



Meeting future food demands with GMO

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EFSA – Parma, Italy

My Competence:

ENS-Lyon, INRA, 1994-6

NMBU ÅS 1996-

UC-Berkeley 2004-5

Yale 2012-13

Risk assessment
-Scientific Com. Food Safety
(VKM) 2007-

-European Food Safety Authoroty
(EFSA) 2012-

Extreame demands take all means

Plant breeding is a long term process, and we need all available tools in the toolbox to succeed

Science – Political Reasoning – Media

Need attention, information and a good environment.
Law against GMOs does not make sense.

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My agenda:

- Short: risk perseption and importance of science based choices

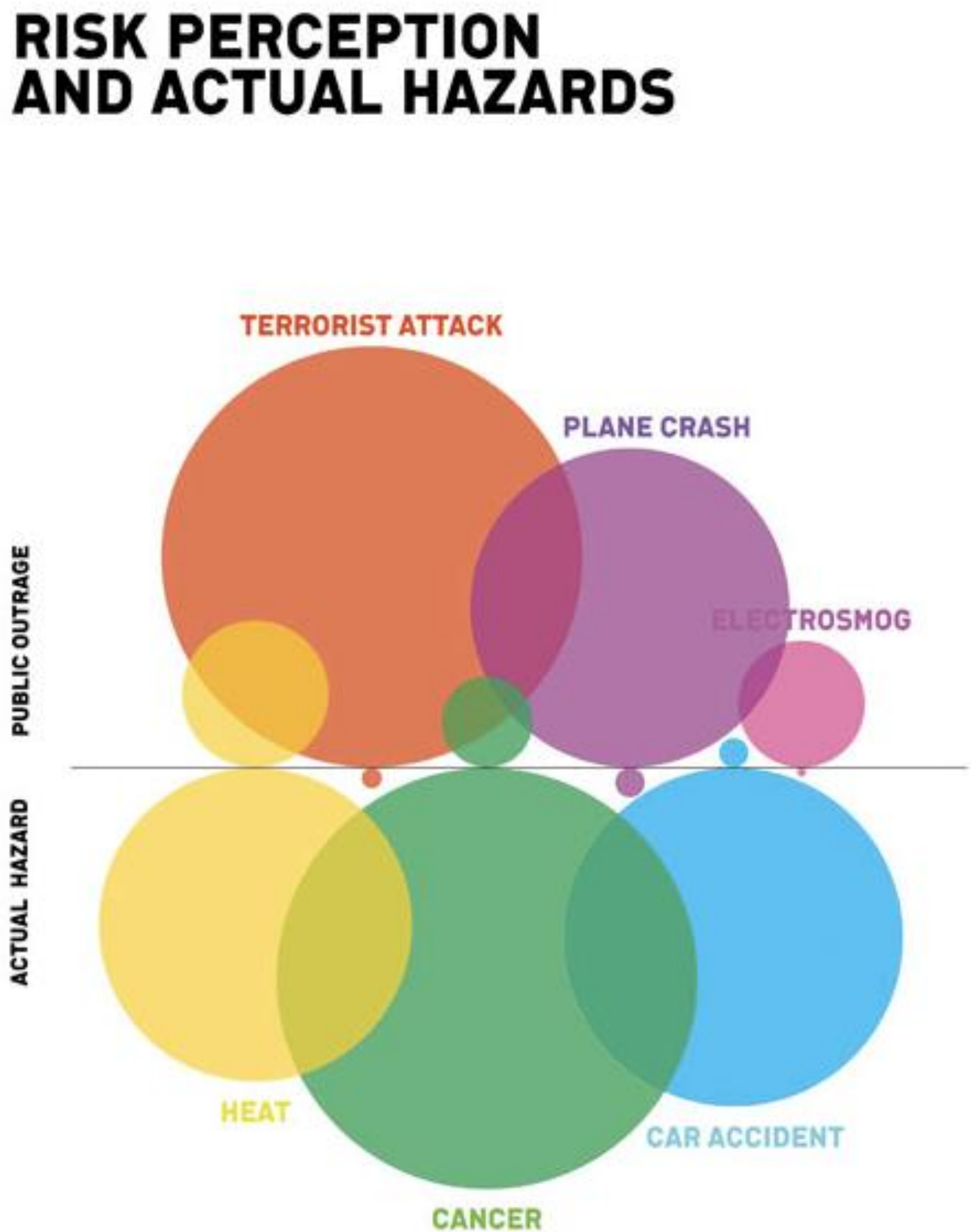
- What GM & GMO is and mean

- Current global GM facts

- Challenges

- Unique possibilities with GM, examples

Intuitive feeling of risk



Most feel terrorists and plane crash wors, while cancer and cars most likely kill us

=> Important to priorities means where most needed

www.susannahertrich.com

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Knowledge essential to understand, see and make good choices

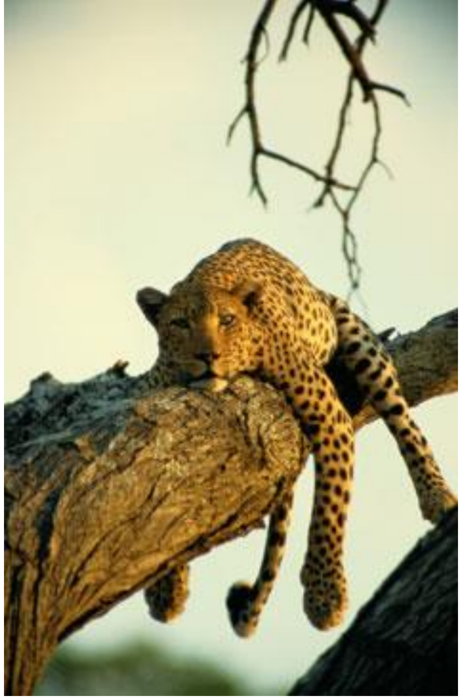
"…nous sommes desoles que notre president soit un idiot. Nous n'avons pas vote pour lui"

Labeling has no value unless the content is understood!

Genetic Modification (GM) involves laboratory techniques

- are great & unique scientific tools
- a plant breeding technique to make new products;
  - regular plant varieties,
  - more sustainable feed &
  - medicine plants
- faster than regular breeding and add new possibilities

Understanding life is a drive
- for a number of reasons



Basic Science Needed for Future Food Security

?

® DiaGenic

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What it takes to make a genetically modified organism (GMO)

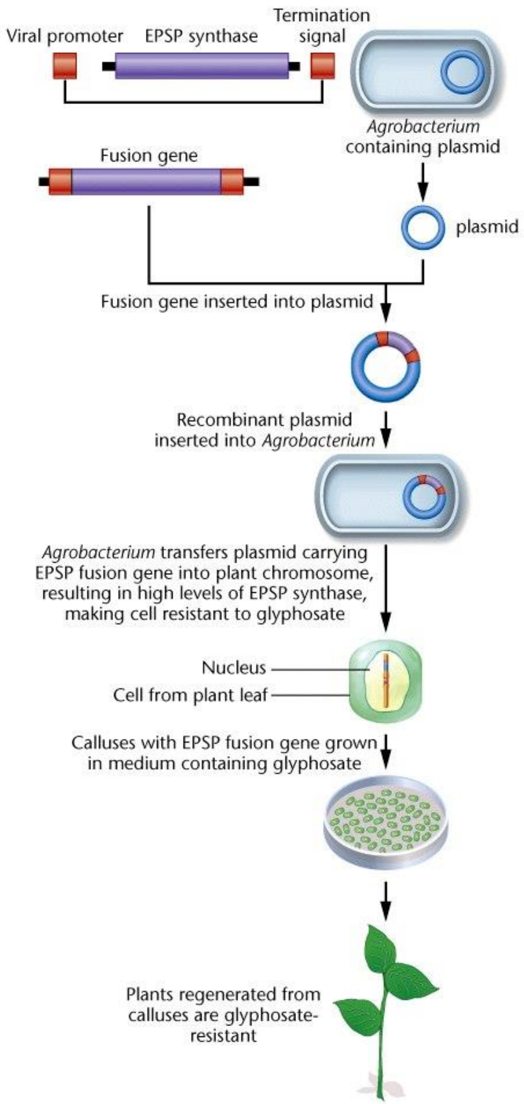


Figure 19-1 Essentials of Genetics, 6/e

1) Cloning of genes (DNA) of interest
 - Add a gene to optain a new function
 - Remove a gene with unwanted function

2) Transfer the gene to an organism
 - *Agrobacterium*

3) Selection of transgenic cells

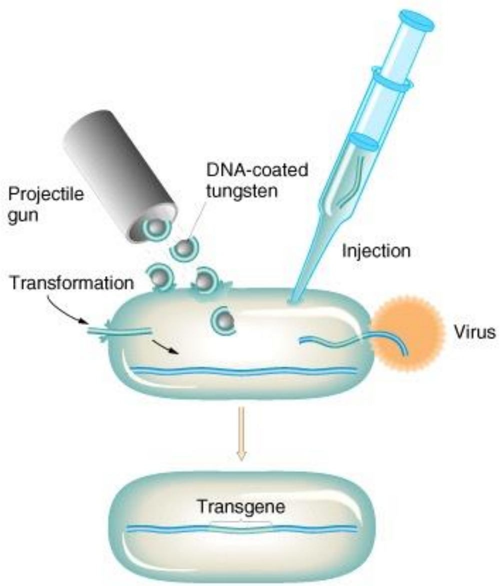
4) Before possible marketing

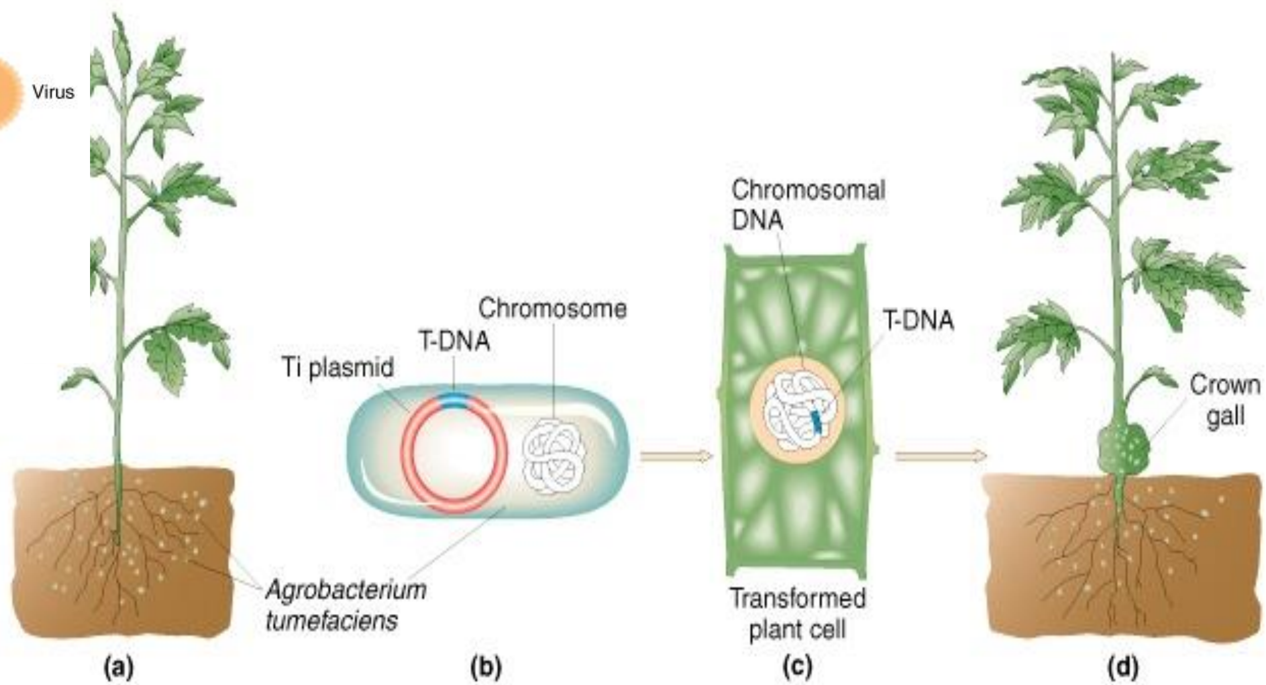
- Risk assessment and acceptance

- Consumer preferance (if not wanted it will not sell/survive)

GM – Methods to Transfer DNA

-*Agrobacterium tumefaciens*, T-DNA transferred from bacteria to plant cells
-Direct DNA-injection
-Particle bombardment (gene canon)





Genes can produce proteins directly or regulate other genes

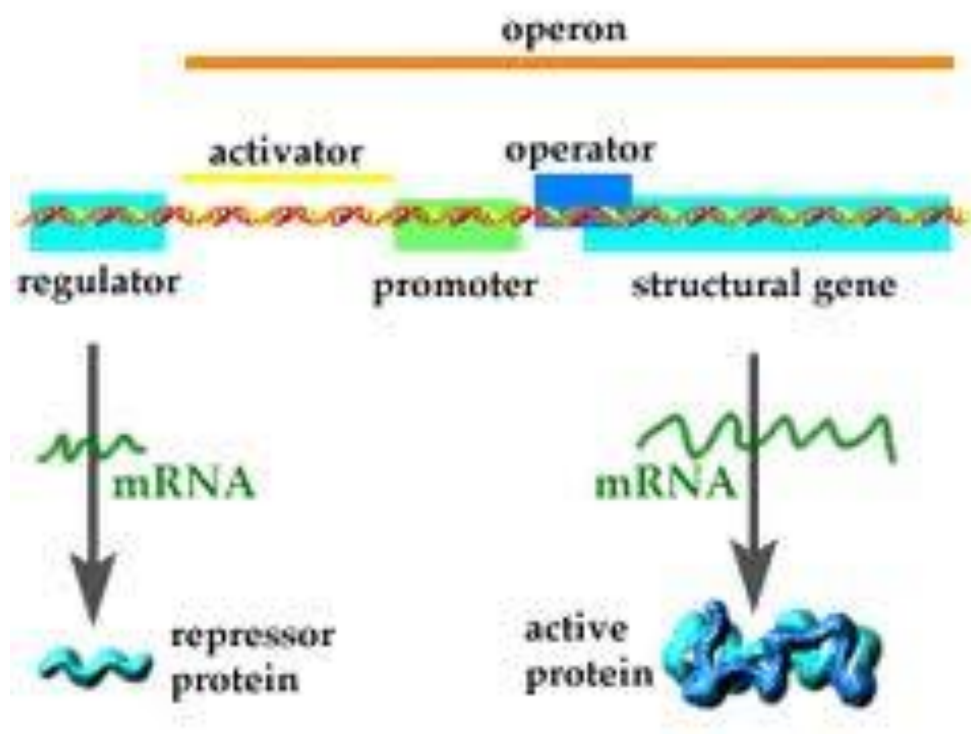
DNA

↓

RNA

↓

Protein



Genes and their generated RNA & proteins - basis for all life

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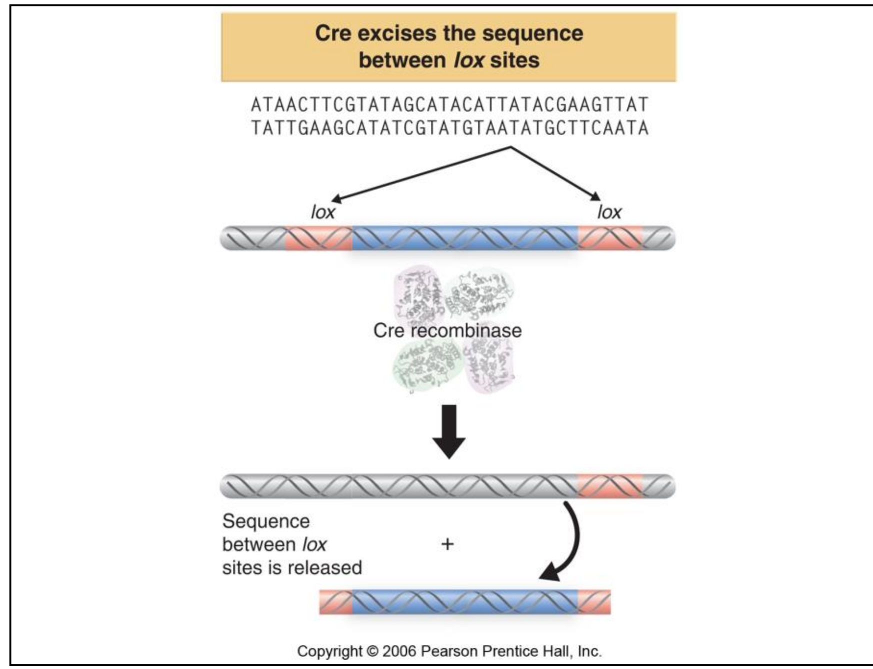
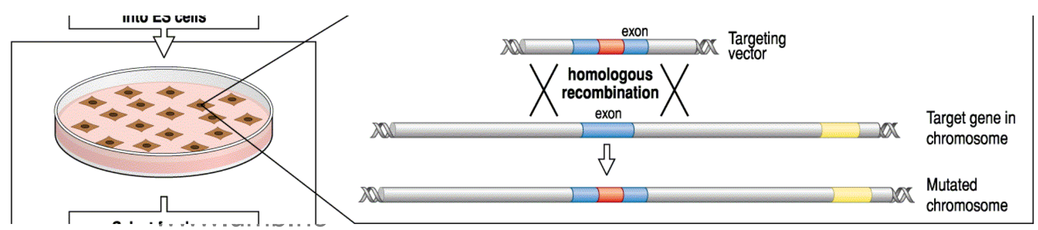
New techniques laser precision and can make non-detectable GMOs

Cre/lox

-Integrate gene at specific places in the genome
-Remove specific genes



Zn-fingers and CRISPR further development of the technology



GMO also called a transgenic

Transgene (gen from another species), Cisgenic/intragenic (gene from the same species)

promoter	Anthocyanin Gene Causing Purple Color

GM facts and opportunities

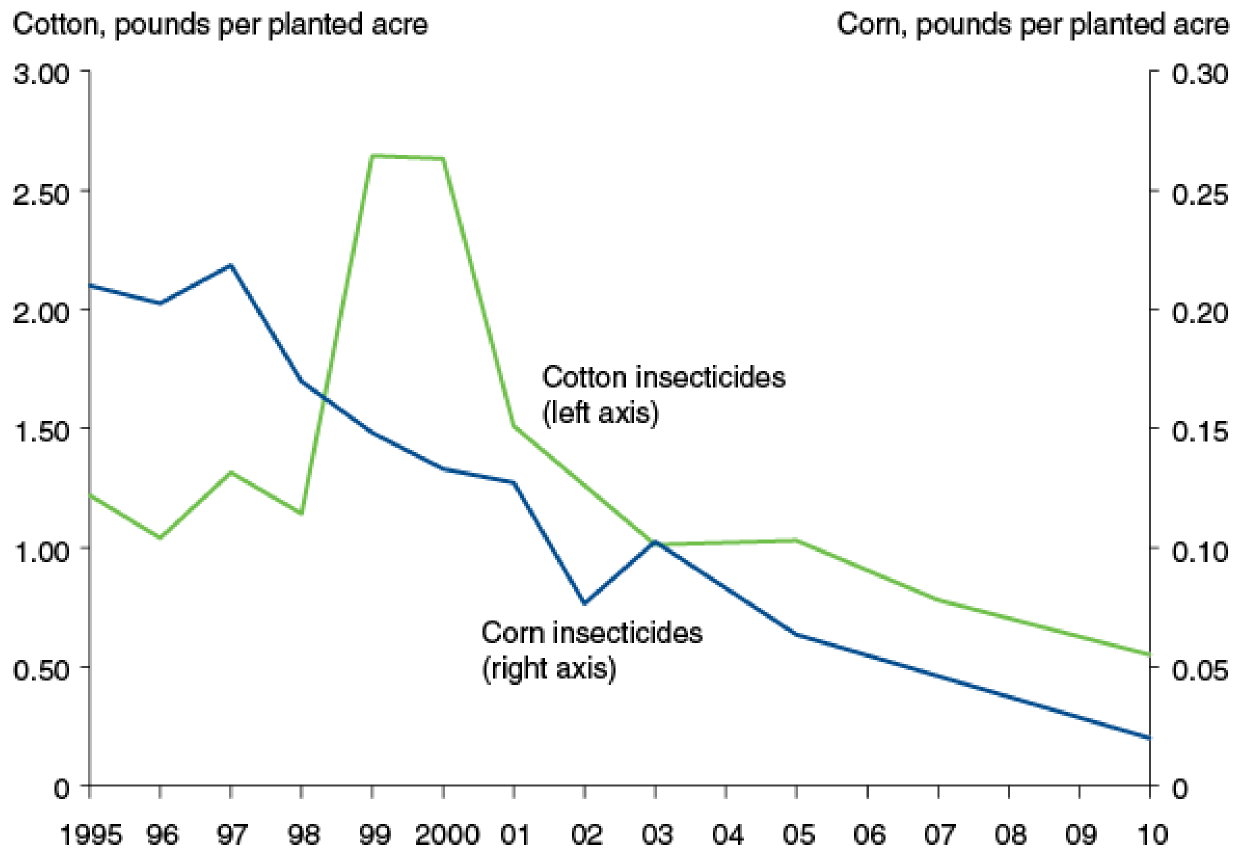
GM increased yield by 21%
GM reduced pesticide quantity by 37%
GM reduced pesticide costs by 39%
Profit gain for GM farmers 69%

Breeding should optimize energy production, it be food, feed or fuel

Efficiency depend on optimal tools and a complete toolbox, such as GM

Metastudy by Klümper & Qaim 2014 PLoS

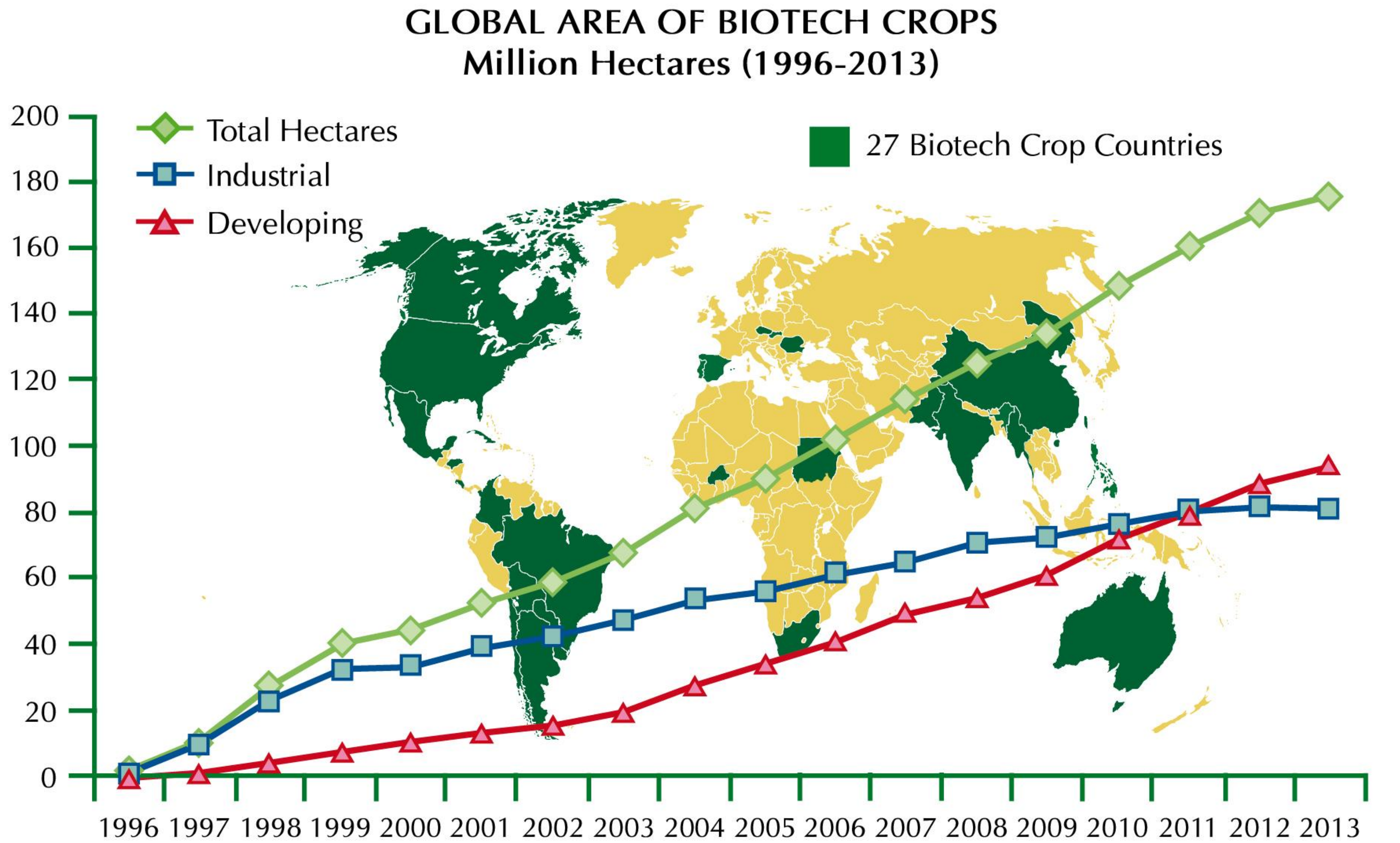
Insecticide use in corn and cotton declined in most years following GE crop adoption



Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, Agricultural Chemical Usage Reports and Quick Stats.

http://www.ers.usda.gov/amber-waves/2014-march/adoption-of-genetically-engineered-crops-by-us-farmers-has-increased-steadily-for-over-15-years.aspx#.VGEL4r619BH

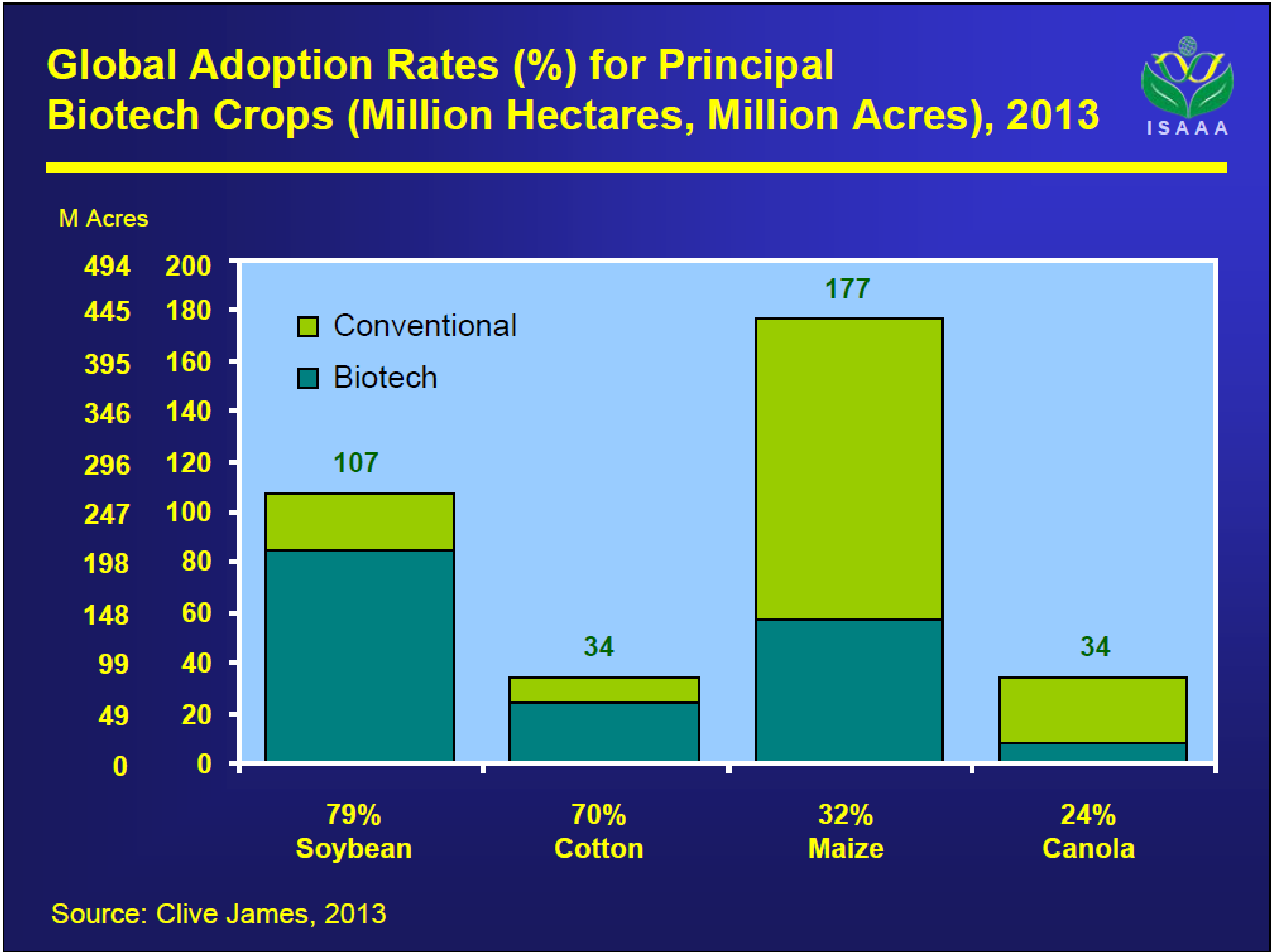
Current Global GMP Map



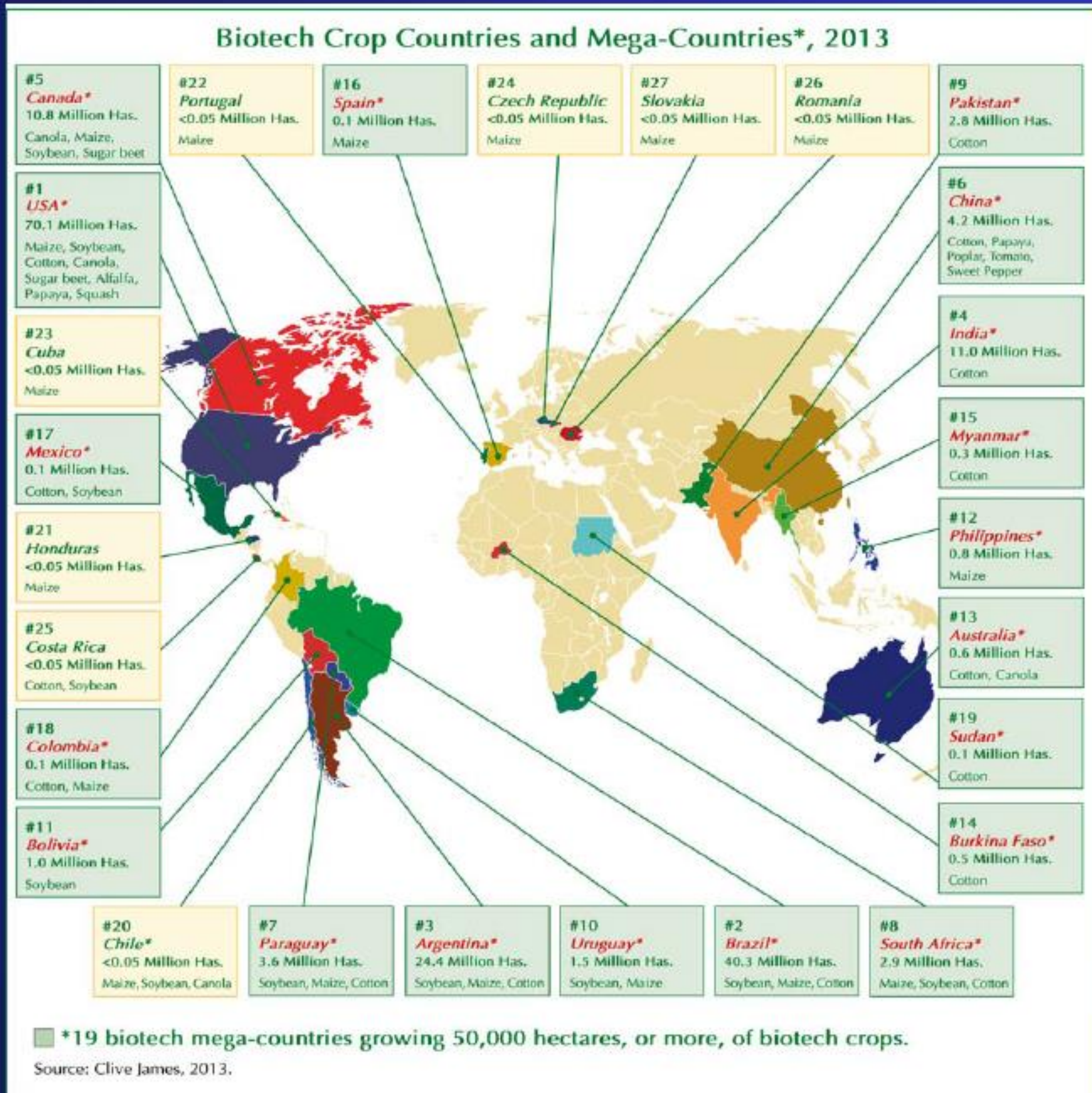
A record 18 million farmers, in 27 countries, planted 175.2 million hectares (433 million acres) in 2013, a sustained increase of 3% or 5 million hectares (12 million acres) over 2012.

Source: Clive James, 2013.

We all Wear GM Cotton



Biotech Crop Countries and Mega-Countries*, 2013



Global Area (Million Hectares) of Biotech Crops, 2013: by Country

ISAAA

Biotech Mega Countries

50,000 hectares (125,000 acres), or more

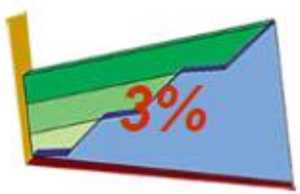
		Million Hectares
1.	USA	70.1
2.	*Brazil**	40.3
3.	*Argentina**	24.4
4.	*India**	11.0
5.	Canada	10.8
6.	*China**	4.2
7.	*Paraguay**	3.6
8.	*South Africa**	2.9
9.	*Pakistan**	2.8
10.	*Uruguay**	1.5
11.	*Bolivia**	1.0
12.	*Philippines**	0.8
13.	Australia	0.6
14.	*Burkina Faso**	0.5
15.	*Myanmar**	0.3
16.	Spain	0.1
17.	*Mexico**	0.1
18.	*Colombia**	0.1
19.	*Sudan**	0.1

Less than 50,000 hectares

*Chile**	Czech Republic
*Honduras**	*Costa Rica**
Portugal	Romania
*Cuba**	Slovakia

* *Developing countries*

Increase over 2012

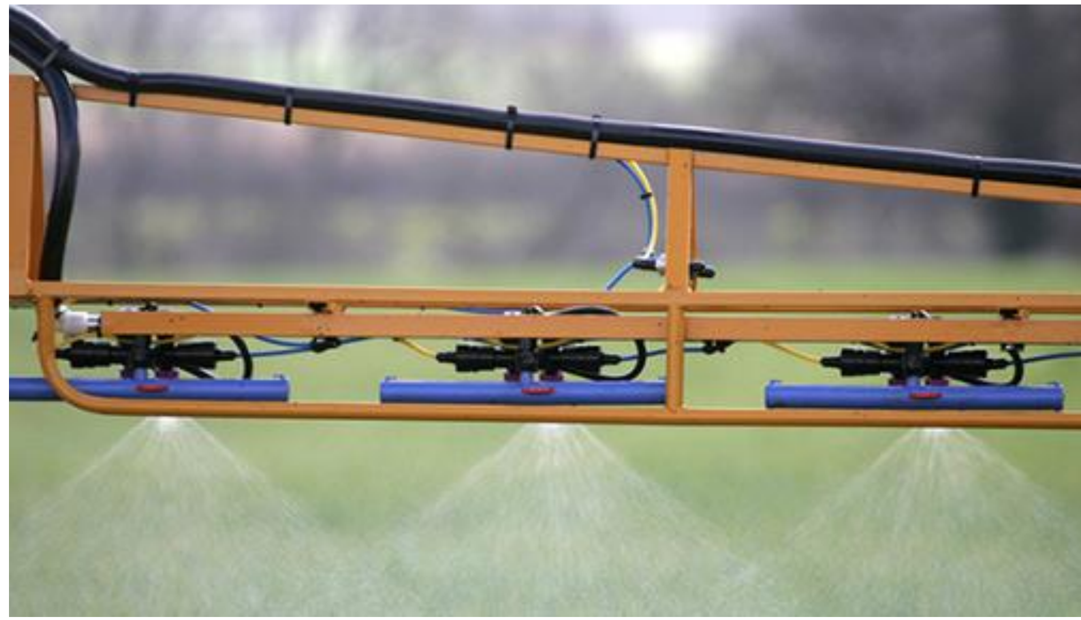


27 countries which have adopted biotech crops

In 2013, global area of biotech crops was 175.2 million hectares, representing an increase of 3% over 2012, equivalent to 5 million hectares.

Source: Clive James, 2013.

Farmers Weekly: Loss of pesticides could cost UK farming £1.6bn



This is another reason why GM might be needed – for plant protection to reduce yield losses.

http://www.fwi.co.uk/arable/loss-of-pesticides-could-cost-uk-farming-1-6bn.htm

Swedish (BASF) Fortuna – dry rot resistance

Potato breeding is very time consuming and inefficient => GM especially important

- 40% of Norways pesticides due to this ”fungi”
- 2 resistance genes taken from *S. Bulbocastanum*

Non-resistent mother Fontana, and GM daughter Fortuna

GMO results depend on know-how and funding

- Available techniques, genes and patents

-Development of products mainly happends in the world outside Europe

The World Outside Europe Prepare and Develop GMO for All, Except EU

Annual World Biotechnology Congresses in Dubai & USA for medical and agricultural sciences including nobel price winners

13th IUPAC International Congress of Pesticide Chemistry / 248th American Chemical Society National Meeting, San Francisco Aug 2014

RNAi (GM method) – *the* hot topic this year

17 000 participants

RNAi can replace pesticides

⇒ cleaner production

DNA => mRNA => Protein

RNAi can target and knock-out specific genes in an organism

RNAi to knock-down or knock-out genes

Used in medicine &
pest management for crop protection

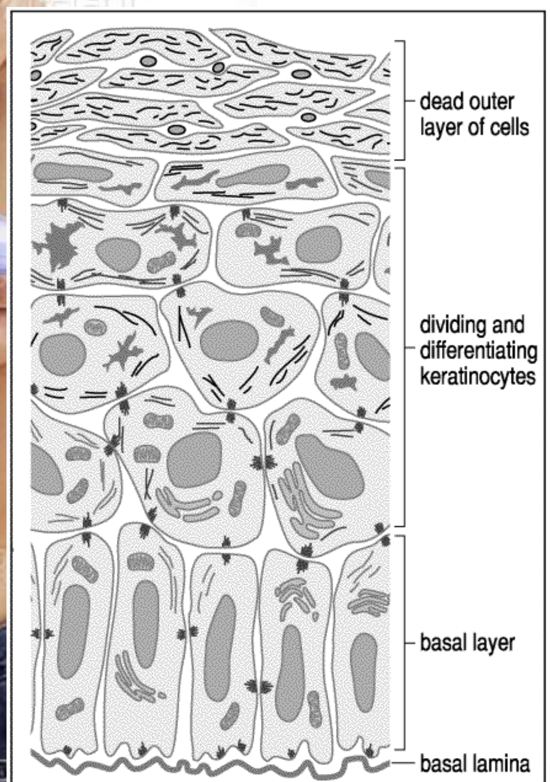
DNA

→ mRNA

→ RNAi (blocking mRNA translation)

=> little or no protein

RNAi to block insect feeding by attacking insect gut genes



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Replacement of epithelial cells in the gut from stem cells

Stem cells

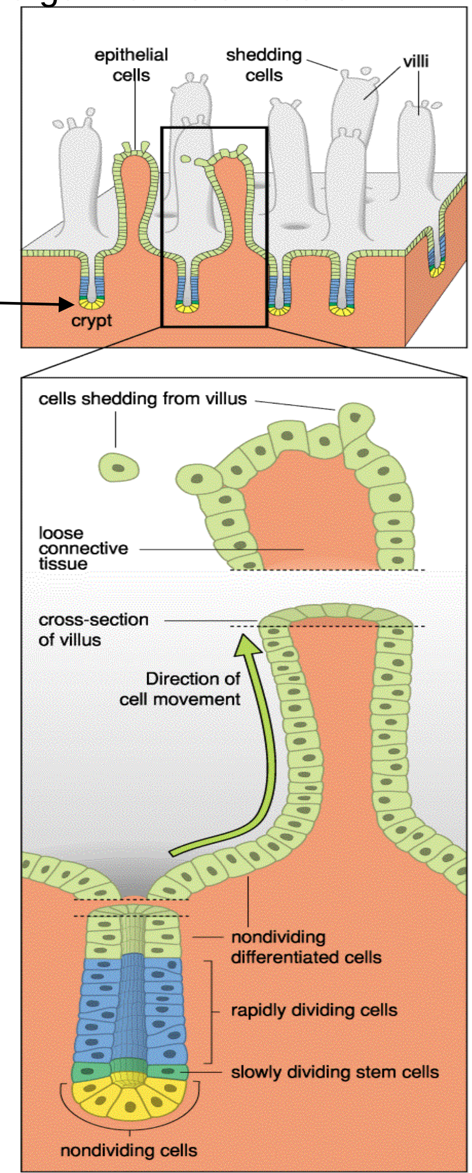
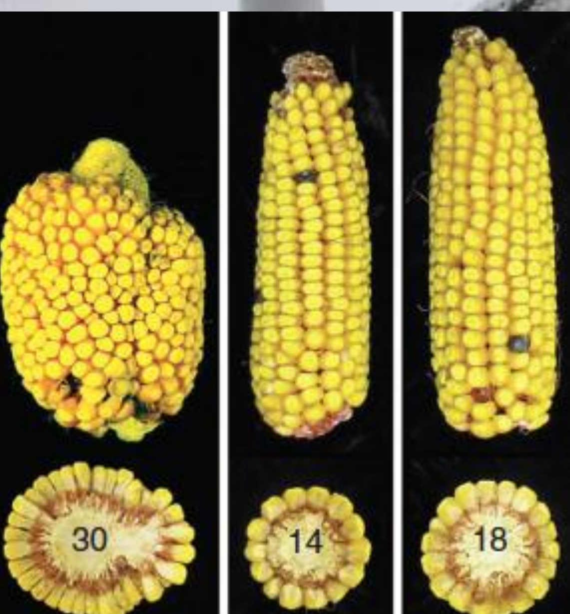


Fig. 8.21

Increased yield by increasing the stem cell pool

Maize selection for higher yield dates back 7000 years.

Genes (*FEA2*/*CLV2*) with a potential to increase seed yield (13%).



Cold Spring Harbor (Long Island, NY, USA)
Bommert et al. 2013 Nature Genetics

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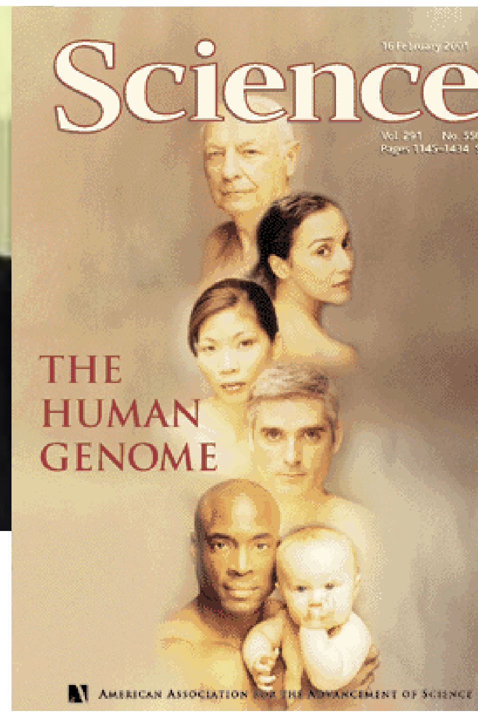
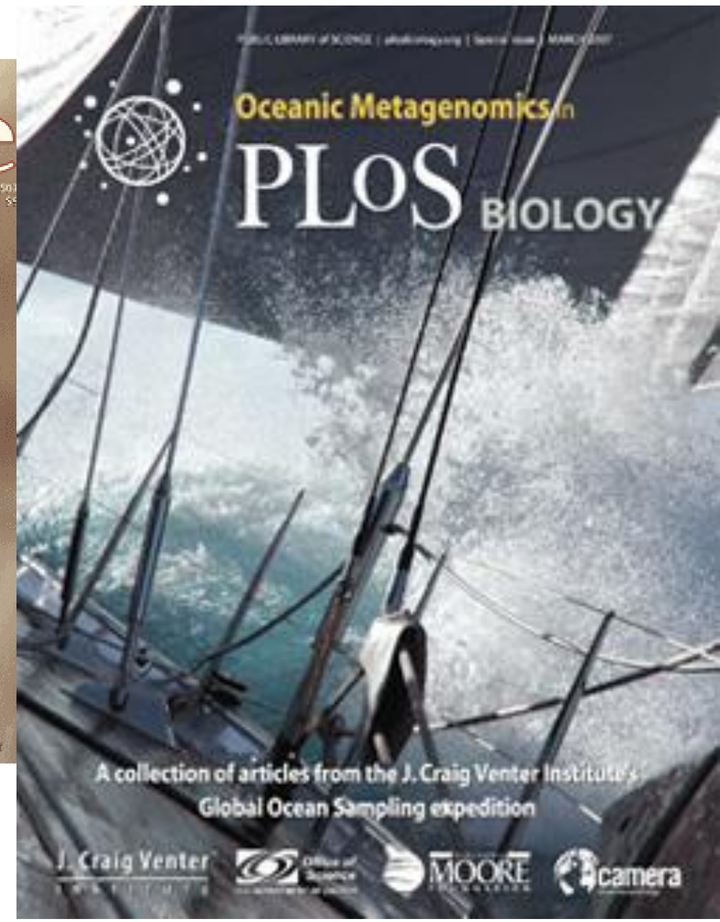
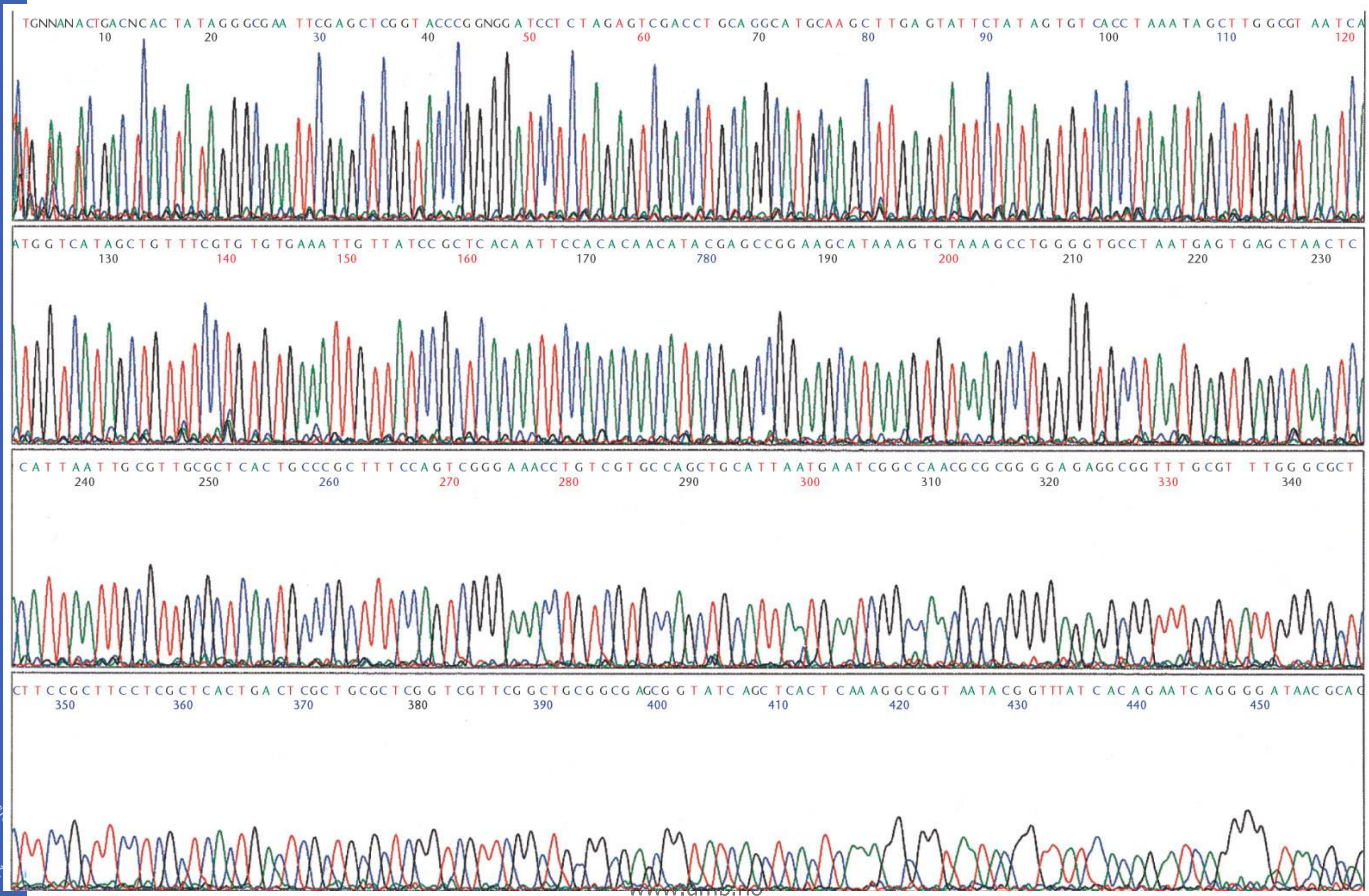
Sequencing species increases our gene bank & knowledge





Craig Venter construction of life

How a DNA fragment/chromosome piece reads (4 variables: A, T, G, C)



Classical GMO

…….AAAATTGGCCTTTCGCGGTATTCCTTC…
…….TTTTAACCGGAAAGCGCCATAAGGAAG……

GTCCCCGTTAA
CAGGGCAATTT

…AAAATTGGCCGTCCCCGTTAATTTCGCGGTATTCCTTC..
…TTTTAACCGGCAGGGCAATTTAAAGCGCCATAAGGAAG..

Hybride nucleic acid = Recombinant DNA

Advanced GMO would produce product WHEN og WHERE needed

- Resistance gene only activated if attacked by insect
- Harvested product in seeds only i.e. marine oils for feed

GMP producing vaccines or treatment by antibodies directly

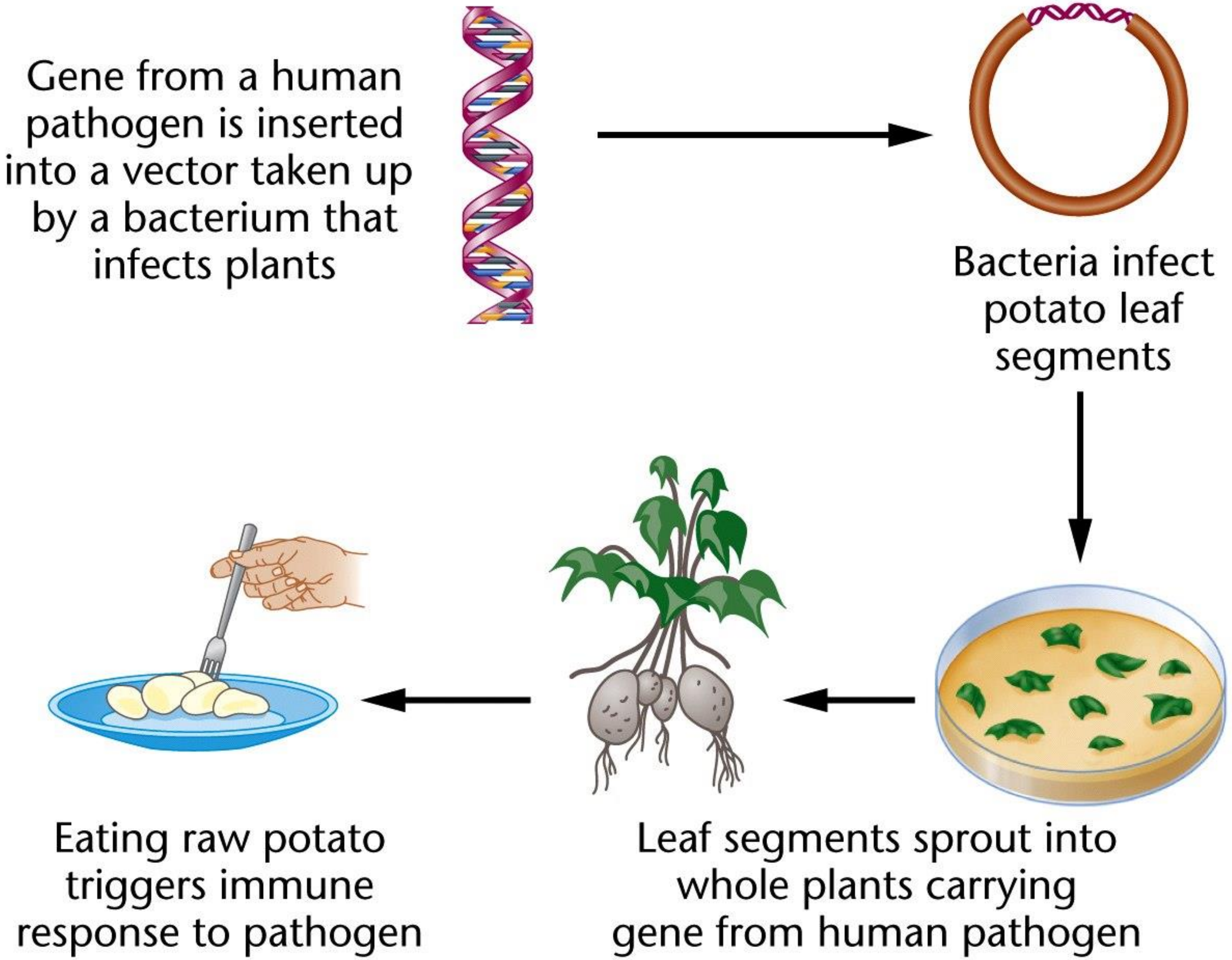
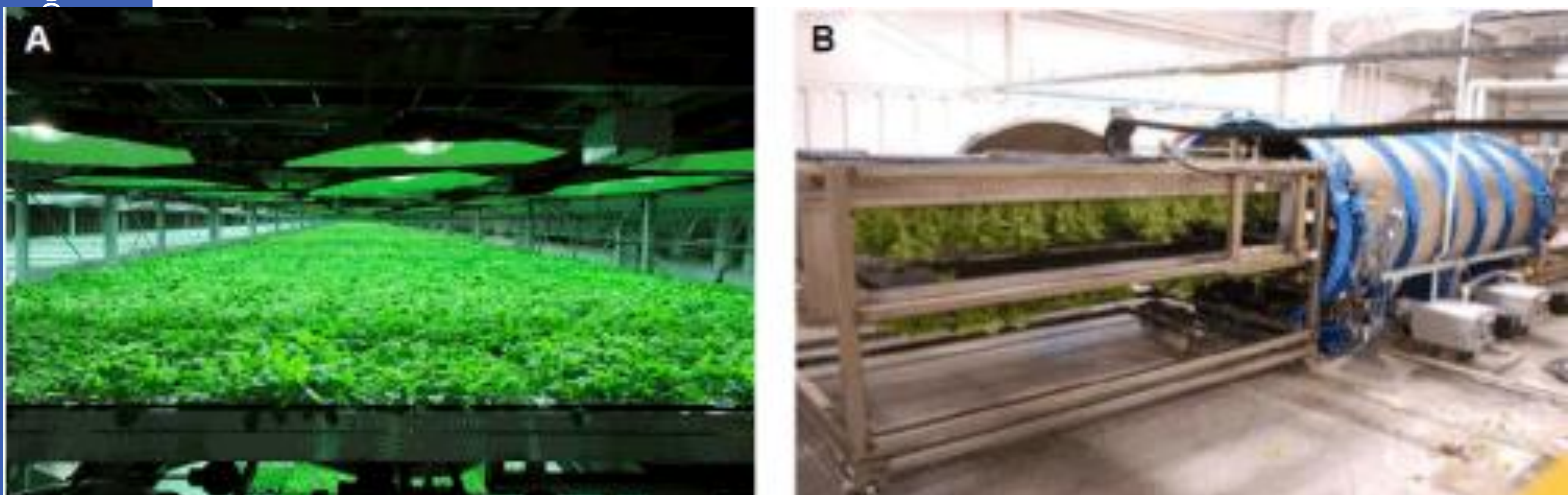


Figure 19-5 Essentials of Genetics, 6/e

Agroinfiltration for time limited, high production of e.g. ebola antibodies



GM could develop a greener medicine production and add high income production to farm fields

GM Chicken not Spreading Influensa

Developed at Cambridge & Edingburgh University

Lyall et al. 2011 Science

Suggested possible to use the same principle on swine and perhaps even human influensa.

Innovasjon Norge Ås example:
Norwegian chickens used to produce antibodies after injections, if GM no treatment needed.

Gene Revolution – Golden Rice (GR) with provitA Update

- Regular rice has provit A only in green plant parts
- The Ingo Potrykus first GR had genes from Easter Lily and a soil bacteria (*Erwina uredivora*)
- GR 2 has the genes from maize and rice
- GR2 crossed into local varieties Philippines, Taiwan & USA
- Planned marketed 2016 in the Philippines

Golden rice – improved for human health

- 23 x higher β caroten (37µg per g rice)
- Bioavailability better than spinach
- One portion enough to secure daily intake of provitamin A


The fish feed is too vegetarian
Fra Ståle Refstie, Nofima & NMBU

Alternative Fish Oil Needed for Sustainable Aquaculture

GM field trial at Rothamsted (High Security Level Needed due to Protesters..)

The GM Camelina sativa Producing Omega-3

Title: Draft Opinion on A comprehensive assessment of fish and fish products in the Norwegian diet – based on new knowledge

Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

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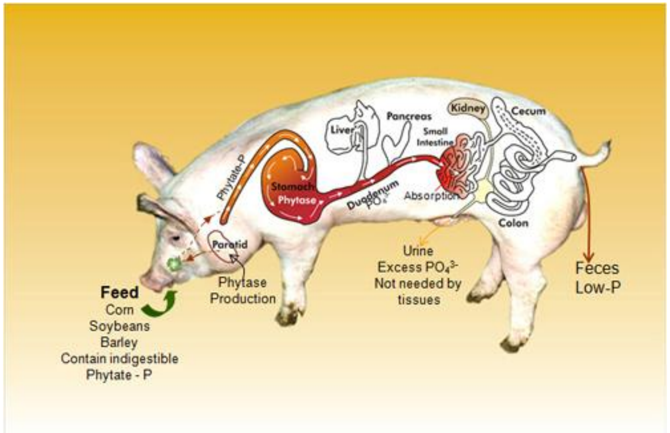
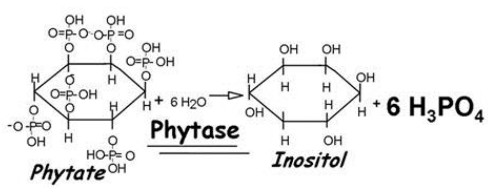
GM salmon with improved meat production can be optained by several means; stronger promoter or stronger growth hormone genes to optained higher meat production

Environpig developed in Canada & China





University of Guelph, Canada

Utilize feed phosphorus (P) => reduce losses via manure.

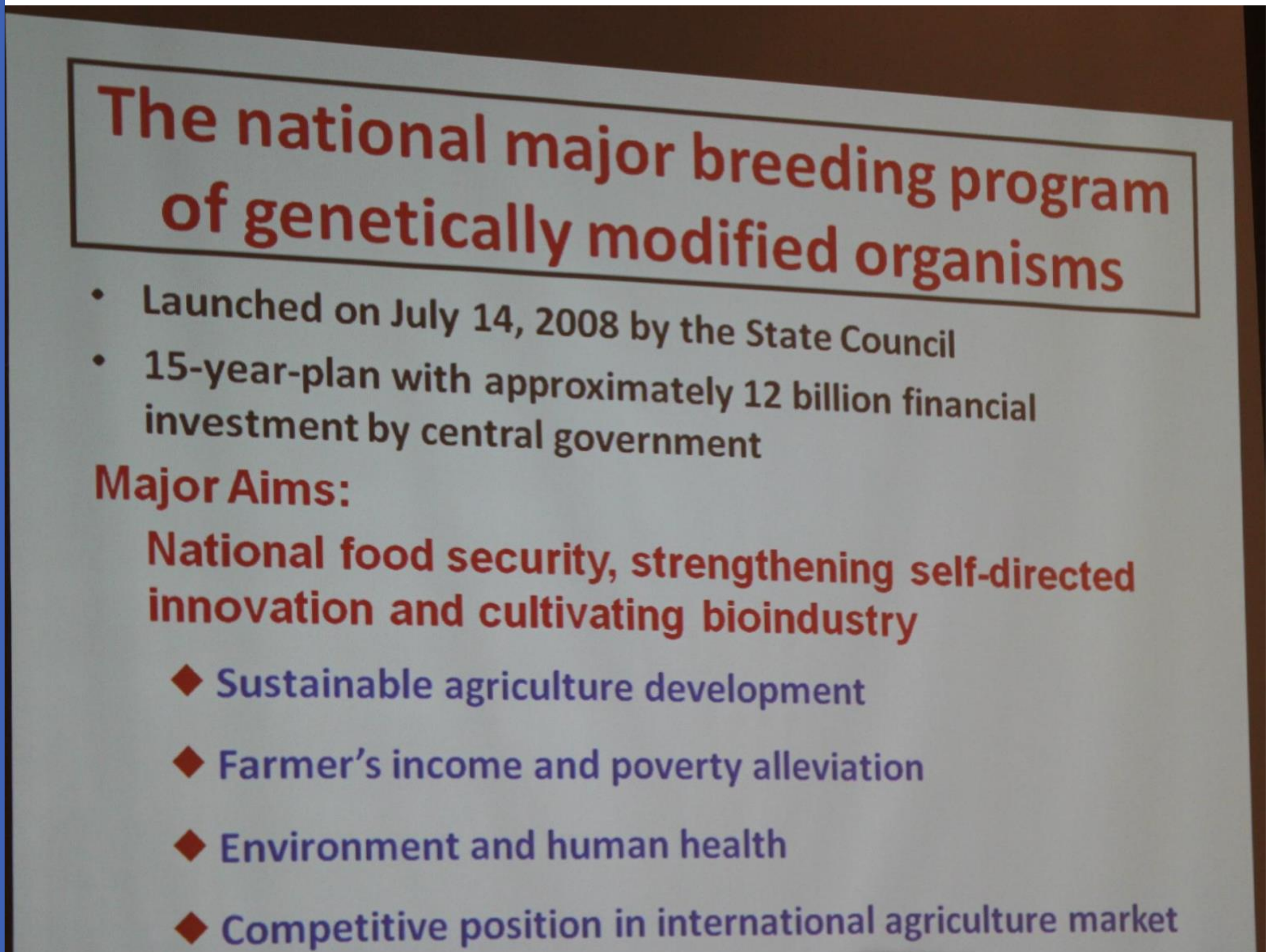
Same principle developed in plants to increase utility of P content in fertilizer.

Especially important to secure global P resourses, since limited and part of DNA. If we run out of P => all life end.

China has developed GM animals

First world conferance on GM animals in Argentina 2011

China invests in GMO to meet food security needs



Financial Strength
Ex: Investments in modern genetics: BGI (formerly Beijing Genomics Institute)

Placed their European headquarter in Copenhagen

4500 employed and hired another 500 in 2010, of which 1500 are bioinformaticians

Sequences genomes & individuals in large numbers, publish in Nature & Science

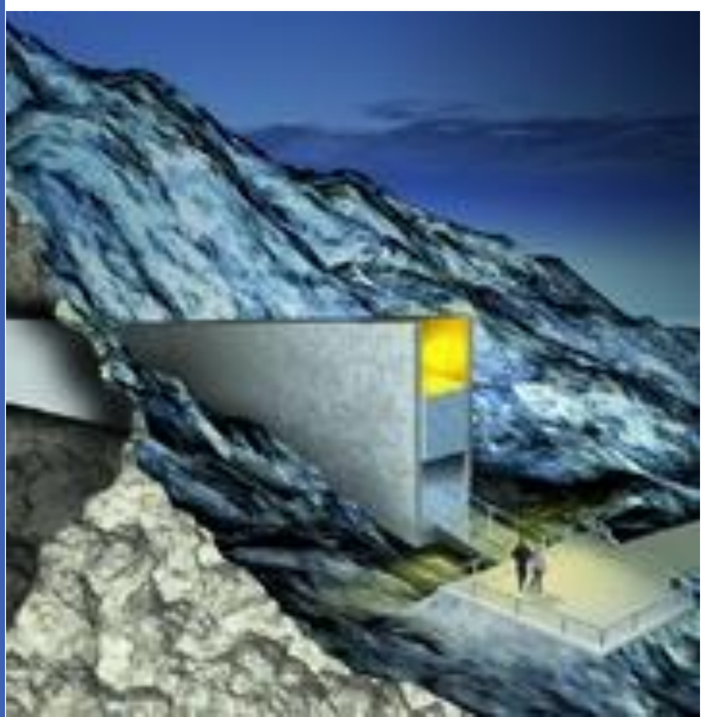
Tested 500 genes in GMOs by 2010

4 main areas of research:

- C4 photosynthesis
- N2 fixation
- Seed and flower development
- Heterosis

GM might be the only mean to utilize the resources in the Svalbard gene vault

- As wildlife conservation realized 20 years ago, there is litle sence in preserving locally adapted seeds to ecosystems disappearing
- Gene transfer might be the exclusive way to keep and make use of resistanse and imortant quality traits (Gordon Conway, chief scientific adviser UK governments Dept for Int. development)



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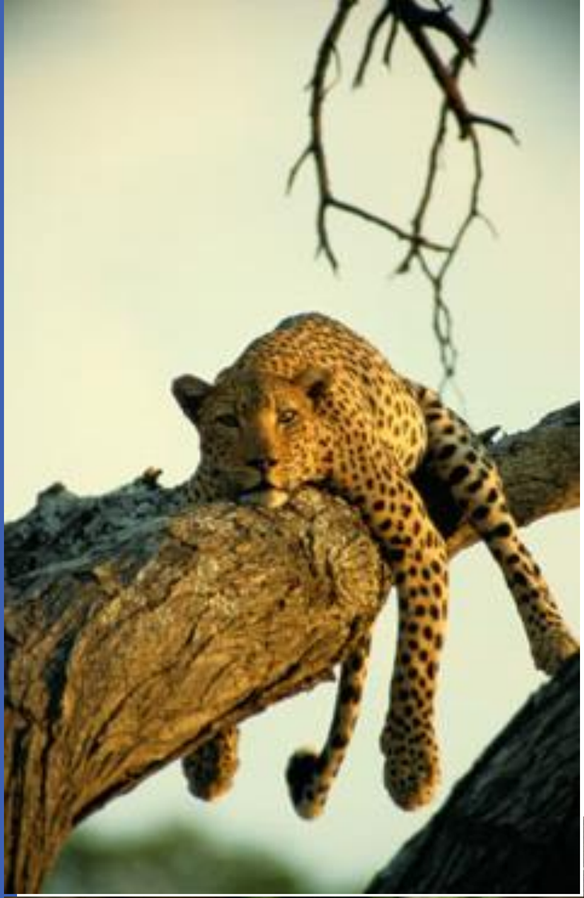
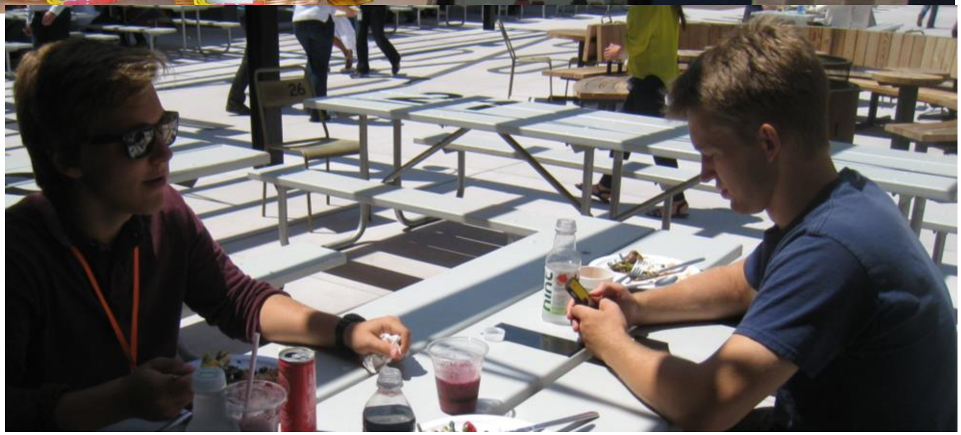


How GM technology will be used depend on the investments and politics

We can participate or depend on other’s choices

Further reading:



Pro-GMO.no

Dag Hessen Gyldendal
Mendel 150 year anniversary
http://www.ted.com/talks/michael_specter_the_danger_of_science_denial

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3566841/

http://www.fjellner.eu/miljoutskottet-forsoker-stoppa-gmo/

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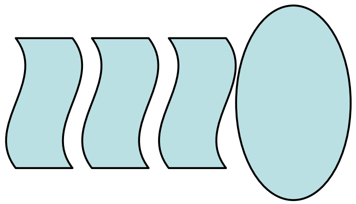
Where is Norway going?

Zinkfingernucleases (ZFN) => non detactable GMO

DNA-binding part: Zinkfinger
(designas för att binda till ett specifikt ställe i DNA)

✓ DNA-cleaving part: Nuklease

ZFN-complex



Marie Nymann

Agroinfiltrering

Växtmaterial doppas i en Agro-lösning -> vaccum.

Agrobacterium tas upp intracellulärt och levererar T-DNA in i cellen.

Avsikten är inte stabil integrering utan snabb produktion av protein eller studera effekten av en viss genprodukt.

Exempel: iBio Inc – kliniska försök fas 1 influensavaccin (H1N1) – pressmeddelande 21 mars.

Pharmaceutiske products produced in GMOs

TABLE 19.1 Some Genetically Engineered Pharmaceutical Products Now Available or Under Development

Gene Product	Condition Treated	Host Type
Tissue plasminogen activator tPA	Heart attack, stroke	Cultured mammalian cells
Human growth hormone	Dwarfism	Cultured mammalian cells
Monoclonal antibodies against vascular endothelial growth factor (VEGF)	Cancers	Cultured mammalian cells
Human clotting factor VIII	Hemophilia A	Transgenic sheep, pigs
C1 inhibitor	Hereditary angiodema	Transgenic rabbits
Recombinant human antithrombin	Hereditary antithrombin deficiency	Transgenic goats
Hepatitis B surface protein vaccine	Hepatitis	Cultured yeast cells
Immunoglobulin IgG1 to HSV-2 glycoprotein B	Herpesvirus infections	Transgenic soybeans
Recombinant monoclonal antibodies	Diagnosis and passive immunization against rabies	Transgenic tobacco, soybeans
Norwalk virus capsid protein	Norwalk virus infections	Potato (edible vaccine)
E.coli heat-labile enterotoxin	*E.coli* infections	Potato (edible vaccine)