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Information Paper 7

Biotechnology and the environment

One area of biotechnology which has not been a major focus to date is the potential environmental applications the technology may offer. Much research is underway around the world looking at opportunities in this area.

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.

A research project is underway in Australia investigating the development of valuable bioproducts from waste. Aimed at reducing the environmental impacts from intensive rural industries such as feedlots, meat processing and piggeries, a multi-million project has been launched that will turn products from the wastewater of intensive rural industries into useful products such as fish and livestock feeds, fertiliser, safe recycled water and biogas.

Researchers in Australia have also announced the development of a new technology which prevents algal blooms by removing high levels of nutrients such as nitrogen and phosphorous from agricultural wastewater. This is the first time such high concentrations have been successfully and reliably removed without the use of chemicals. This research has implications for industries such as the meat processing industry and its abattoir wastewater treatment systems.

Biomonitoring
Researchers in the USA 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. This has major implications for the environment in relation to more efficient use of resources. For example, if GM plants were modified to signal when they were under pressure by a particular pest, the farmer would be able to look for this signal, and respond strategically, for example spray the problem area rather than the whole area, or spray when there is early evidence of a problem rather than in anticipation of a problem.

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 animal pathogens such as anthrax.

Using a combination of gene technology and nanotechnology, Australian researchers are aiming to design sensors that can rapidly detect the presence of problem organisms in water or food.

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 have identified two plant genes which can modify the fatty acids within a plant, and therefore reduce chemical processing and polluting waste. 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 within the material industry. 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'. A breeding program to stock a 'silk milk' herd is currently underway. The environmental advantage of such silk is that it is expected to be biodegradable over time in the presence of water, and in comparison to the production of synthetic materials, it has the potential to be non-polluting and therefore more environmentally friendly.

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.

Targeted plants
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 are occurring in Australia.

Experience to date
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 – insect resistant crops have allowed farmers to reduce pesticide applications. In Australia this has translated into a reduction of approximately 85 per cent.
- Easier weed control – the current herbicide tolerant crops allow farmers easier weed control and the use of more benign herbicides.
- Energy savings – GM crops offer energy savings on the farm: the use of tractor diesel is reduced as fewer sprayings means fewer trips across the fields, making a contribution to energy saving and a reduction in greenhouse gases.
- Reduced ploughing - certain GM crops allow minimal soil cultivation which promotes soil moisture conservation and reduces fuel usage and gas emissions.
- Reduced soil erosion – some GM crops allow conservation tillage practices to be used and such practices conserve moisture and soil fauna and flora, and reduce water and wind erosion.

Further information
Environmental Biotechnology Cooperative Research Centre www.ebcrc.com.au

'Environmental applications of biotechnology', Australian Government Department of Environment and Water Resources
www.environment.gov.au/settlements/biotechnology/index.html