

# Application of Biotechnology to Boost Economy: A Review with Special Reference to Sri Lanka

(1) Department of Biological Sciences, Faculty of Applied Science, South Eastern University of Sri Lanka, Sammanthurai, Sri Lanka.

( email: safeenim@fas.seu.ac.lk)

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**Abstract:** Biotechnology is the multidisciplinary integration of sciences and engineering in order to utilize the huge biochemical potential of biological systems for the protection, restoration and preservation of the environment and for the sustainable use of natural resources. The diverse disciplines of biotechnology reinvigorated by advances in emerging genomics, proteomics and metabolomics. The developments of biotechnological and engineering techniques are applied to solve many environmental, agricultural and industrial problems. In addition, agricultural biotechnology has been advancing very rapidly among the major disciplines of biotechnology. Although, it would give many promises in Sri Lankan contexts, it also poses as many questions.

Although, biotechnology has been at the forefront of scientific enterprise during the last three decades or more, Sri Lanka has failed to make progress in the field. Lack of human resources and sophisticated laboratory facilities may have greatly retarded advancement in this area. Therefore, this review will address the current status of application of biotechnology in the world and its present position in Sri Lanka.

**Keywords:** Biotechnology, applications, biotech products, research policy

## Introduction

Sustainable economic growth is one of the key strategic challenges for the 21st century. Innovative technological change has raised living standards, improved quality of life and enabled mankind to combat hunger, disease and environmental degradation. The expansion of biotechnology in a growing number of economic sectors has played an important role in contributing to this change and has enormous potential to improve a broad range of human activities (Ernst and Young, 2011).

As this technology continues to develop and rapidly change a wide range of activities from the delivery of vaccines to manufacturing processes, growing numbers of governments and international organisations have increased their attention on how to stimulate its development. The importance of biotechnology was realized all over the world within the last three decades. In many countries governments as well as private sector organizations have given high priority for R & D in biotechnology. As such, commercialization of biotechnology has become a major industry worldwide (Table 1. and fig. 1)

Traditional biotechnology involves mainly fermentation technology i.e., manufacturing of bread, alcohol, wine, beer and fermented milk products using microorganisms. The modern biotechnology includes recombinant DNA technology, tissue culture and mutagenesis.

Rank 2012	Company	Country	Market Cap in 2012 (USD billions)	Market Cap in 2011 (USD billions)	Website
1	<a href="http://www.novonordisk.com">Novo Nordisk</a>	Denmark	76.92	60.09	<a href="http://www.novonordisk.com">novonordisk.com</a>
2	<a href="http://www.amgen.com">Amgen</a>	USA	60.09	49.72	<a href="http://www.amgen.com">amgen.com</a>
3	<a href="http://www.gilead.com">Gilead Sciences</a>	USA	40.16	32.68	<a href="http://www.gilead.com">gilead.com</a>
4	<a href="http://www.biogenidec.com">Biogen Idec</a>	USA	34.26	25.6	<a href="http://www.biogenidec.com">biogenidec.com</a>
5	<a href="http://www.tevapharm.com">Teva Pharmaceutical Industries</a>	Israel	34.23	42.96	<a href="http://www.tevapharm.com">tevapharm.com</a>
6	<a href="http://www.baxter.com">Baxter International</a>	USA	32.27	33.36	<a href="http://www.baxter.com">baxter.com</a>
7	<a href="http://www.celgene.com">Celgene</a>	USA	28.38	27.52	<a href="http://www.celgene.com">celgene.com</a>
8	<a href="http://www.merckgroup.com">Merck KGaA</a>	Germany	21.16	20.14	<a href="http://www.merckgroup.com">merckgroup.com</a>
9	<a href="http://www.csl.com.au">CSL</a>	Australia	21.11	18.33	<a href="http://www.csl.com.au">csl.com.au</a>
10	<a href="http://www.alxn.com">Alexion Pharmaceuticals</a>	USA	18.85	10.48	<a href="http://www.alxn.com">alxn.com</a>

Source: FAO report, 2012

## Methods and Materials used in Biotechnology

Advances in biotechnology have always been based on the development of new methods. In traditional processes developed centuries ago, such as the production of wine, bread and various fermented foods. These methods were developed over long periods of experience, in an essentially 'trial and error' process with the aim to 'conserve and reproduce successful recipes'.

Modern Biotechnology brings together subjects such as microbiology, engineering, agriculture, genetics and biochemistry, in a combined effort to increase production of commercially interesting products or to solve environmental problems. Various methods are employed at the different steps of a biotechnology process: upstream processing (inoculum and substrate preparation), bioconversion (by microorganisms, plants or animals or parts thereof), and downstream processing (product recovery, waste disposal) (David and Adrina, 2002).

The Biotechnology Industry

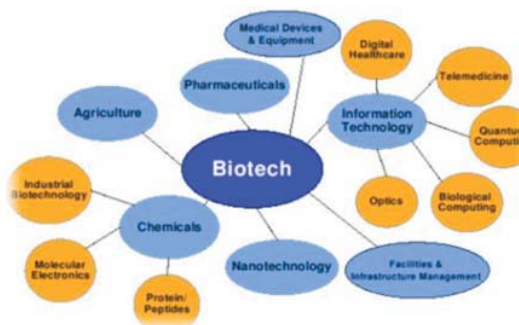


Fig. 1: Biotechnology industries in the world.

## Biotechnology Applications

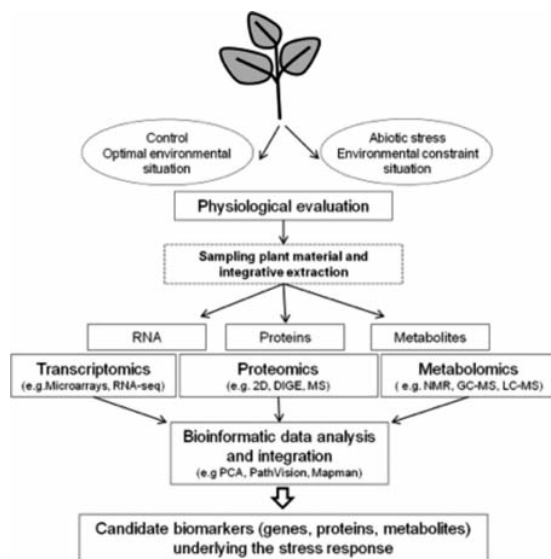
Biotechnology has benefits to society in the health, environmental, agricultural and food sectors (Table 2). In the pipeline, there are products that can help address famine and malnutrition, improve human health and reduce the environmental impact of industrial activities. Biotechnology provides an increasing range of tools for industry to improve economic and environmental performance beyond what could normally be achieved using conventional technologies.

Table 2: Common Applications of Biotechnology

<p><b>Agriculture</b> Improved foods, pest control, plant and animal disease control, improved food production. Stress tolerance (fig.2).</p>	<p><b>Industry</b> Oil/mineral recovery, environmental protection, waste reduction. Improved detergents, chemicals, stronger textiles.</p>
<p><b>Health Care</b> Drugs, vaccines, gene therapy, tissue replacements.</p>	<p><b>Research</b> Understanding the human genome and better detection of diseases.</p>

Experts on the World Economic Forum's Council on Biotechnology have selected the following 10 developments which they believe could help not only meet the rapidly growing demand for energy, food and healthcare, but also increase productivity and create new jobs, should issues such as regulatory certainty, public perception and investment be tackled successfully (John and Henry, 2006).

1. Bioproduction of sustainable chemicals, energy and other materials
2. Genetically modified crops to increase sustainable food production
3. Seawater bioprocesses to produce fuel and chemicals
4. Zero-waste bio-processing
5. Carbon dioxide as a raw material
6. Regenerative medicine to create new organs
7. Rapid and precise development and manufacturing of medicine and vaccines
8. Accurate, fast, cheap, and personalized diagnostics and prognostics
9. Biotech improvements to soil and water
10. Advanced healthcare through genome sequencing



**Fig. 2: Schematic overview of a common System Biology approach to study abiotic stress responses in plants.**

## Where does Sri Lanka stand in the development of biotechnology industries?

Although biotechnology has been at the forefront of scientific endeavor during the last three decades or more, Sri Lanka has failed to make headway in this field. Lack of trained personnel in the different areas of biotechnology as well as the lack of sophisticated laboratory facilities may have greatly related advancement in this area in Sri Lanka.

In spite of these deficiencies, there are few biotech industries involved in tissue culture, fermentation, diagnostics and bioremediation. There is a great potential for agricultural biotechnology in Sri Lanka as a tool in crop improvement programmes. Future developments in other fields like medicine, natural resources, industry, and food science waste management, etc. will be possible on advances made through novel biotechnological approaches.

Some private companies are involved in various agro biotech activities, more specifically in plant tissue culture. They have well developed tissue culture laboratories set up in 1980s. Some of the private companies, namely, Serendib Horticulture Technologies (Pvt.) Ltd., CIC Agro Industry, Hayleys Agro Biotech, Mike Flora (Pvt.) Ltd., and Ramya Horticulture are involved in micropropagation of ornamental plants, fruit crops, economically important plants and vegetables, exporting cut flowers, foliage, rooted plants, and accessories, production and sale of agricultural seeds, and production and conservation of aquatic plants. Many of the private tissue culture laboratories in the country are mainly involved with the production of ornamental plants for the local and/or the foreign market. Some companies such as Serendib Horticulture and Hayleys Agro Biotech do large volumes of fruit plants, especially Banana and Pineapple as well. In addition to the above, some companies are working as consultants and collaborators with foreign governments and companies. Very few companies have public-private partnerships within the country.

Sri Lanka does not have much progress in medical biotech industries. A few private laboratories are involved in molecular diagnostics, PCR techniques, DNA fingerprinting and genotyping. Recently some companies in the field of medicine started to develop diagnostic kits, paternity testing, etc. A few local biotech industries are involved in producing bio-fertilizers and biopesticides.

Alcohol fermentation, especially brewing beer is the most mature area biotechnology in Sri Lanka. There are many examples of domestic, small and medium scale industries applying these techniques.

Commercial application in biotechnology and the establishment of biotechnology industries need more state patronage to make it sustainable. The private sector in Sri Lanka is yet to play an important role in contributing to the economic development through biotechnology innovations. Although heavy investments in biotech industries may not be possible, with the available physical and human resources. Sri Lanka can exploit the full potentialities of biotechnology. A crucial issue is lack of proper mechanism for transferring mature technologies.

Advances in biotechnology have also led to address safety and ethical aspects of biotech industry and products. Quarantine regulations should be streamlined to facilitate research and innovation. Guidelines should be developed for collaborative research with foreign scientists/organizations involving local biological materials. Patenting is also very important in commercialization of products or processes.

Some of the potential Industrial applications of biotechnology for improving agriculture, human health and environment in Sri Lanka are:

- Development of recombinant vaccines for infectious diseases i.e., dengue, tuberculosis, and hepatitis
- Development of immuno diagnostics, drugs, antibiotics and steroids, monoclonal

antibodies, human insulin, vitamins and amino acids, DNA probes, DNA fingerprinting, molecular testing services.

- Screening for stress factors in vitro and producing diseases free plants, crops with improved nutritional value.
- Development of fermentation methods and facilities for production of ethanol
- Production of enzymes, chemicals, organic acids, industrial solvents, flavours
- Enhancement of industries in biofertilizers, biopesticides, bioherbicides
- Production of biofuels, bioethanol, bio-gas
- Bioremediation and biofiltration

## Why should biotechnology industries be promoted in Sri Lanka?

Sri Lanka is mainly depending on agriculture and agriculture based products to feed its population. As Sri Lanka has a high potential and scope for technological advances in biotechnology and commercialization of agricultural biotechnology the productivity of agriculture should be improved with the available technologies in order to achieve food sufficiency.

There is also growing demand for animal based foods in the developing countries, hence, this demand could be met by using technologies in modern biotechnology such as artificial insemination, embryo transfer, etc., Modern biotechnology increases overall productivity, nutritional status and resistance to diseases and extreme environmental conditions such as drought, salinity etc. it also helps to produce diagnostic tools and vaccines to control animal diseases. DNA Typing is now widely used in Sri Lanka for both criminal and civil procedures. DNA fingerprinting facilities are provided by Genetech, a private biotech company established in the country.

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## Future Prospects to develop Agricultural biotechnology industries in world

The future of biotech crops looks encouraging. A number of developing countries are expected to plant biotech crops before 2015, especially the Asian countries. Some African countries may also contribute in the biotech crop hectareage in the near future, with the first drought tolerant maize planned for release in Africa in 2017. The same biotech crop is expected to be released in North America in 2013; the first stacked soybean (with herbicide tolerance and insect resistance traits) will be planted in Brazil in 2013; vitamin-A enriched Golden Rice could be released in the Philippines in 2013 or 2014; drought tolerant sugarcane in Indonesia; and biotech maize in China. Biotech crops is not a panacea; but they have the potential to make a substantial contribution to the 2015 MDG goal of cutting poverty by half, by optimizing crop productivity, which can be achieved by public-private sector partnerships (OECD, 2011).

## Future directions to be taken to promote biotechnology industry in Sri Lanka

1. Develop infrastructure, expertise and skills in biotechnology
2. Provide advanced training in already existing techniques such as tissue culture, micro-propagation etc.
3. Strengthen the link between the private sectors and government research organizations in commercialization of research
4. Direct future development towards genetic improvement of crops, drought and disease tolerant varieties, improving nutritional quality of certain crops, production of useful hybrid varieties of plants

### M.I.S. Safeena

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5. Attract joint venture partners from developed countries in order to access foreign markets for biotechnology products
6. Encourage biotech industry development through granting pioneering status
7. Promote and create public-private partnership programmes in research and product development in biotechnology
8. Setup a government body to approve locally developed testing kits (i.e., ELISA and PCR)
9. Protect Intellectual property rights and biodiversity
10. A biotech association should be formed with the biotechnologists in the public and private sectors: regular meetings to be conducted to discuss advancements and progress made, regional and international biotechnology network should be formed.

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