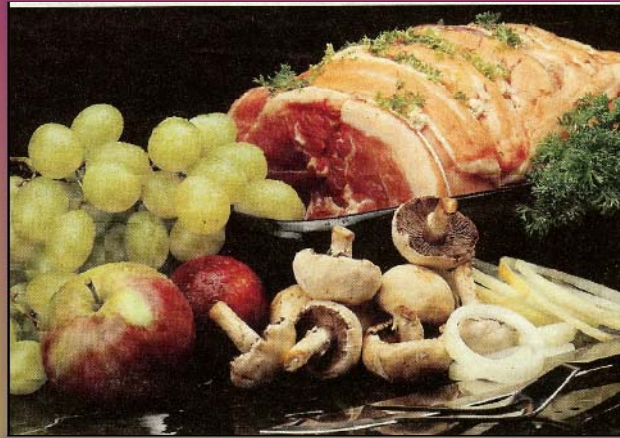


Presentations to ASAC and ISPFMRA



Feeding 9 Billion People: What Will It Take?

J.S. McLaren, Ph.D., StrathKirn Inc
2010

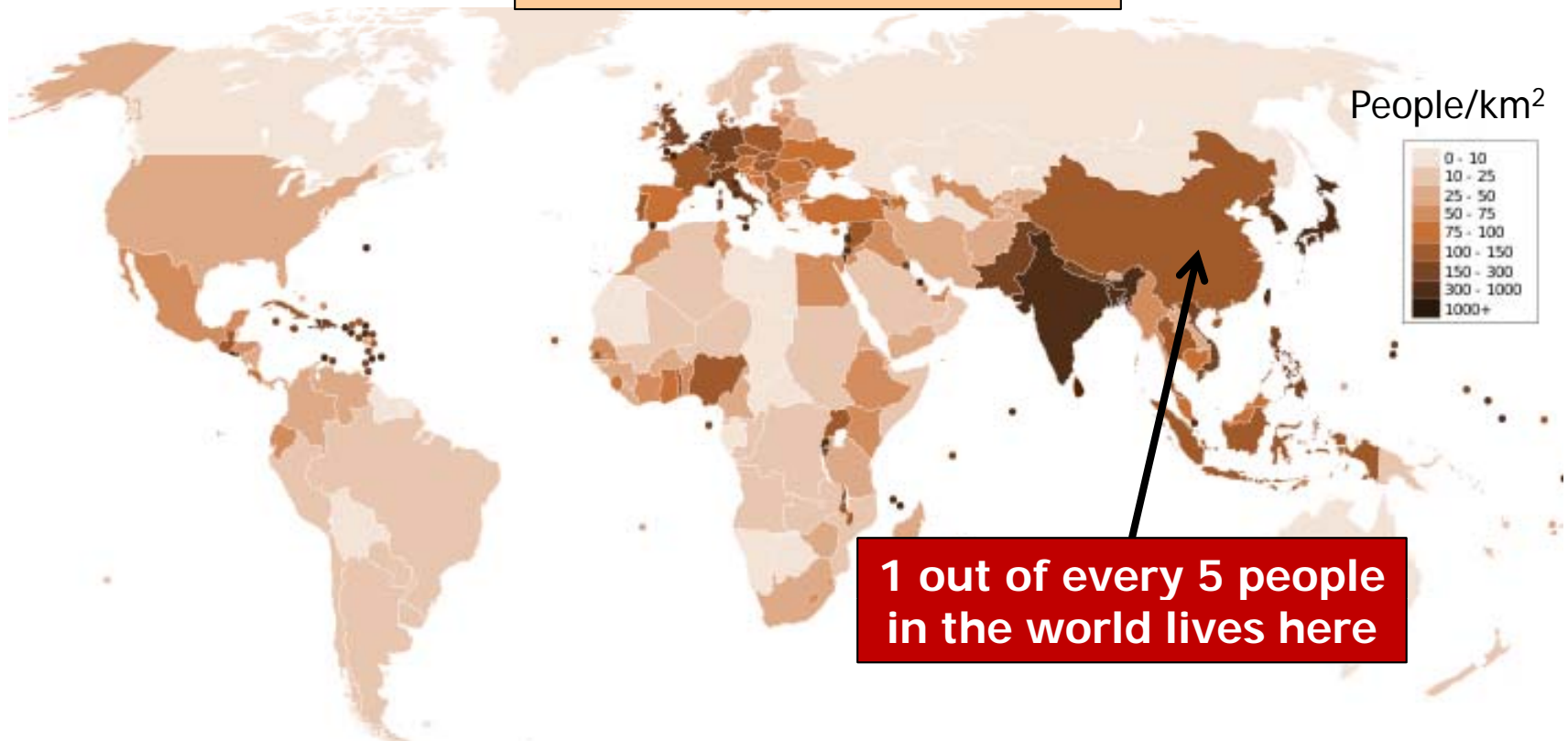
People and distribution density...

Global population: 6,857,645,026

At July 12, 2010

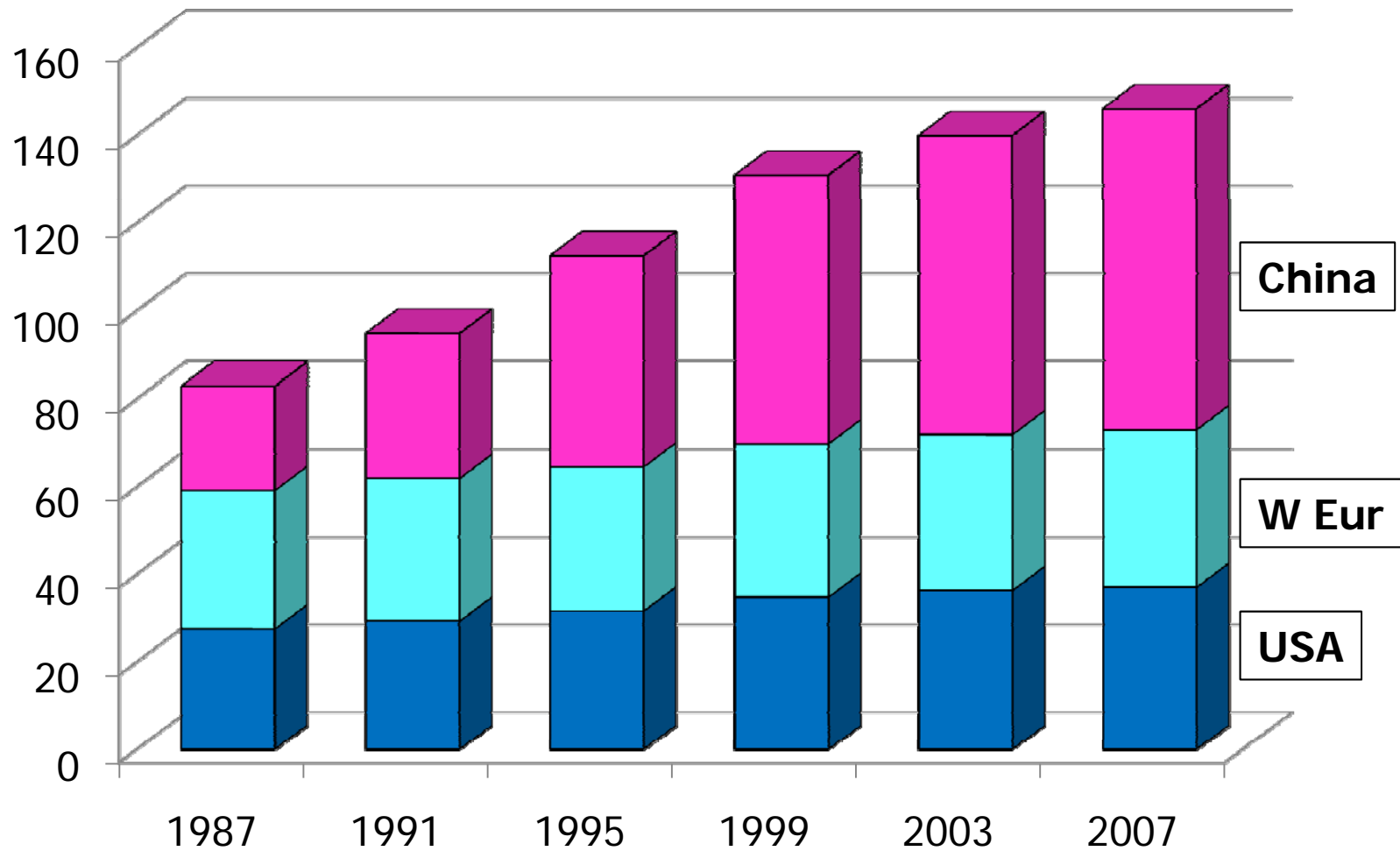
Births, YTD: 73,842,528

Deaths, YTD: 32,264,121



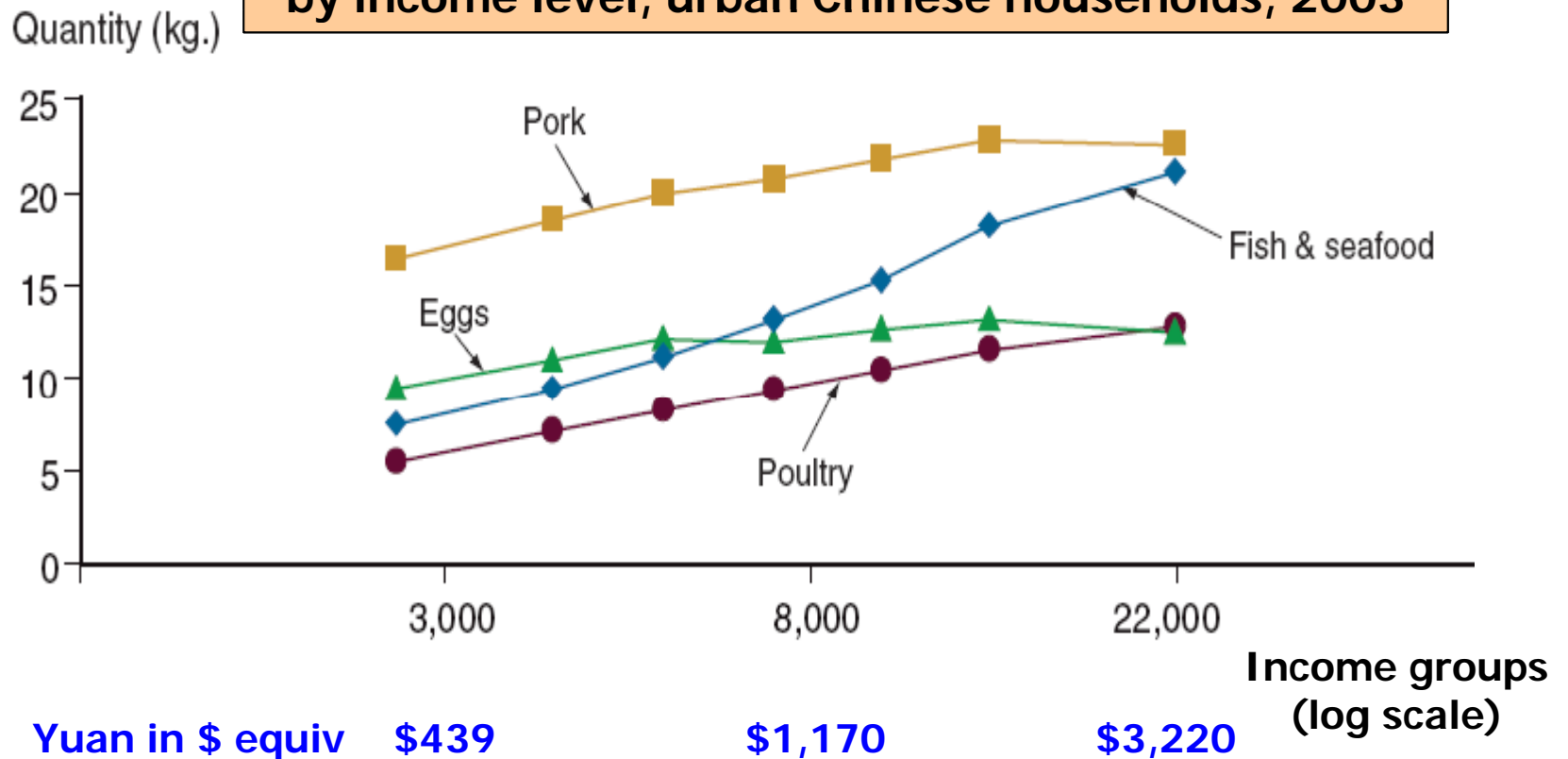
And, it's not just carbohydrates...

Meat Consumption, MM metric tonnes



Huge latent demand for meat in China...

Annual per capita purchases of livestock products, by income level, urban Chinese households, 2003

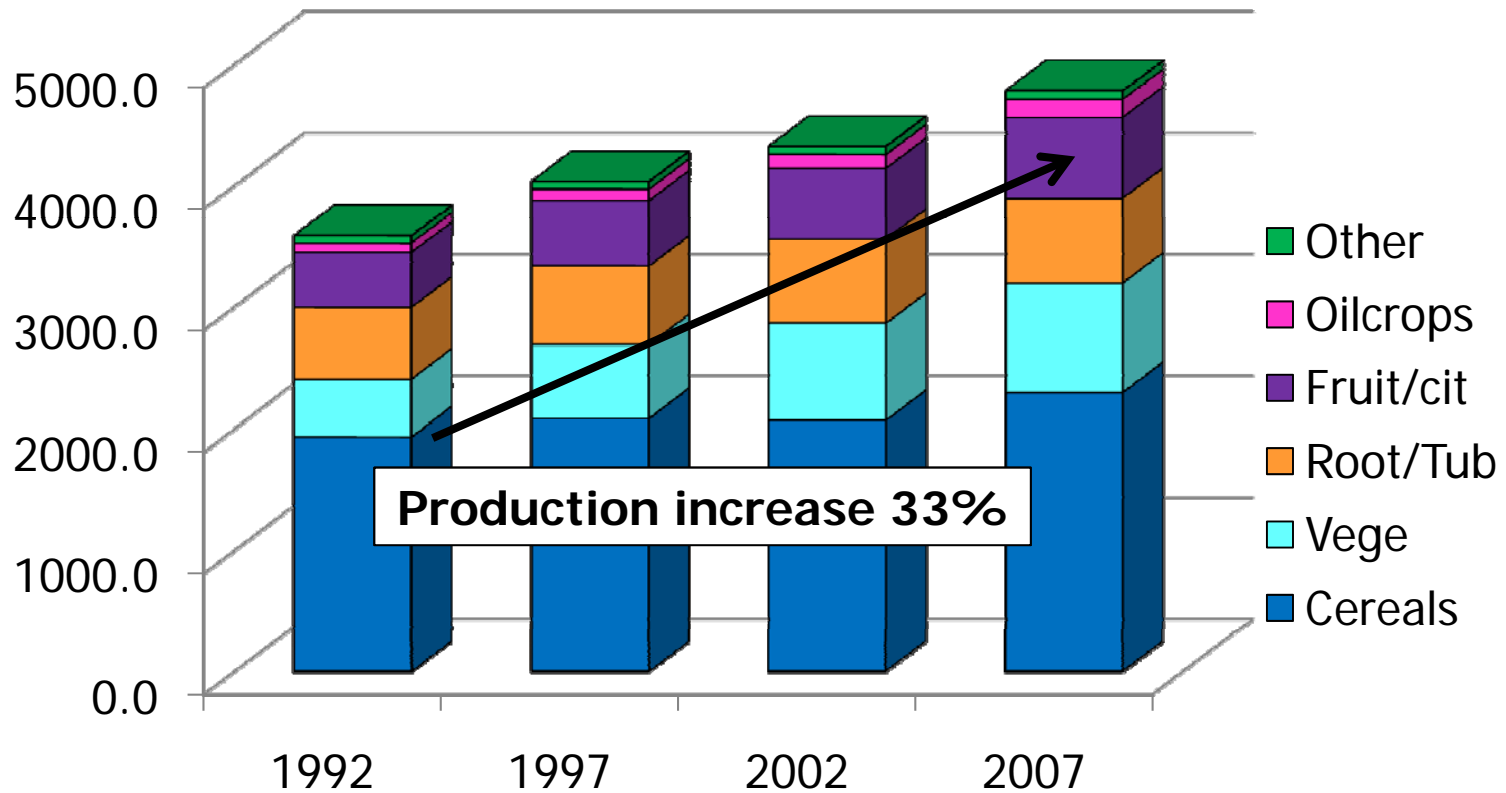


As income increases then meat (protein) consumption increases. Demand is also for improved quality, convenience, and safe food.

Performance in recent years...

Global crop basket = cereals, oilcrops, pulses, root/tubers, sugar, citrus, treenuts, fruits, vegetables

World Production, MM MT



Kg/person

658

689

693

722

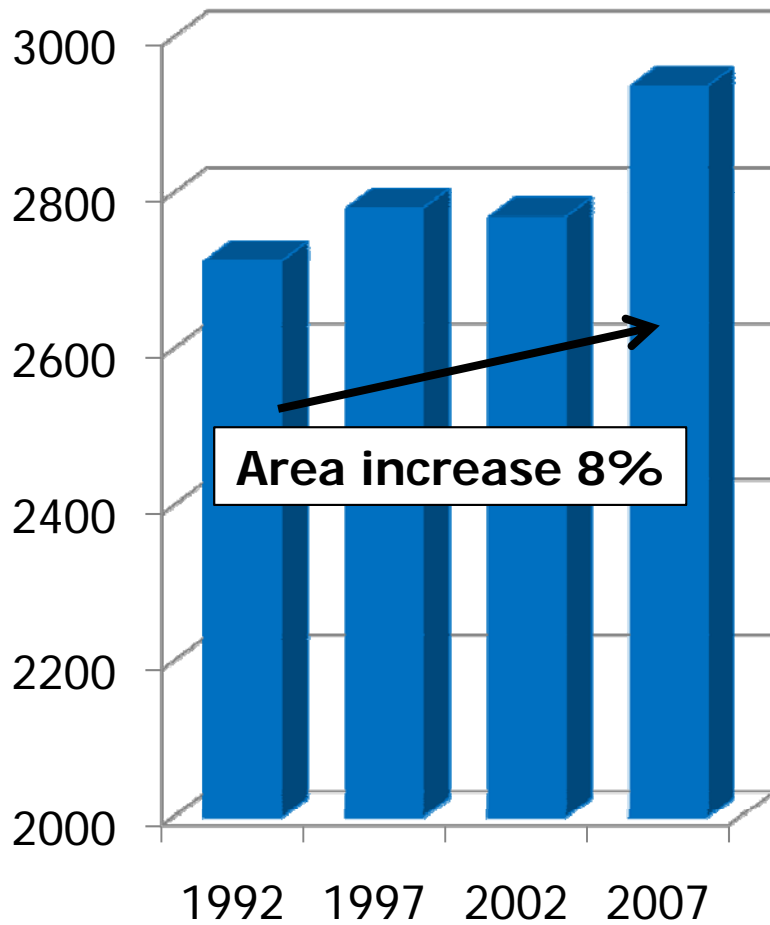
Increase in consumption ~10%

Per cap increase in main crop consumption; partly due to meat.

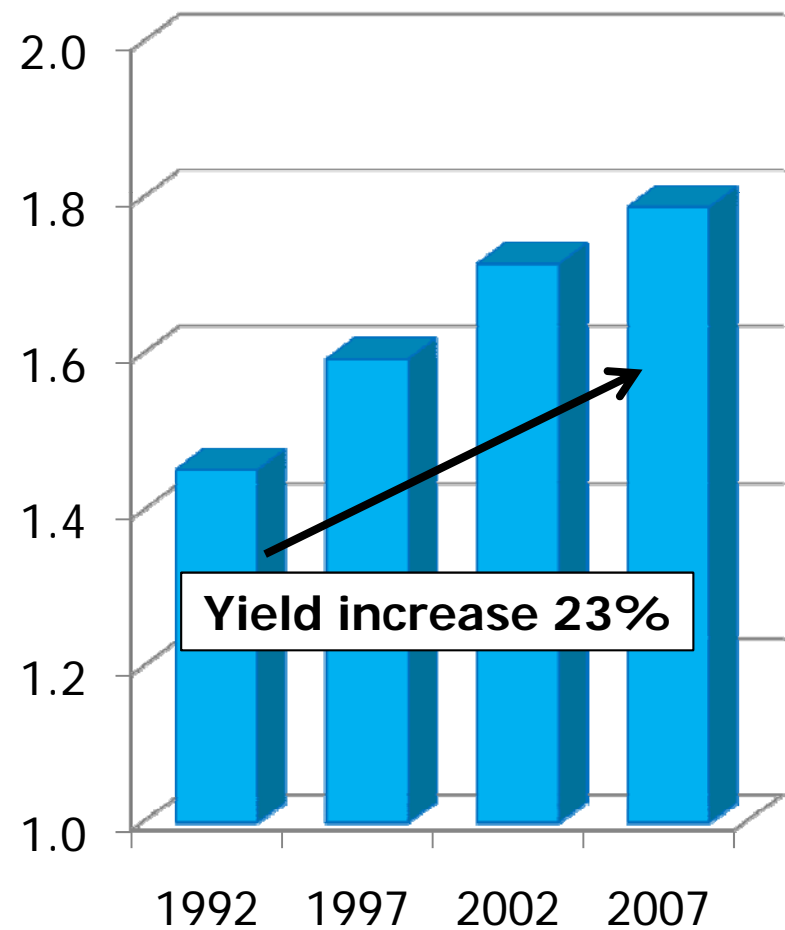
Performance in recent years: driving factors...

Global crop basket = cereals, oilcrops, pulses, root/tubers, sugar, citrus, treenuts, fruits, vegetables

Area harvested, MM acres



Global aver yield, tons/acre



What is required going forward...

9 B people is 2200 million increase in next ~35 years
At same standard, will need extra 722 kg X 2200 = 1588 MM MT

Scenario 1: No further yield increase

Crop basket aver Y is 4.02 MT/Ha.

Incremental land required = $1588/4.02 = 395$ MM Ha

Equal to a 33% global increase, or 970 million extra acres

Extra required = 2X the arable land in the US

Scenario 2: No additional land available

Crop basket aver Y is 4.02 MT/Ha, and we use 1189 MM Ha.

Incremental yield required = $1588/1189 = 1.34$ MT/Ha

Equal to a 33% increase, on every acre, worldwide

Scenario 3: The Malthus situation – Not a solution we want

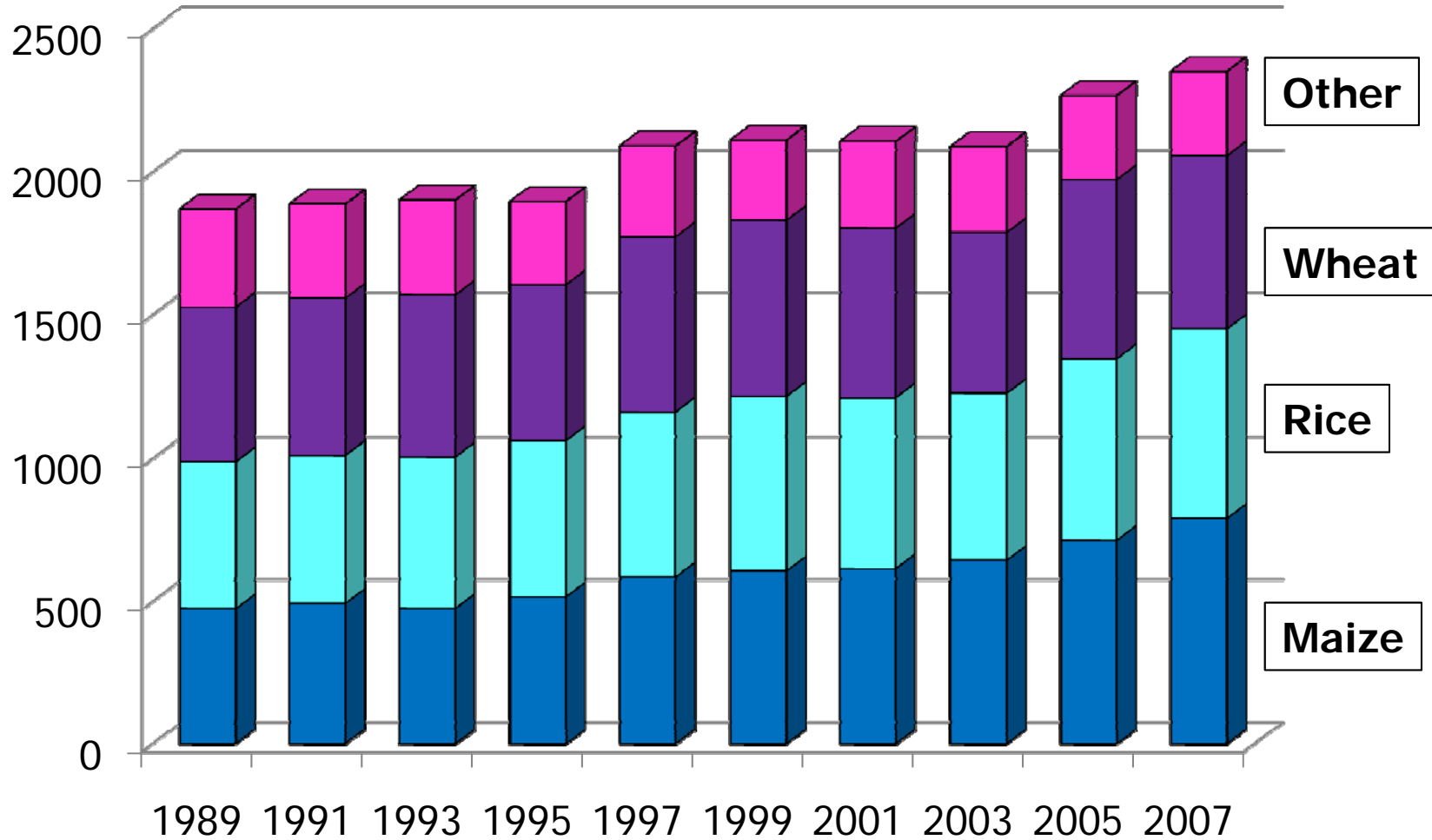
Scenario 4: Probable that more meat will be required

Crop basket averages underestimate the demand.

Cereals will be required to increase more than other crops

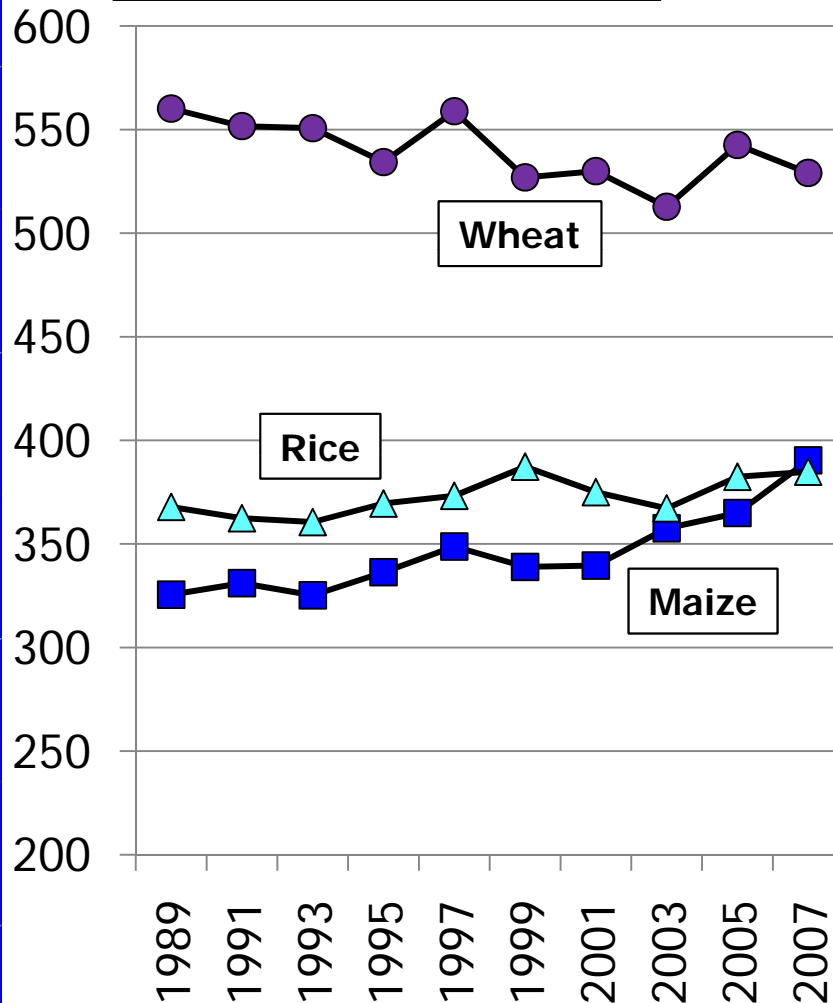
Cereal production is a major component of recent performance: details...

Global Cereals, MM metric tonnes

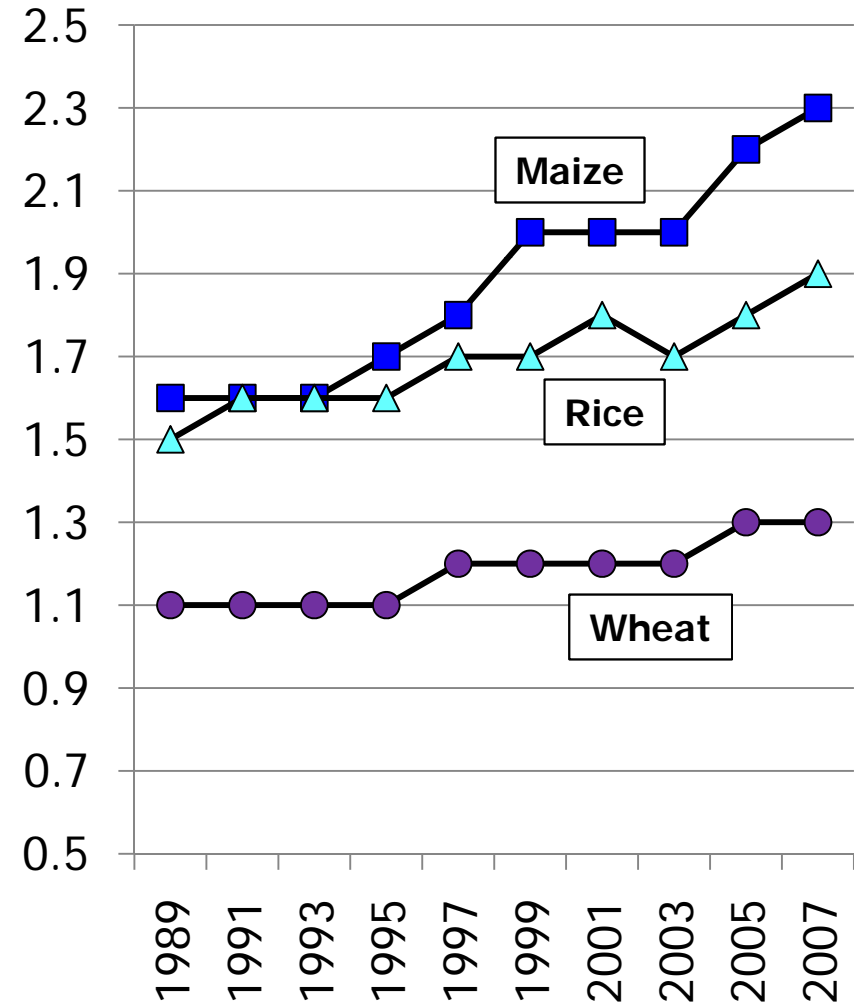


World cereal area and yield...

Harvested, MM acres



Global aver yield, tons/acre



What do you think we need to achieve...



What will be required?

What will be the mechanism?



Estimates of what we think is needed... (in the next 30 years)

We believe the effective new land available is limited due to:

1. Physical useful land and access to fresh water
2. Indirect land use change, and other regulations



Yield will be the main driver



Rice yield increase >35%



Wheat yield increase >40%



Corn yield increase >65%

PLAN A



Science continues to be a major platform for the new agricultural revolution...

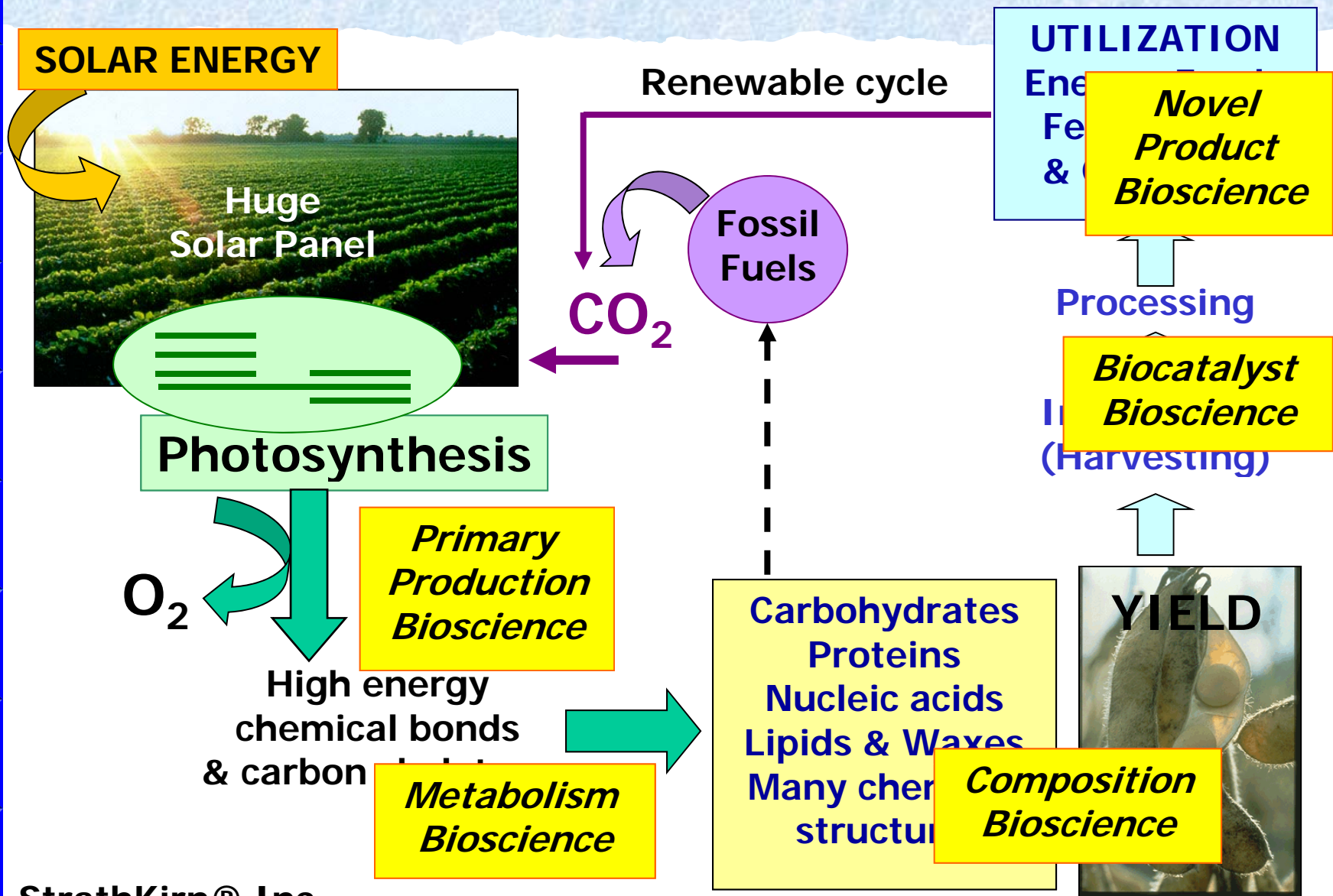
"There's a misconception that it would be better to go back to more primitive methods of agriculture because chemicals are bad or genetics is bad. This is not true.

*We need to use the science and technology we have developed in order to feed the world's population, a growing population. And the more yield we get per acre of land the less nature has to be destroyed to do that...
It's simple arithmetic."*

Patrick Moore

- co-founder of the original environmental group, "Greenpeace".
- resigned due to the group putting politics before the environment.

Biotech and bioscience has huge potential



October 2009: UK scientists acknowledge the need for biotech...



Prof John Beddington, the UK Chief Scientist, said

- World needs 50% more food by 2030.
- The only way to do this is to grow more crops on less land by using crops genetically modified to be drought or disease resistant.

**Royal Society report also recommends GM crops
to tackle the impending food crisis.**

New tools are arriving every day...

A few examples

Inducible promoters

Epigenomics & 3rd code

Artificial mini-chromosomes

Zn-finger nucleases

Gene stacking strategies

Homologous recombination

Gene discovery arrays

3' UTR modifiers

Proteomics

RNAi control

Synthetic sequences

Functional genomics

2 hybrid screens

Directed evolution

High-throughput sequencing

Gene shuffling

PCR-mediated mutagenesis

Regulation cascades

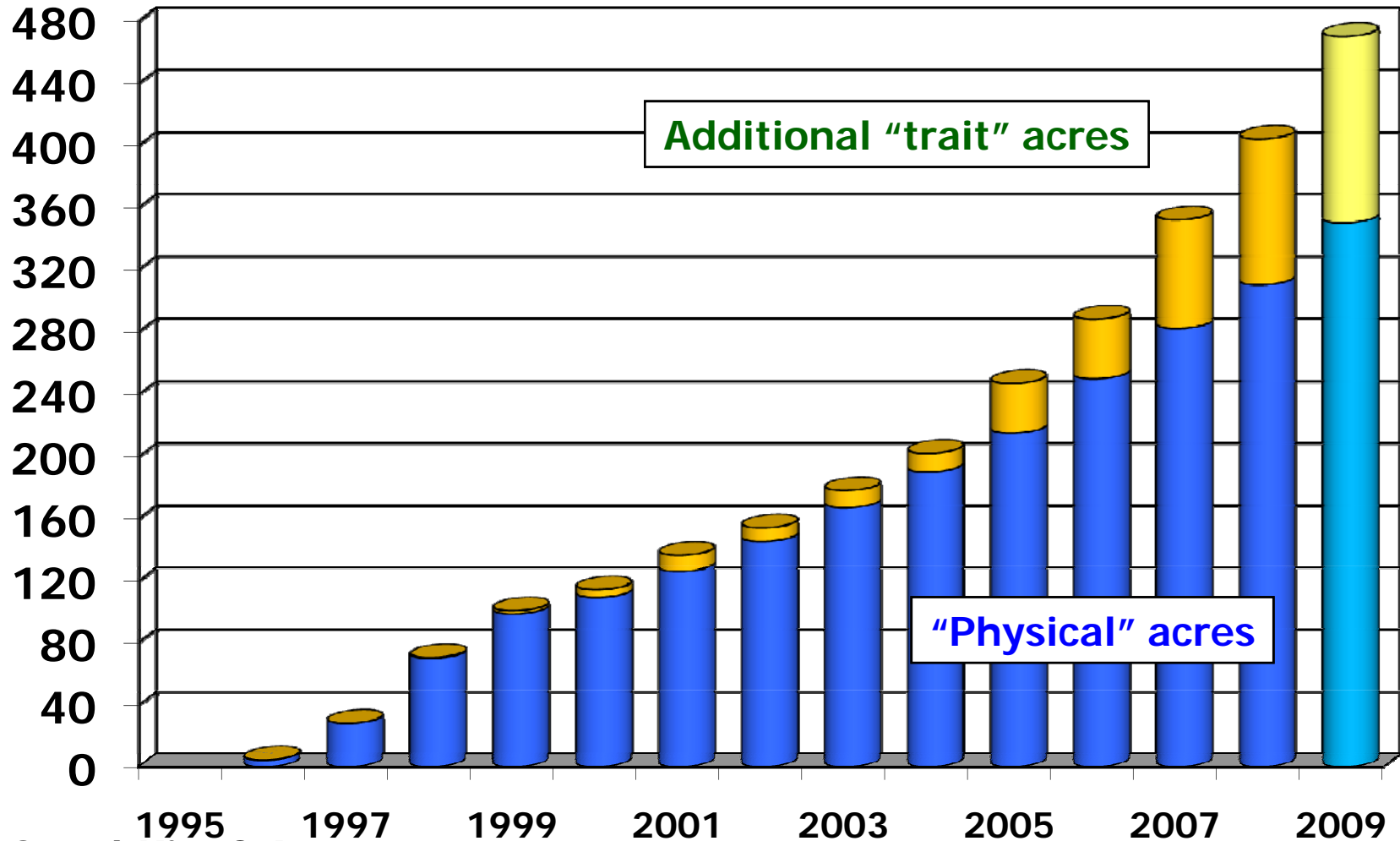
Synthetic biology



Global commercial biotech crops

trait stacking is increasing....

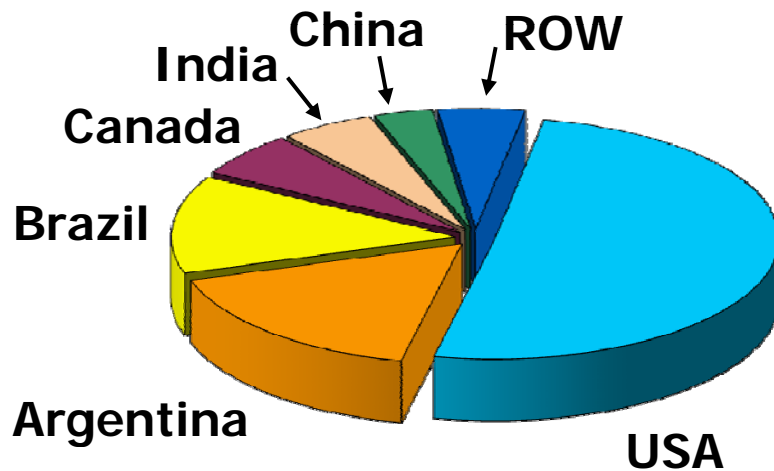
Million acres commercial biotech



Global biotech crop situation...

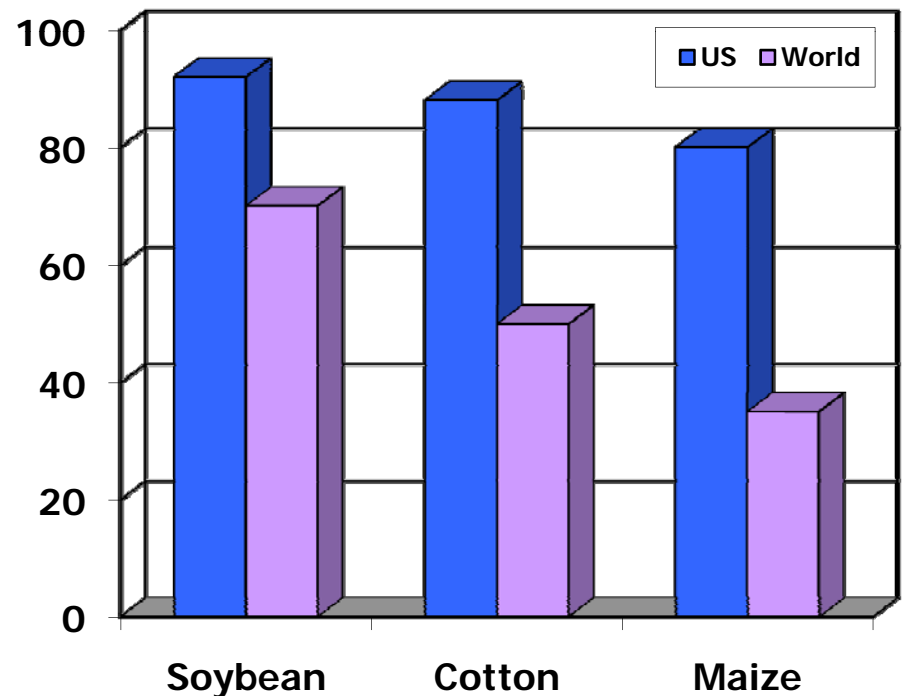
Commercial total :
~ 340 MM physical acres; ~ 440 MM trait acres

Top countries by area

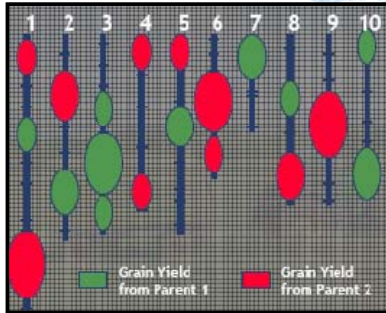


25 countries:
> 13 million growers
with 90% being small
or resource-poor farmers.

% planted acres



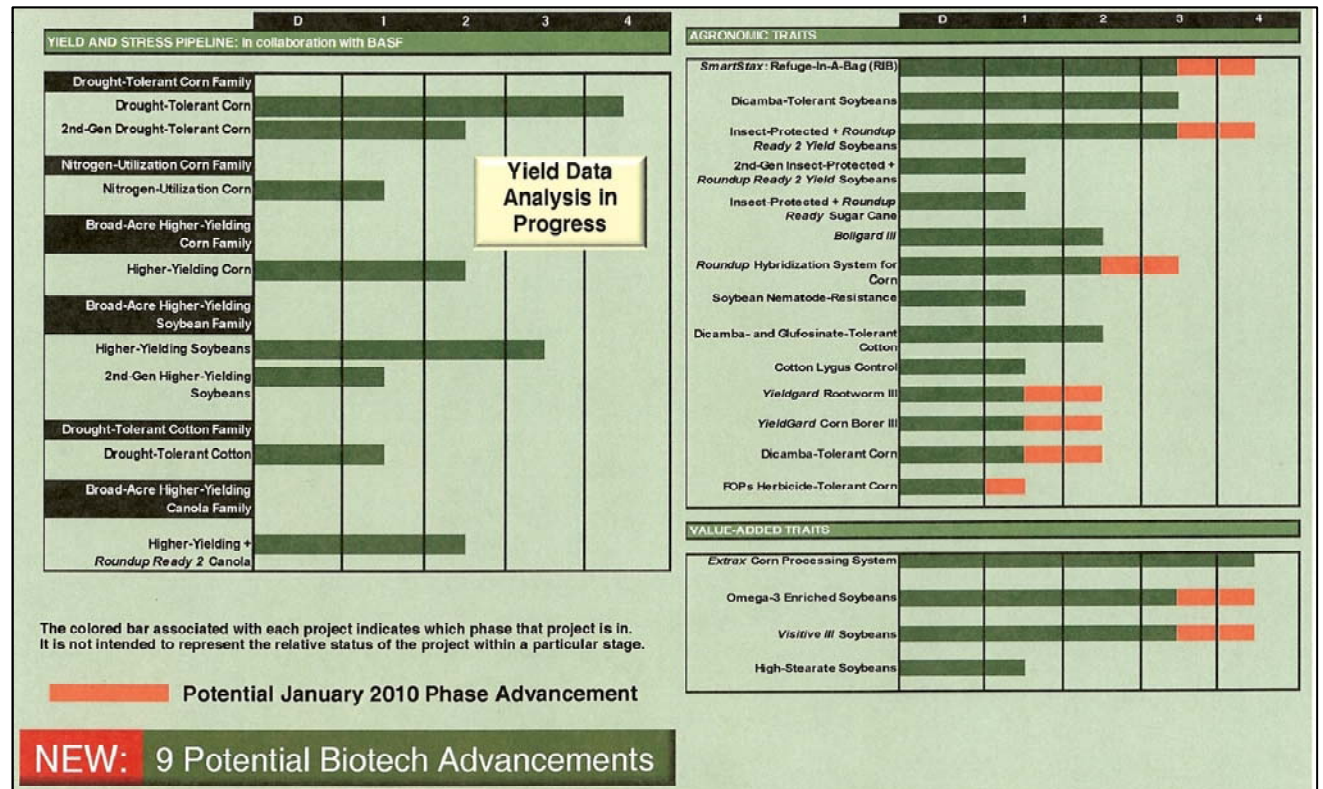
Intense focus on new traits...



Marker Assisted Breeding (MAB) using genomic tools → huge gain

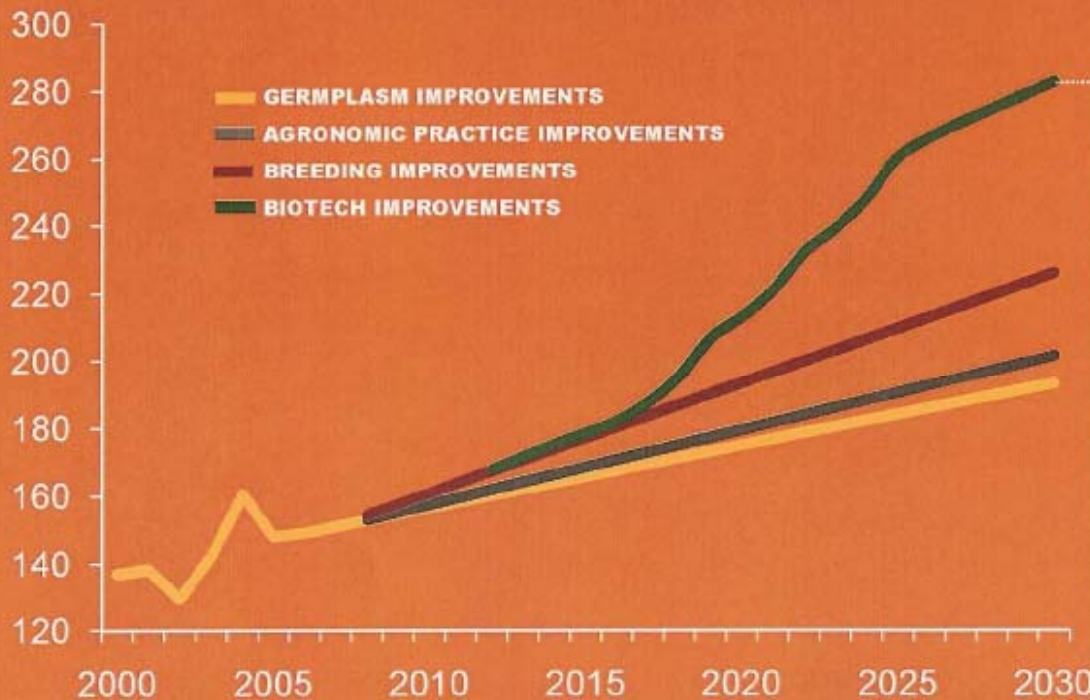
Majors realize basic yield delta of 8-10%

New trait pipeline



Monsanto commits to deliver yield...

DOUBLING YIELD WITH TECHNOLOGY: U.S. CORN EXAMPLE



2030 U.S. YIELD TARGET
2030: **>2x 2000 BASELINE OF 137 BU/AC**

DOUBLING YIELD BY 2030

U.S. BASELINE

CROP	2000 BASELINE ¹
Corn:	137 bu/ac
Soybeans:	37 bu/ac
Cotton:	632 lbs/ac

STRATEGIC RATIONALE

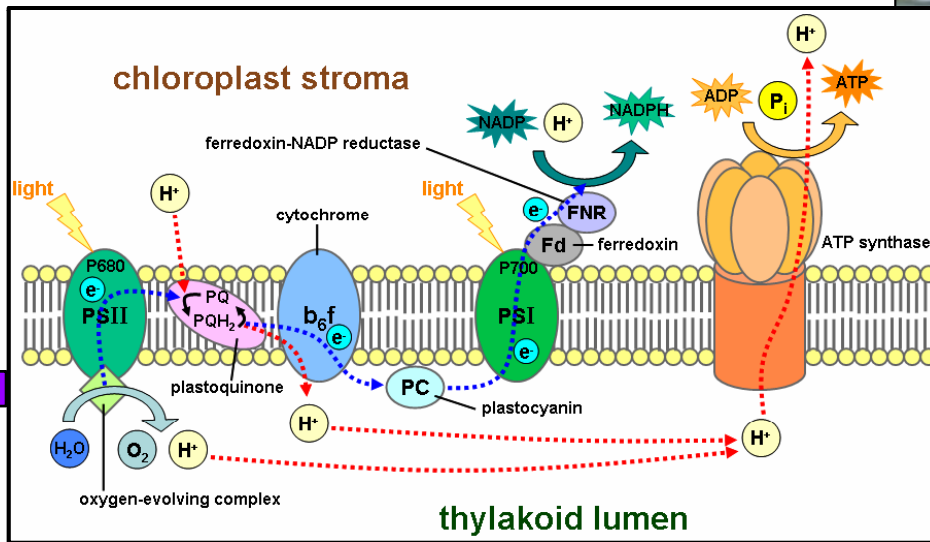
- ① Helping meet global demand
- ② Furthering competitive lead
- ③ Creating new value for farmers that creates sustainable growth opportunities

Algae as a potential crop...

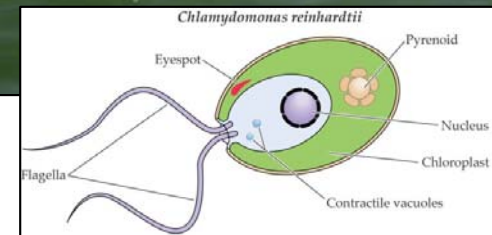
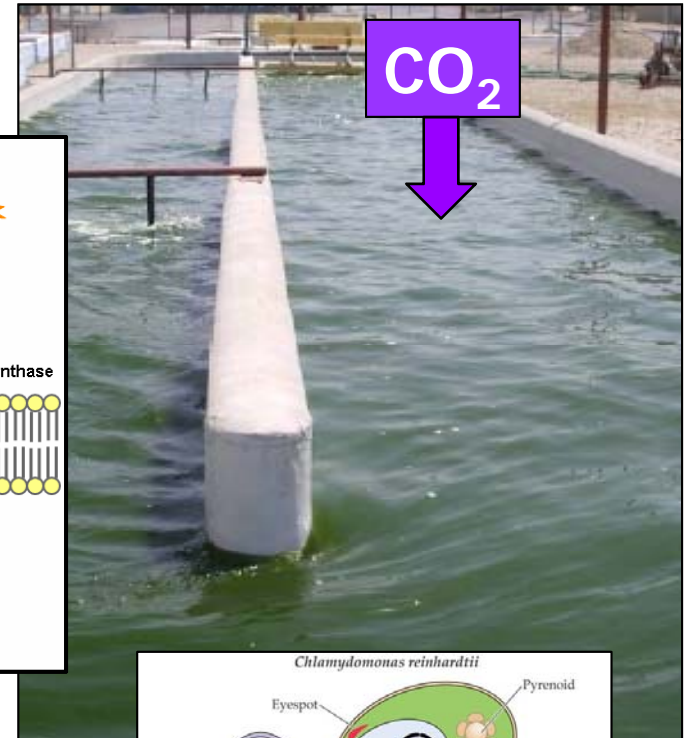


Photon trapping and energy conversion

Solar energy



O₂

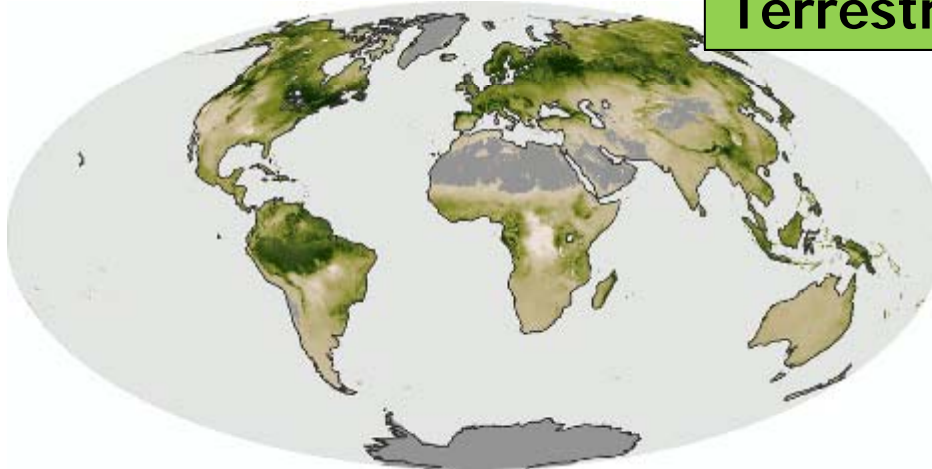


Why consider algae...

- ◆ **High potential** (solar energy conversion)
 - Achieving 25% of the theoretical conversion = 38.8 tons/acre/year
 - Best tropical crops = 35 tons/acre/year
- ◆ **Do not need to use arable land**
 - Will not compete for other crop uses
- ◆ **Carbon dioxide enrichment easier than with terrestrial crops**
 - Potential to use for CO₂ mitigation

Why are we only using a small portion of the planetary resources?...

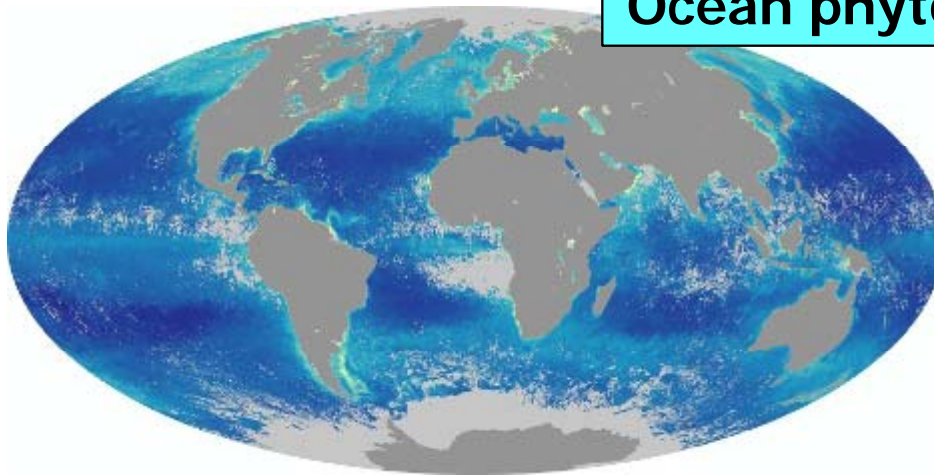
Terrestrial trees and crops



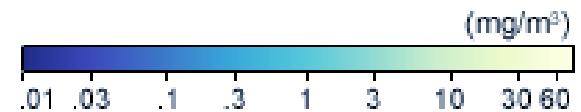
Net Primary Productivity
July 2008


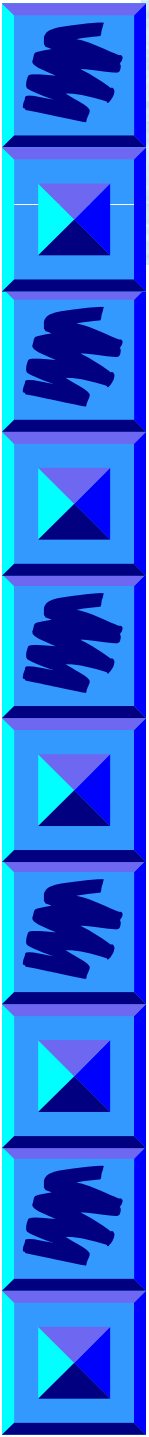


Ocean phytoplankton/marine algae



Chlorophyll: Sept 2008





"The object of life is not to be on the side of the majority, but to escape finding oneself in the ranks of the insane."

Marcus Aurelius, Roman Emperor, 121-180 A.D.

**It may sound insane but we believe the current trajectory of science application to agriculture will allow:
safer, healthier, improved quality food,
and enough to feed the upcoming 9 billion.
Beyond that, we'll need a Plan B, and C, and D....**