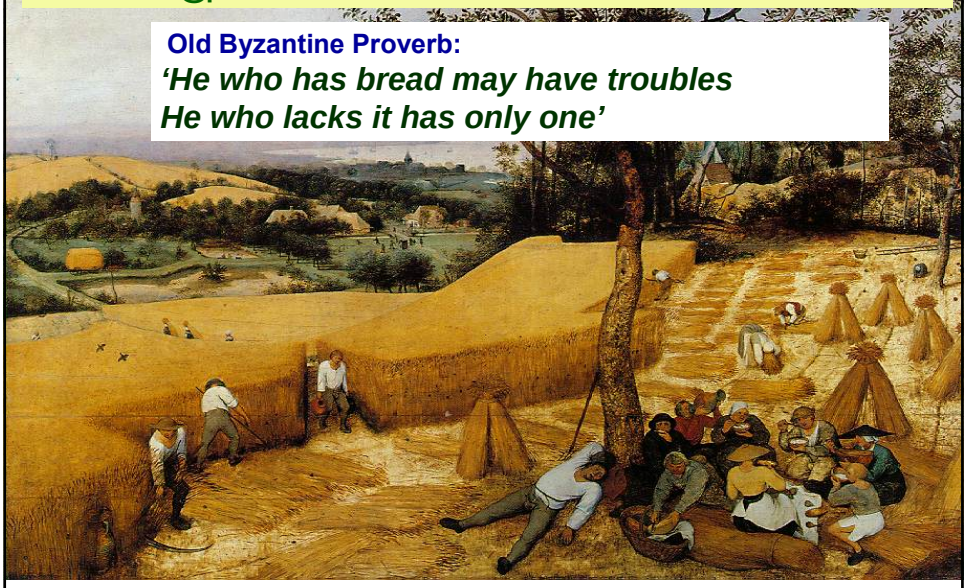
Garden of Earthly Delights or Paradise Lost?
chris.leaver@plants.ox.ac.uk

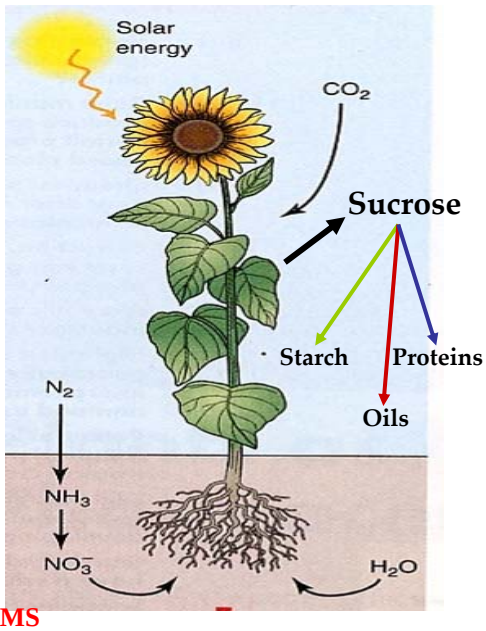
Old Byzantine Proverb:
'He who has bread may have troubles
He who lacks it has only one'



Peter Bruegel the Elder: The Harvest (1565) (Metropolitan Museum of Art, New York. USA)

PHOTOSYNTHESIS

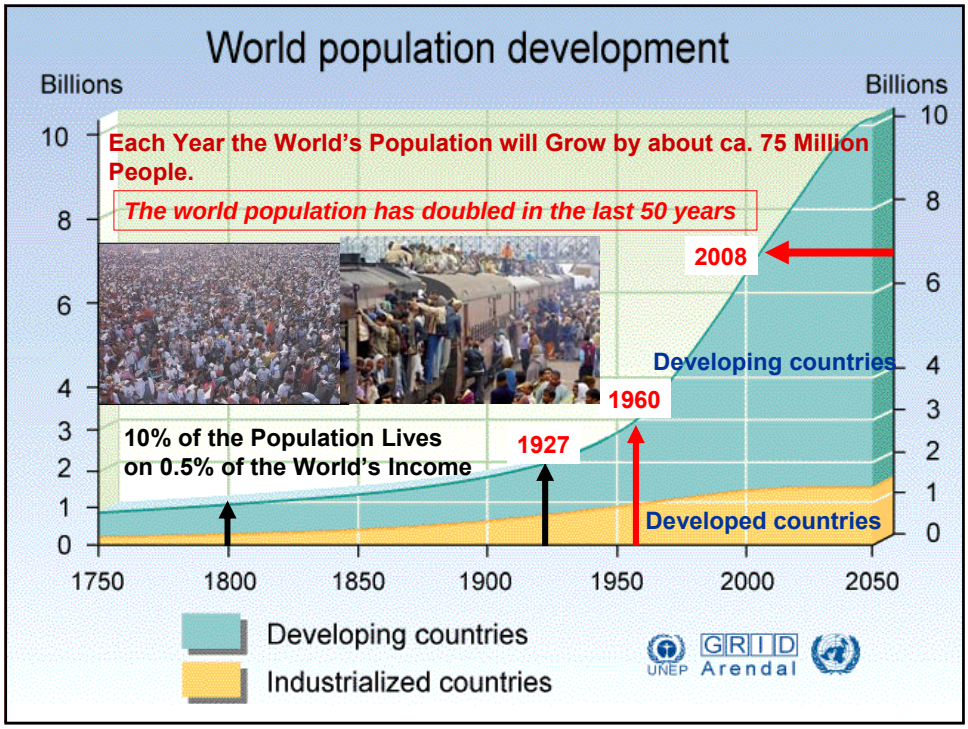
- **Life on earth ultimately depends on energy derived from the sun.**
- **Photosynthesis by green plants is the only process of biological importance that can capture this energy.**
- **It provides energy, organic matter and oxygen, and is the only sustainble energy source on our planet.**



WE DEPEND TOTALLY ON PLANTS TO SUSTAIN ALL OTHER LIFE FORMS

Agriculture the most important event in human history

Agriculture is part of the knowledge based bio-economy of the 21st century



Four innovations brought about change in agriculture in the twentieth century. What are the innovations which will change agriculture in this century?

- **Mechanisation:** Tractors freed up perhaps 25 % of extra land to grow human food instead of fodder for draught horses and oxen;
- **Fertilisers:** Fritz Haber's 1913 invention of a method of synthesising ammonia transformed agricultural productivity, so that today nearly half the nitrogen atoms in your body were 'fixed' from the air in an ammonia factory, not in a soil bacterium;
- **Pesticides:** Chemicals derived from hydrocarbons enabled farmers to grow high-density crops year after year without severe loss to pests and weeds;
- **Genetics:** In the 1950s Norman Borlaug crossed a variety of dwarf wheat, originally from Japan, with a different Mexican strain to make dwarf wheats that responded to heavy fertilisation by producing more seeds, not longer stalks. The varieties, imported into India and Pakistan, rapidly replaced the subcontinent's hunger with surplus in the 'Green Revolution'.

The effect of these four innovations was to allow more and more food to be produced from less and less land.

What has happened to our planet in the last 100 years?

To feed and resource 6.6 billion people we have already lost…..

- **1/5 of our topsoil (due to erosion, desertification and salinity)**
- **1/5 of our agricultural land (overgrazing marginal land)**
- **1/3 of our forests**

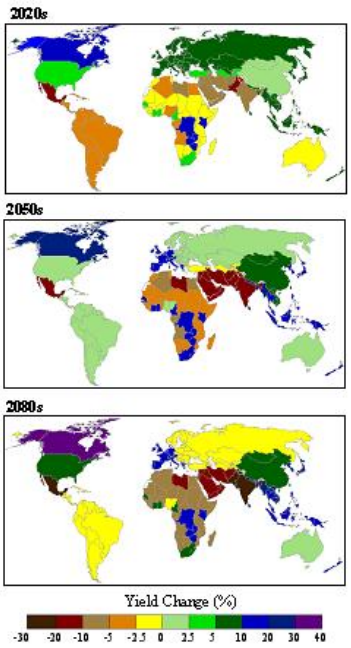
•Plus Today Additionally…..

- **Environmental pollution**
- **Climate change, groundwater depletion**
- **Depletion of the Ozone layer**
- **Massive fossil fuel usage/CO_2 increase by 15% since 1950**
- **Species extinction, biodiversity loss**
- **Urbanisation → increased meat consumption (India and China etc)**
- **Obesity/starvation**
- **Zoonotic disease transmission SARs, BSE, F and M, Bird Flu etc**

THIS IS UNSUSTAINABLE : DOING NOTHING IS NOT AN OPTION

And now climate change.....

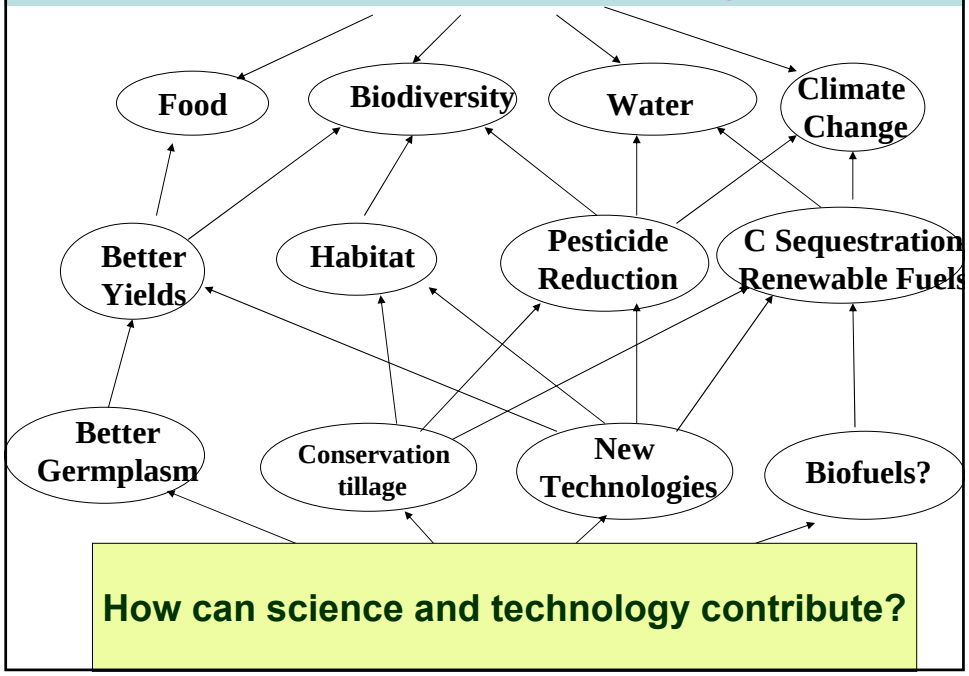
Models suggest that climate change effects on crop yield are positive or neutral at high latitudes, but negative at low latitudes



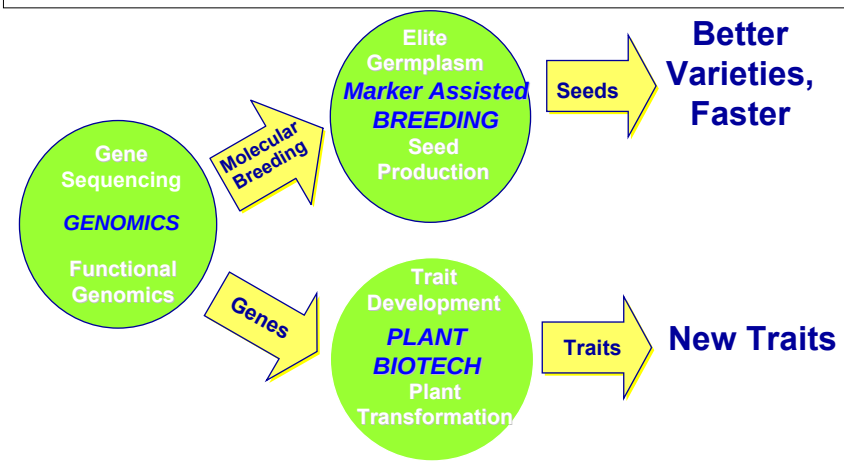
Future Agriculture
To Support Everyone Adequately
Many Improvements Will Be Necessary

- Integrated pest management
- Reduction of chemical use
- Water conservation
- Genetic modification by marker assisted breeding and transgenesis where appropriate
- No-till practices
- Precision agriculture where appropriate
- Conserving genetic diversity
- Orphan Crops and Specialized crops

Global Environmental Challenges



NEW TOOLS FOR CROP IMPROVEMENT



Targets for Plant Gene Technology: Finding the genes

REDUCED STRESSES
Biotic and Abiotic

- Pests and Diseases
- Weeds
- Saline or acid soils
- Increased greenhouse gases
- Drought or Flooding
- High or low Temperature
- Phytoremediation

MORE SUSTAINABLE PRODUCTION

Environment

IMPROVED PLANT PERFORMANCE

- Nutrient use efficiency
- Control of flowering
- Plant architecture
- Heterosis
- Yield

Plant Gene Technology

IMPROVED NUTRITION AND HEALTH

- Vitamins & Minerals
- Post harvest quality
- Taste
- Proteins
- Oils
- Carbohydrates
- Fibre & Digestible energy
- Bloat Safety

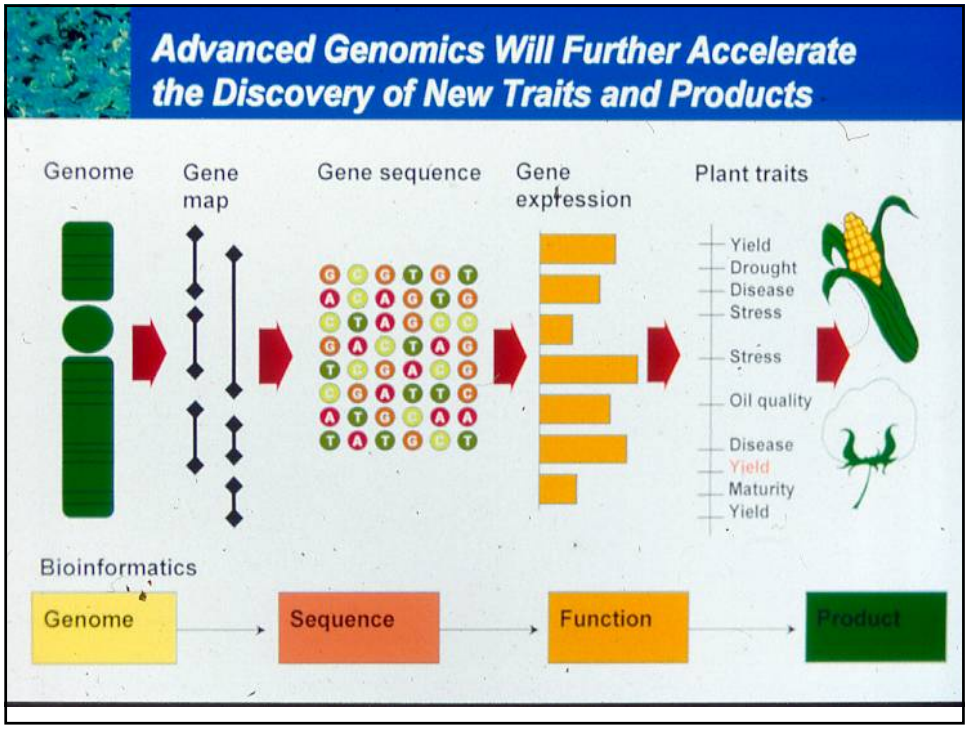
NEW INDUSTRIES

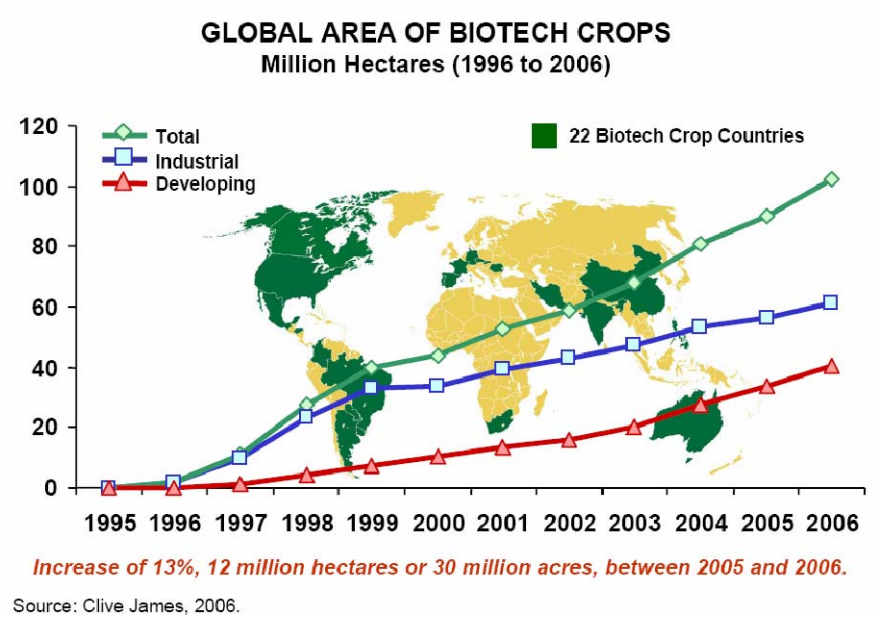
CHEMICAL FEEDSTOCKS

- Biodegradable Plastics
- Biofuels

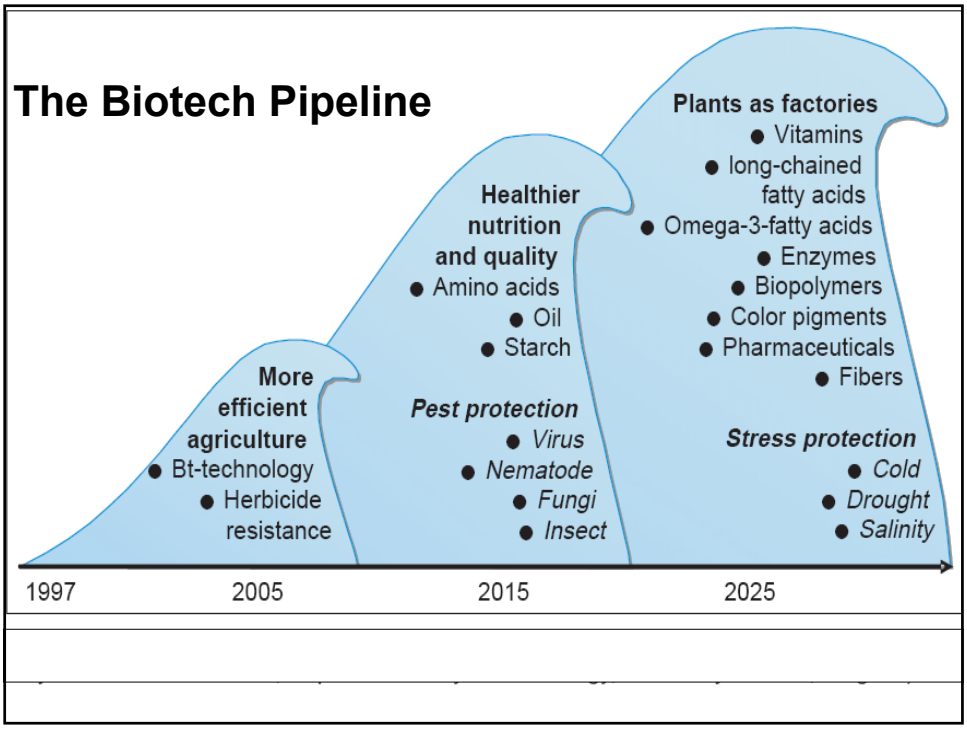
PHARMACEUTICALS

- Vaccines
- Antibodies
- Diagnostics





100 million Hectares=247 Million Acres



Scientific officials report on transgenic crops safety and benefits :

"...in those countries where transgenic crops have been grown, there have been no verifiable reports of... health or environmental harm."

- FAO

- World Health Organization
- Food & Agriculture Organization (FAO) of the United Nations
- National Academy of Sciences (USA)
- Royal Society (UK)
- American Medical Association (USA)
- French Academy of Medicine
- European Commission
- U.S. Food & Drug Administration
- Society of Toxicology
- Institute of Food Technologists

Public-Private Partnerships

In the early 21st century 500'000 children per year become blind and 6'000 per day die from vitamin A-malnutrition.

This could be ameliorated with the help of GMO' such as Golden Rice. However, for many in our society GMO's are taboo!

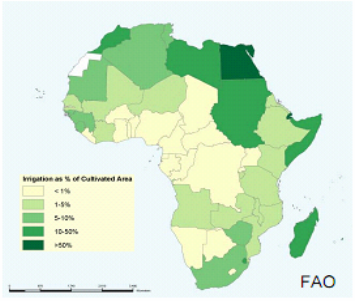
Improved provitamin A accumulation

Public-Private Partnerships

Water-Efficient Maize for Africa (WEMA)

- Multi-party effort to develop drought tolerant maize to Africa
- Begins with adapted germplasm, includes both marker-assisted breeding and Monsanto's drought tolerance trait

Irrigation as % of cultivated area



http://www.aatf-africa.org/

CIMMYT International Maize and Wheat Improvement Center

MONSANTO imagine

Gates Foundation

NARO

ARC • LNR

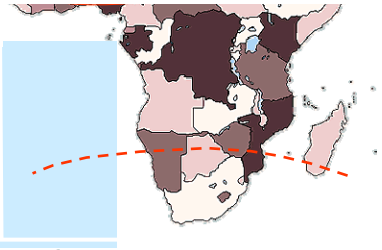
Public-Private Partnerships

Dr T J Higgins-CSIRO Canberra

Cultivated area (x1000 hectare)

	Cowpeas	Lupins	Maize	Wheat
Australia	7	660	79	12200
Nigeria	5000	-	4700	67
Niger	3500	-	9	3

Cowpea weevil



THE ROCKEFELLER FOUNDATION 1913

USAID FROM THE AMERICAN PEOPLE

AATF

NGICA

CSIRO

How Do We Move Forward?

- Given present trends in population, food production, trade, and the environment, the necessary increases in production and income generation in rural areas cannot be achieved simply by expanding cultivated land and using current technologies
- We must strive to attain global sustainability as a precondition for human progress
- We must address population, affluence, and technology simultaneously to move toward sustainability
- While agricultural production must be intensified to meet projected demands for food, feed, fibre and biofuels, intensification strategies must also change to avoid adverse environmental impacts and to reverse the effects of past practices

We must use all safe, appropriate, socially responsible and sustainable opportunities to increase food supplies locally and also improve 'orphan crops. This can be achieved by combining the best of conventional plant breeding with the new biotechnologies including marker assisted breeding and genetic modification of crop plants

DOING NOTHING IS NOT AN OPTION

Finally I would recommend you read a thought provoking new book by
Robert Paarlberg:STARVED FOR SCIENCE
How Biotechnology is being kept of Africa

He purports to show how a recent withdrawal of donor support for modern agricultural science in Africa, plus outright opposition to new farm science on the part of some global pressure groups is contributing directly to the continued growth of poverty and hunger…….

He further suggest that low-income, food deficit nations are being advised by governments and pressure groups in privileged nations to reject agricultural, **GREEN** biotechnology, mostly because this is a technology the rich countries themselves do not at the moment happen to need. When it comes to new applications of medical science, which prosperous countries still need and value,genetic engineering (**RED** biotechnology) is not seen as a threat..

This is a rich world argument that is hurting the poor.

His concerns are indeed -FOOD FOR THOUGHT!!!

Swift's dictum:

'And he gave it for his opinion that whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together'

Johnathan Swift, Gulliver's Travels,1726