Agricultural Biotechnology Council of Australia

Biotechnology and the environment

The International Society for Environmental Biotechnology (ISEB) defines environmental biotechnology as, 'the integration of science and engineering for the development, use and regulation of biological systems for remediation of contaminated environments (land, air, water), and for environment-friendly processes development (green manufacturing technologies and sustainable development).'

Some of the potential environmental management applications of biotechnology under investigation include:

- bioremediation
- waste management and treatment
- biomonitoring
- pest and weed species management
- cleaner, more efficient industrial processes
- novel bioproducts
- targeted crops.

Bioremediation — reducing contamination

Scientists are investigating the use of naturally occurring micro-organisms and fungi to clean up sites contaminated by toxins such as heavy metals, petroleum derivatives and acids.

An example of such research is being undertaken by University of Georgia researchers in the USA. They are investigating the potential of plants modified to grow in arsenic contaminated soils. The plants, at the experimental stage, are able to survive and grow in contaminated soil and metabolise the arsenic. The plants transport the arsenic to their leaves and they are then harvested and safely disposed of, leaving the soil ready for planting other crops/plants.

In Australia, research incorporating living bacteria in paints, so called biopaints, is being investigated to degrade hazardous waste and for use in bioremediation processes. Applications for such technology could include odour control and pathogen removal.

Waste management — human and industry waste

Certain bacteria and microbes can adapt to, and live in, various environments, where they break down materials for their own use, including mine waste and solid waste. Using gene technology, researchers have the potential to enhance these properties and create new waste solutions.

Queensland researchers are investigating the development of valuable bioproducts from waste. The project specifically targets small and medium scale biosolids producers, including feedlots, meat processors, other food processing industries, and communities less than 100,000 persons. The project aims to turn products from waste into useful products such as fish and livestock feeds, fertiliser, recycled water and biogas.

Researchers in Australia are also developing new technology to address algal blooms by removing high levels of nutrients such as nitrogen and phosphorous from agricultural wastewater. This research has implications for industries such as the meat processing industry and its abattoir wastewater treatment systems.

Biomonitoring

Globally, researchers are investigating the use of plants as 'sensors' for changes within an environment. Such research may have implications for agriculture, the environment, and military and humanitarian operations.

Researchers aim to understand and modify plant responses to environmental triggers such as microbes, insects, soil, drought and chemicals, so that they can genetically modify plants to signal, for example by glowing, when a problem exists. Some applications developed focus on the detection of:

- radioactive pollution of soil and water
- heavy metal contamination of soils
- herbicide contamination of soils
- water and pathogen stresses in plants and crops.

Military and humanitarian operations, may also find such technology useful, for example modifying plants to detect or signal the presence of land mines, chemical warfare agents or pathogens such as anthrax.

Pest animal management

Introduced pests cause a myriad of problems for the environment, such as erosion, and loss of native vegetation and wildlife. Researchers in Australia are investigating control options for carp using gene technology, and research is underway in New Zealand to control possums biologically.

Cleaner industrial processes

The production of components for detergents, nylon, glue, paints, lubricants and plastics from plants is being investigated around the world as a cheaper, biodegradable alternative to current methods.

Raw materials used to make industrial chemicals and polymers such as plastics are modified fatty acids, and these fatty acids are often produced from non-renewable petroleum sources. CSIRO scientists are researching plants as 'bio-factories' by modifying the fatty acids within a plant. This has the potential to reduce the chemical processing and polluting waste normally associated with the production of industrial products. These genes may now be transferred to oilseed crops to create cheap, biodegradable and renewable sources of the raw materials required for products such as araldite, lubricants and high quality surface coatings.

Researchers in Canada and Europe are using gene technology to produce canola with high erucic acid content. Erucic acid can be used in products such as cosmetics, lubricants and pharmaceuticals.

Novel bioproducts

Spider silk is highly regarded for its unique high-performance properties including strength, lightness and flexibility and much research has been invested in trying to match its properties. In 2002, researchers from a biotechnology company in the USA announced the creation of BioSteel®, a GM spider silk for medical, military and industrial purposes. Spider silk genes have been implanted into goats, to enable the goats to produce spider silk proteins in their milk, sometimes referred to as 'silk milk'.

The environmental advantage of such silk is that it is expected to be biodegradable and non-polluting.

To-date commercial quantities of BioSteel have not been pursued, although the technology has been bought by a US-based biodefense company which develops and commercialises medical products to counter biological and chemical weapons.

In Australia, research to prevent unwanted biofouling and corrosion on submerged surfaces and building walls is underway. The science is based on the incorporation of metabolically active bacteria (living paints) or enzymes into coatings thereby preventing things like barnacles growing on them.

GM crops

Genetically modified crops commercially available around the world are already contributing to better environmental outcomes. Some of the environmental advantages of GM crops include:

- reduced pesticide use
- easier weed control
- energy savings
- reduced ploughing/cultivation
- reduced soil erosion

Plants that can grow under tougher environmental conditions are also in the pipeline across the globe — for example drought resistant and salt tolerant crops. Field trials of drought tolerant wheat, barley and sugarcane are occurring in Australia.

Further information

Anaerobic Technologies Research Projects, Advanced Water Management Centre, University of Queensland: www.awmc.uq.edu.au/anaerobic-technologies-research-projects.

BioSteel®: www.pharmathene.com.

Environmental Biotechnology Cooperative Research Centre (Legacy website): www.ebcrc.com.au.

Environmental biotechnology and genomics, CSIRO Ecosystems Sciences: www.csiro.au/en/Organisation-Structure/Divisions/Ecosystem-Sciences/Environmental-Biotechnology-Genomics.aspx.

Growing plastic (2008), CSIRO, Food and Agriculture: www.csiro.au/en/Outcomes/Food-and-Agriculture/Biofactories-PlantOils.aspx.

Transgenic Plants as Sensors of Environmental Pollution Genotoxicity. Sensors 2008, 8, 1539–1558: http://scholar.google.com.au/scholar_url?hl=en&q=http://www.mdpi.com/1424-8220/8/3/1539/pdf&sa=X&scisig=AAGBfm0UbrsM7Yo8Rpj-VlnUPddwBojzvw&oi=scholarr&ei=1VBAUObnJsauiQek50CgBA&ved=0CCAQgAMoAjAA.

Table of applications and licences for Dealings involving Intentional Release (DIR) into the environment, 2012. Office of the Gene Technology Regulator (OGTR): www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/ir-1.