Introduction to Environmental Biotechnology

Contents

- The Organization for Economic Co-operation and Development (OECD) defines biotechnology as:

“The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services”

- Environmental Biotechnology is application of biotechnology to natural, agriculture and man made environment.
- Generally associated with Bioremediation i.e. use of living organisms to clean up the environment.

Conclusion:

Environmental Biotechnology is application of biotechnology for solving environmental problems both in environment or man made ecosystem.

- Despite the inclusiveness of this definition, there was a time when the biotechnology sector was seen as largely medical or pharmaceutical in nature, particularly amongst the general public.
- While to some extent the huge research budgets of the drug companies and the widespread familiarity of their products made this viewpoint understandable, it somewhat unfairly distorted the picture.
- Thus therapeutic instruments were left forming the ‘acceptable’ face of biotechnology, while elsewhere, the science was all too frequently linked with an uneasy feeling of unnatural interference.

- The agricultural, industrial and environmental applications of biotechnology are potentially enormous.
- Genetic engineering may be relatively commonplace in pharmaceutical thinking and yet when its wider use is mooted in other spheres, such as agriculture, for example even today much of society views the possibility with suspicion, if not outright hostility.

History

- It is then, perhaps, no surprise that the European Federation of Biotechnology begins its ‘Brief History’ of the science in the year 1859, with the publication of On the Origin of Species by Means of Natural Selection by Charles Darwin.
- Though his famous voyage aboard HMS Beagle, which led directly to the formulation of his (then) revolutionary ideas, took place when he was a young man, he had delayed making them known until 1858, when he made a joint presentation before the Linnaean Society with Alfred Russell Wallace, who had, himself, independently come to very similar conclusions.

- Their contribution was to view evolution as the driving force of life, with successive selective pressures over time endowing living beings with optimised characteristics for survival.
- Neo-Darwinian thought sees the interplay of mutation and natural selection as fundamental. The irony is that Darwin himself rejected mutation as too deleterious to be of value, seeing such organisms, in the language of the times, as ‘sports’ – oddities of no species benefit.
- Indeed, there is considerable evidence to suggest that he seems to have espoused a more Lamarckism view of biological progression, in which physical changes in an organism’s lifetime were thought to shape future generations.

- Darwin died in 1882. Ninety-nine years later, the first patent for a genetically modified organism was granted to Ananda Chakrabarty of the US General Electric, relating to a strain of Pseudomonas aeruginosa engineered to express the genes for certain enzymes in order to metabolize crude oil.
- Twenty years on from that, the first working draft of the human genome sequence was published and the full genetic blueprint of the fruit fly, Drosophila melanogaster, that archetype of eukaryotic genetics research, announced – and developments have continued on what sometimes feels like an almost daily basis since then.
- Today biotechnology has blossomed into a major growth industry with increasing numbers of companies listed on the world's stock exchanges and environmental biotechnology is coming firmly into its own alongside a raft of 'clean technologies' working towards ensuring the sustainable future of our species and our planet.

- Thus, at the other end of the biotech timeline, a century and a half on from Origin of Species, the principles it first set out remain of direct relevance, although increasingly in ways that Darwin himself could not possibly have foreseen.

Environmental Contaminants

Contaminants release into the environment are:

- ✓ Solvent
- ✓ Pesticides
- ✓ Herbicides
- ✓ Fungicides
- ✓ Insecticides
- ✓ Petrochemicals
- ✓ Explosives
- ✓ Heavy metals

Environmental Biotechnology deals with:

- ✓ Decontamination of environmental pollutants
- ✓ Production of Chemical biosensors
- ✓ Pollution prevention
- ✓ Waste minimization

Components of Environmental Biotechnology

It includes:

- ✓ Bioremediation
- ✓ Biosensors
- ✓ Bioindicators
- ✓ Pollution prevention

Bioremediation:

Use of living organism to transform contaminants to less toxic or non toxic forms

Processes:

- ✓ Physically removal of contamination
- ✓ Separation of contamination from medium
- ✓ Degradation
- ✓ Immobilization

It includes:

- ✓ Waste water treatment
- ✓ Soil bioremediation
- ✓ Solid waste bioremediation
- ✓ Biotreatment of gaseous streams
- ✓ Bioabsorption
- ✓ Biodegradation of hydrocarbons

Diverse examples of these include:

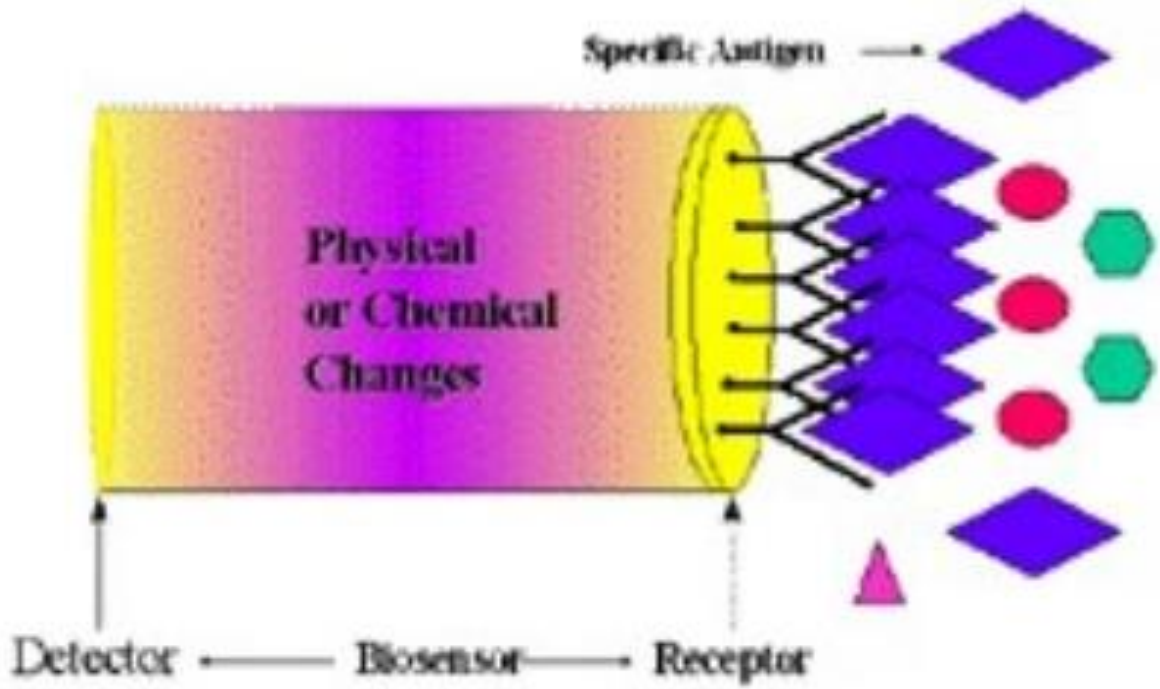
- ✓ Use of microorganism in ore leaching(extracting metals from ore by the use of microorganims)
- ✓ Development of bio fertilizers and bio pesticides for use in agriculture environment

Traditionally environmental biotechnology is usually restricted to employment of microbial activities

With increasing application of higher plants in environmental biotechnology notably in bioremediation environmental biotechnology no longer be thought of merely as an extension of applied microbiology.

Biosensors

- Environmental biosensors are analytical device composed of biological sensing elements and a physical transducer which together related to measure able signal.


Specific Antigen
Physical
or Chemical
Changes
Detector
Biosensor
Receptor

Types of Biosensors on the basis of transduction of signal

- Electrochemical
- Optical
- Piezoelectric
- Thermal sensor

Types of Biosensors on the basis of Biorecognition Principal

- Microorganims
- Enzymes
- Antibody

Bioindicators

- Biological indicators are the species that can used to monitor the environment of ecosystem

Example:

✓ Copepods

✓ Algae

Role of Environmental biotechnology

- Cleaning up contamination and dealing rationally with wastes is, of course, in everybody's best interests
- For most people, this is simply addressing a problem which they would rather had not existed in the first place.
- Even for industry, though the benefits may be noticeable on the balance sheet, the likes of effluent treatment or pollution control are more of an inevitable obligation than a primary goal in themselves.
- In general, such activities are typically funded on a distinctly limited budget and have traditionally been viewed as a necessary inconvenience. This is in no way intended to be disparaging to industry; it simply represents commercial reality.

Role of Environmental biotechnology

- Some of the potentially most beneficial uses of biological engineering, and which may touch the lives of the majority of people, however indirectly, involve much simpler approaches.
- Less radical and showy, certainly, but powerful tools, just the same.
- 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.

Role of Environmental biotechnology

- Thus, the principal aims of this field are the manufacture of products in environmentally harmonious ways, which allow for:
  - ✓ The minimization of harmful solids, liquids or gaseous outputs
  - ✓ The clean-up of the residual effects of earlier human occupation
- The means by which this may be achieved are essentially two-fold:
  - ✓ Environmental biotechnologists may enhance or optimise conditions for existing biological systems to make their activities happen faster or more efficiently, or they resort to some form of alteration to bring about the desired outcome.
- The variety of organisms which may play a part in environmental applications of biotechnology is huge, ranging from microbes through to trees and all are utilised on one of the same three fundamental bases – accept, acclimatise or alter.
- For the vast majority of cases, it is the former approach, accepting and making use of existing species in their natural, unmodified form, which predominates.

SCOPE FOR USE

- There are three key points for environmental biotechnology interventions, namely:

✓ manufacturing process

✓ waste management

✓ pollution control

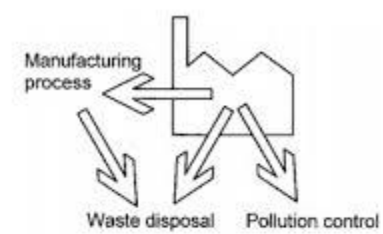


Figure 1.1 The three intervention points

Three Intervention Point

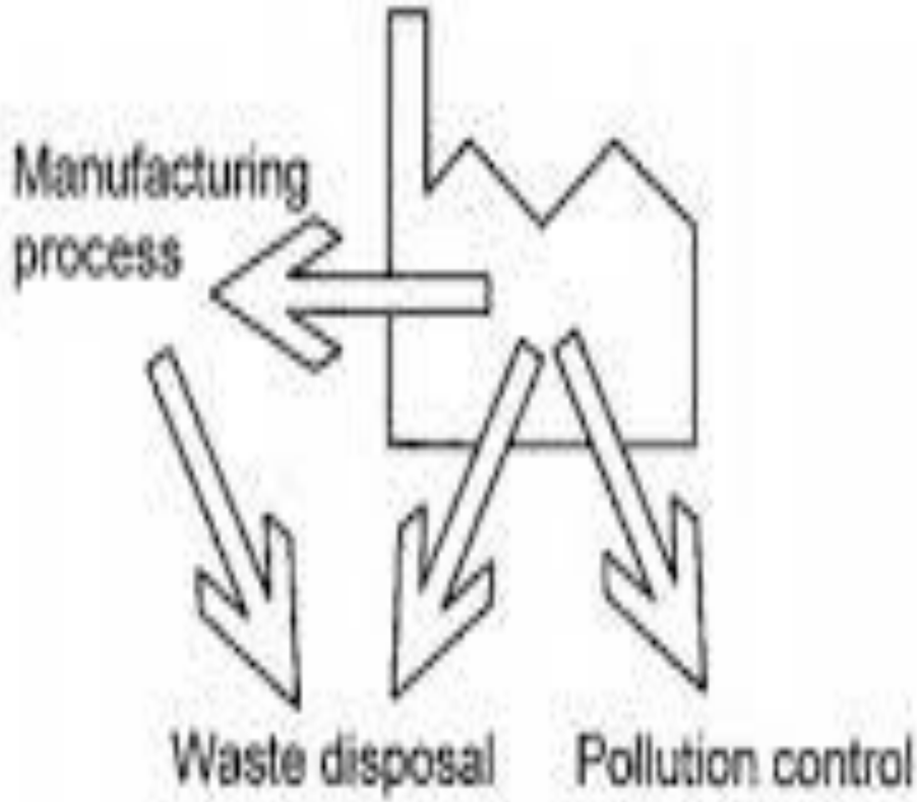


Figure 1.1 *The three intervention points*

SCOPE FOR USE

- Accordingly, the range of businesses to which environmental biotechnology has potential relevance is almost limitless.
- One area where this is most apparent is with regard to waste. All commercial operations generate waste of one form or another and for many, a proportion of what is produced is biodegradable.
- With disposal costs rising steadily across the world, dealing with refuse constitutes an increasingly high contribution to overheads.
- Thus, there is a clear incentive for all businesses to identify potentially cost-cutting approaches to waste and employ them when possible.

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- Changes in legislation throughout Europe, the US and elsewhere, have combined to drive these issues higher up the political agenda and biological methods of waste treatment have gained far greater acceptance as a result.
- For those industries with particularly high bio waste production, the various available treatment biotechnologies can offer considerable savings.

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- Manufacturing industries can benefit from the applications of whole organisms or isolated bio components.
- Compared with conventional chemical processes, microbes and enzymes typically function at lower temperatures and pressures. The lower energy demands this makes leads to reduced costs, but also has clear benefits in terms of both the environment and workplace safety.
- Additionally, biotechnology can be of further commercial significance by converting low-cost organic feedstocks into high value products or, since enzymatic reactions are more highly specific than their chemical counterparts, by deriving final substances of high relative purity.

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- Almost inevitably, manufacturing companies produce wastewaters or effluents, many of which contain biodegradable contaminants, in varying degrees.
- Though traditional permitted discharges to sewer or watercourses may be adequate for some, other industries, particularly those with recalcitrant or highly concentrated effluents, have found significant benefits to be gained from using biological treatment methods themselves on site.
- Though careful monitoring and process control are essential, biotechnology stands as a particularly cost-effective means of reducing the pollution potential of wastewater, leading to enhanced public relations, compliance with environmental legislation and quantifiable cost-savings to the business.

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- Those involved in processing organic matter, for example, or with drying, printing, painting or coating processes, may give rise to the release of volatile organic compounds (VOCs) or odours, both of which represent environmental nuisances, though the former is more damaging than the latter.
- For many, it is not possible to avoid producing these emissions altogether, which leaves treating them to remove the offending contaminants the only practical solution.
- Especially for relatively low concentrations of readily water-soluble VOCs or odorous chemicals, biological technologies can offer an economic and effective alternative to conventional methods.

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- The use of biological cleaning agents is another area of potential benefit, especially where there is a need to remove oils and fats from process equipment, work surfaces or drains. Aside from typically reducing energy costs, this may also obviate the need for toxic or dangerous chemical agents.
- The pharmaceutical and brewing industries, for example, both have a long history of employing enzyme-based cleaners to remove organic residues from their process equipment.
- In addition, the development of effective biosensors, powerful tools which rely on biochemical reactions to detect specific substances, has brought benefits to a wide range of sectors, including the manufacturing, engineering, chemical, water, food and beverage industries. With their ability to detect even small amounts of their particular target chemicals, quickly, easily and accurately, they have been enthusiastically adopted for a variety of process monitoring applications, particularly in respect of pollution assessment and control.

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- Contaminated land is a growing concern for the construction industry, as it seeks to balance the need for more houses and offices with wider social and environmental goals.
- The reuse of former industrial sites, many of which occupy prime locations, may typically have associated planning conditions attached which demand that the land be cleaned up as part of the development process.
- With urban regeneration and the reclamation of 'brown-field' sites increasingly favoured in many countries over the use of virgin land, remediation has come to play a significant role and the industry has an ongoing interest in identifying cost-effective methods of achieving it.

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- Historically, much of this has involved simply digging up the contaminated soil and removing it to landfill elsewhere.
- Bioremediation technologies provide a competitive and sustainable alternative and in many cases, the lower disturbance allows the overall scheme to make faster progress.

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- Environmental biotechnology must compete in a world governed by the best practicable environmental option (BPEO) and the best available techniques not entailing excessive cost (BATNEEC).
- Consequently, the economic aspect will always have a large influence on the uptake of all initiatives in environmental biotechnology and, most particularly, in the selection of methods to be used in any given situation.

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- Environmental biotechnology remain largely devoted to the application of microbial activities to environmental problems by employing the diverse metabolic activities of bacteria and filamentous fungi(molds).
- As a result anyone intending to study or conduct research on environmental biotechnology have a good understanding of microbial metabolism and environmental chemistry.

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- Genetic engineering is also increasingly becoming important in all aspects of Biology including environmental biotechnology.
- Environmental biotechnology is not only about solving environmental problems but is a means of generating income and any suggested process must be demonstrating economically viable if it is to be successfully applied on the environment.

Market For Environmental Biotechnology

- The UK's Department of Trade and Industry estimated that 15–20% of the global environmental market in 2001 was biotech-based, which amounted to about 250–300 billion US dollars and the industry is projected to grow by as much as ten-fold over the following five years.
- This expected growth is due to greater acceptance of biotechnology for clean manufacturing applications and energy production, together with increased landfill charges and legislative changes in waste management which also alter the UK financial base favourably with respect to bioremediation.

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- Biotechnology-based methods are seen as essential to help meet European Union (EU) targets for biowaste diversion from landfill and reductions in pollutants.
- Across the world the existing regulations on environmental pollution are predicted to be more rigorously enforced, with more stringent compliance standards implemented.
- All of this is expected to stimulate the sales of biotechnology-based environmental processing methods significantly and, in particular, the global market share is projected to grow faster than the general biotech sector trend, in part due to the anticipated large-scale EU aid for environmental clean-up in the new accession countries of Eastern Europe.

Problems facing by environmental Biotechnologists

- Gap in the attitudes between laboratory based scientists and chemical process engineers.
- Environmental biotechnology process have to scaled up for use in environment.
- For this considerable engineering skills are required which most Biologists do not possess.

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- Engineers on the other hand often have a rudimentary knowledge of general biology and microbiology.
- Opportunity must be provided for joint courses which hopefully could produce rounded environmental biotechnologists