Biotechnology integrated in agricultural and food sciences

Preben Bach Holm

University of Aarhus, Faculty of Agricultural Sciences, Dept. of Genetics and Biotechnology, Research Centre Flakkebjerg, Denmark

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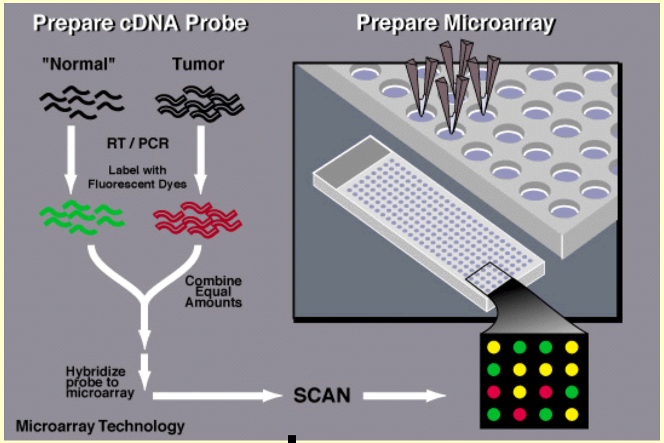
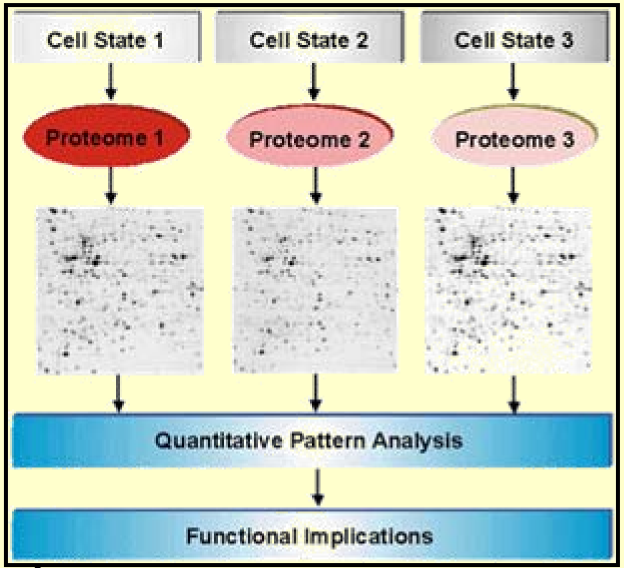
Aspects to be adressed

- A status on plant biotechnology
- Global and European challenges
- Research priorities
- Genetically modified crops in European agriculture
- Recommendations for EU Framework programmes

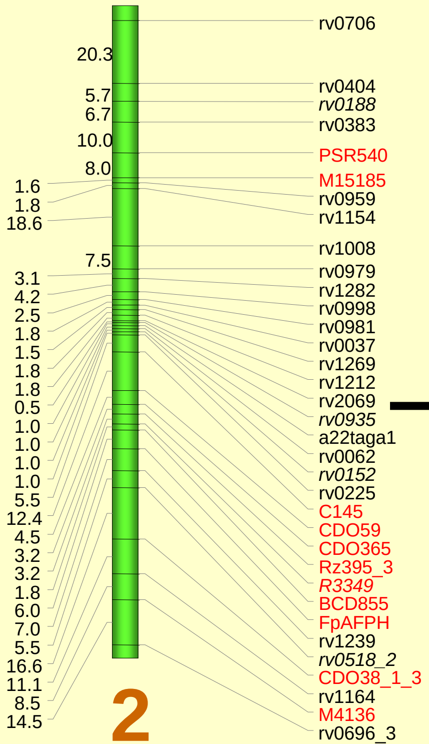
Plant Molecular Biology and Genetics undergoes at present a very significant development

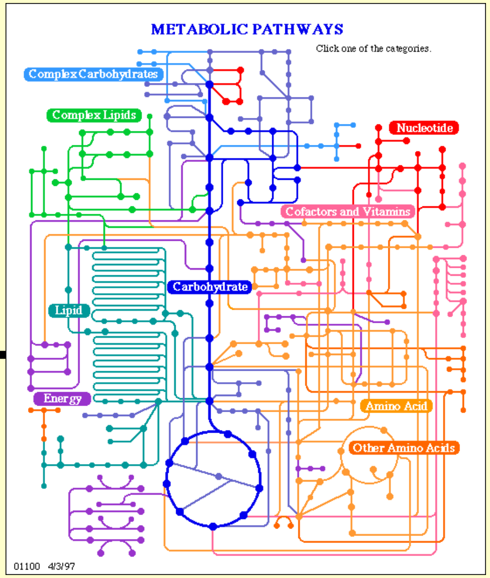
- Formerly, plant molecular biology and genetics were limited to the studies of individual genes and their effects: ”THE CANDIDATE GENE APPROACH”
- A number of new discoveries and technologies now allow for the analysis of a large number of genes and their interactions: ”THE HOLISTIC APPROACH”
- Both approaches are indispensible and are integrated



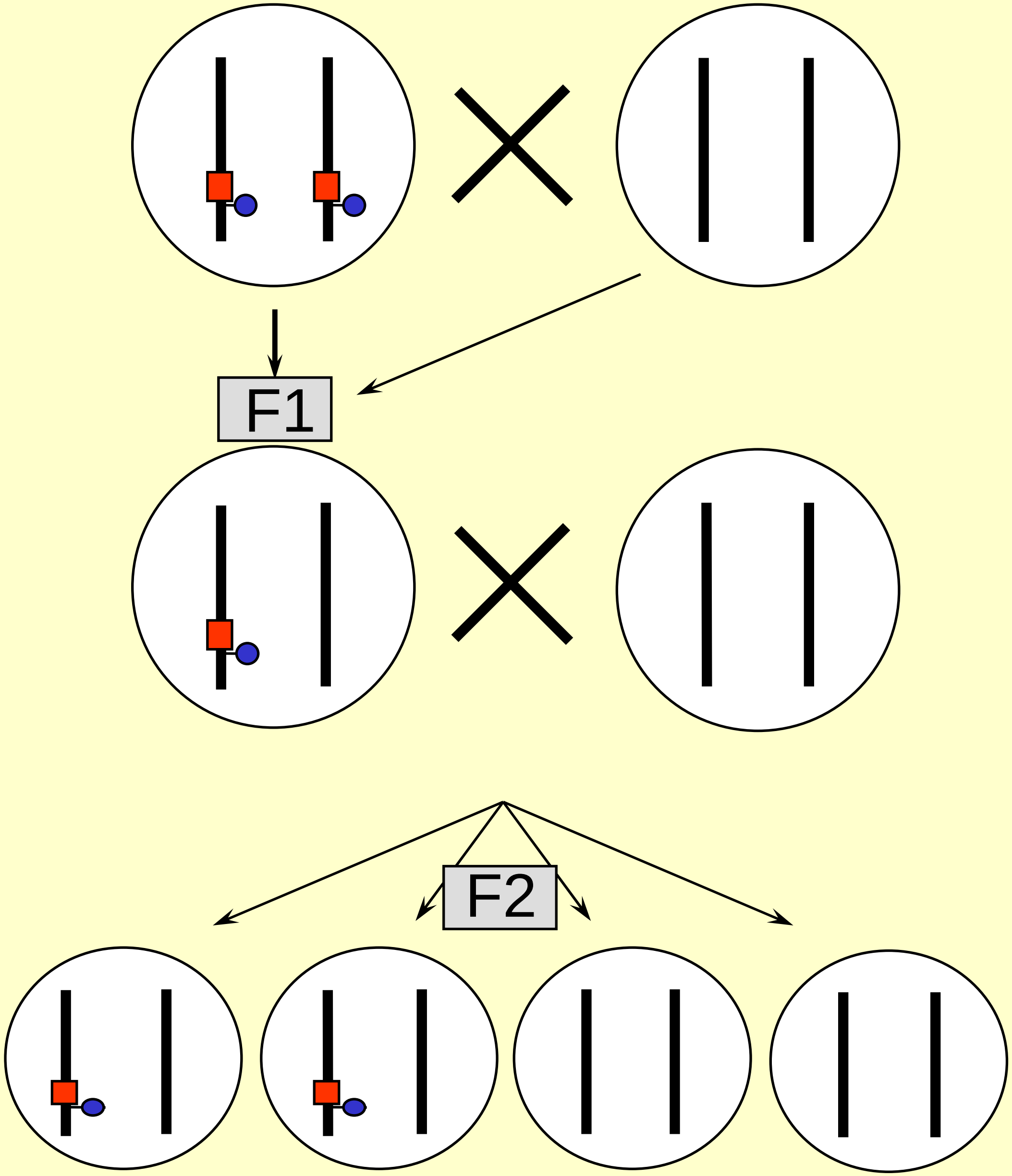


-omics, genetics and bioinformatics



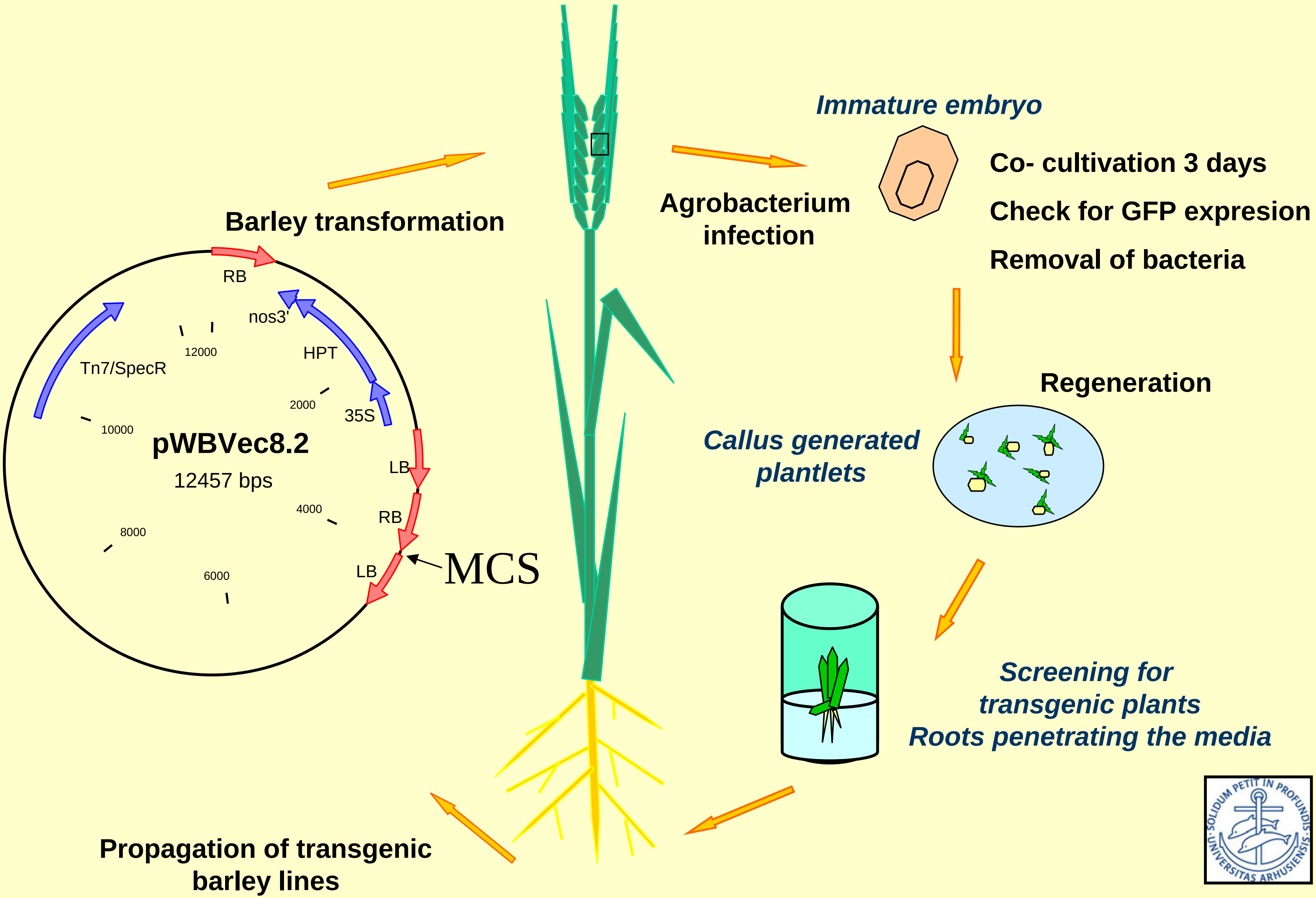


Marker based selection

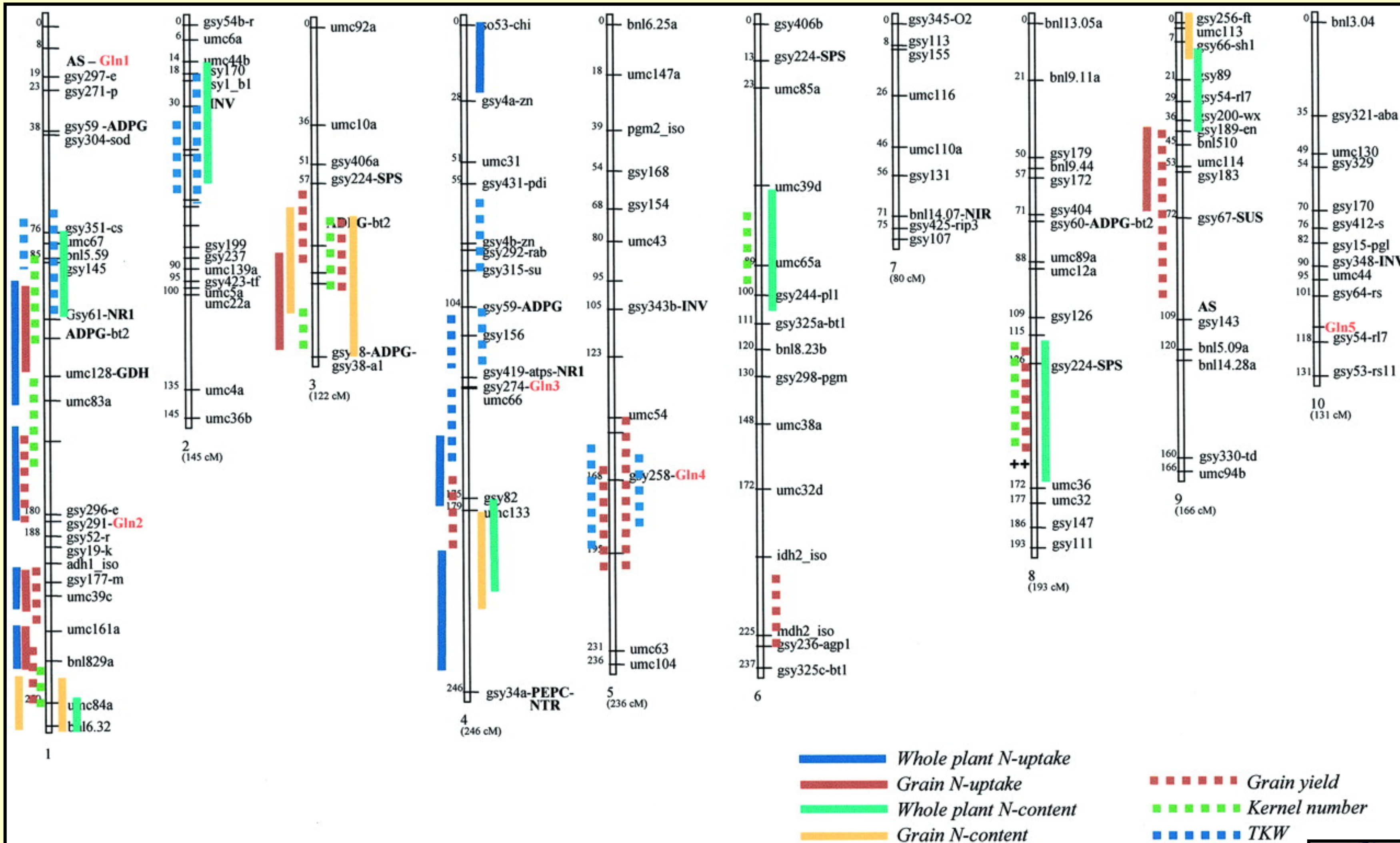


Allows for that the gene of interest can be followed through the breeding process by a simple DNA marker instead of by often costly pheno-typic analyses

Agrobacterium mediated transformation of barley



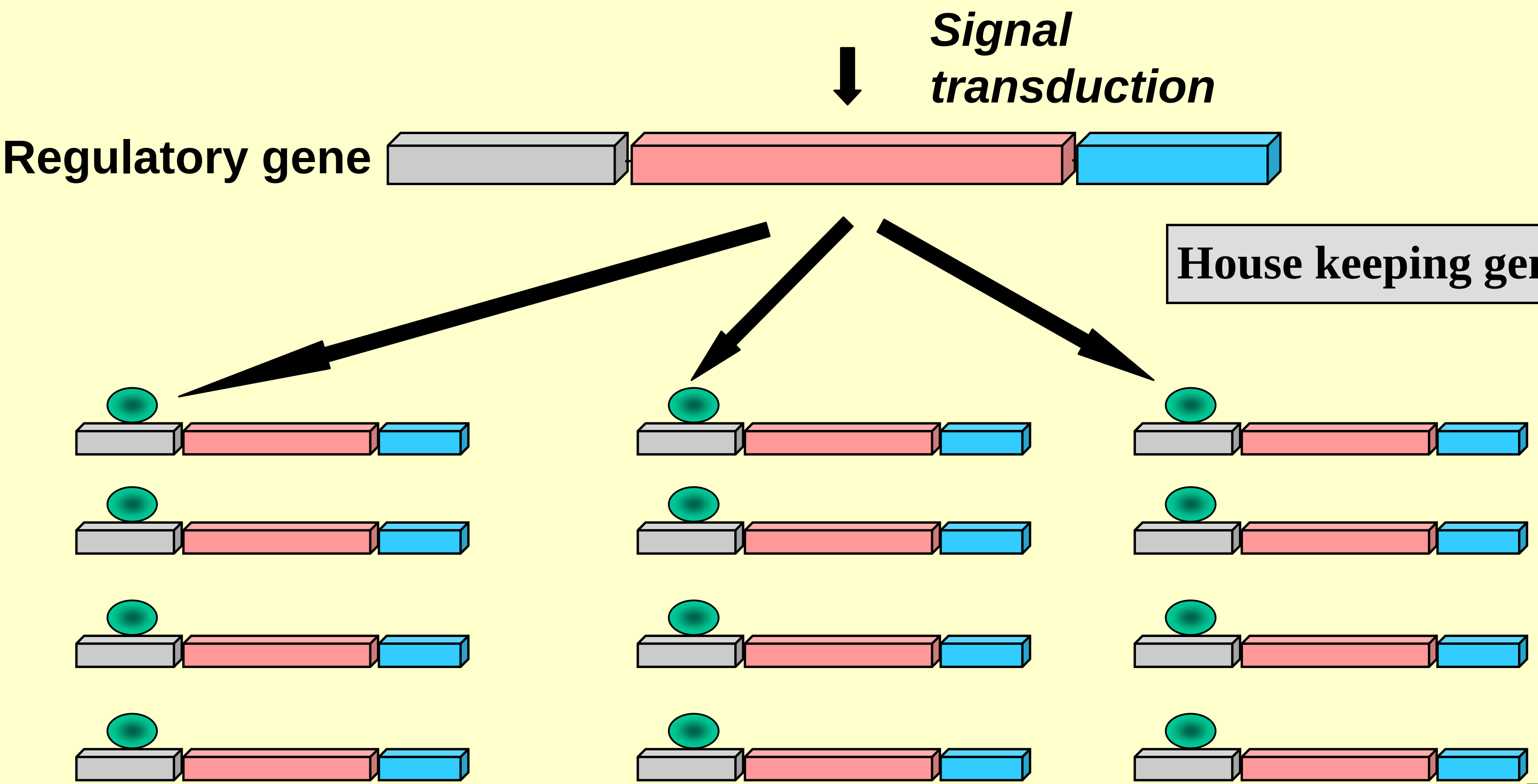
Nitrogen use efficiency in maize



Gallais, A. et al. J. Exp. Bot. 2004 55:295-306; doi:10.1093/jxb/erh006

Regulatory genes

Drought, disease, plant achitecture, nutrient uptake and mobilisation etc.



Global challenges

9 billion people in 2050

Increased demand for dairy products and meat

Loss of agricultural land due to rises in sea level and the building of infrastructure

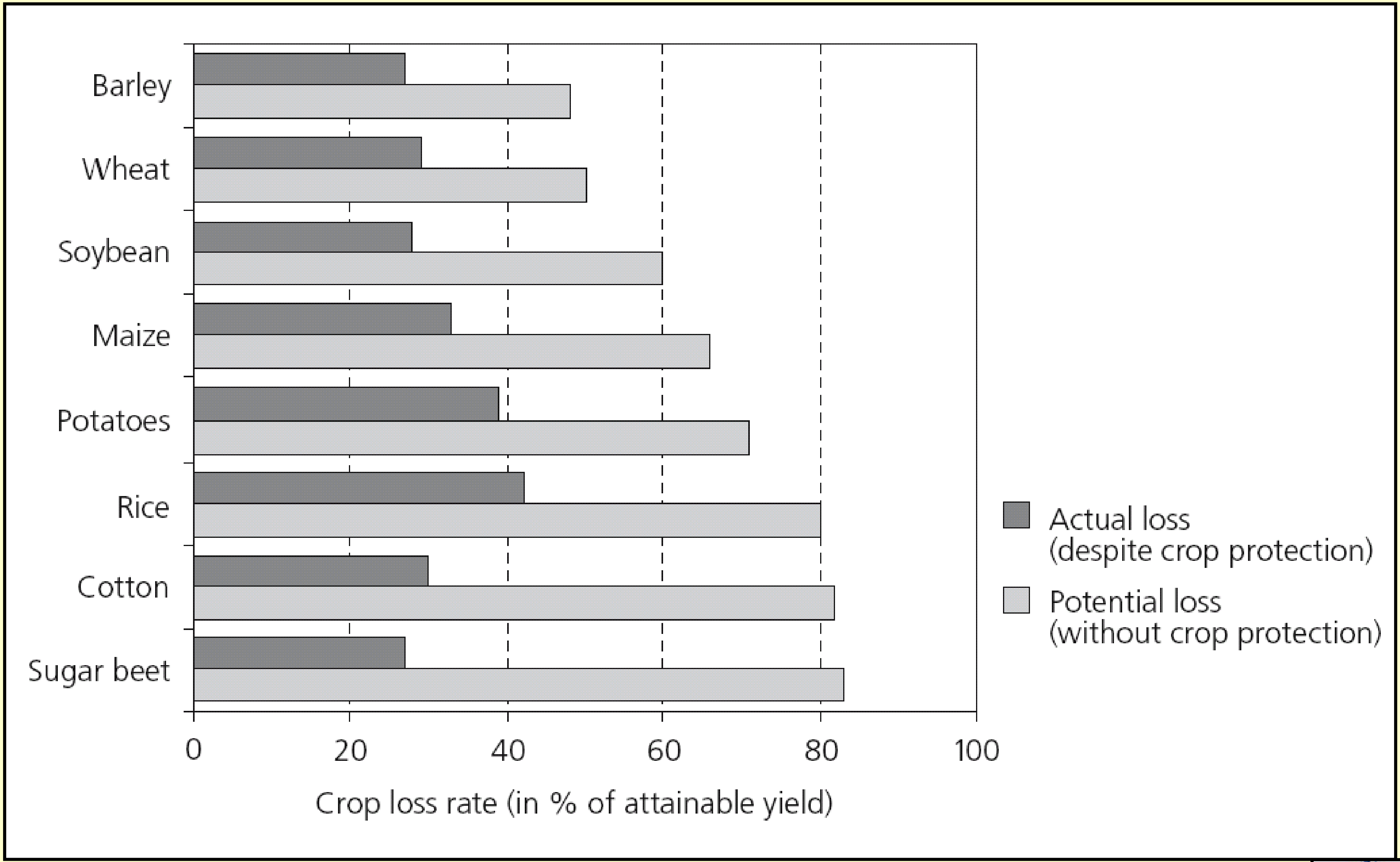
Biomass and Bioethanol

Climate change

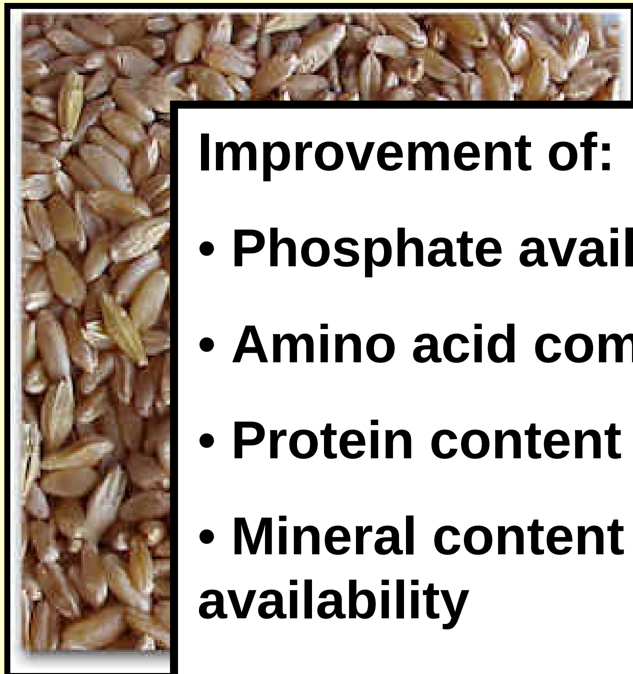
Research priorities

- Increased yield
- Improved disease resistance
- Improved tolerance to abiotic stress
- Improved nutrient use efficiency
- Improved nutritional quality af food and feed
- Optimize feed for reducing the environmental impact

Reducing pre- and postharvest loses

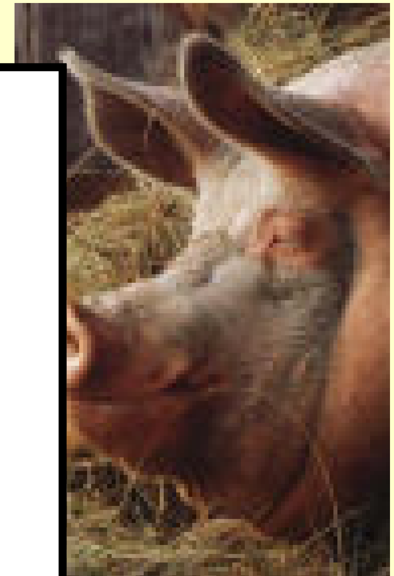


Oerke and Dehne 2004. Crop Protection 23, 275-285



Improvement of:

- **Phosphate availability**
- **Amino acid composition**
- **Protein content**
- **Mineral content and bio-availability**
- **Cell wall digestibility**



Reduced N and P load on the environment

Monsanto: Research and Development

Pipeline	Gene identifi-cation	Proof of concept	Phase 2	Phase 3	Phase 4
2. Gen. Insect- and herbicide resistense					
Drought tolerant maize, soybean and cotton					
Maize and soybean with higher yield					
Commitment	Double the yield of the core crops by 2030				
Feed maize with a balanced protein composition					
Soybean with a better protein composition					
Soybean with oils that make less trans fatty acid					
Soybean that make omega-3 fatty acids					

Examples of nutritional improvements via GM (1)

- Increased vitamin content (vitamin A in rice and wheat, vitamin E in oilseed rape, vitamin C in maize)
- Increased iron content (rice)
- Improved amino acid composition (lupin, maize, oilseed rape, potato)
- Improved oil composition (lauric acid, γ-linoleic acid, omega-3 fatty acids, 8:0 and 10:0 fatty acids in oil seed rape, oleic acids in soybean and cotton)
- Improved fibres (fructans in beet, inulin in potato, lignin in alfalfa and Sorghum)
- Increased protein content (sweet potato)
- Improved starch (high amylose starch, bypass starch)
- Increased antioxidants (isoflavones in soybean and flavonoids in tomato)

Examples of nutritional improvements via GM (2)

- Removal of antinutritional factors (phytic acid in wheat, oilseed rape, rice, maize, soybean)
- Removal of allergenic compounds (rice, soybean)
- Removal of toxic compounds (solanin in potato and cyanogenic glucosides in cassava)
- Caffeine (coffee)
- Nicotine (tobacco)

Climate change

Higher temperatures

Larger fluctuations in the weather

Biotic stress:

Vira

Bacteria

Fungi

Insects and worms

Abiotic stress:

Drought

Water logging

Salinity

Mineral availability and toxicity

Reduced yield

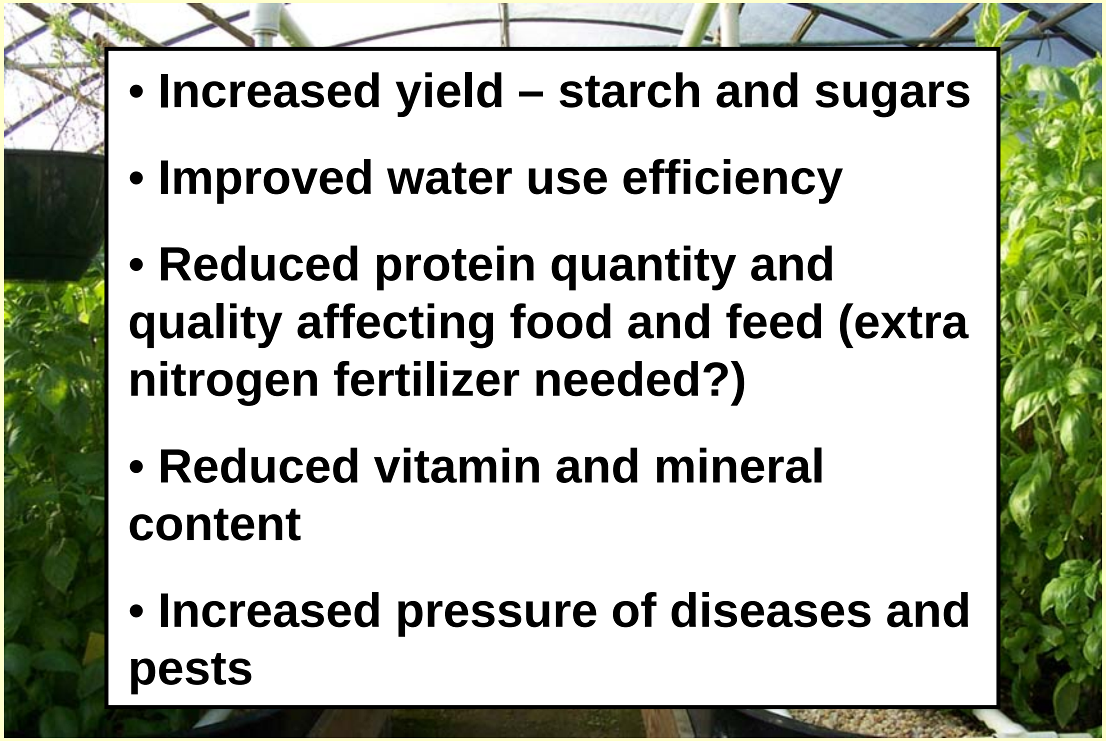
Lower product quality

Climate change

↕

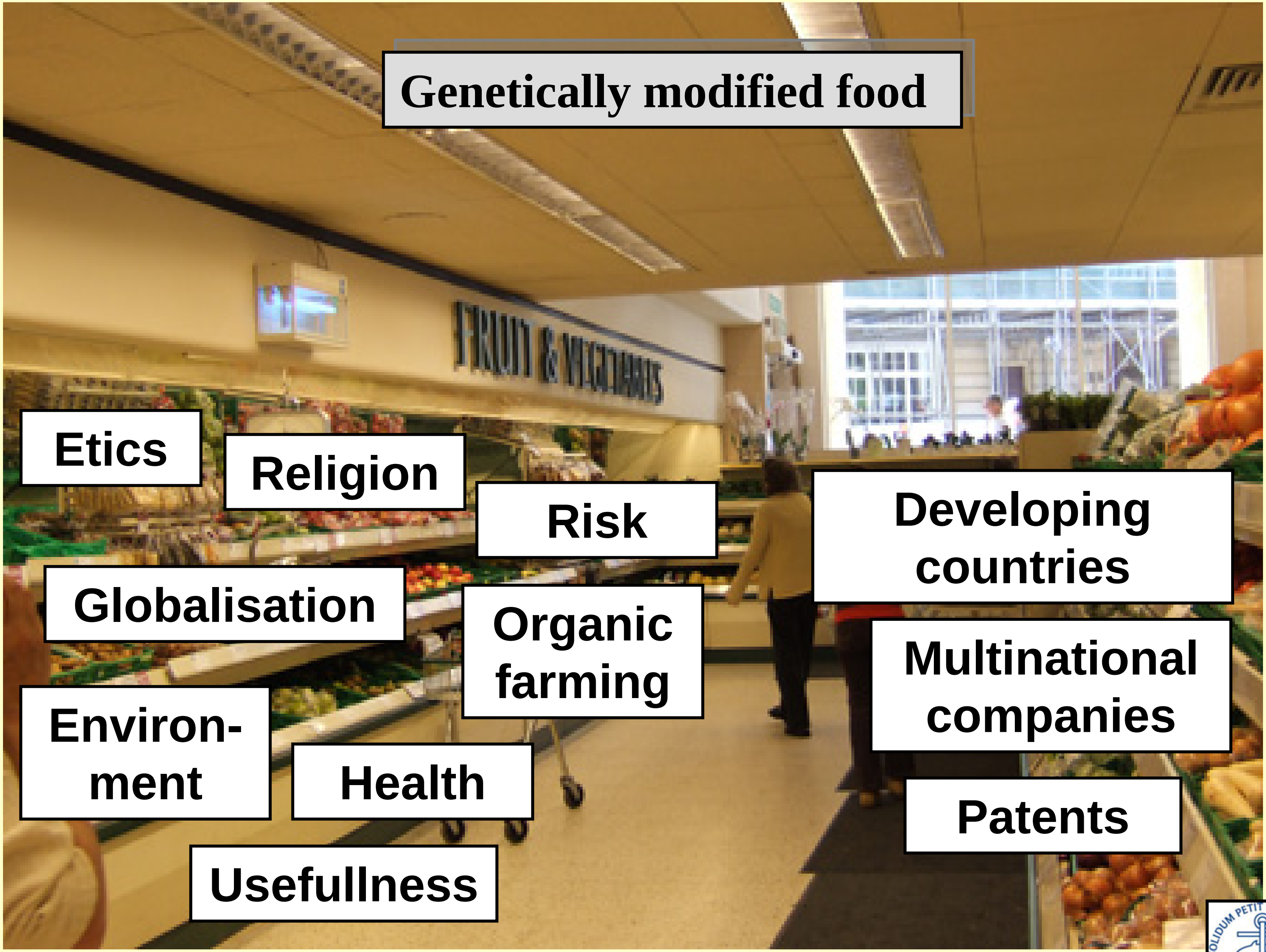
Doubling of the CO_2 level by the end of the century

↕



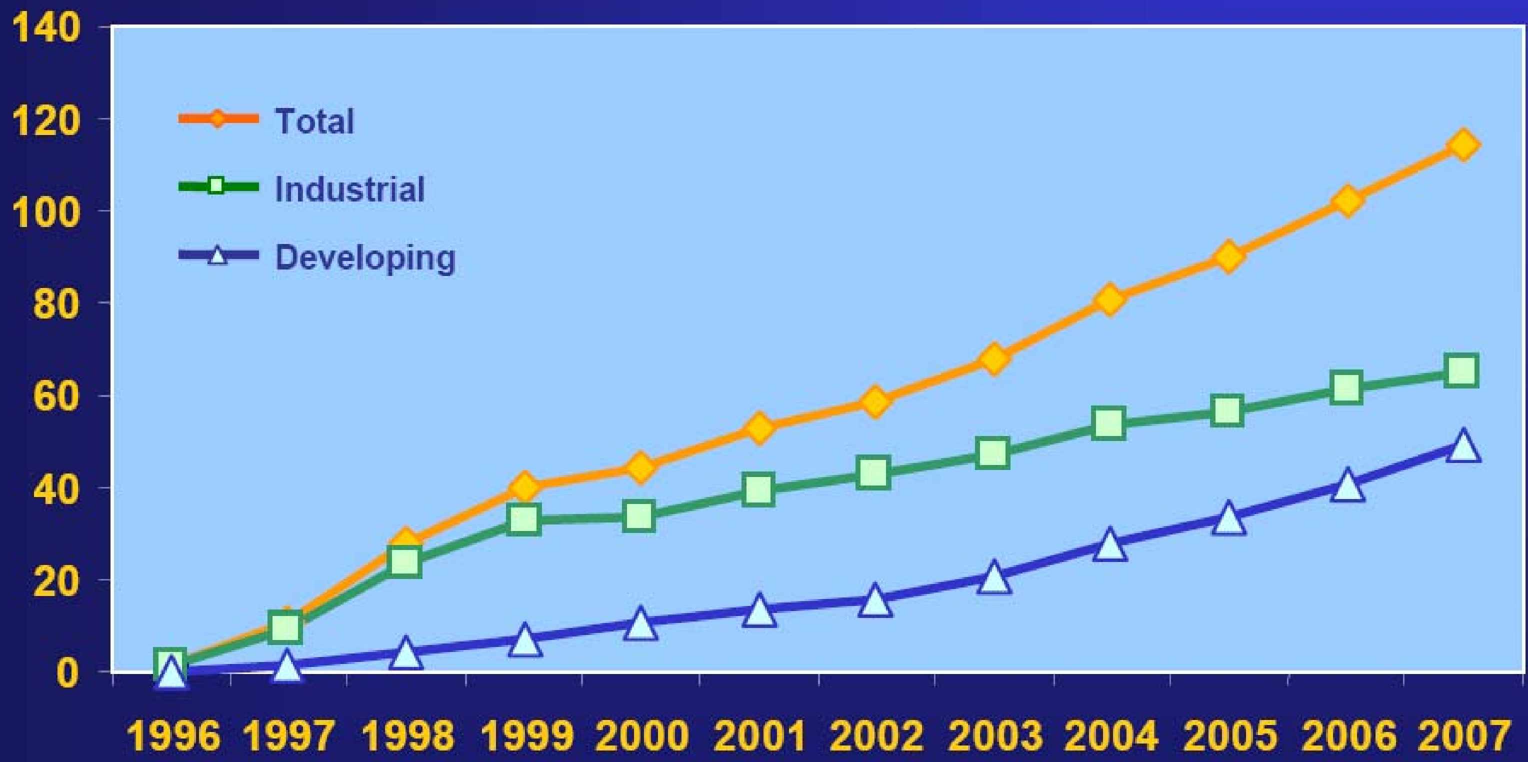
- Increased yield – starch and sugars
- Improved water use efficiency
- Reduced protein quantity and quality affecting food and feed (extra nitrogen fertilizer needed?)
- Reduced vitamin and mineral content
- Increased pressure of diseases and pests

Genetically modified food



- Etics
- Religion
- Risk
- Developing countries
- Globalisation
- Organic farming
- Multinational companies
- Environ-ment
- Health
- Patents
- Usefullness

Global Area of Biotech Crops, 1996 to 2007: Industrial and Developing Countries (Million Hectares)



Source: Clive James, 2008

Brookes G and Barfoot P (2006): Global impact of biotech crops: Socio-economic and environmental effect in the first ten years of commercial use.

AgbioForum 9, 139-151

- **Increased net income for GM-growers of US$ 27 billion (US$ 5 billion i 2005)**
- **Reduction in pesticide amounts of 224.000 tonnes of active ingredient.**
- **15% reduction in the so called ”Environmental Impact Quotient” (EIQ), that is a measure of the amount of active ingredient, toxicity and degradation rate**
- **The cultivation of GM-crops has led to a reduction of 1 million tonnes CO_2 emission due to reduced traffic in the field and 8 million tonnes of CO_2 has been sequestered in the soil due to reduced tilling.**
- **The implementation of in particular Bt cotton has led to increased profits for farmers in developing countries and had postitive effects on farmers health.**

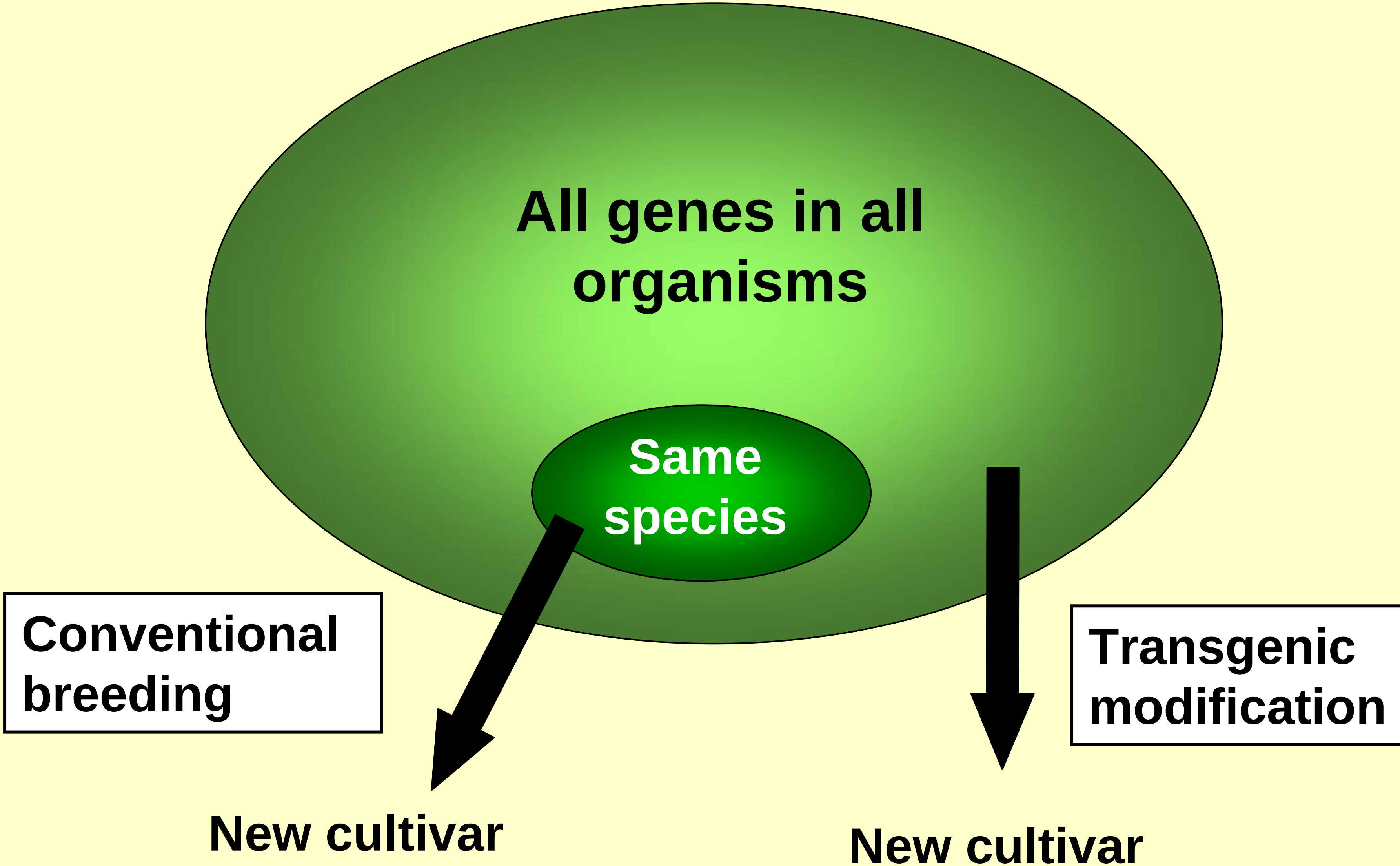
Genetic modification

Whoever could make two ears of corn, or two blades of grass grow upon a spot of ground where only on grew before would deserve better of Mankind and do more essential service to his country, than the whole race of politicians put together
The King of Brobdingnag, Gullivers travel, by Jonathan Swift 1727

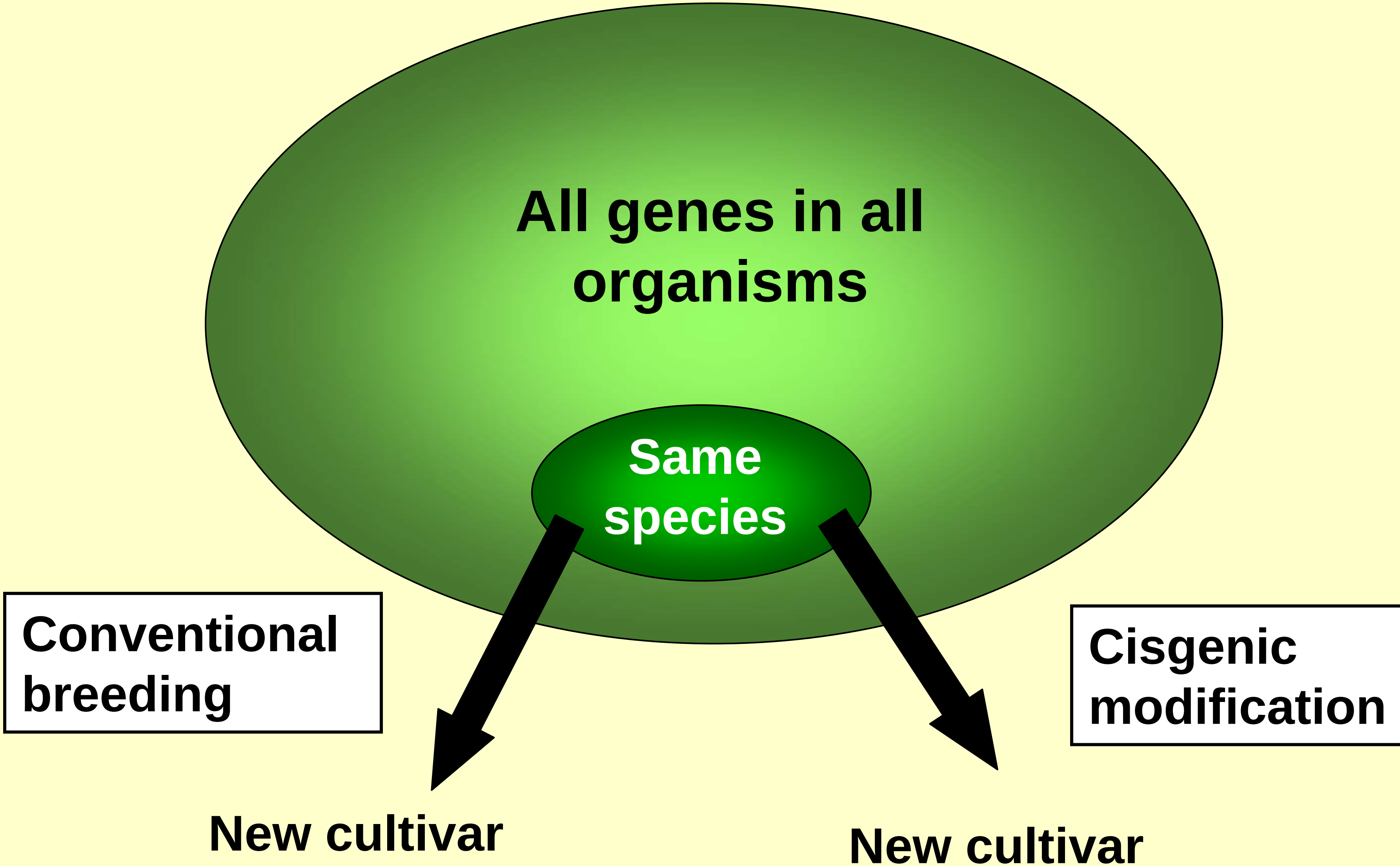
I believe that we have now reached a moral and ethical watershed beyond which we venture into realms that belong to God, and to God alone. Apart from certain medical applications, what actual right do we have to experiment, Frankenstein-like, with the very stuff of life?
Prince Charles of Windsor, heir to the British throne (Windsor 1998)

Current problems encountered with transgenic techniques:

- Residual foreign DNA in the transgenics (selection genes, vector backbone etc.)
- Integration by illegitimate recombination (messy)
- ”Random” non-controlled integration
- ”Low efficiency”, at least for clean single copy integration
- Size limitations with respect to cassette length
- Transferring DNA between sexually non-compatible species (ethics, ”risk”)
- IPR


All genes in all organisms
Same species
Conventional breeding
Transgenic modification
New cultivar
New cultivar

Cisgenesis instead of transgenesis



DuRPh: A Dutch 10 year, 10 million € cisgenesis project on potato resistance to late blight

Potato is the most important arable crop of the Netherlands. Dutch growers cultivate potatoes for food and non-food applications on an area of 165 000 ha with a total yield of 7.4 million ton.

In the potato cultivation, lots of pesticides are used, in comparison with other crops. Growers use these pesticides primarily against late blight (*Phytophthora infestans*). A conventional field with potatoes is treated with fungicides 10-15 times in a season. This goes along with a high burden for the environment, especially surface water. Moreover, late blight control costs Dutch farmers about € 130 million per annum, equal to about 20% of the production costs. Worldwide, the costs associated with late blight (yield losses and crop protection costs) equal billions.

http://www.durph.wur.nl/UK/Why+DuRPh/

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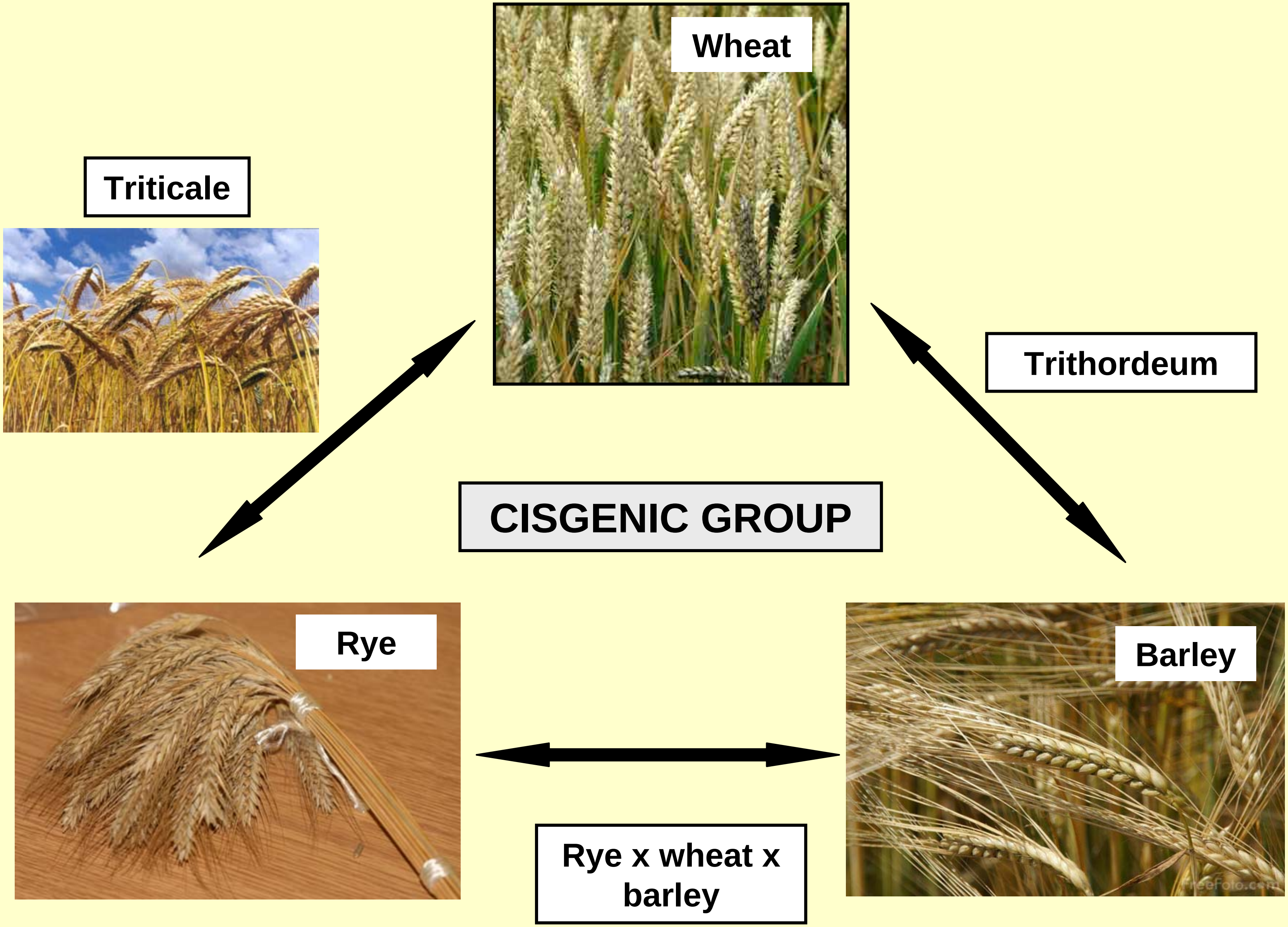
Wheat
Triticale
Trithordeum
CISGENIC GROUP
Rye
Barley
Rye x wheat x barley

Recommendations

There is in Europe a substantial expertise on European crop plants, plant quality parameters and abiotic/biotic stress in plants. The EU Framework programmes have to a large extent ensured the integration of European plant science but have lacked focus and continuity of the research.

1) **To make plant biotechnology a strategic research objective in EU**
2) **A realization among decision makers that plant research primarily is an obligation of the public sector with limited possibilities for co-financing from the breeders and the agroindustry**
3) **A realization that a comprehensive knowledge about plants will be the best starting point for meeting future challenges**
4) **Identify EU plant research priorities and initiate research programmes with a sufficiently large time-span to allow testing under field conditions**
5) **To support the participation of EU plant research in international research programmes addressing the needs of plant production in developing countries**

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Thank you for your attention