The Third Wave in Biotechnology: Creating a New and More Sustainable Industrial Revolution

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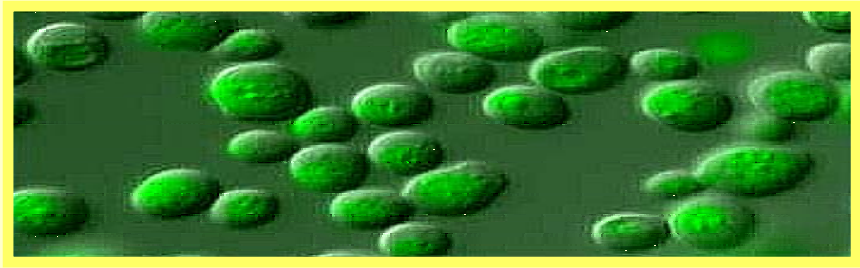


Industrial Biotechnology

= the application of life sciences to conventional manufacturing and synthesis processes

Industrial biotech use s genetically enhanced bacteria, yeasts, fungi and results in;

lower production costs, more profit

reduces or prevents pollution

enhances resource conservation

Industrial and Environmental Biotechnology Companies

are using the same

genomic, proteomic & bioinformatic

tools employed in

medical biotechnology

these tools facilitate the discovery of new ways to make industrial raw materials, intermediates and consumer goods

Some Industrial Biotech Applications by Industrial Sector

- Biopulping (paper industry)
- Specialty Textile Treatment
- Metal Ore Heap Leaching
- Electroplating/Metal Cleaning
- Rayon and Other Synthetic Fibers
- Metal Refining
- Vitamin Production
- Sweetener Production (high fructose syrup)
- Oil Well Drill Hole Completion (non-toxic cake breakers)
- Road Surface Treatment for Dust Control
- Textile Dewatering
- Vegetable Oil Degumming
- Enzyme Food Processing Aids
- Fine and Bulk Chemicals
- Chiral Compound Synthesis
- Pharmaceuticals
- Food Flavoring Compound
- Biopolymers/Plastics
- Bio-Ethanol Transportation Fuel
- Nutritional Oils
- Oil and Gas Desulphurization
- Leather Degreasing
- Bio-hydrogen
- Coal Bed Methane Water Treatment
- Chem/Bio Warfare Agent Decontamination
- Pulp and Paper Bleaching
- Baking

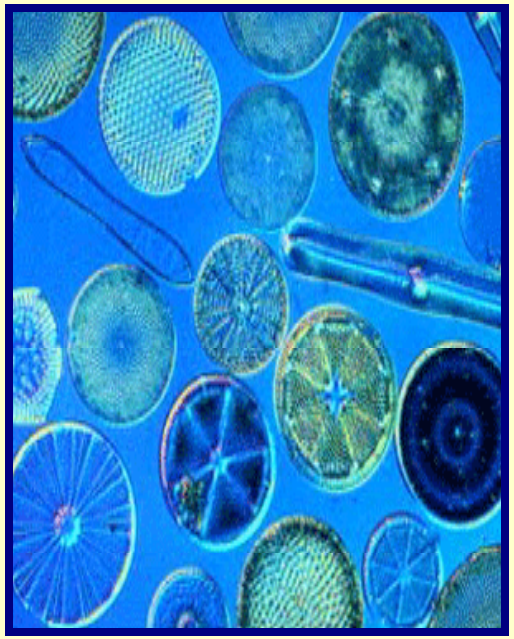
Modern Industrial Biotechnology

Range of Activities

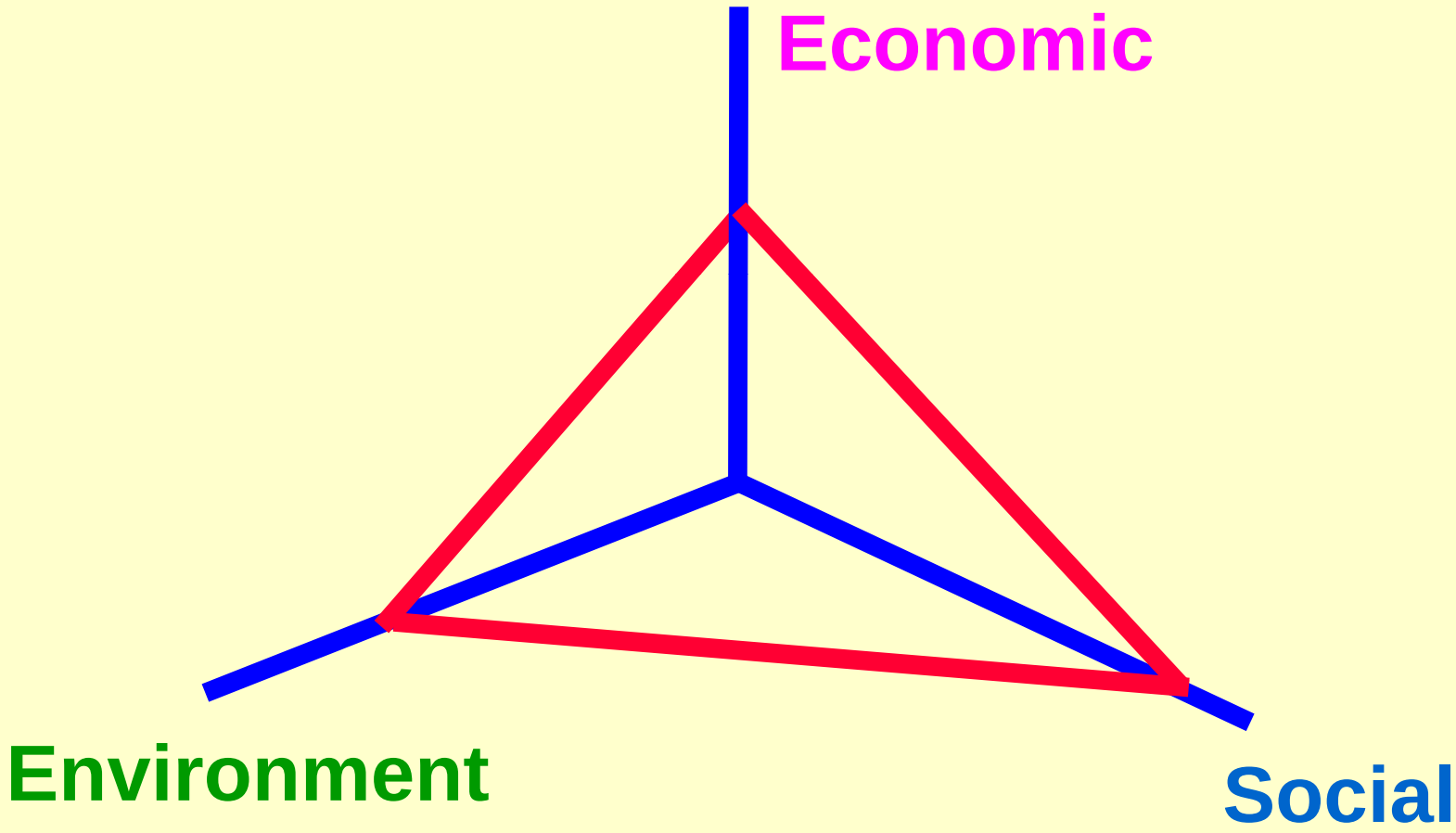
Biobased Products & Bioenergy

Manufacturing and Synthesis

Nanotechnology Biotech Interface

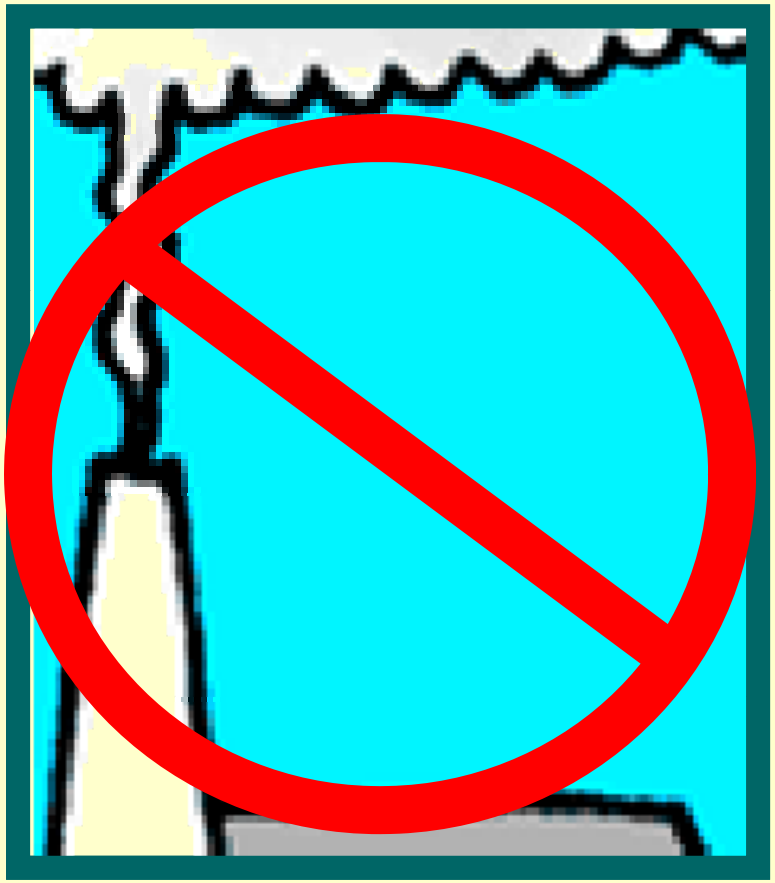


The Triple Bottom Line



Size of triangle = indicator of sustainability

In manufacturing a more sustainable and less expensive alternative is to **prevent the pollution in the first place !**



Organization for Economic Cooperation and Development (OECD)

Headquarters in Paris

Members - the developed nations

OECD Working Party on Biotechnology (WPB)

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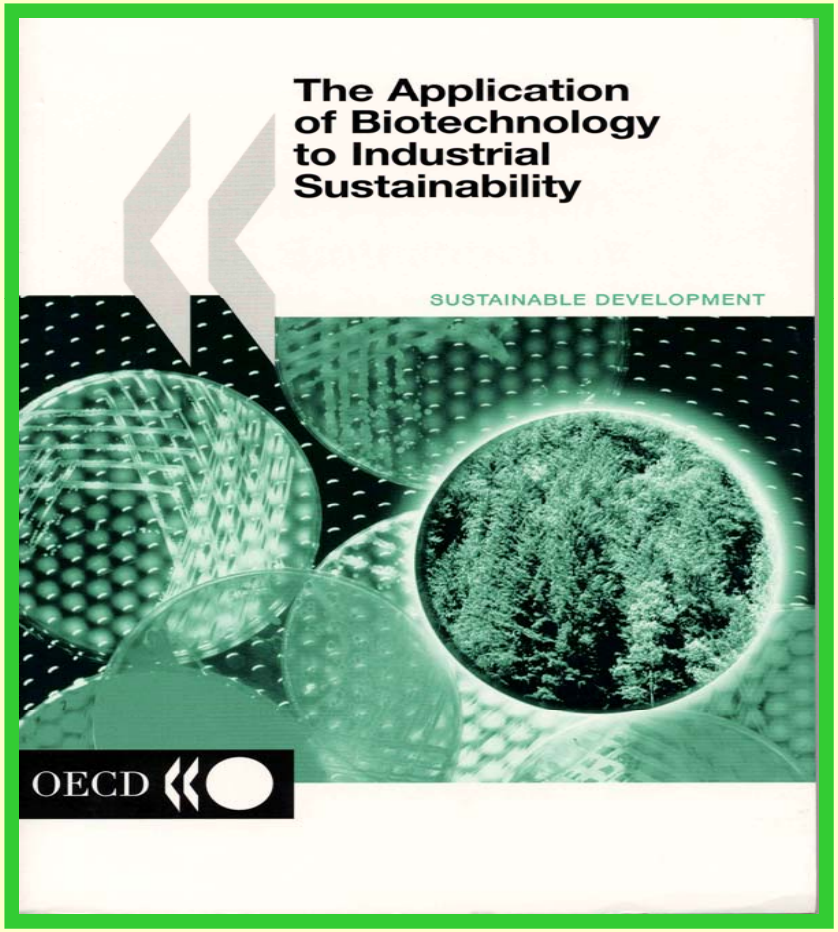
Task Force on

Biotechnology for Sustainable Industrial Development

The Application of Biotechnology to Industrial Sustainability



Completed November 2001

Prepared by Dr. Mike Griffiths

Why the OECD study?

- No collections of comparable case studies existed, and
- No analysis to-date of the policy implications

Why did we do it?

- Industrial biotech should be on every industrial agenda--

  and on every list of parameters

Basis of the Study

- Identification of companies which have adopted new biotechnology processes (21 case studies)
- The factors in their decision making
- The policy lessons which emerged

Unanswered Questions

- Some assessments already existed but were
  - academic studies of environmental problems
  - specific in-house analyses of process development

We wanted to know:

- Can biotechnology provide a cheaper option?
- Can economic and environmental improvement go hand in hand?

Two distinct audiences

- Industrial policy makers (senior management)
  - show what others have done and the benefits
  - demonstrate new sustainability strategy to their companies
- Policy makers within government
  - learn how the “early adopters” have made decisions
  - support regulatory guidelines or national financing programmes

Participating Companies

- Avecia
- Baxenden
- Billiton
- Biochemie (Novartis)
- Cargill Dow
- Cereol
- Ciba
- Domtar
- DSM
- ICPET
- Iogen
- Leykam
- M-I, BP Amoco
- Mitsubishi Rayon
- Oji Paper
- Paques (Budel Zinc, Pasfrost
- Roche
- Tanabe Seiyaku
- Windel

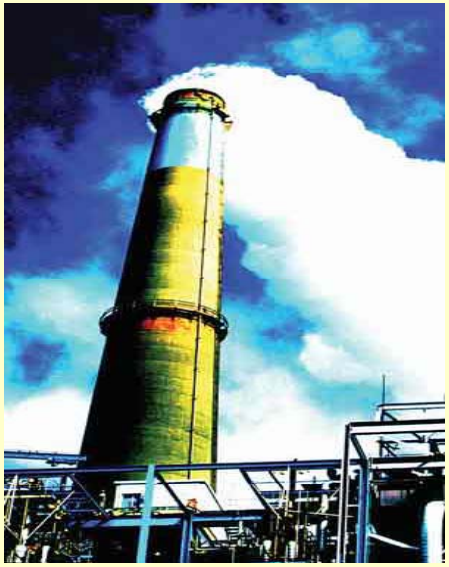
Breakdown of Cases by Sector and Country

Industry sector	Pharma	Fine chemicals	Bulk chemicals	Food & Feed	Textiles	Pulp & paper	Minerals	Energy
Austria						1		
Canada						2		2
Germany	2			1	1			
Japan		1	1	1				
Netherlands	1			1			1	
S. Africa							1	
UK		1	2					1
USA			1					

Selected Case Study Results

from

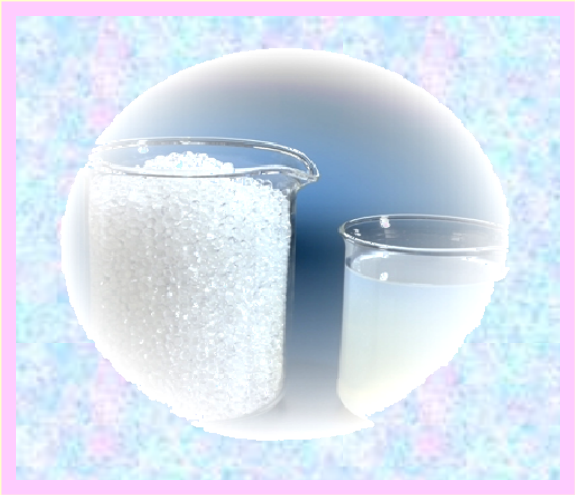
"The Application of Biotechnology to Industrial Sustainability"



Manufacture of Vitamin B_2 (Hoffman La-Roche, Germany)

- Substituted multi-step chemical process with a one-step biological process using a genetically modified organism
- Land disposal of hazardous waste greatly reduced
- Waste to water discharge reduced 66%
- Air emissions reduced 50%
- Costs reduced by 50%

Production of Acrylamide (Mitsubishi Rayon, Japan)



- Conversion to enzymatic process reduced levels of all waste products as a result of high selectivity of enzymatic reaction
- Lower energy consumption for enzymatic process,

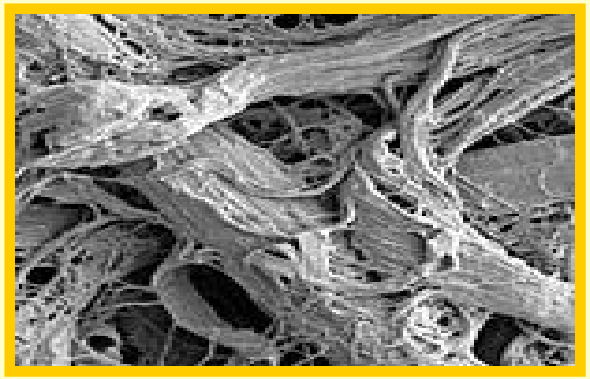
  1.9 MJ/kg for old process - 0.4 MJ/kg for new process
- Enzymatic process produced lower CO_2 Emissions

  old process – 1.5 kg CO_2/kg product

  enzyme process 0.3 kg CO_2/kg product

Removal of Textile Finishing Bleach Residues (Windel, Germany)

- Hydrogen peroxide used for bleaching textiles usually requires several rinsing cycles
- New enzyme process -- only one high temperature rinse is needed to remove bleach residues
- Reduced production costs
- Reduced energy consumption by 14%
- Reduced water consumption by 18%



Wood Pulp Brightening (Domtar, Canada)

- Wood pulp digestion is followed by bleaching in a multi-stage process to yield bright, strong pulp
- Two options to reduce chlorine
  1) reduce lignin prior to bleaching (enzymes still in R&D)
  2) change bleaching chemistry
- Enzyme xylanase produced third option - "activating" lignin so less bleach is needed
- Xylanase treatment reduces the use of bleaching chemicals by 10-15% and reduces toxic dioxin formation

Ethanol from Biomass (Iogen, Canada)

- Ethanol currently produced by fermenting grain (old technology)
- Cellulose enzyme technology allows conversion of crop residues (stems, leaves and hulls) to ethanol
- Results in reduced CO_2 emissions by more than 90% (compared to oil)
- Allows for greater domestic energy production and it uses a renewable feedstock

OECD Report Significant Findings

- **Biotech invariably led to a more environmentally friendly process**
- **It also resulted in a cheaper process**

  but….
- **The role of the environment was secondary to cost and product quality**

  unless….
- **Environmental legislation/regulation is driver -**

  then the decision might be change or close!

Significant findings

- **Approaches were rarely systematic – each company took a different approach**
- **Biotech skills had to be acquired – it was helpful to have industrial or academic partner(s)?**
- **Lead times improved with succeeding developments!**

Key Messages

- Why adopt biotechnology? To cut costs and be environmentally friendly
- Companies -- be aware of new technology; find yourself an R & D partner
- Find a champion in house; assemble arguments to convince doubters
- Build your own in-house biotech skill base
- Companies -- work with government and stay close to the regulators—work in concert
- Government -- companies still need help – incentives and R & D funding

Why Should Regulators Care?

- Because, unlike most command and control pollution reduction strategies, industrial biotech can reduce/prevent pollution and costs

- Industrial biotech would stand up very well in regulatory regimes requiring the calculation of economics - - costs and benefits

BIO members wanted to know…

What if industrial biotechnology were more widely used?

Answer?

- BIO decided to generate a new report to examine this issue
- Start with OECD base case
- Then extrapolated from real world EPA data
- Develop best case projections to illustrate what is possible by using industrial biotech

Groundbreaking Report
Released by BIO on June 3, 2004

New Biotech Tools for a Cleaner Environment

- First of its kind report—follow on to OECD report
- Analyzed 5 industrial sectors where industrial biotech is being used
- Used EPA data to make projections on environmental and cost benefits for those sectors
- Report showed industrial biotech delivers clear cost savings and environmental benefits in every sector examined

Industrial Sectors Analyzed

- Pulp and Paper Production and Bleaching
- Textile Finishing
- Plastic and Chemical Production
- Fuels Production
- Pharmaceutical and Vitamin Production

Results of Analysis

Pulp & Paper

Biotechnology process changes result in:

- Reduction in the amount of chlorine chemicals necessary for bleaching by 10-15%
- Changes could reduce chlorine in water and air by a combined 75 tons per year

Results of Analysis

Textile Finishing

Biotechnology process changes result in:

- Reduction in water usage by about 17-18%
- Reduction in costs associated with water usage and air emissions by 50-60%
- Reduction in energy demand for bleaching by about 9-14%

Results of Analysis

Plastics Production

Biotechnology process changes result in:

- Reduction in demand for petrochemicals by 20-80%
- Reduction in plastics in the waste water stream by up to 80%

Results of Analysis

Bioethanol Production

Biotechnology process changes result in:

- A net energy generation of 8 to 10 times the energy required for production for bioethanol from cellulose
- Replacement of 30 gallons of imported oil equivalent for every one gallon of cellulosic ethanol
- Substantial contribution to the mitigation of greenhouse gas emissions

Key Findings

- **Industrial biotechnology offers the private sector remarkable new tools for pollution prevention that have not been widely available before now**

- **These new tools not only prevent pollution but can also significantly cut energy demand, natural resource consumption, and production costs while creating high quality intermediates or consumer products**

- **Accelerated uptake of new industrial biotechnology processes could lead to further pollution prevention, waste reduction, and energy cost savings in related services such as waste disposal or energy production**

- **Public policies and regulations do not provide adequate incentives for technological innovations, such as biotechnology-based pollution prevention and energy savings**

- **The industrial biotechnology processes used in this analysis involve cutting-edge technologies. More research and development must be undertaken to increase the utility and efficiency of these biotechnology processes across a broad range of industrial applications.**

What Makes Industrial Biotech Attractive from a Business Perspective?

- Decreases productions costs
- Increases sustainability profile
- Allows broader use of ag feedstocks instead of petroleum
- Provides precision catalysis
- New biocatalysts constantly being discovered and improved rapidly
- Not controversial

Market Potential

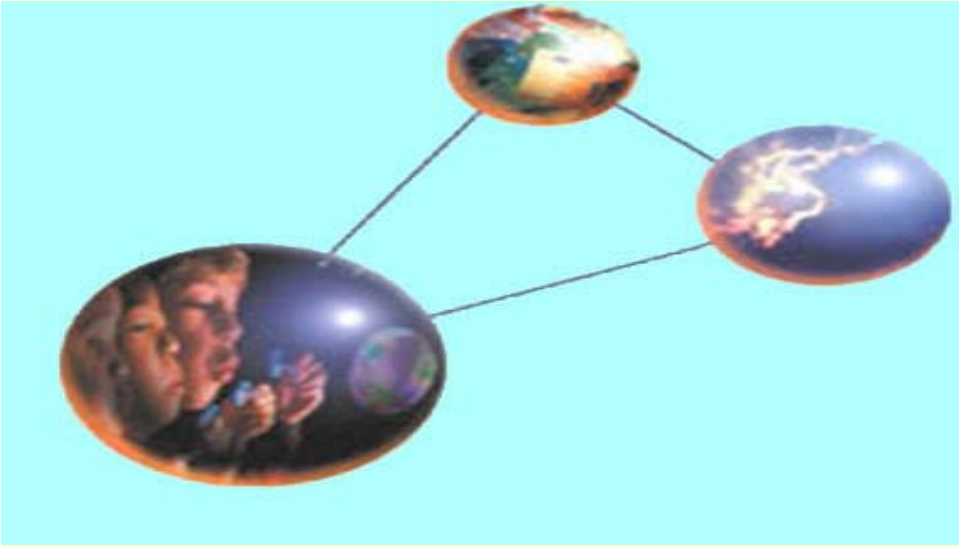
- The trend towards industrial biotech will continue and accelerate
- McKenzie and Co. estimates show that in 2010, about 20% of the chemical market (worth $280 Billion)
- The total value creation potential in the chemical industry alone could be as high as $160 billion US

Conclusions

- Industrial Biotechnology is in the early stages of development
- It's innovative applications are increasing and spreading rapidly into all areas of manufacturing
- It is already providing useful tools that allow for cleaner, more sustainable production methods and will continue to do so in the future
- It is in the interest of both business and government to foster the diffusion of these innovative applications into many sectors of the manufacturing economy

Industrial Biotechnology Is Key For

- Developing new biobased production methods and consumer products
- Creating jobs in rural areas
- Conserving resources
- Achieving industrial sustainability
- Finding new uses for agriculture crops and residues
- Bequeathing a cleaner environment to future generations



Catch The Third Wave