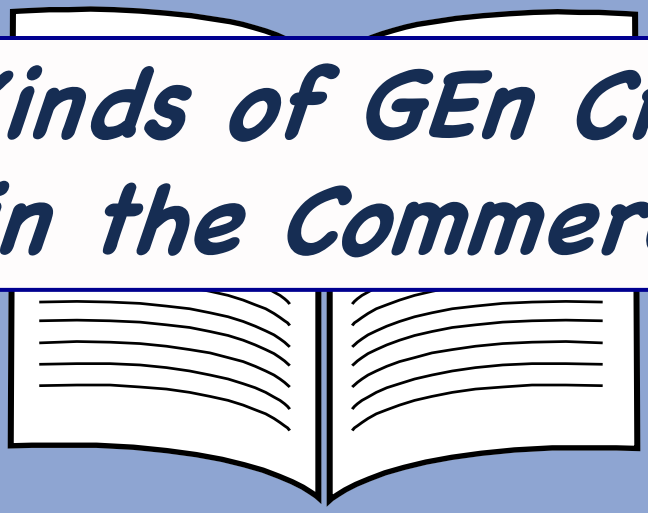
Another means to modify genomes uses genetic engineering (GEn) to create "GMOs"



Inserts randomly in genome

What Kinds of GEn Crops and Foods Are in the Commercial Market?

Inserted gene(s)



One-half page equivalent to a gene

1700 books (or 1.7 million pages)

Genetic modification that is GEn and GMO

1700 books (or 1.7 million pages)

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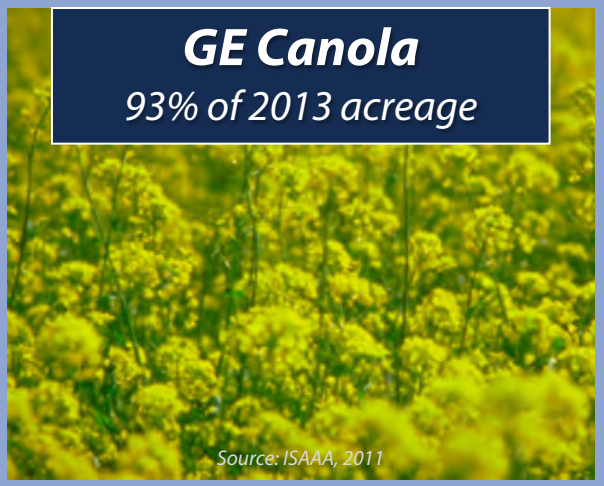
Number of different commercially available, large acreage GEn (GMO) crops is limited

GE Cotton

96% of 2014 acreage

(Insect Resistant: 5% Herbicide tolerant: 12% Stacked gene: 79%

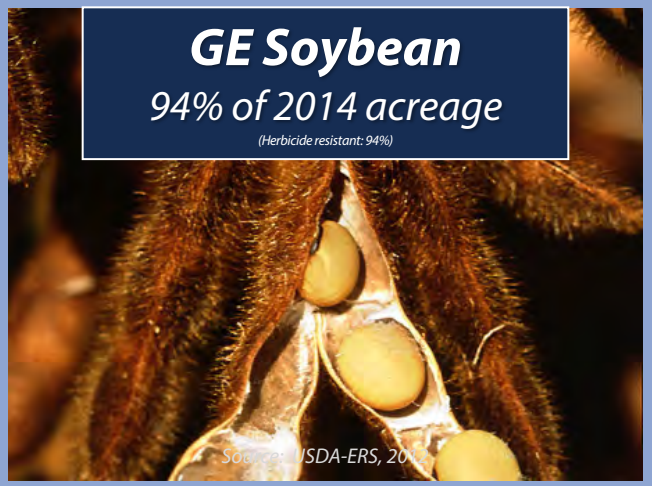
Source: USDA-ERS, 2014



GE Canola

93% of 2013 acreage

Source: ISAAA, 2011

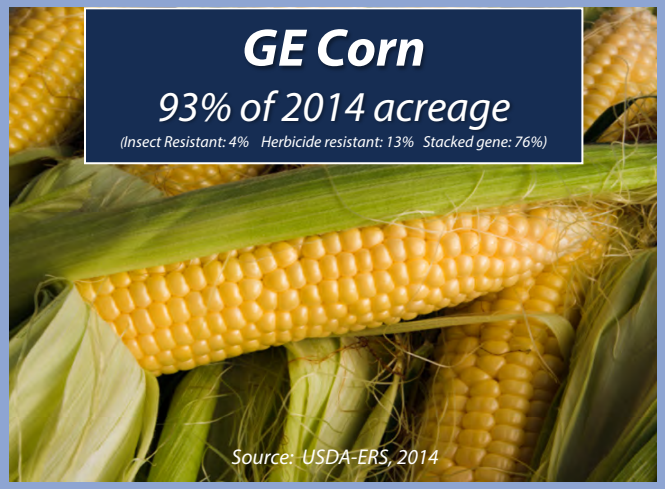


GE Soybean

94% of 2014 acreage

(Herbicide resistant: 94%)

Source: USDA-ERS, 2014

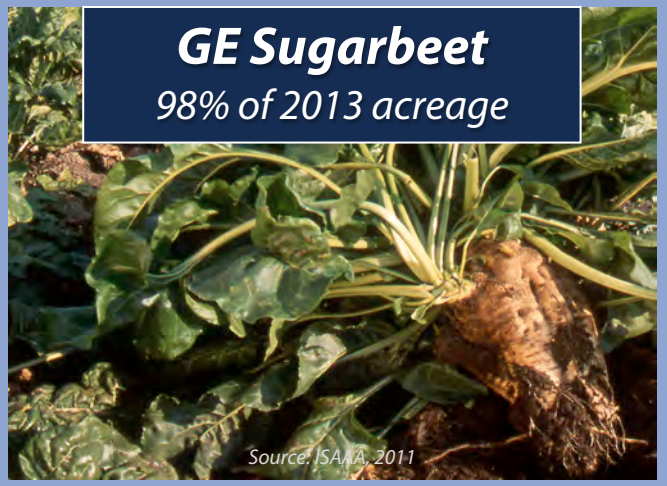


GE Corn

93% of 2014 acreage

(Insect Resistant: 4% Herbicide resistant: 13% Stacked gene: 76%)

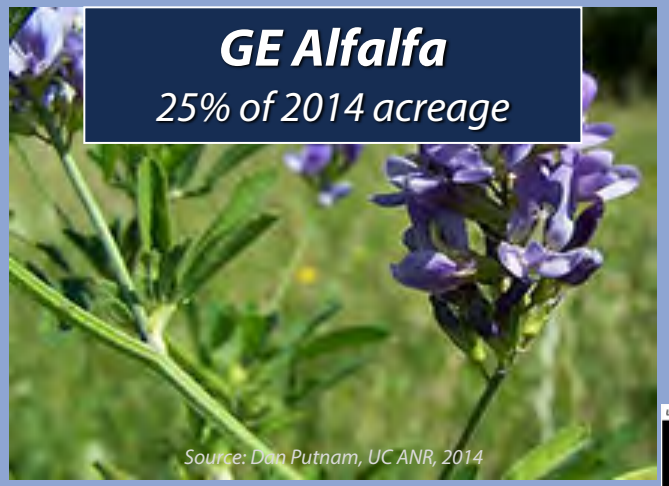
Source: USDA-ERS, 2014



GE Sugarbeet

98% of 2013 acreage

Source: ISAAA, 2011



GE Alfalfa

25% of 2014 acreage

Source: Dan Putnam, UC ANR, 2014

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These traits are not aimed at changing nutritional qualities

Insect-tolerant Bt crops - engineered for resistance using gene from naturally occurring bacterium

Herbicide-tolerant - engineered with gene to tolerate herbicide application

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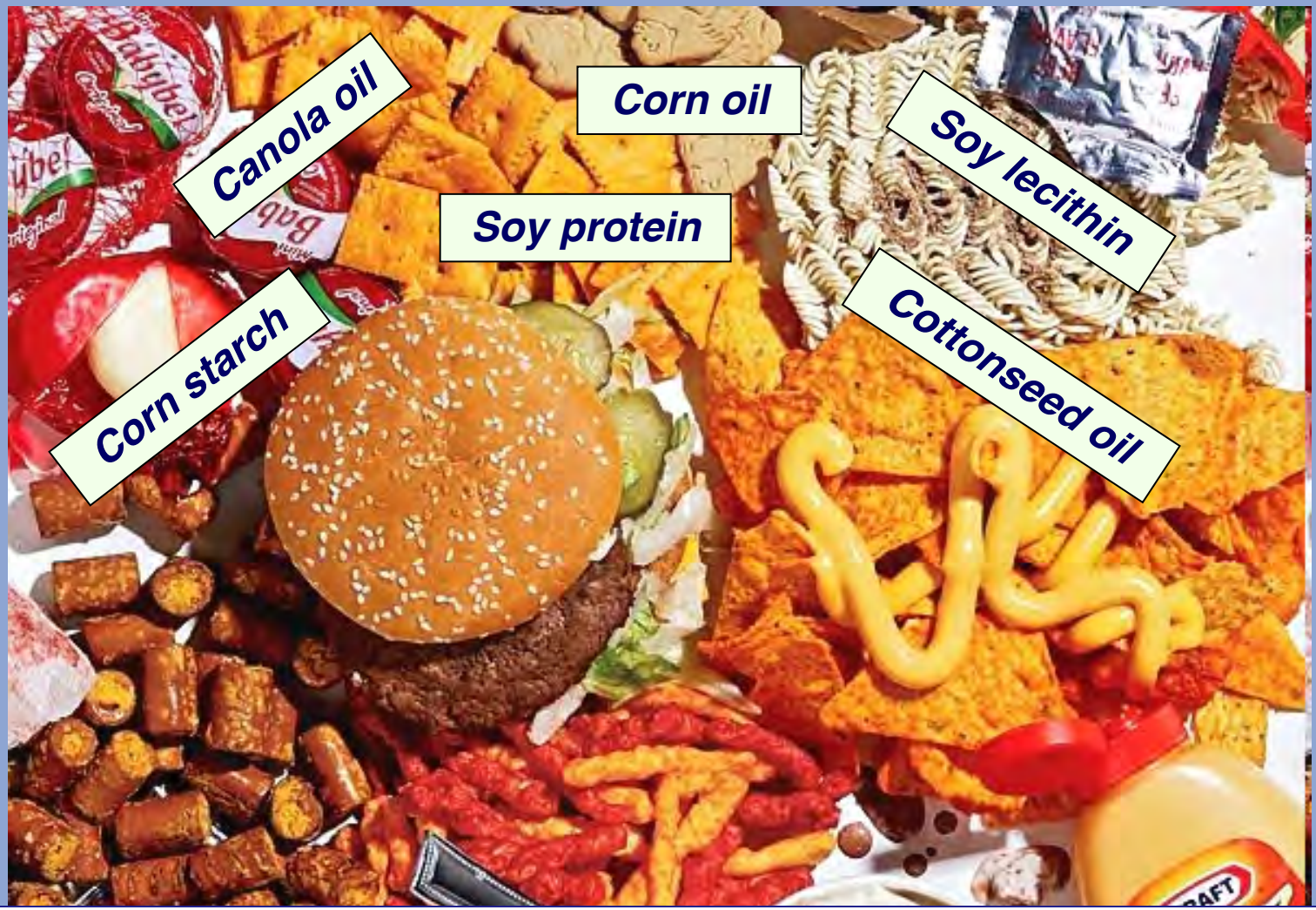

But because these are large-acreage GEn crops, it leads to estimates that 60-80% of processed foods in U.S. have GEn or GMO ingredients – mostly minor

SOURCE: https://factsaboutgmos.org/disclosure-statement

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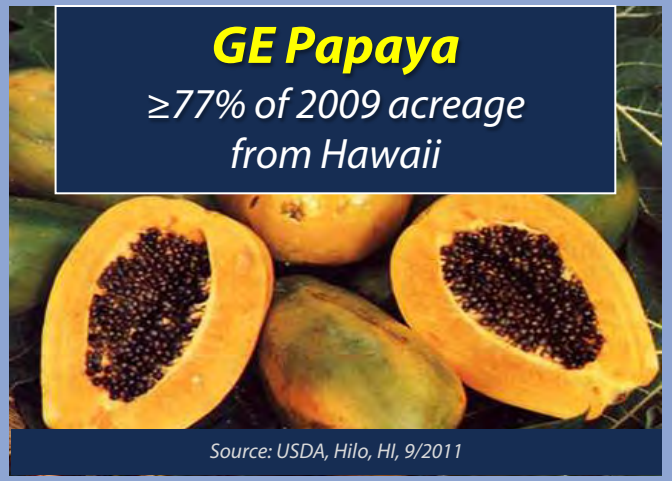
There are only a few whole, genetically engineered foods in the U.S market

GE Squash
~25,000 acres in 2011

Source: Non-GMO Project

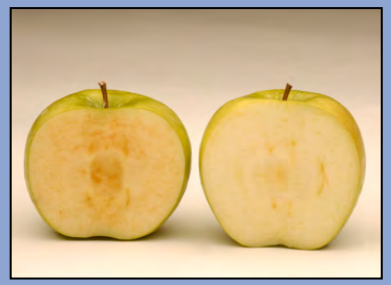
GE Sweet Corn
Acreage unknown

GE Papaya
≥77% of 2009 acreage from Hawaii



Source: USDA, Hilo, HI, 9/2011

Two more are just being introduced



Arctic Apple™

Introduced in 400 Midwest stores in Oct. 2017

Innate™ Potato

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What's in the pipeline?
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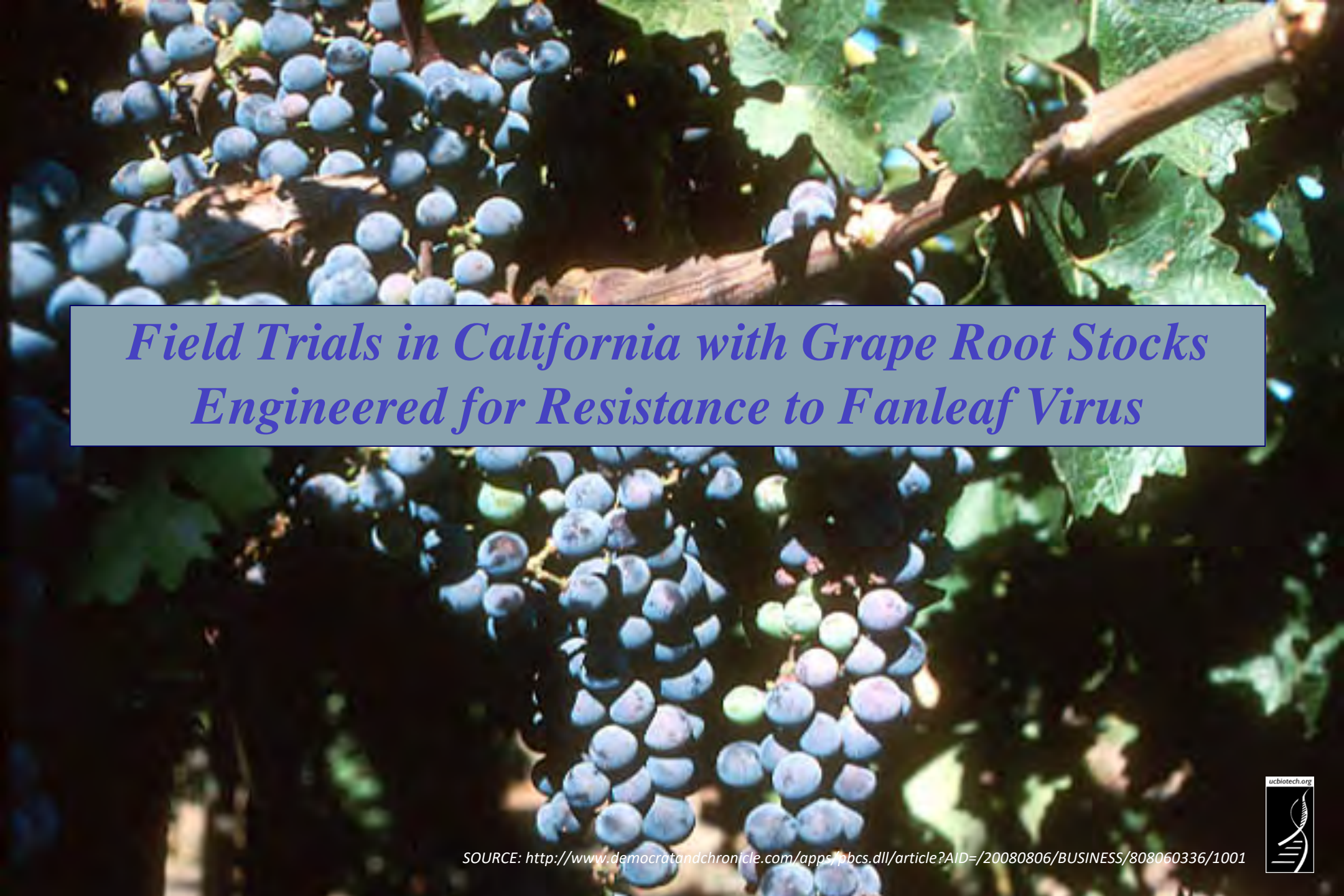

Field Trials in California with Grape Root Stocks Engineered for Resistance to Fanleaf Virus

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

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2013 engineered potato field study – Ireland
Desiree potato variety, highly susceptible to late blight, engineered with gene from wild potato variety

amiga
Assessing and Monitoring the Impacts of Genetically modified plants on Agro-ecosystems

teagasc
Agriculture and Food Development Authority

WAGENINGEN UR
For quality of life

ucbiotech.org

Tear-free onion developed by turning off tear-inducing enzyme

SOURCE: "Scientists create 'no tears' onions", Herald and Weekly Times, 2/1/08
http://www.checkbiotech.org/green_News_Genetics.aspx?Name=genetics&infoId=16834

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First Multi-nutrient Rice Engineered with Increased Iron, Zinc and Vitamin A

SOURCE: "Multi-nutrient rice against malnutrition", Morning Ag Clips, 8/8/17 (https://www.morningagclips.com/multi-nutrient-rice-against-malnutrition/)

Singh et al. 2017. Single genetic locus improvement of iron, zinc and β-carotene content in rice grains, doi:10.1038/s41598-017-07198-5. https://www.nature.com/articles/s41598-017-07198-5

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Genetically modified wheat used to make coeliac-friendly bread

Daily bread: if gluten's not for you
Superstock

Used genetics to knock out" 35 of the 45 gliadin genes involved in coeliac; efforts

Sanchez-Leon S. et al., 2017. Plant Biotechnology Journal September 18, 2017 DOI: 10.1111/pbi.12837

High anthocyanin purple engineered tomatoes protect against cardiovascular disease and certain cancers. Diets with 10% purple tomatoes increased lifespan of cancer-prone mice

MIT Technology Review

Chinese Researchers Stop Wheat Disease with Gene Editing

Researchers have created wheat that is resistant to a common disease, using advanced gene editing methods.

By David Talbot on July 21, 2014

Advanced genome-editing techniques have been used to create a strain of wheat resistant to a destructive fungal pathogen – called powdery mildew – that is a major bane to the world's top food source, according to scientists at one of China's leading centers for agricultural research.

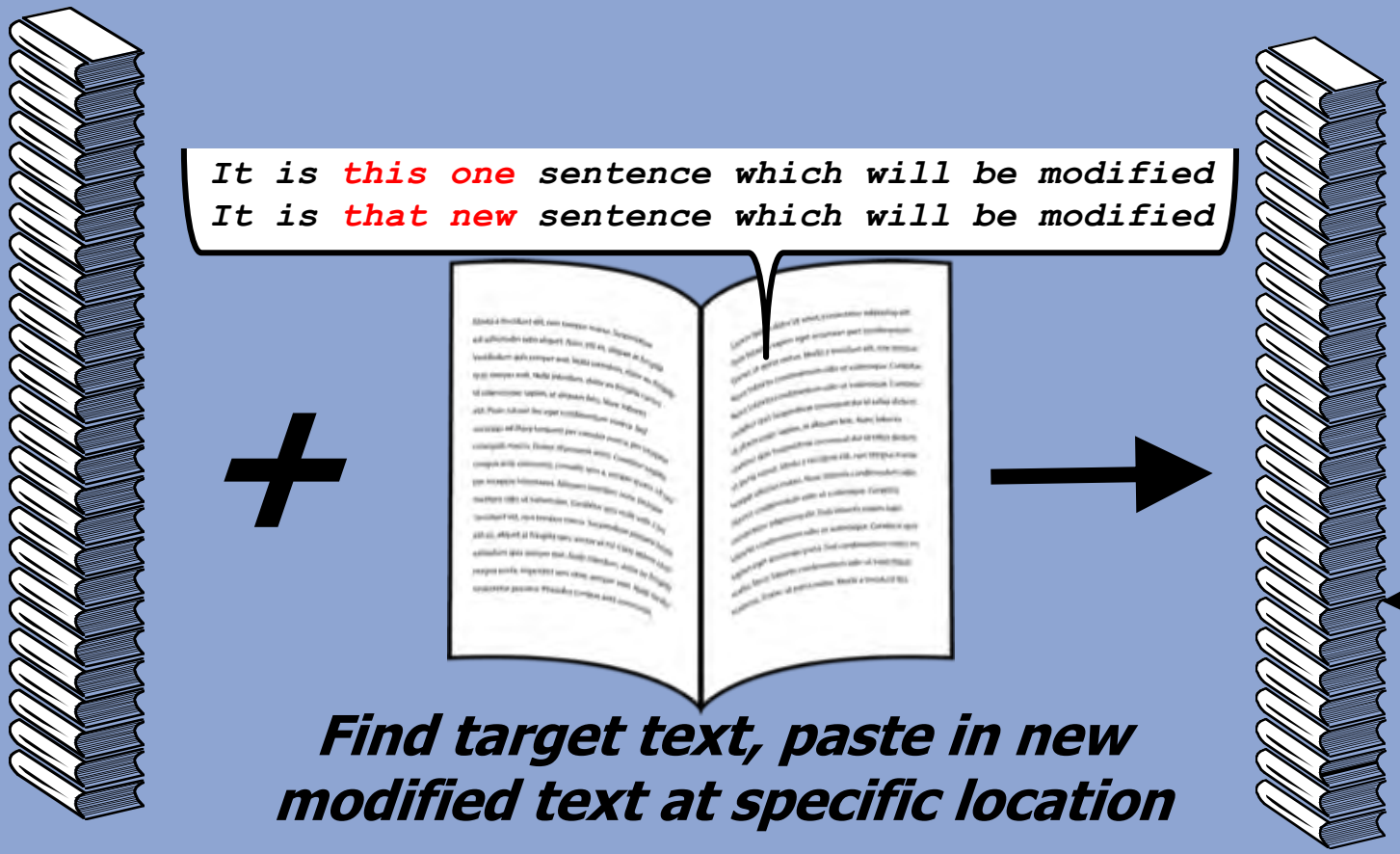
And now there is a new method of genetic modification: Genome Editing (GEd)

Advanced genome-editing techniques used to create wheat resistant to powdery mildew by deleting genes that repress defenses against mildew

Also use genome editing to make tomatoes with more inner compartments and higher yields

Rodriguez-Leal, A. et al. 2017. Engineering Quantitative Trait Variation for Crop Improvement by Genome Editing. Cell 171: 480-490.

New Genetic Method: Genome Editing-1



EXAMPLES of such edited products:

nature

NATURE | NEWS

Gene-edited CRISPR mushroom escapes US regulation

Jose A. Bernat Bacete/Getty Images

University

Dupont Develops Corn Using New CRISPR Technology

A new genetically engineered corn variety developed by one of the world's largest seed companies won't undergo the same review by regulators as other GMO crops.

Company

Capital Press

Gene-edited camelina cleared by USDA

CRISPR-developed trait increases oil content

By MATEUSZ PERKOWSKI

Company

Capital Press

USDA won't regulate biotech wheat variety

Cultivar modified to 'knock out' mildew-susceptible gene

By MATEUSZ PERKOWSKI

Capital Press

Wheat is shown in this file photo. The Animal and Plant Health Inspection Service has found that a new mildew resistant wheat cultivar doesn't fall under its jurisdiction for regulating genetically engineered crops.

Turn to WHEAT, Page 12

Company

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The New York Times | http://nyti.ms/2jmyzyo

SCIENCE

These Foods Aren't Genetically Modified but They Are 'Edited'

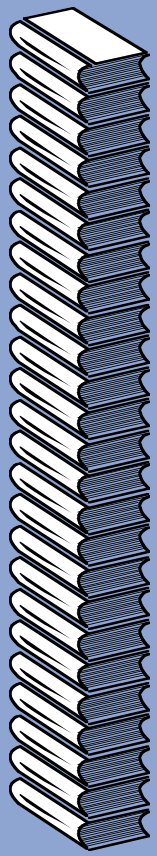
By KENNETH CHANG JAN. 9, 2017

In a few years, you could be eating the next generation of genetically altered foods — potatoes that do not turn brown or soybeans with a healthier mix of fatty acids.

And you may have no idea that something is different, because there may be no mention on the labeling even after a law passed by Congress last year to disclose

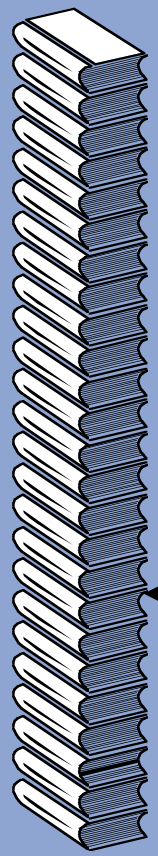
Cellectis, a company creating edited crops, hosted a dinner at Benoit New York, the Alain Ducasse Manhattan restaurant, and served dishes made from its gene-edited soybeans and potatoes. Guests included professors, journalists and celebrities like actor, Neil Patrick Harris.

New Genetic Method: Genome Editing-2



It is a different…kind of sentence which will be modified INSERTION
It is that new sentence which will be modified
It is that sentence which will be modified DELETION

Find target text, paste in new modified text at defined location



Inserts gene edits specifically in genome

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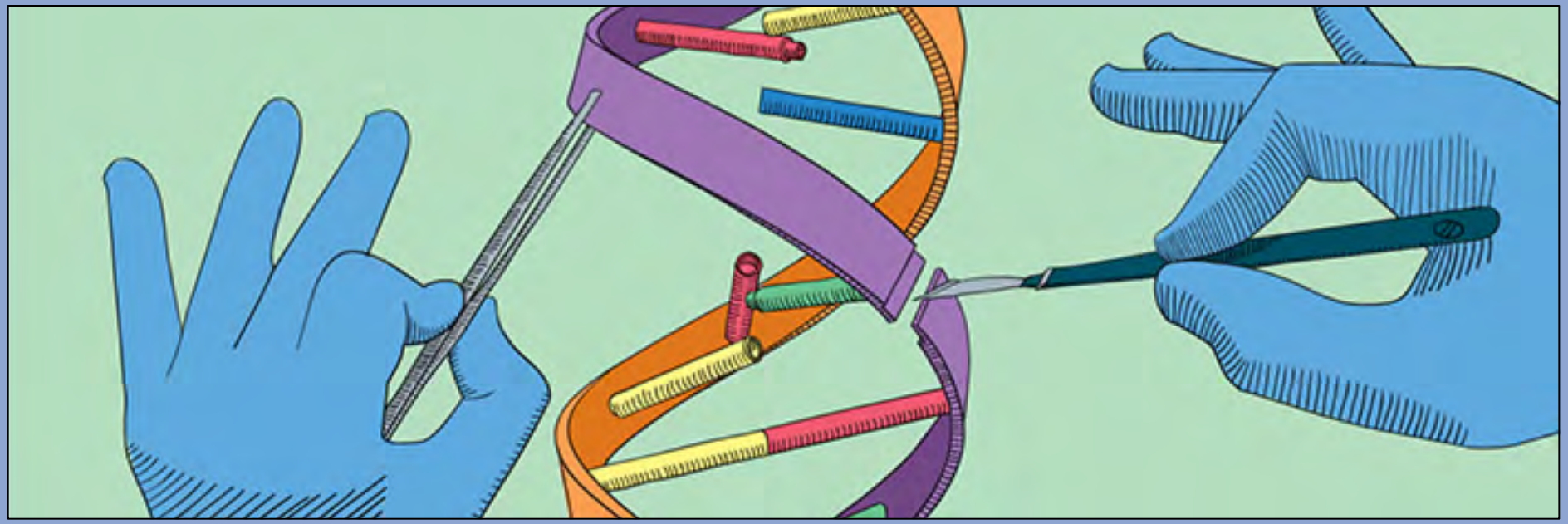
Michael will give you more information on Genome Editing