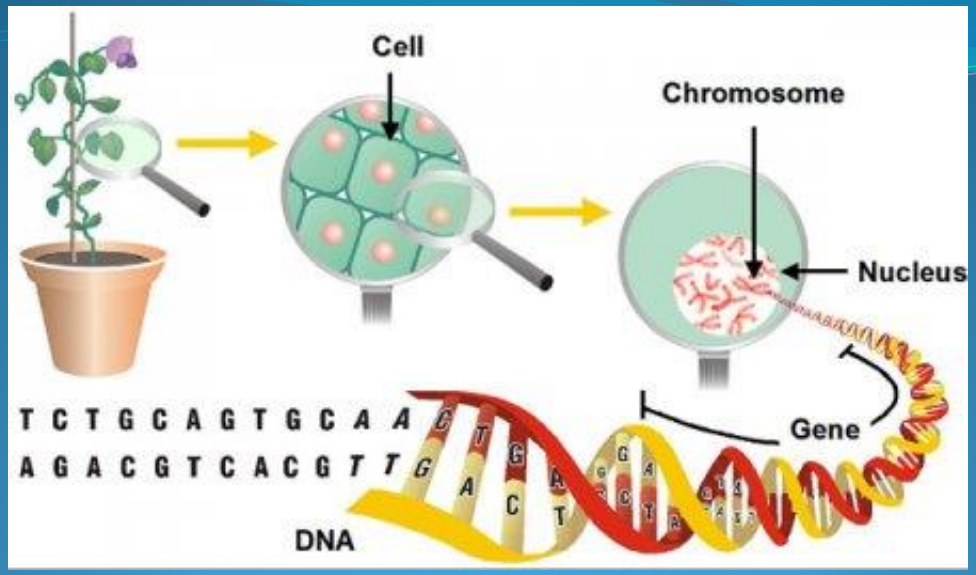


Harnessing Biotechnology to Address Today's Needs

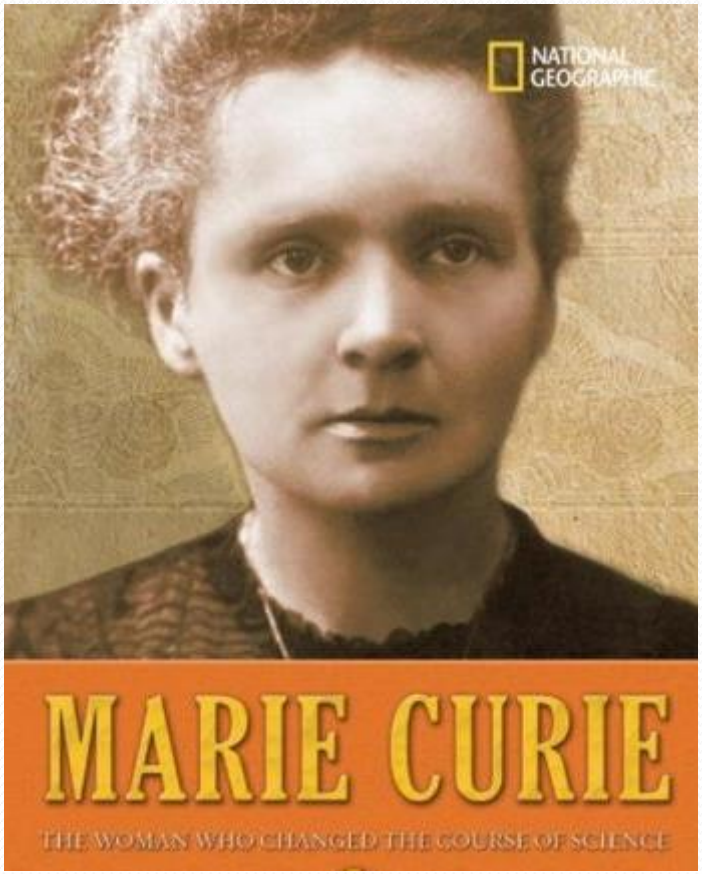
Violeta N. Villegas, PhD
Outstanding Young Scientist 1991
(Once a Young Scientist)
Biliran
17 October 2017

Outline

- Introduction to biotechnology
- Why we need biotechnology
- Applications of biotechnology (medicine, industry, agriculture, etc.)
- Genetic principles
- Safety assessment of biotech crops
- One example
- Co-existence of biotech, conventional and organic crops
- Concluding remarks

Should we be afraid of biotechnology?

Nothing in life is to be feared,
it is only to be understood.
Now is the time to understand more
so that we may fear less.



Marie Curie is remembered for her discovery of radium and polonium, and her huge contribution to the fight against cancer.

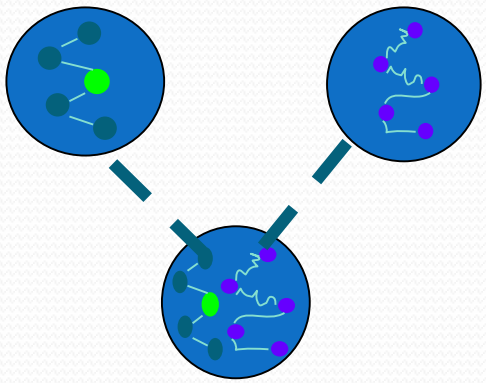
Now, let us understand what **Biotechnology** is and what it can do.

What is Biotechnology?

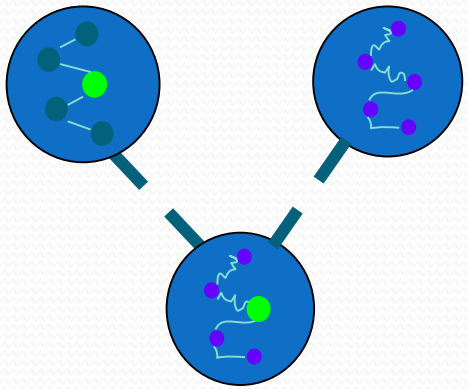
Biotechnology (as applied to agriculture) is:

- A technique to transfers gene(s) of interest make better products.
- An option to improve agricultural production
- An extension of traditional plant breeding
- Precision breeding

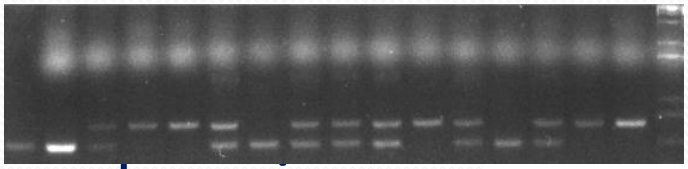
Traditional Breeding



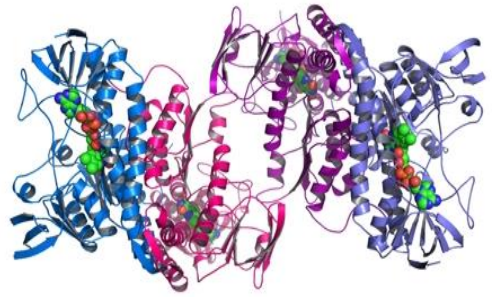
Genetic engineering (biotech)



New tools in crop improvement



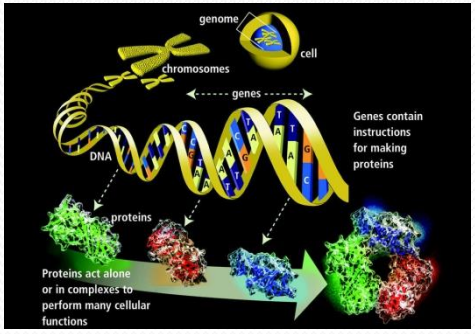
- Molecular markers
- The “omics” (genomics, proteomics, me
- Genetic engineering
- New breeding techniques: gene editing TALENS, ZFN)



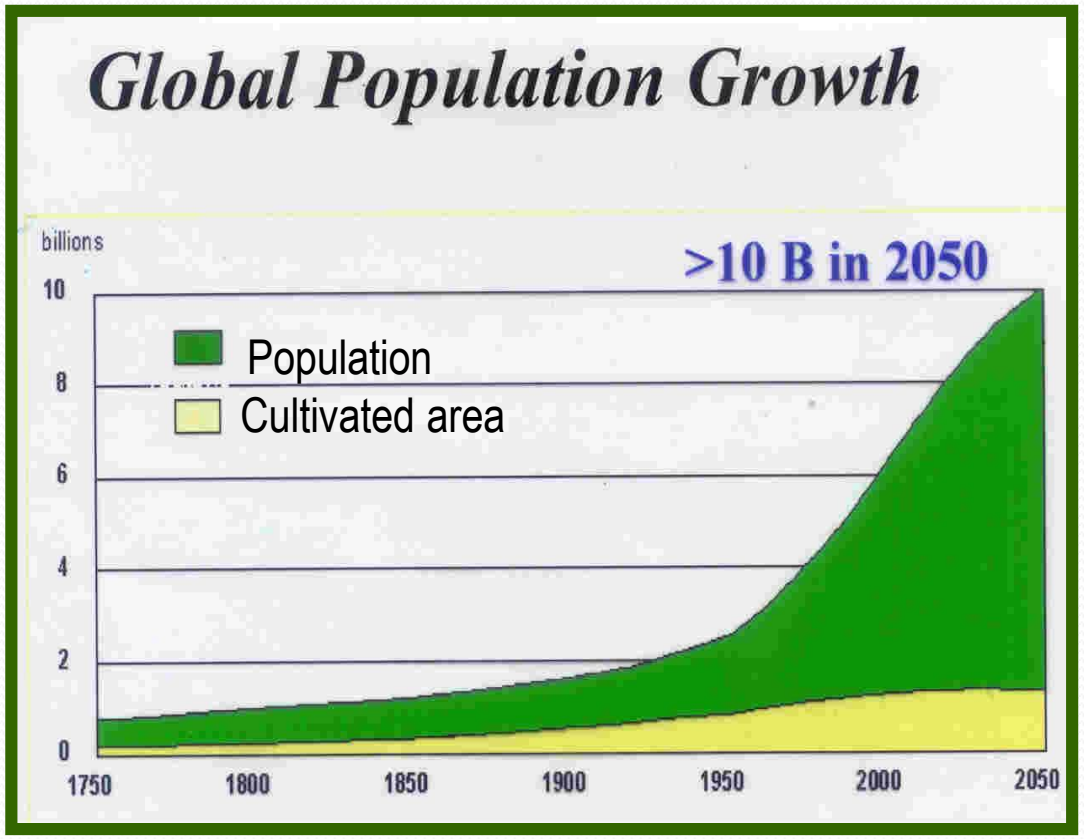
CRISPR : Clustered randomly interspersed short palindromic repeat

TALENS : Transcription activator-like effector nucleases

ZFN: Zinc finger nucleases



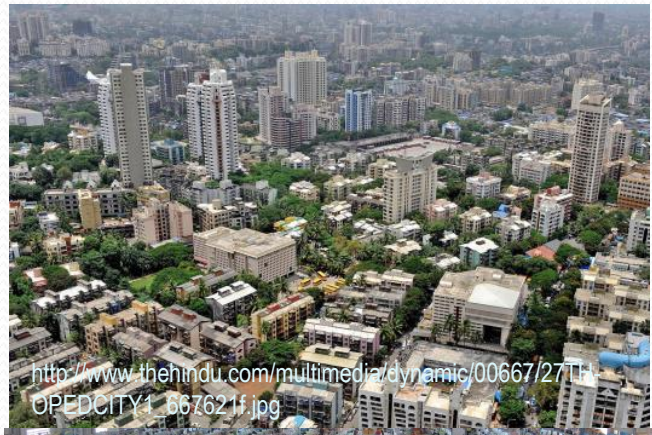
Biotechnology is an OPTION
Why do we need this option?



- Every second, 3 people are born
- Population of 10 B by 2050
- Every 7.67 seconds, 1 ha of productive land is lost

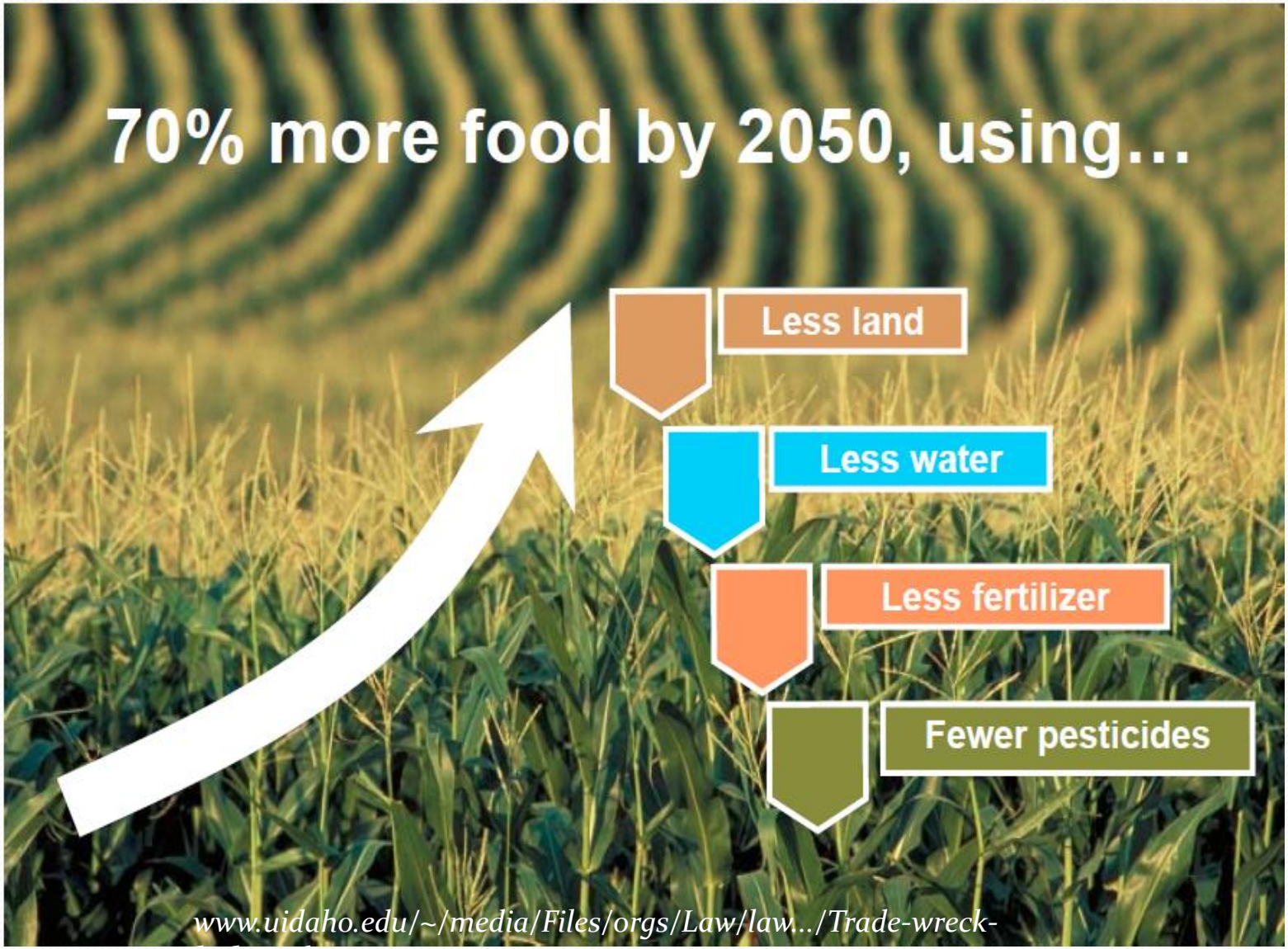
Worsening resource scarcity

Land →

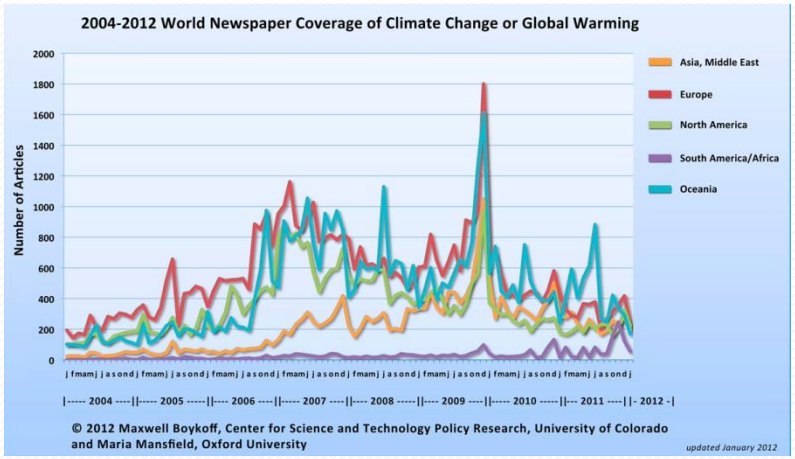


Labor →

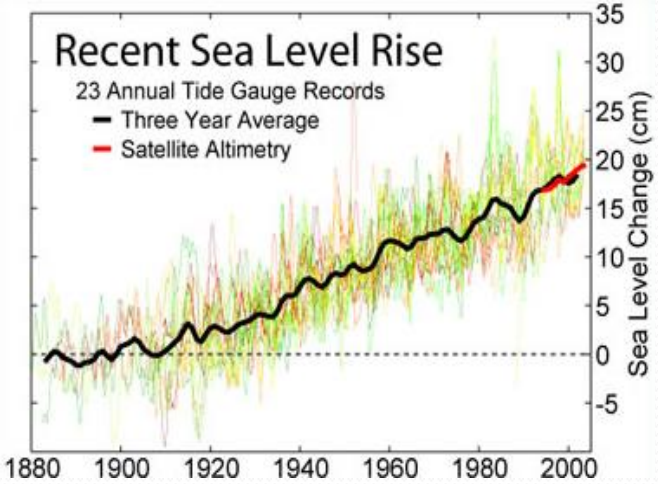
Water →


70% more food by 2050, using…
Less land
Less water
Less fertilizer
Fewer pesticides
www.uidaho.edu/~/media/Files/orgs/Law/law.../Trade-wreck-

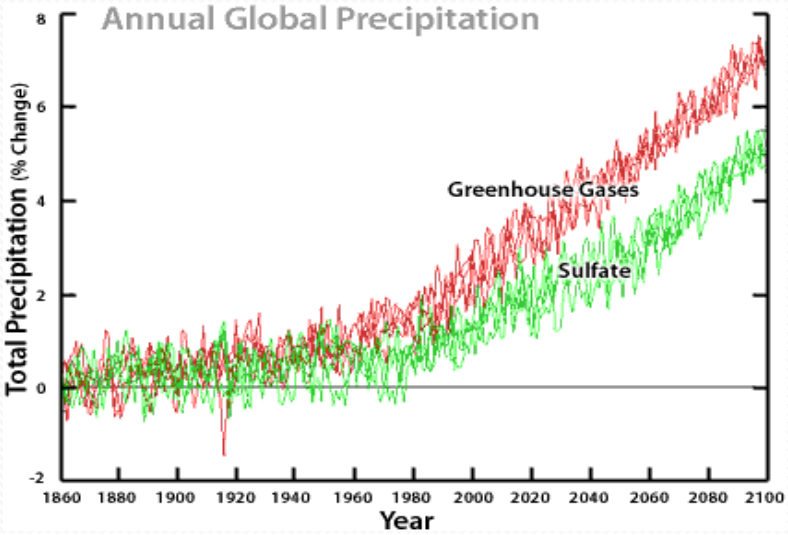
Climate change will negatively affect crop productivity



Global warming, rise in temperature



Sea level rise

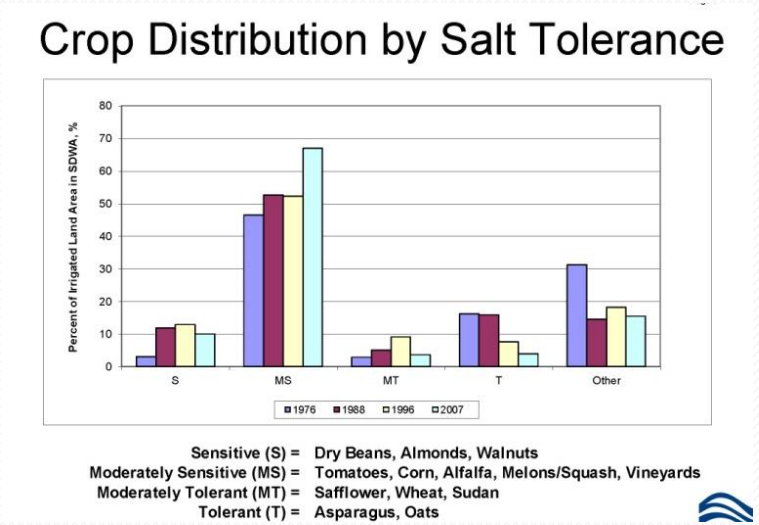


Changes in rainfall pattern

Weather disturbances

We need climate-resilient crops

Drought tolerant crops



Flood tolerant crops

Heat tolerant crops

Water: On the average, it takes 3,000 liters of water per person to produce our daily food (UN World Water Report, 2006)

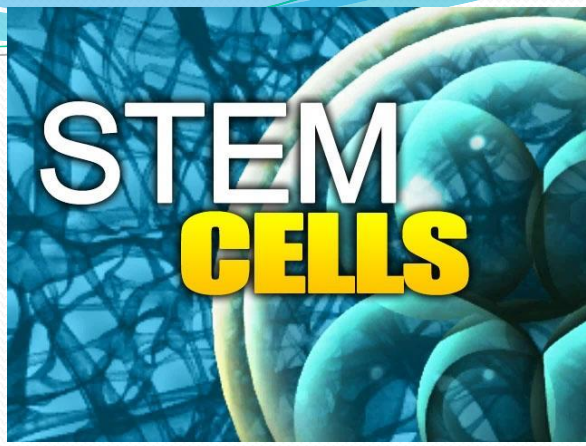
It takes 3,000 to 5,000 liters of water to produce 1 kg of rice

Biotechnology is NOT NEW

- It is as old as civilization and has helped man prepare various foods and food products

- The range of application of biotechnology is broad:
  - Medicine
  - Industry
  - Agriculture
  - Other examples

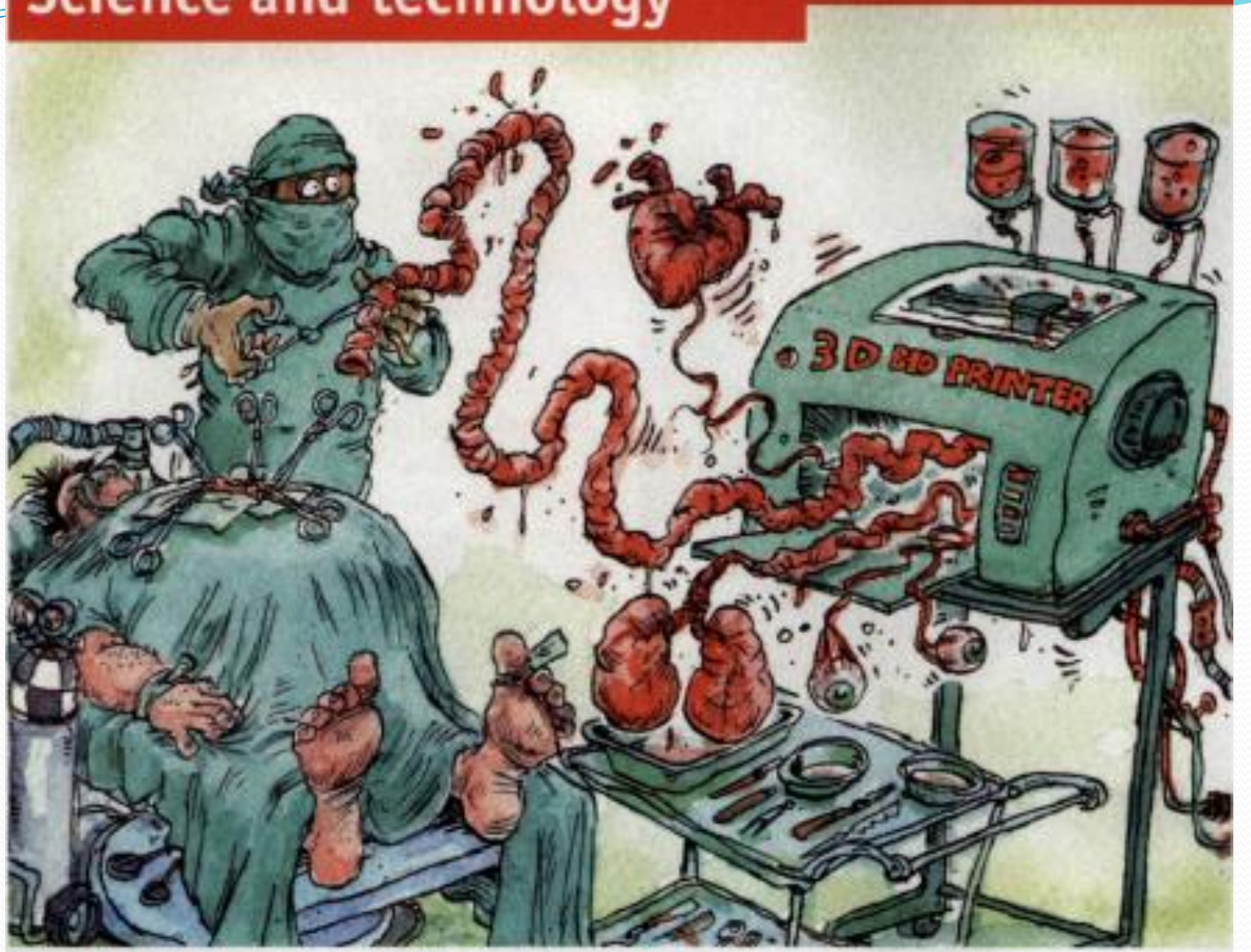
Applications of biotechnology



Medicine

- Insulin for diabetic patients
- Factor VIII (blood clotting) for haemophiliac
- Interferon for cancer treatment
- Hepatitis vaccine
- Stem cells

Science and technology



Printing body parts

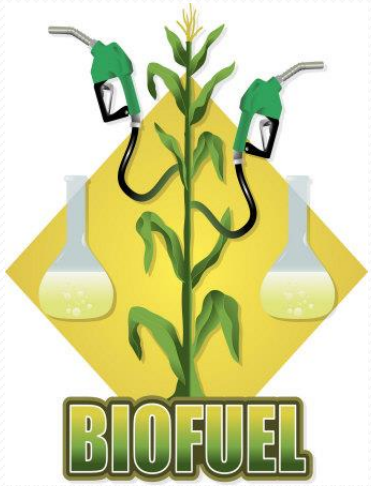
Making a bit of me

The Economist, 20 Feb 2010, p. 69

Applications of biotechnology

Industry

- Enzymes (chymosin for cheese making, phytase for animals)
- Biofuels (corn amylase)
- Biodegradable plastics
- Plants that absorb pollutants



Applications of biotechnology

Agriculture

- Insect/disease resistant crops (corn, cotton, veg, fruits)
- Herbicide tolerant crops (corn, soybean, cotton, canola)
- Quality traits (fortified food, better shelf-life, healthy oils)
- Resistant to abiotic stresses (drought, flooding, salinity)
- Nutrient use efficient crops


Insect resistant corn


Insect resistant eggplant


Herbicide tolerant corn


Virus resistant papaya


Golden Rice


Drought tolerant sugarcane


Innate potato
USDA: Nov 2014; FDA: 20Mar2015

USDA, 13 Feb 2015
FDA, 20Mar 2015

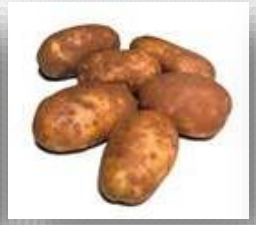
APPROVAL REGISTRY (Philippines)

http://biotech.da.gov.ph/Approval_Registry.php

For direct use as food and feed or for processing


Corn


Cotton


Potato


Soybean


Alfalfa


Canola


Sugar beet

- 37 single transformation events
- 35 stacked genes

For propagation (commercial cultivation)

- 6 single transformation events (corn)
- 6 stacked genes (corn)


Corn

Under R & D (Philippines)

Bt eggplant, Delayed ripening papaya,
Bt cotton, Golden Rice, high iron/zinc rice

Promising developments (still in R & D)

Rice with cholesterol-reducing resveratrol (Nat'l Inst of Crop Science, Korea)

Peanuts with very low allergen levels that have the potential to eliminate life-threatening peanut allergies

Applications of biotechnology

Others

GM silkworm producing glowing silk
(Japan; gene from coral and jellyfish)

Fast growing GM salmon
(FDA approval in Nov 2015)

Florigene/Suntory's
blue rose (delhinidine
gene from pansy)

Glo Fish (fluorescent gene from coral)

Interesting product in the making (still in R &D)

http://www.davidicke.com/wp-content/uploads/legacy_images/stories/April20120/goat-

http://www.theguardian.com/science/2012/jan/14/synthetic-biology-spider-goat-genetics

GM goat that produces spider silk in milk

Uses of spider silk (also called “bio-steel”):

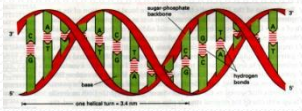
- thin sutures for eye and nerve surgery
- plasters and wound covers
- artificial ligaments and tendons
- textiles for parachutes
- protective clothing and body armor,
- ropes, fishing nets, etc.

GM goat milk containing higher levels of a human antimicrobial protein (lysozyme) was effective in treating diarrhea in young pigs- a finding that displays a potential benefit of genetically modified organisms in promoting human digestive health.

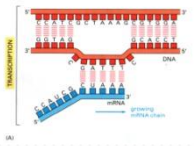
(UC Davis)

Genetic principle

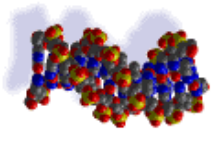
All organisms share the same genetic material and the same biological processes responsible for observed traits



Gene
(DNA)



mRNA
(transcription)



Protein
(translation)

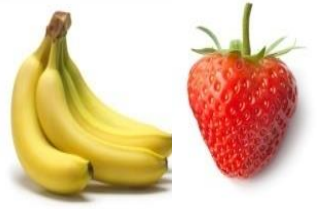
Trait
(Blue rose)

DNA similarities among organisms

Organism	 CHIMP	 MOUSE	 CHICKEN	 FRUIT FLY
Gene Conservation with Humans (%)	99.5	88	75	60

http://www.vce.bioninja.com.au/_Media/gene_conservation_med.jpeg

(50% with banana, 60% with Strawberry!)



The Safety of Biotech Products is Established Through the Following Approach

Gene(s)

- Source(s)
- Molecular characterization
- Insert / copy number / gene integrity

Protein(s)

- History of safe use and consumption
- Function / specificity / mode of action
- Levels
- Toxicology / allergenicity testing

Crop Characteristics

- Morphology
- Yield

Food / Feed Composition

- Proximate analysis
- Key nutrients
- Key anti-nutrients

GM crops undergo rigid food/feed safety assessment

Food and feed safety

Toxicity, allergenicity, nutritional composition, feed performance are assessed prior to commercialization

Environmental safety assessment of GM crops

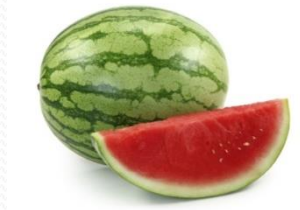
- Gene flow/gene transfer
- Effect on non-target organism
- Possible development of weedy species
- Possible development of resistant pests
- Persistence in the environment
- Possible effects on biodiversity

What do they have in common?

None of these products would be approved today if held to the same standard as biotechnology

https://www.ncbiotech.org/sites/default/files/pages/Bobo%20-%20Ag%20Biotech%20Summit%20Presentation%20(10-10-2012).pdf

Plant Breeding has along history



Genetic diversity is the source of new traits

For example: 127,000+ varieties of rice conserved in IRRI's International Rice Genebank

But, what if the genes are not present in the germplasm?

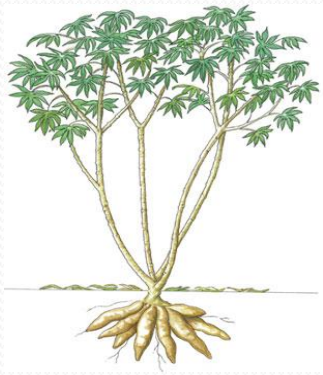
Example: micronutrient deficiency

Interventions

- Dietary diversification
- Promotion of optimum infant and young child feeding practices (breast-feeding)
- Supplementation
- Food fortification
- Biofortification: a complementary approach

Examples of biofortification of crops

Rice with beta-carotene (also with zinc and iron



Biofortified cassava

http://www.spyghana.com

Vitamin A banana

Biofortified sorghum

Can GM, conventional and organic farming co-exist?

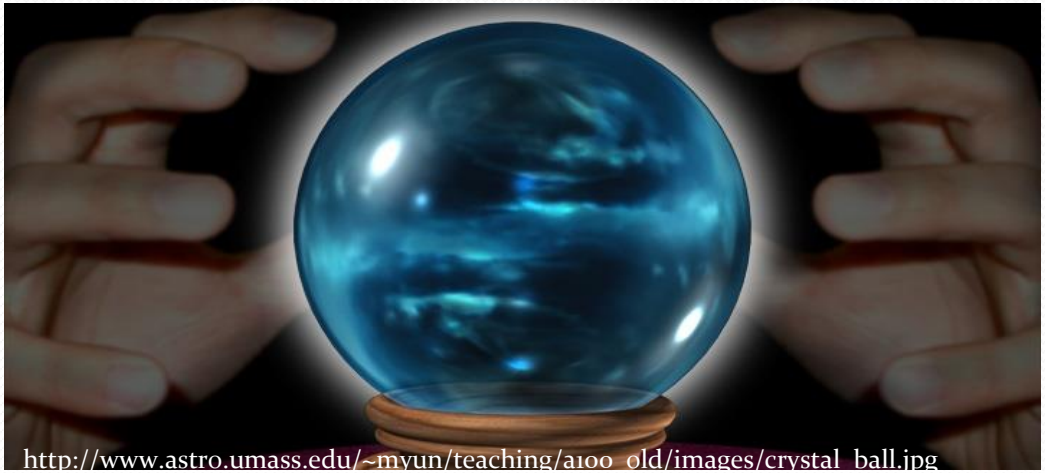
- Co-existence requires mutual respect and tolerance between practitioners of different production systems: no single system has any right to dominate others.
- Co-existence is possible; need to consider:
  - Type of crops: corn and rice don't inter-cross
  - Pollination habit (self-pollinating/cross-pollinating)
  - Distance between crops

Farmers and consumers must be free to choose.

Have a vision

Predict what will be needed tomorrow and work on it NOW!

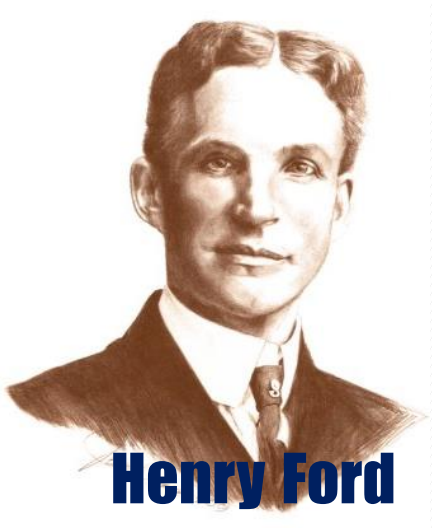
(because tomorrow will be too late)



http://www.astro.umass.edu/~myun/teaching/a100_old/images/crystal_ball.jpg

APPs: Anticipate, Prepare, Proactive strategies

(and use available technologies)



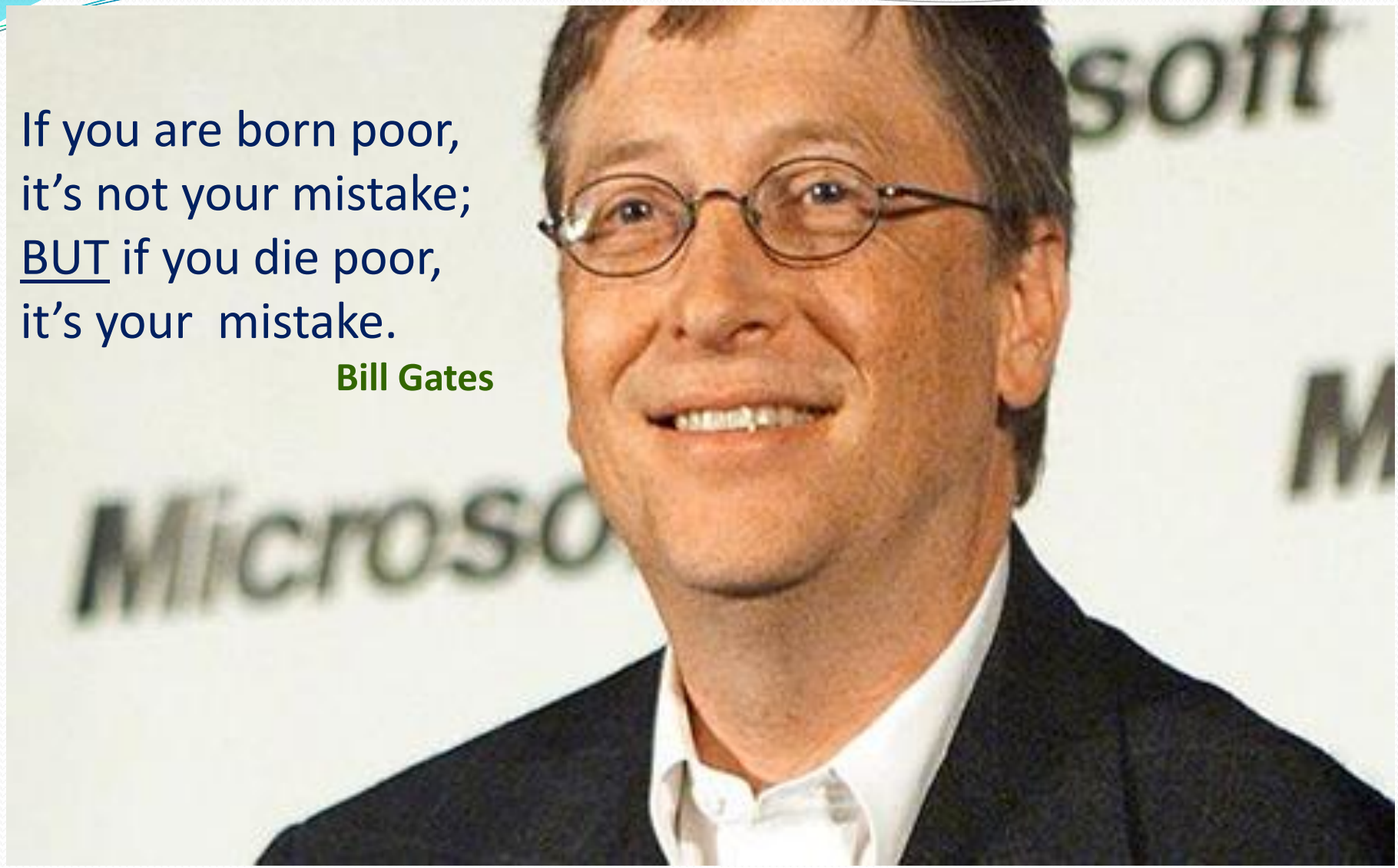
If I gave people what they wanted,

I would have given them a better horse.

Henry Ford

Henry Ford developed the affordable car

Today's Ford car


If you are born poor,
it's not your mistake;
BUT if you die poor,
it's your mistake.
Bill Gates

DAMO NGA SALAMAT

DAGHANG SALAMAT

Salamat po

Thank you