BCH 462-Biotechnology and Genetic Engineering

Environmental Biotechnology

Lecture 3 outline, aim, and objectives

Definition and importance of Environmental biotechnology

Environmental biotechnology areas:

Biofuels

Bioremediation for waste and pollution treatments

Environmental applications of genetically modified organisms

Biosensors

Environmental Biotechnology

Environmental Biotechnology is the multidisciplinary integration of sciences and **engineering** in order to utilize the biochemical potential of microorganisms and plants for the **restoration and preservation** of the environment and for the **sustainable use of resources**.

It solves (or prevents) environmental problems through technology.

Biofuels

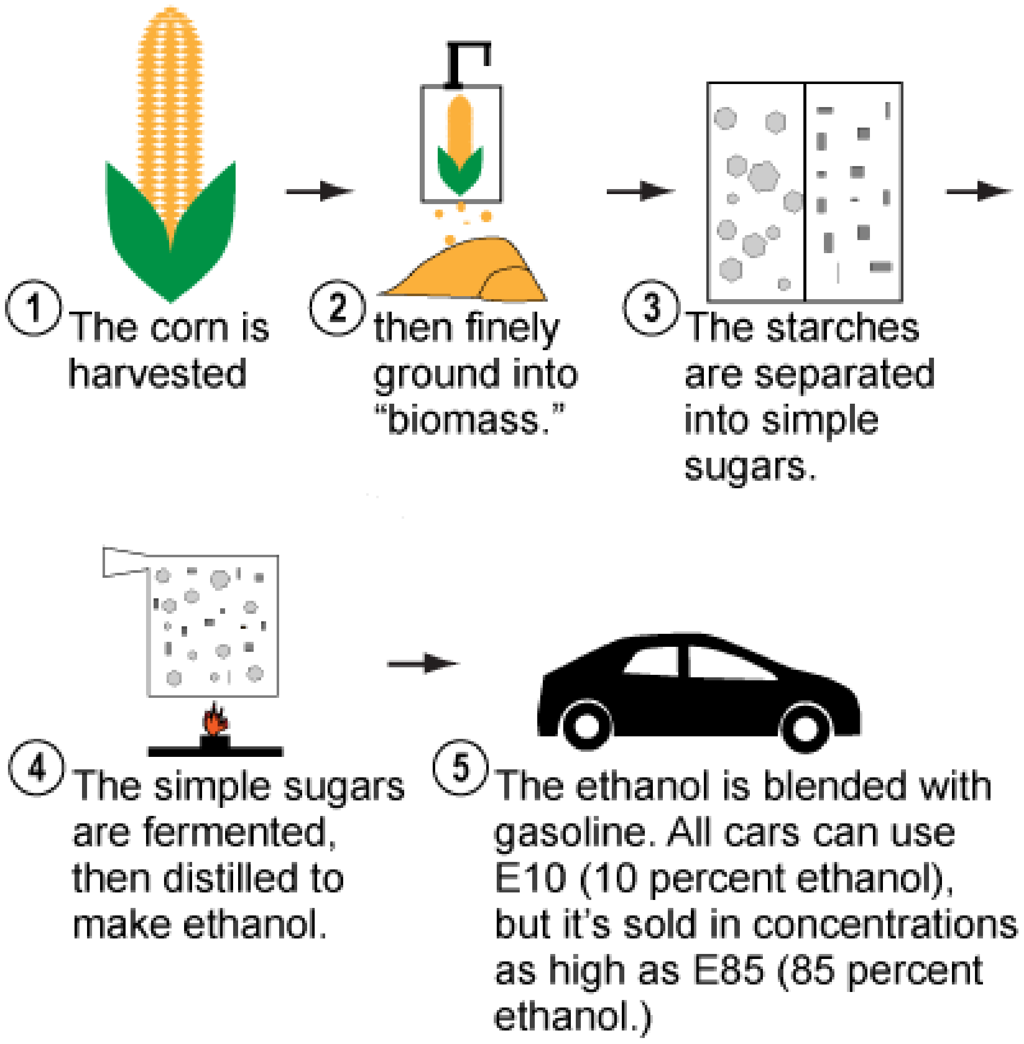
Biofuel is a fuel that is produced through biological processes.

Examples of biofuels include:

1- Ethanol fuel: the most common biofuel worldwide.

It is produced by fermentation of sugars derived from wheat, corn, sugar beets, sugar cane, potato, etc.

Could be used to fill cars instead of gasoline (or in addition to gasoline).



Source: U.S DEPARTMENT OF ENERGY, PURDUE UNIVERSITY

Biofuels

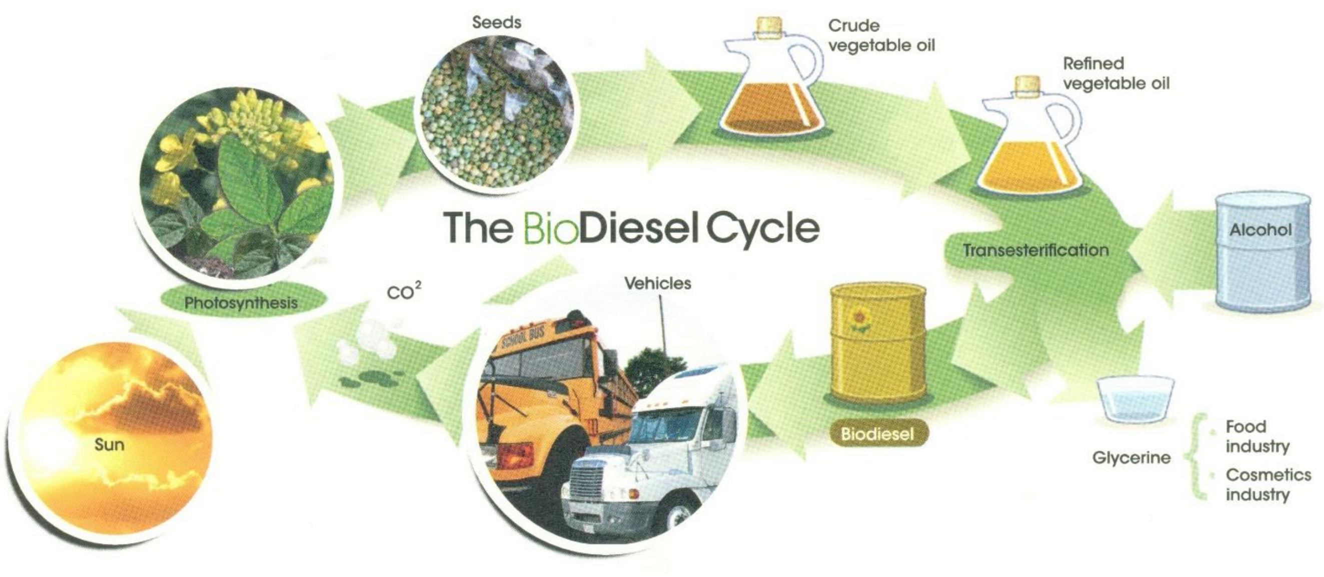
2-Biodiesel: the most common biofuel in Europe.

It is produced from oils or fats using transesterification.

In many European countries, it is available at thousands of gas stations.

It contains a reduced amount of carbon and higher hydrogen and oxygen content than diesel.

Therefore, it is safe to handle and transport because it is non-toxic and biodegradable.



Current research in Biofuels and limitations

In 2008, A group at the Russian Academy of Sciences had isolated large amounts of lipids from single-celled fungi and turned it into biofuels.

Research is ongoing into finding more suitable biofuel crops and improving the oil yields of these crops.

Using the current yields, vast amounts of land and fresh water would be needed to produce enough oil to completely replace fossil fuel usage.

For example, It would require twice the land area of the US to be devoted to soybean production to meet current US heating and transportation needs.

Bioremediation and Biotechnology for waste and pollution treatments

"Remediate" means to solve a problem, and "bio-remediate" means to use biological organisms to solve an environmental problem.

A “treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non toxic substances.”

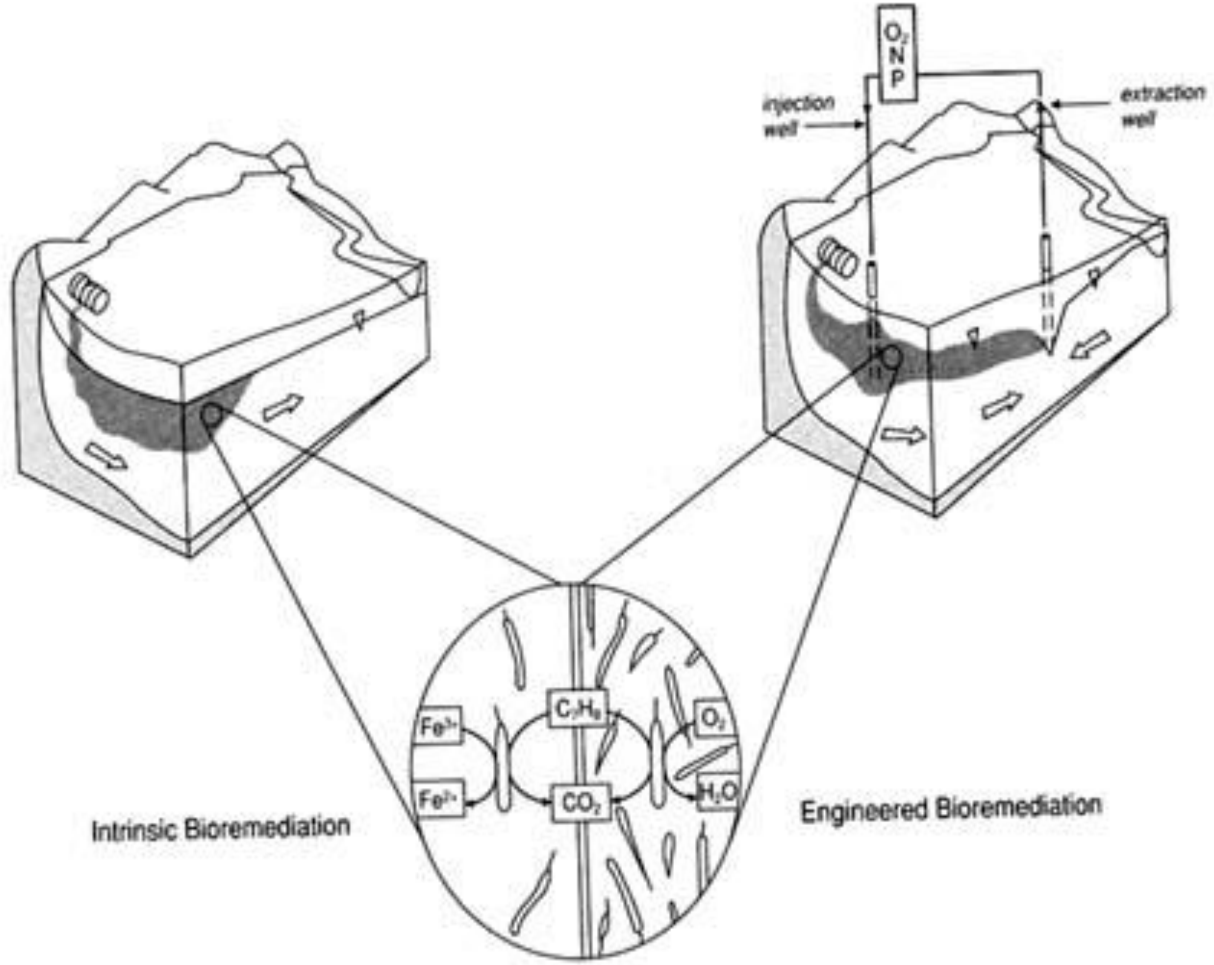
Without the activity of microorganisms, the earth would be buried in waste.

For example, Pseudomonas bacteria capable of degrading chemical pollutants in the environment.

Bioremediation for waste treatments

It could be divided to: **Intrinsic bioremediation**: A type of bioremediation that manages the innate capabilities of naturally occurring microbes to degrade contaminants without taking any engineering steps to enhance the process.

Engineered bioremediation: A type of remediation that increases the growth and degradative activity of microorganisms by using engineered systems that supply nutrients, electron acceptors, and/or other growth-stimulating materials.



Bioremediation for waste treatments

It can be generally classified as in situ or ex situ.

In situ bioremediation: involves treating the contaminated material at the site.

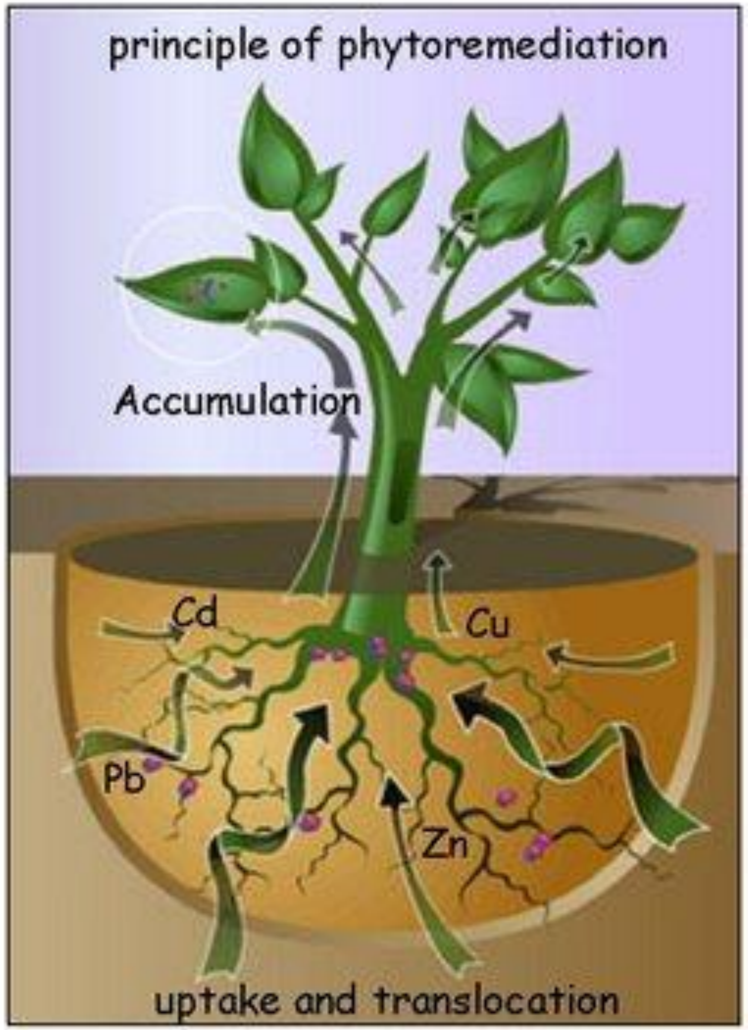
ex situ: involves the removal of the contaminated material to be treated elsewhere.

Phytoremediation

Refers to the technologies that use living plants to clean up soil contaminated with hazardous chemicals.

It is cost-effective and takes advantage of the ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues.

Pollutants are absorbed in roots, thus plants removed could be disposed or burned. The contaminants could also become harmless in the plant.



Phytoremediation

Toxic heavy metals and organic pollutants are the major targets for phytoremediation.

Transgenic plants with an exogenous metal binding protein has been used to remove metals .

Contaminants such as metals, pesticides, solvents, explosives, and crude oil and its derivatives, have been removed in phytoremediation.

For example, sunflower plants were used to remove radioactive waste after the Chernobyl disaster in the Ukraine.

Sunflowers can remove 95% of the radiation in soil in 20 days. The root structure is so dense and strong

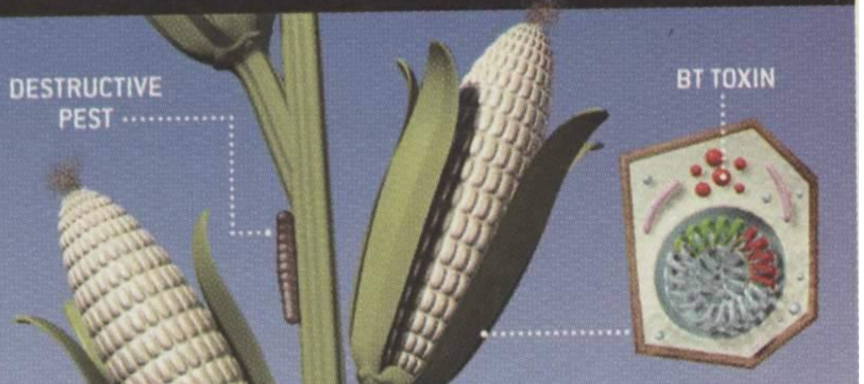
Environmental applications of genetically modified organisms

Example: GM Corn resistant to insects

How are they made?

HOW TO MAKE A GENETICALLY MODIFIED PLANT

Manufacturers can produce genetically modified plants in different ways. The diagram below presents a highly simplified version of how insect-resistant corn might be made. Insect-protected GM plants are typically engineered to carry a gene from the bacterium *Bacillus thuringiensis* (Bt). This gene instructs plant cells to produce a protein that is toxic to some insects, such as caterpillars, but benign to most other creatures.

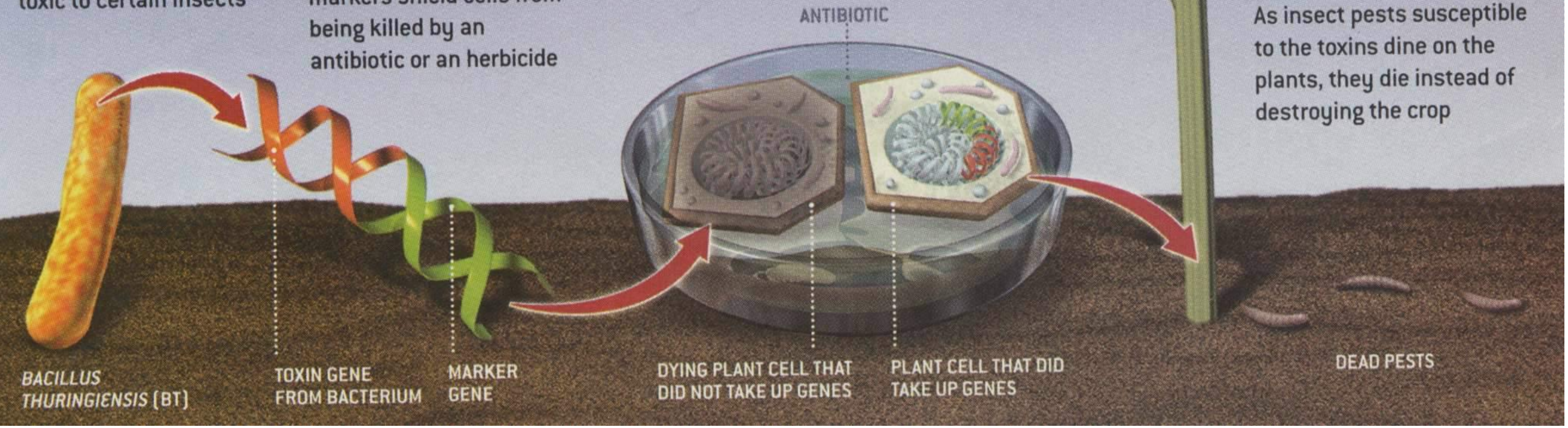


1 From the bacterium *Bacillus thuringiensis*, isolate the gene that directs cells to produce a protein toxic to certain insects

2 Try to insert into plant cells the Bt gene and a "marker" gene, able to flag cells that have taken up the Bt gene. Common markers shield cells from being killed by an antibiotic or an herbicide

3 Identify the cells that have taken up the genes, such as by exposing them to an antibiotic; only cells containing the newly inserted genes will survive the exposure

4 Allow the genetically altered cells to grow into plants. Those plants—and crops derived from their seeds—produce the Bt toxin in their cells. As insect pests susceptible to the toxins dine on the plants, they die instead of destroying the crop



Environmental applications of genetically modified organisms

It has been extensively used in the past 20 years.

A major example is: insect resistance in crops, producing a bacterial toxin called bacillus toxin so that insects die when eating the plants:

Bacillus thuringiensis (Bt) is a bacteria that produces proteins which are toxic to insects (Bt toxin).

Bt is the most widely used biological pesticide in the world.

It is widely used on corn, cotton, and potatoes, among other crops.

The benefit of the expression of this protein by corn plants is a reduction in the amount of insecticide that farmers must apply to their crops.

Controversy on the long term effect of GMOs

In 2016, 1400 plant scientists confirmed the safety of GMOs.

For a debate between two teams about GMO where there are questions and answers:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3639326/

For further reading on long term effects of GMOs:

http://www.sciencedirect.com/science/article/pii/S0278691515300715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Plant scientists: GM technology is safe

THE AMERICAN SOCIETY of Plant Biologists (ASPB) "supports the continued responsible use of genetic engineering... as an effective tool for advancing food security and reducing the negative environmental impacts of agriculture" (1). A recent petition advocating the ASPB position collected more than 1400 signatories from the plant science community (2). The ASPB, the petition signatories, and other scientists in governmental and scientific organizations throughout the world (3, 4) demonstrate a clear consensus: Current use of genetic modification technology for crops is safe and effective, and future use should be guided by scientific evidence.

Despite such broad support for the technology, anti-genetically modified organism (GMO) advocates have had an extensive and troubling impact on policy—at the governmental level and through biasing public opinion—regarding the use of GMO-based ingredients in consumer products and food. More worrisome is that these arguments are often founded on science previously demonstrated to be unsound (5), such as the retracted Séralini *et al.* paper (6), which claimed that rats fed genetically modified corn and the herbicide RoundUp have higher rates of tumor formation.

consensus" exists regarding the safety of GMOs for human health and the environment (7). Commercial entities have seized upon ENSSER's statements. The Non-GMO Project, for example, cites the ENSSER petition (8) in its efforts to verify the absence of GMOs in over 4500 branded products. The fast-food restaurant chain Chipotle cites the ENSSER petition to justify a campaign against GMO ingredients (9).

Questions abound about how to best implement GM technologies, but as we move forward, we must make decisions informed by science. To meet our current and future food supply demands, without destroying our planet, we need every efficacious tool available (10). We hope that the consensus on GM technology among plant scientists is heard by policy-makers, the business community, and the general public. We invite advocates of the responsible use of such tools to make your voices heard to encourage a scientific approach in agricultural research and GMO policy.

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REFERENCES

1. American Society of Plant Biologists, "Revised position statement on plant genetic engineering" (2014).

Biosensors

Using some part of an organism to generate a signal to measure or monitor the presence of a substance.

It could also be defined as: an analytical device for the detection of a substance that combines a biological component with a physical transducer.

The biological component can be an enzyme, a receptor antibody, or DNA.

The transducer — which can be physicochemical, or electrochemical — produces an electrical signal proportional to the concentration of the substance being measured.

An example of a biosensor

Glucose sensors used by millions of diabetics to measure their blood sugar.

They contain an enzyme called glucose oxidase, which changes the glucose in a drop of blood into a chemical that can be detected with electrical measurements.

The test meter runs a small voltage through the sample and the amount of current that flows is directly proportional to the amount of glucose in the blood.

The device is fast, accurate, easy to use, and inexpensive

Environmental biosensors

They are expensive to purchase and maintain.

One of the first environmental biosensors was a nerve gas detection device developed in the late 1970s:

It was based on the enzyme acetylcholinesterase that produces an electrochemical reactive product.

When nerve gasses are present they inhibit acetylcholinesterase enzyme and stop the production of the electrochemical signal.

Various modifications of this biosensor were adapted for detecting various pesticides and pesticide contamination in the environment and with foods.

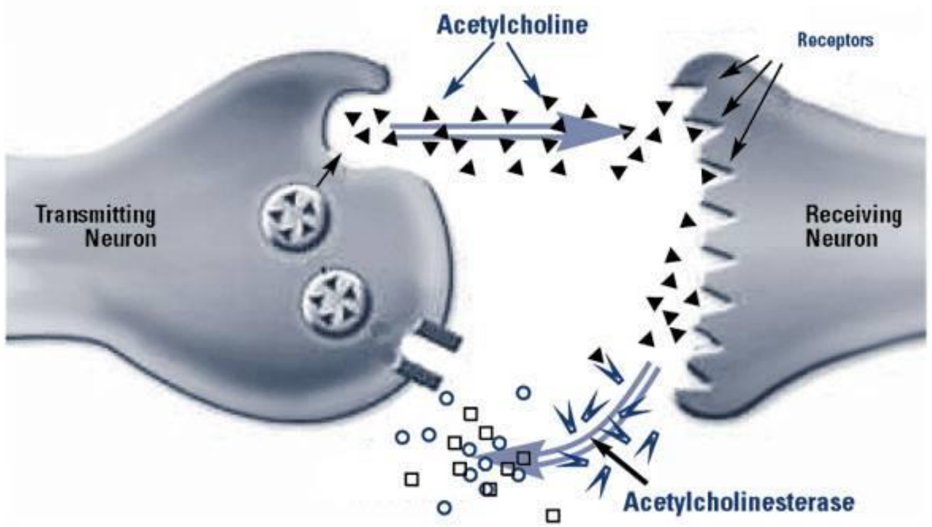

Fig. 1. After signalling, acetylcholine is released from receptors and broken down by acetylcholinesterase to be recycled in a continuous process.