



A Future Direction for Environmental Engineering: Environmental Biotechnology

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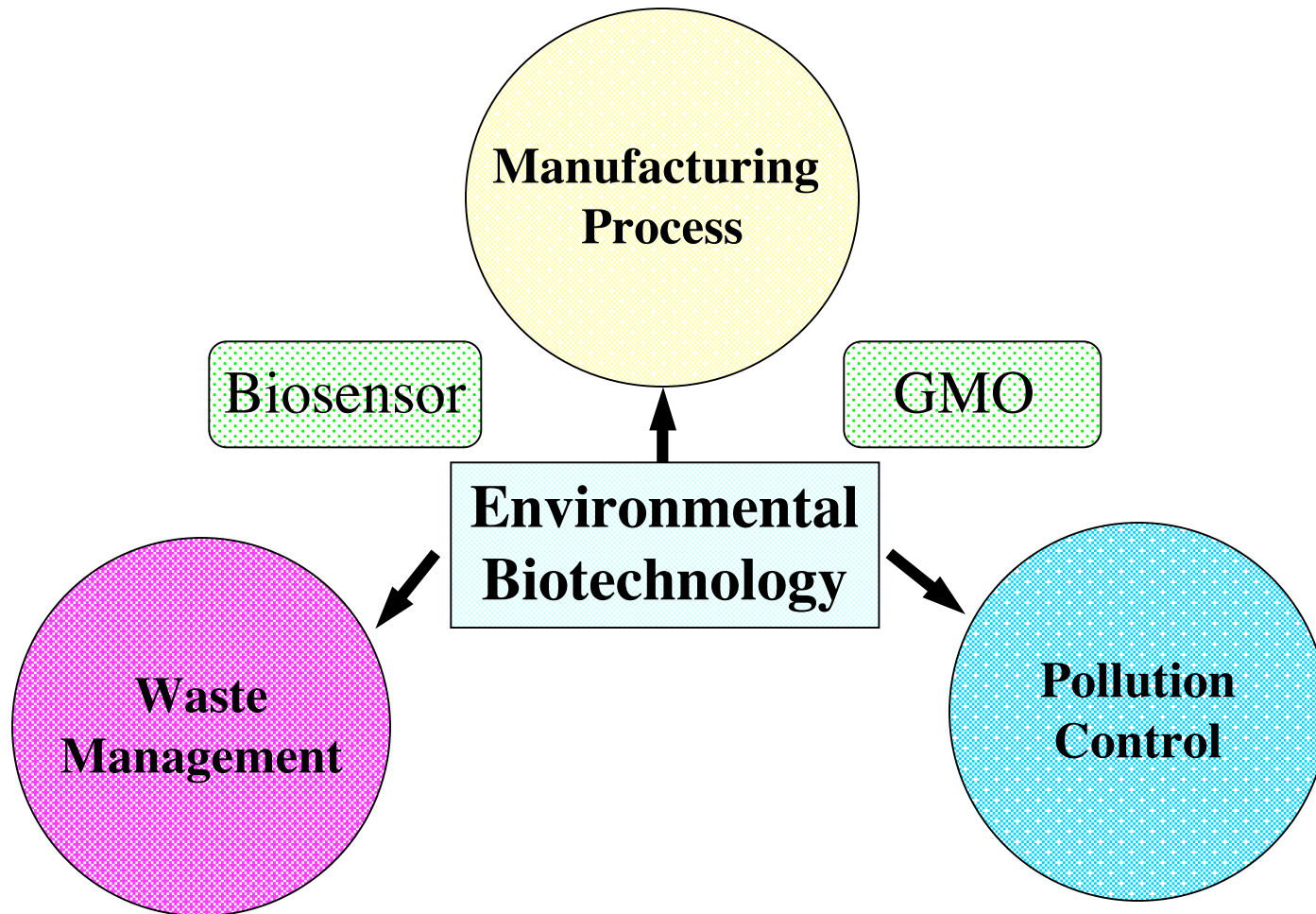
“Biotechnology is the use of organisms or their components in industrial or commercial processes, which can be aided by the techniques of genetic manipulation in developing e.g. novel plants for agriculture or industry”

Chambers Science and Technology Dictionary

“Environmental biotechnology is fundamentally rooted in waste, in its various guises, typically being concerned with the remediation of contamination caused by previous use, the impact reduction of current activity or the control of pollution”

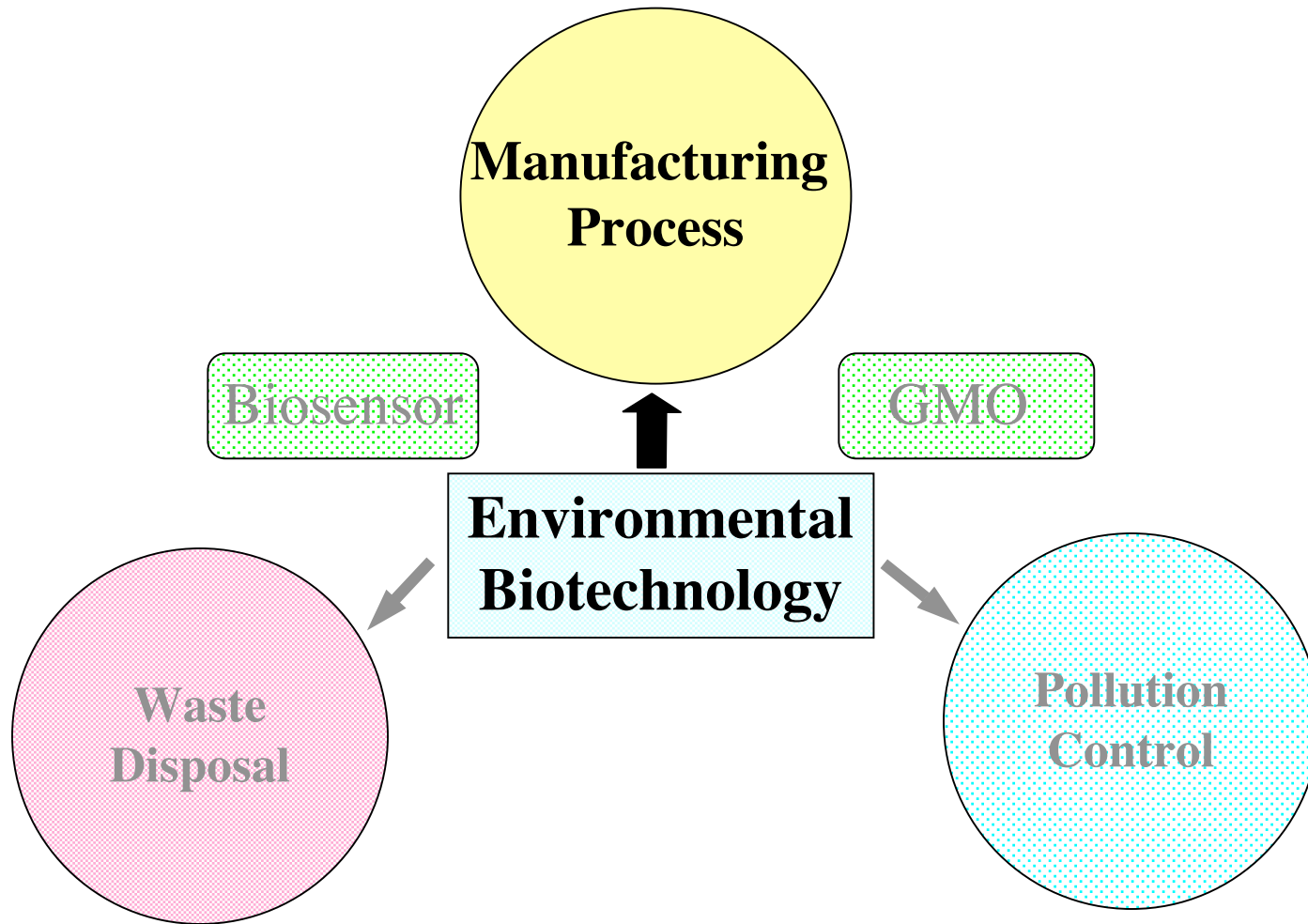
Evans and Furlong (2003). Environmental Biotechnology: Theory and Application

Environmental Biotechnology (Three Intervention Points)



GMO, Genetically Manipulated Organisms

Environmental Biotechnology (Three Intervention Points)

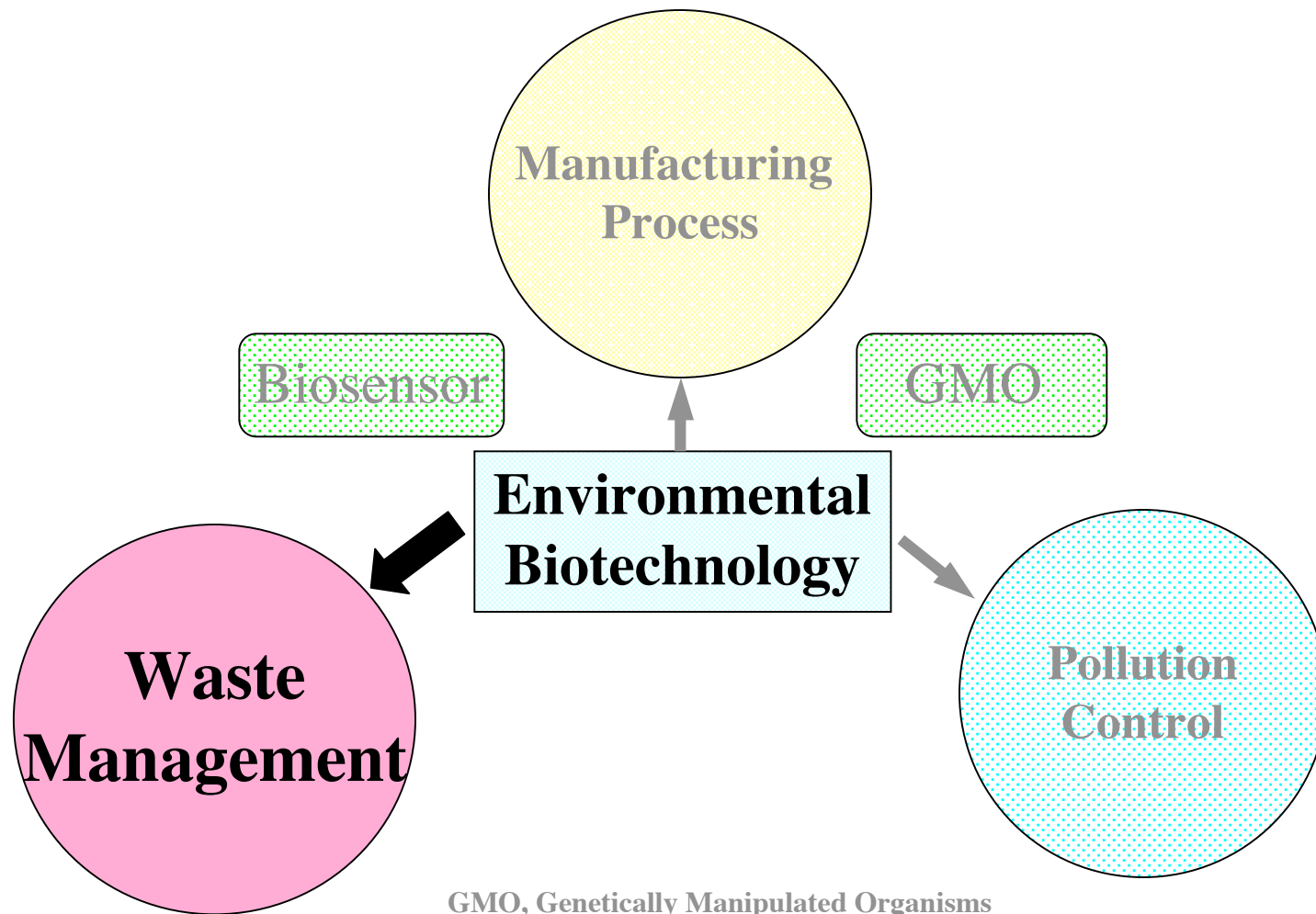


GMO, Genetically Manipulated Organisms

Manufacturing Processes (Clean Technology)

- **Process changes:** biological synthesis
 - Use of whole microorganisms or enzymes
 - ✓ Lower operational temperature: lower energy requirement
 - ✓ Higher specificity: higher yield
 - ✓ Less harmful and/or reduced wastes for disposal
- **Biological control**
 - Use of biological pesticides
 - e.g.) *Bacillus thuringiensis*: Bt insecticide
 - ✓ Target specific: reduced danger to other nonpest species
- **Biosubstitutions**
 - Use of biological substances
 - e.g.) biofuels, biolubricants, biopolymer

Environmental Biotechnology (Three Intervention Points)

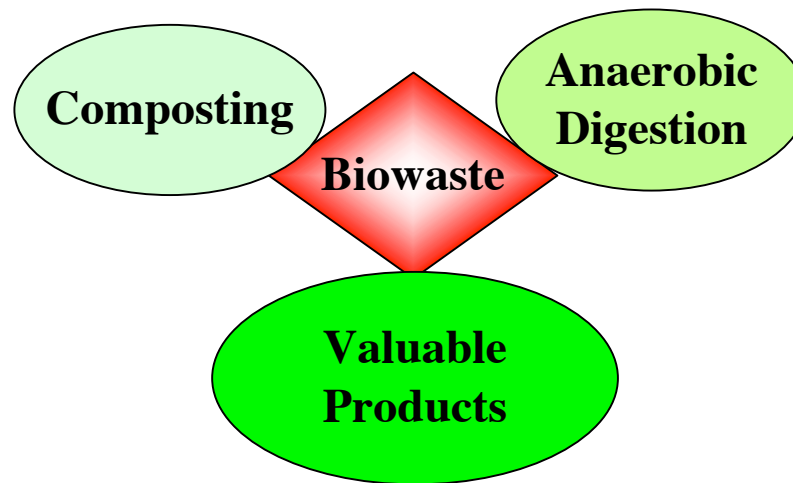


(Bio)Waste

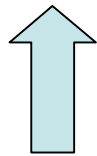
- Carbon-rich materials: faeces/manures, raw plant matter, and process waste
- 2,500 million tonnes/year (EU, 1998)
- Treatments
 - Incineration: not ideal for biowaste
 - Landfill
 - Emission of green-house gas (methane)
 - Production of polluting leachates
 - Biological waste treatment

Waste Biotechnologies

- Reducing the potential for adverse effects to the environment or human health
- Reclaiming valuable minerals for reuse
- Generating a useful final product



Composting



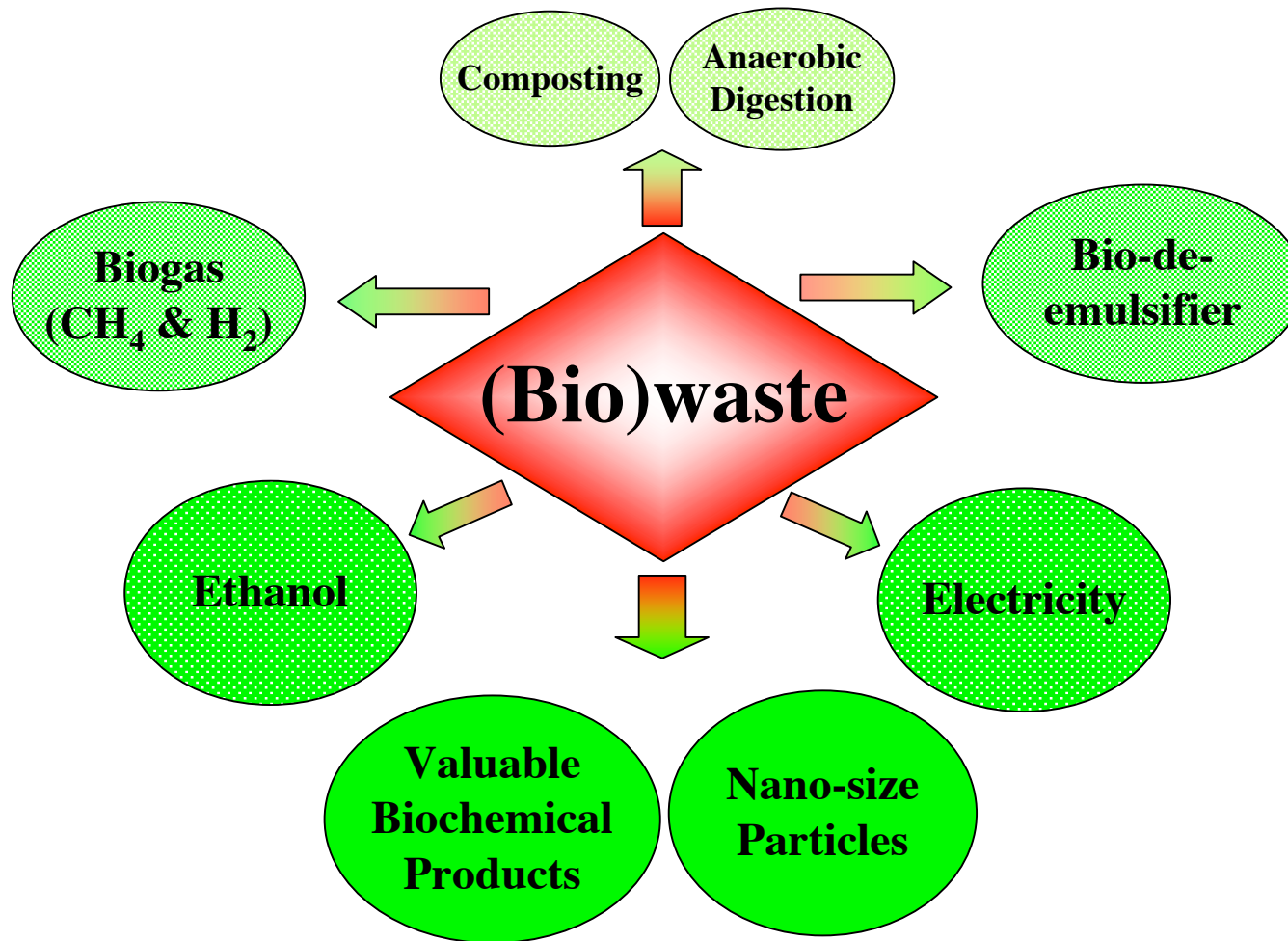
Anaerobic Digestion



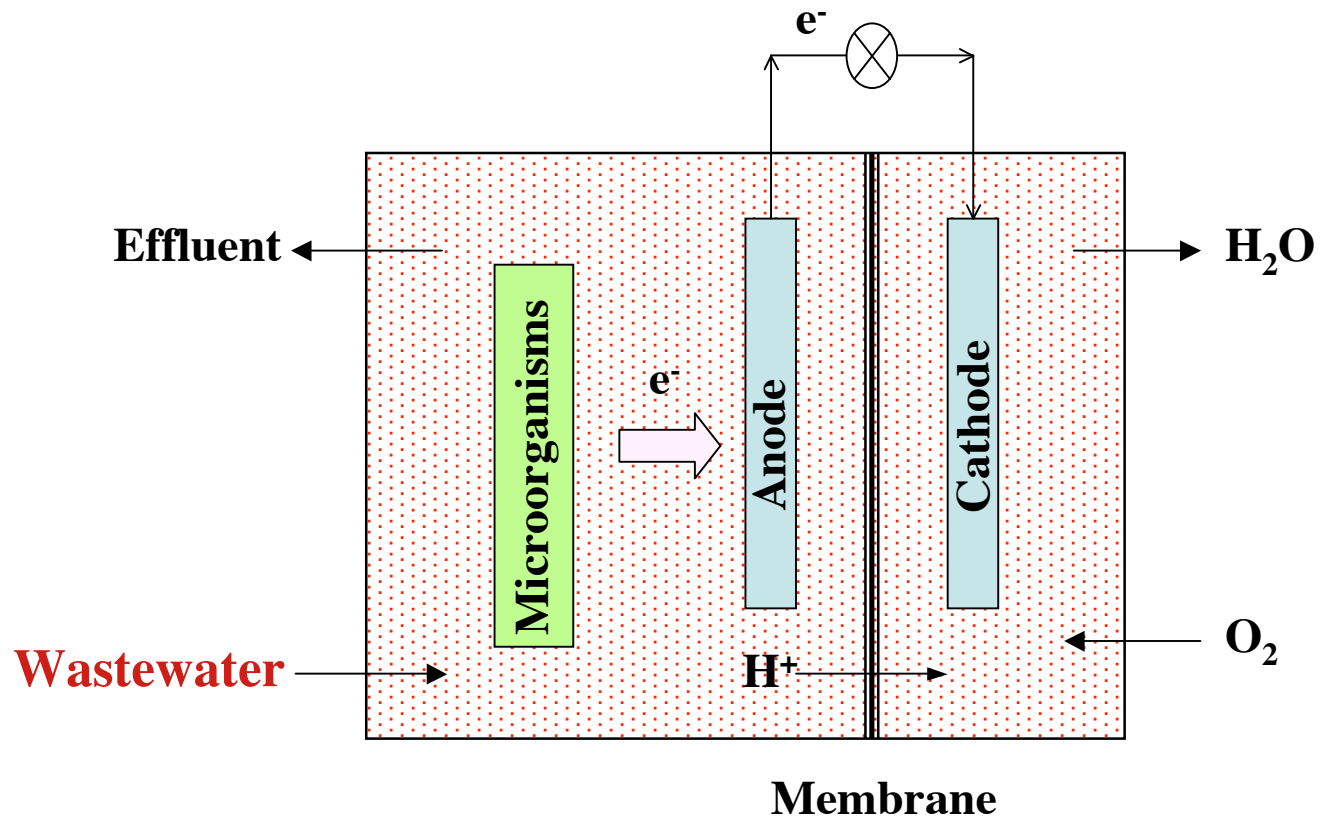
- Breaking down organic waste by bacteria in an oxygen-free environment.
- Producing a methane-rich biogas



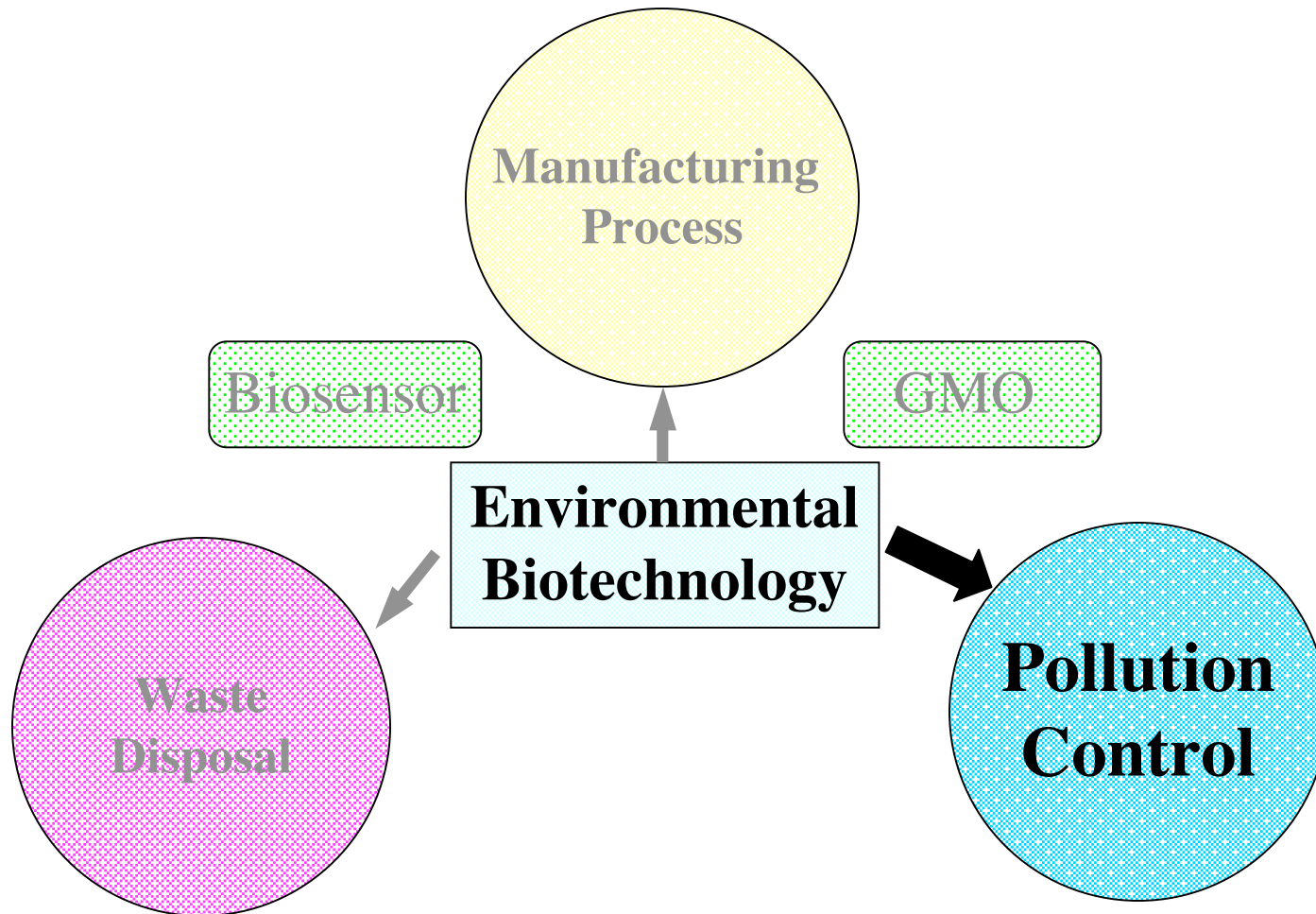
(Bio)waste (Valuable Resources)



Microbial Fuel Cells

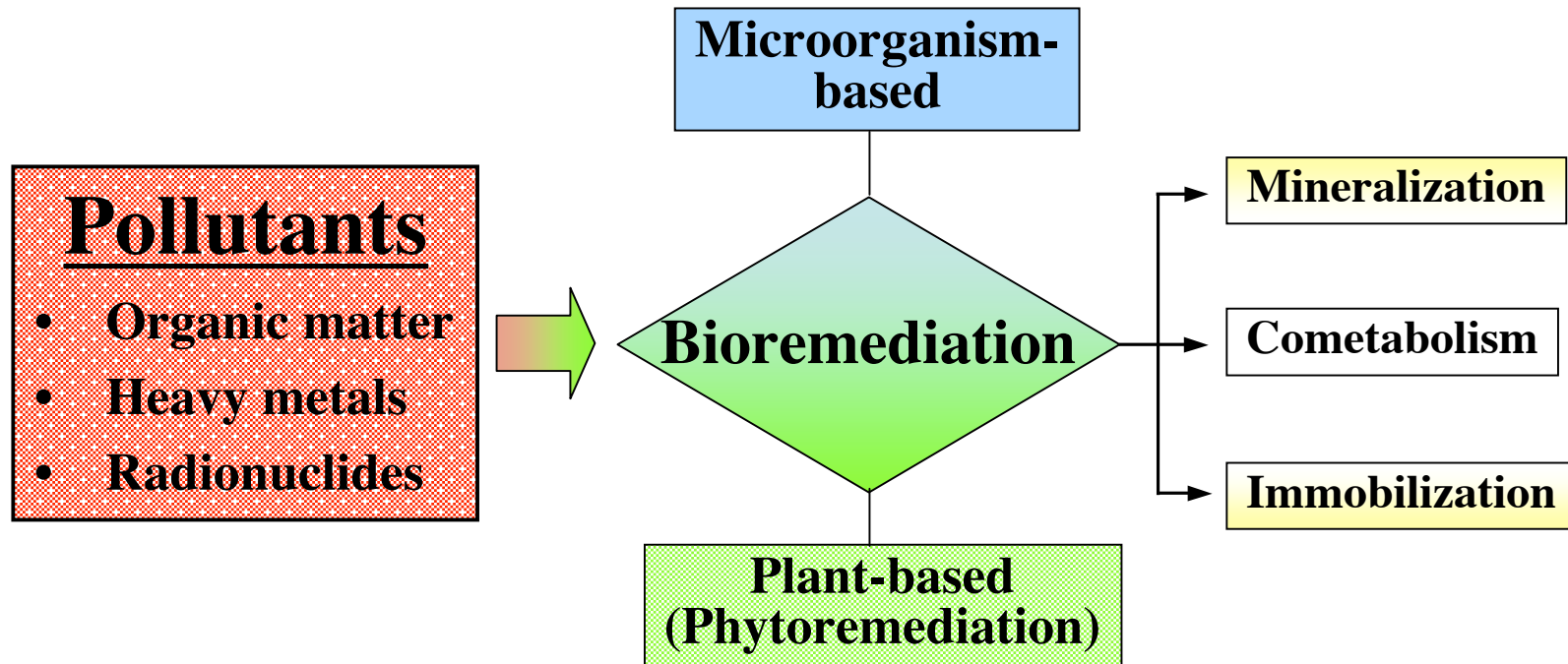


Environmental Biotechnology (Three Intervention Points)



GMO, Genetically Manipulated Organisms

Pollution Control: Bioremediation



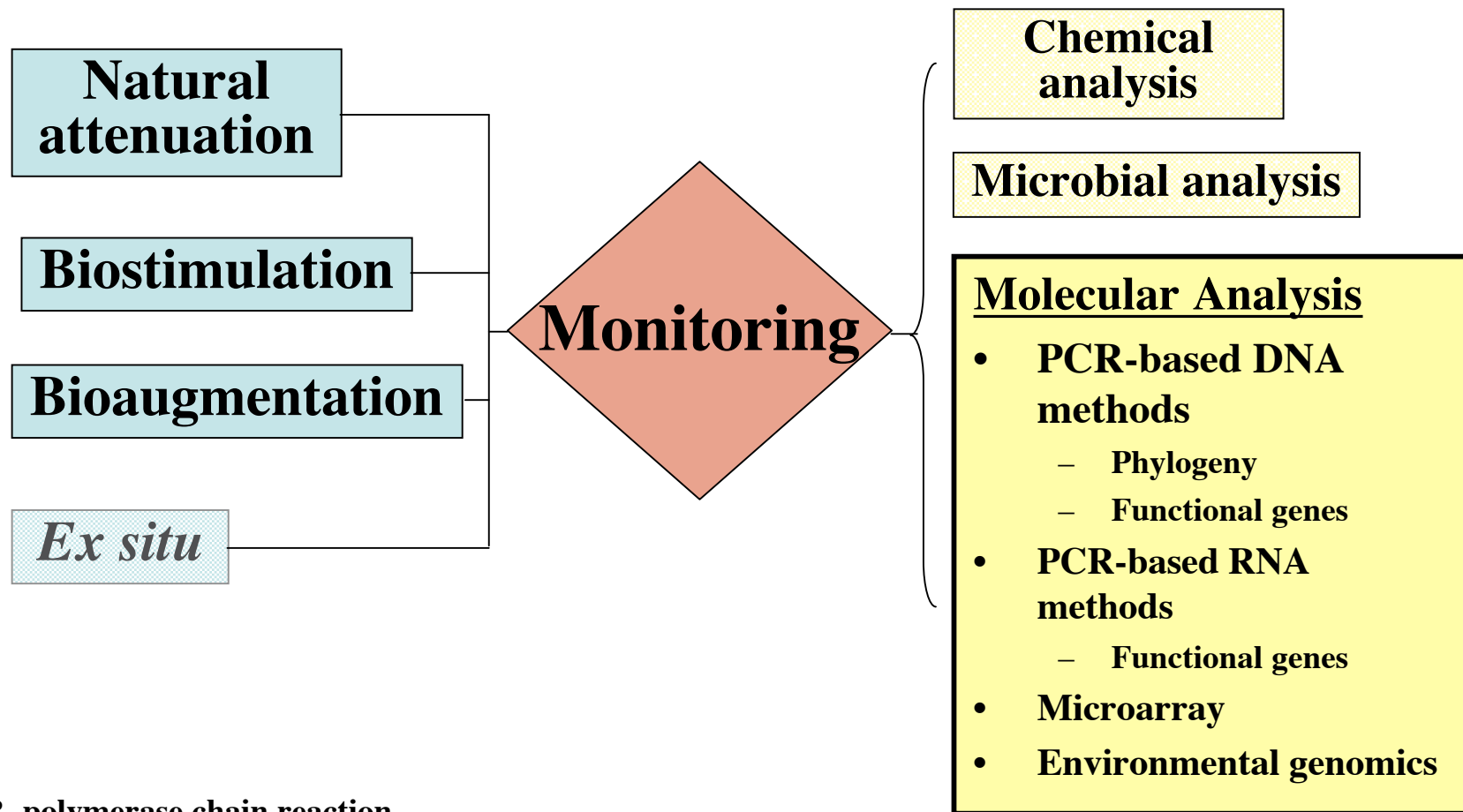
Definition: **Bioremediation** is a biotechnological intervention for cleaning up the residual effects of previous human activities on a site.

Bioremediation:

Microbe-mediated Pollutant Degradability

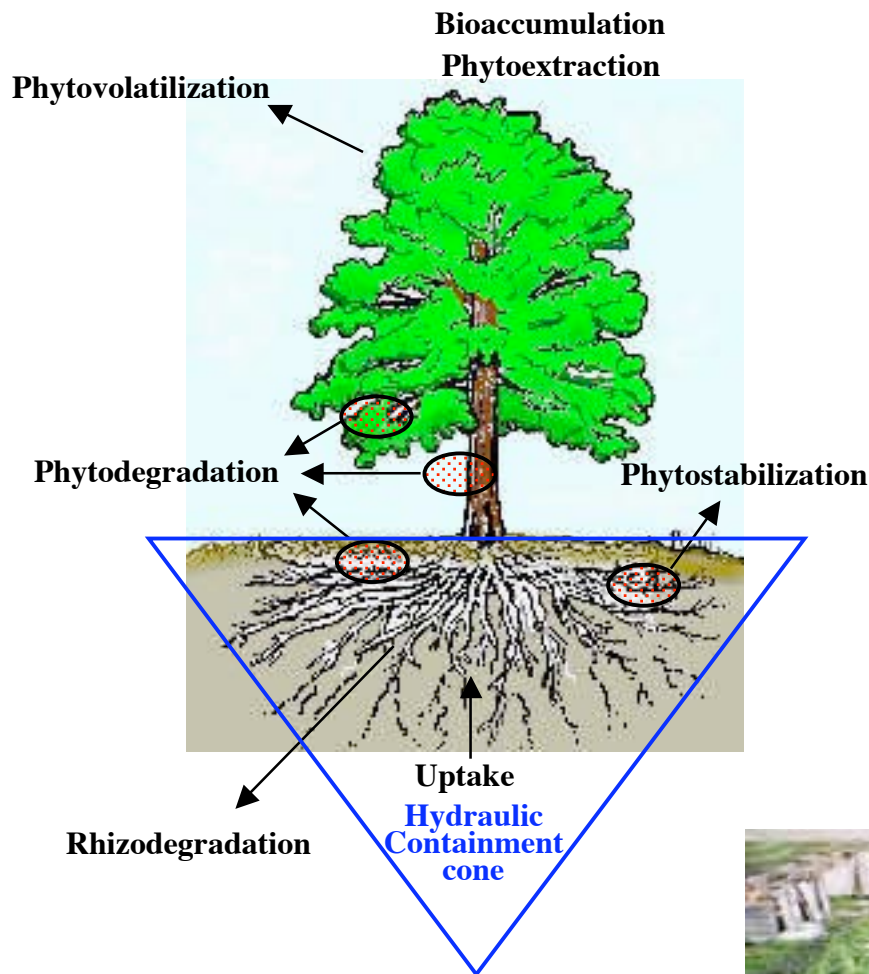
Readily Degradable	Degradable under certain circumstances	Currently Non-Degradable
Acids	Chlorinated solvents	Asbestos
Alcohols	Cyanides	Asphalt
Aldehydes and ketones	Explosives	Bitumen
Ammonia	PCBs	Inorganic acids
Creosote	PAHs	
Chlorophenols	Pesticides, herbicides and fungicides	
Crude oil and petroleum hydrocarbons	Tars	
Glycols	Timber treatments	
Phenols		
Surfactants		

Bioremediation: (Microbe-mediated)



PCR, polymerase chain reaction

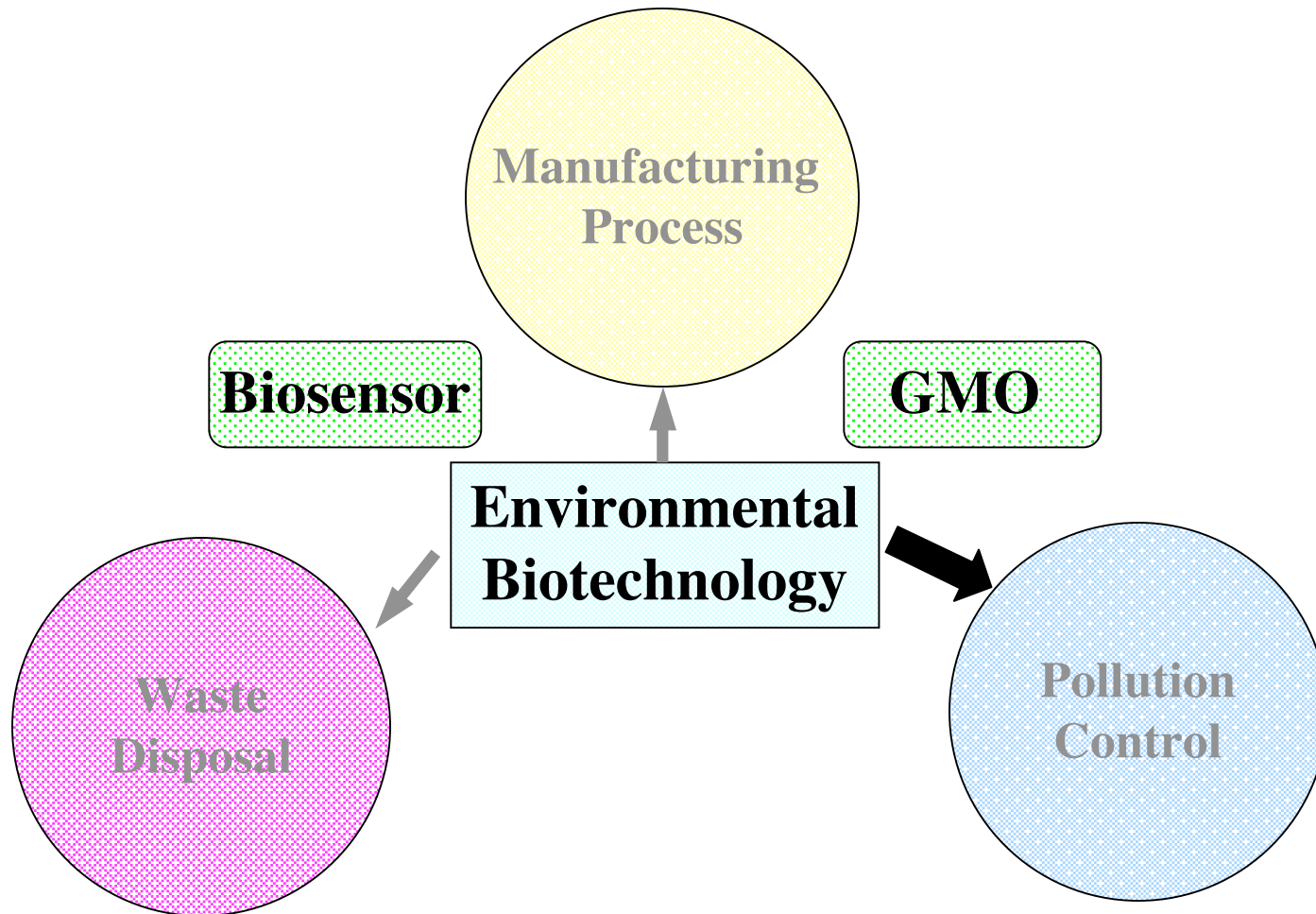
Phytoremediation



- Metal phytoremediation
 - Bioaccumulation
 - Phytoextraction
 - Phytostabilization
- Organic phytoremediation
 - Phytodegradation
 - Rhizodegradation
 - Phytovolatilization
- Hydraulic containment

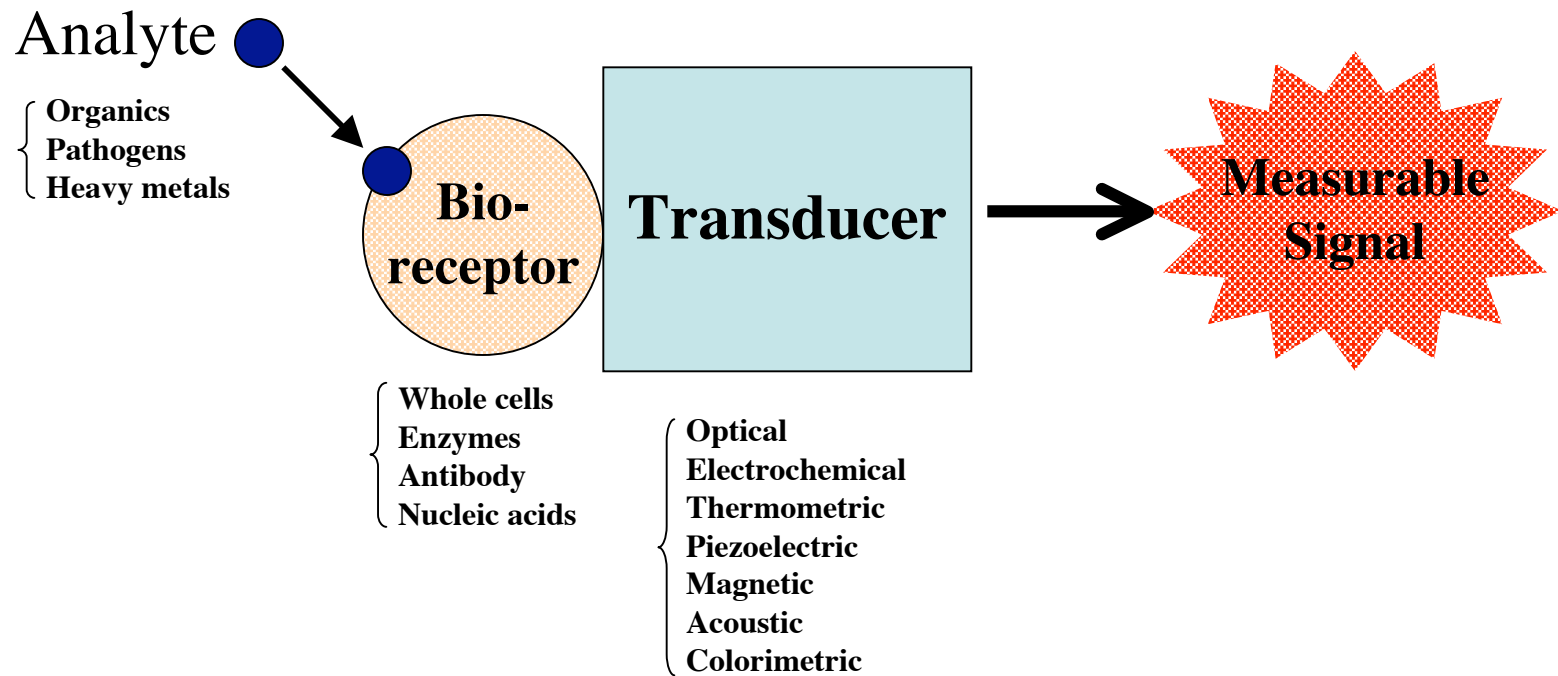


Environmental Biotechnology (Three Intervention Points)

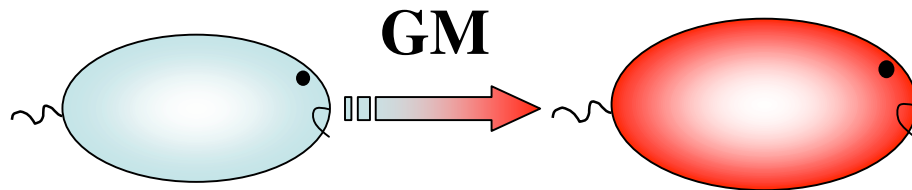


GMO, Genetically Manipulated Organisms

Biosensors



Genetic Manipulation (GM)



GM Microorganisms

: Broader and improved metabolic capability

- ✓ Improved pollutant degradation
- ✓ More versatile activity
- ✓ Production of more rugged enzymes for industry

→ “Clean technology”



Transgenic Plant

- ✓ Improved resistance to disease
- ✓ Improved tolerance
- ✓ Improved for phytoremediation
- ✓ Production of new products

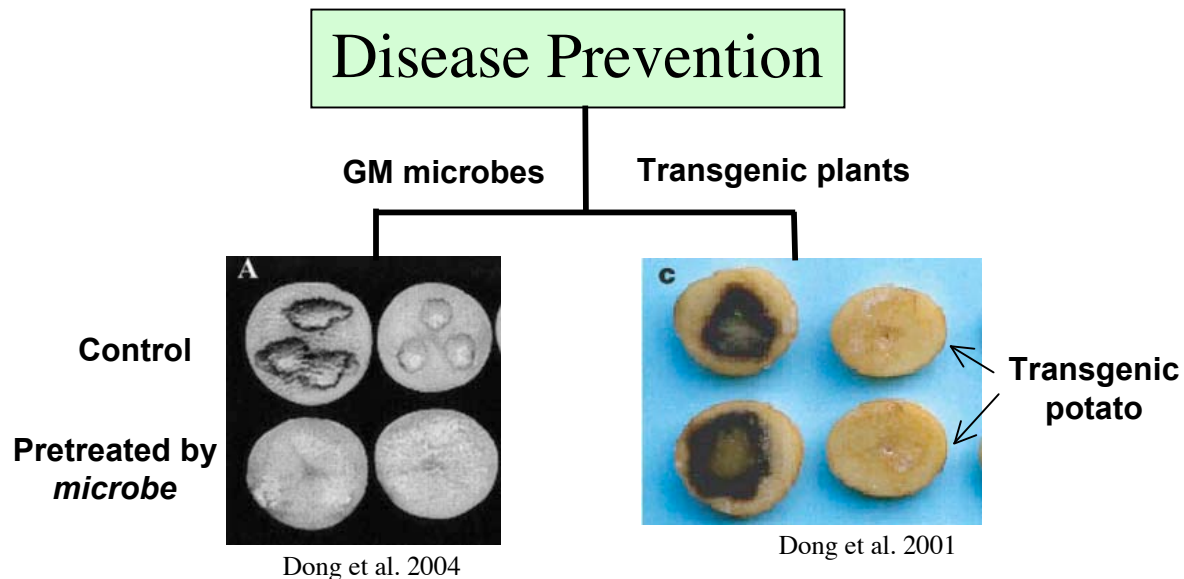
GM Example: Microbial Talk and Disease Prevention

Many pathogenic microbes can talk!!

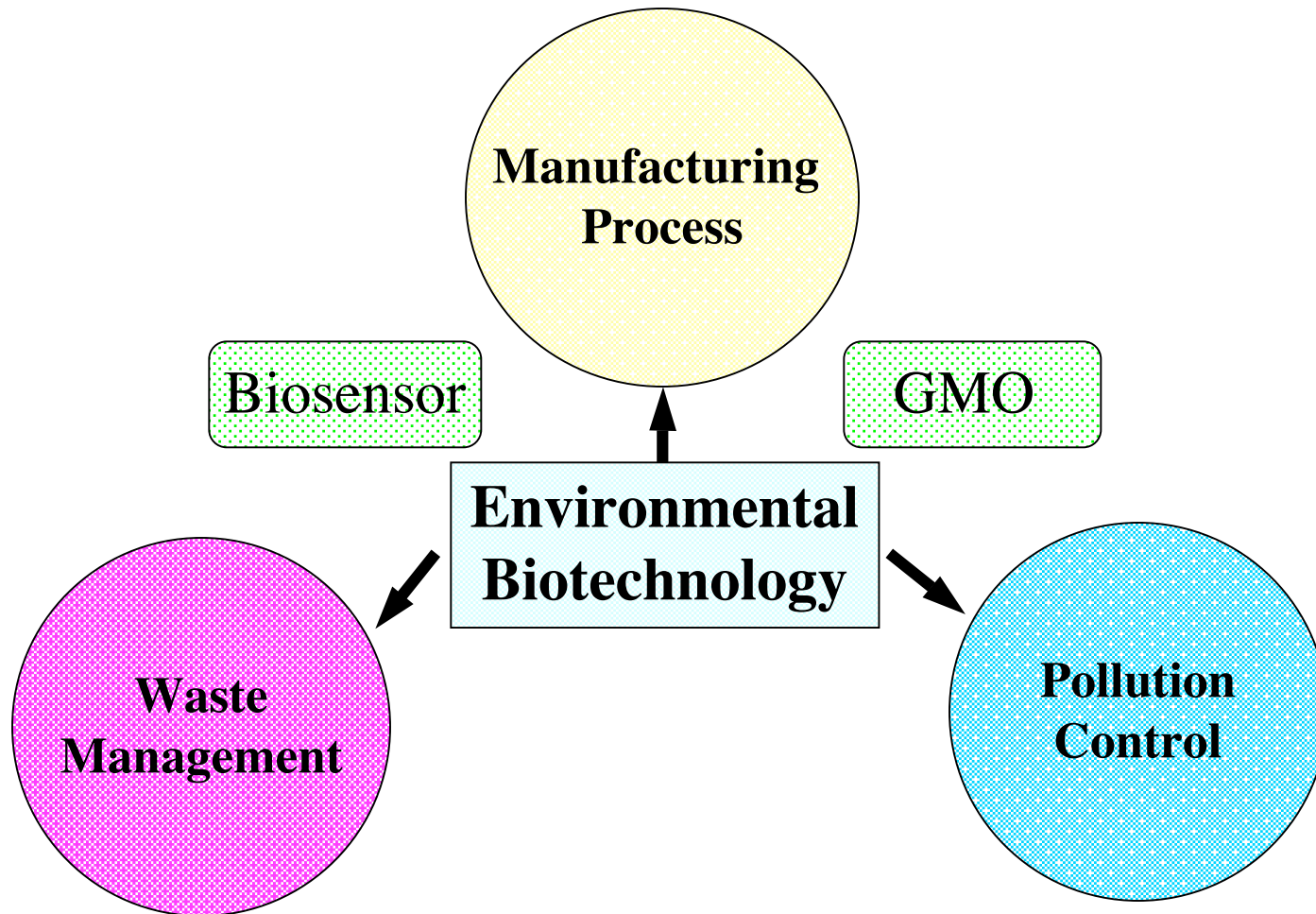
- Via chemical signals called quorum-sensing
- Causing various diseases

Certain bacteria can interrupt neighbor's talk!!

- By the enzymatic degradation of the chemical signals



Any Driving Force?



Market for Environ Biotech

Until now

- Global market in 2001 (UK's Department of Trade and Industry)
 - ✓ 15-20% of overall environmental market (\$250 - 300 billion).
 - ✓ as much as 10-fold increase over the following 5 years.
- US market in 2000 (OECD)
 - ✓ 15-20% of overall environmental market (\$75 billion).
 - ✓ 5.5% per year of growth rate.
 - Greater acceptance for biotechnology for clean manufacturing application and energy production
 - Increased landfill charges and legislative changes in waste management

In the future

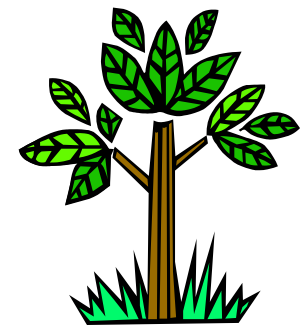
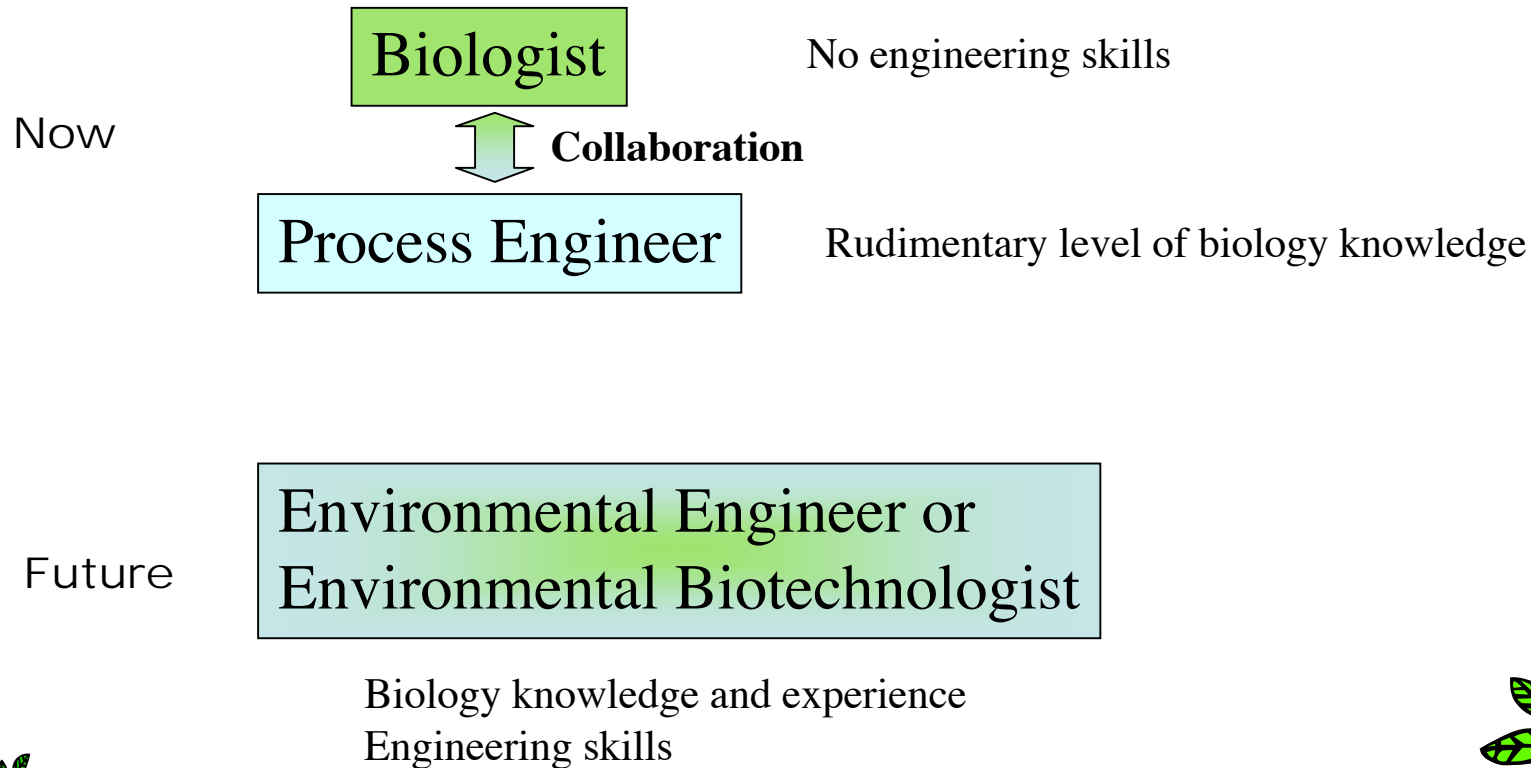
- Existing regulations on environmental pollution will be more rigorously enforced
- More stringent compliance standards will be implemented.
- Technologies will ripen.

Thus market for environmental biotechnology will continue to grow steadily!!!

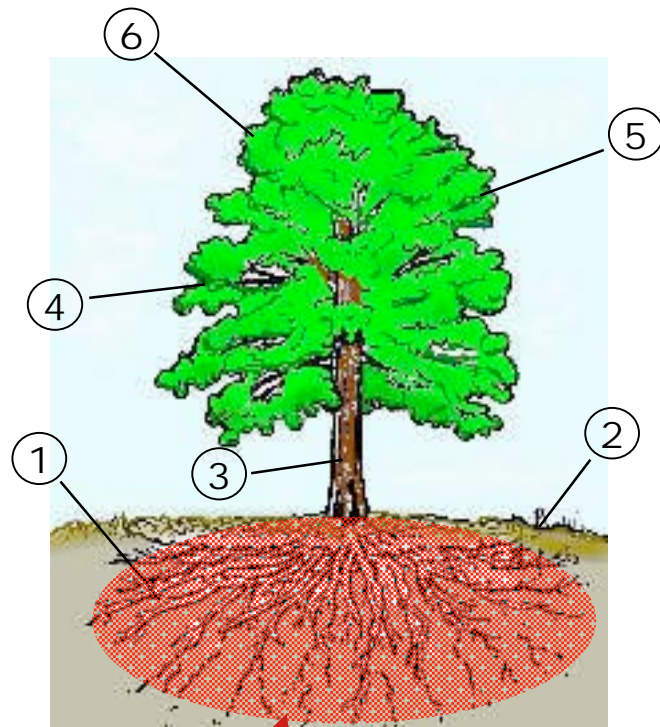
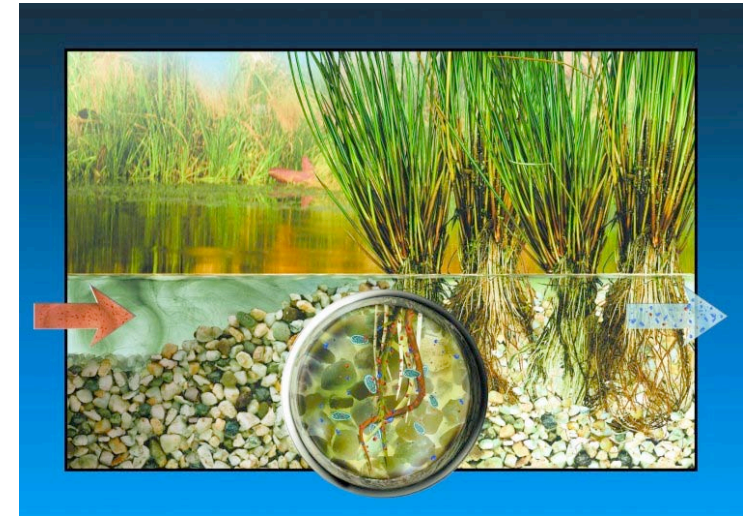
Educational Direction



“Most environmental biotechnology processes must be **scaled up** for use in the environment.”



Phytoremediation (Plant: Nature's Filters)



Rhizosphere

1. Uptake water, nutrients, and other elements from the ground
2. Stabilize soil with root system
3. Convert nutrients into wood
4. Sequester CO₂
5. Produce O₂
6. Evapotranspire clean water into the atmosphere

Biowaste: Biofuel

