BIOTECHNOLOGY AND ITS APPLICATIONS – IMPLICATIONS FOR GHANA

INTRODUCTION

Biotechnology is regarded in Ghana as a promising technology for the improvement of the living conditions of the population, for increase in food production and for providing better health delivery. Nonetheless, the use of biotechnology is still at an embryonic stage in the West African sub region, particularly in the case of genetic manipulation. This report describes the distinct role of biotechnology in sustainable development and examines the opportunities and challenges that the application of biotechnology offers Ghana in the sectors of agriculture, industry, health and environment. The report covers;

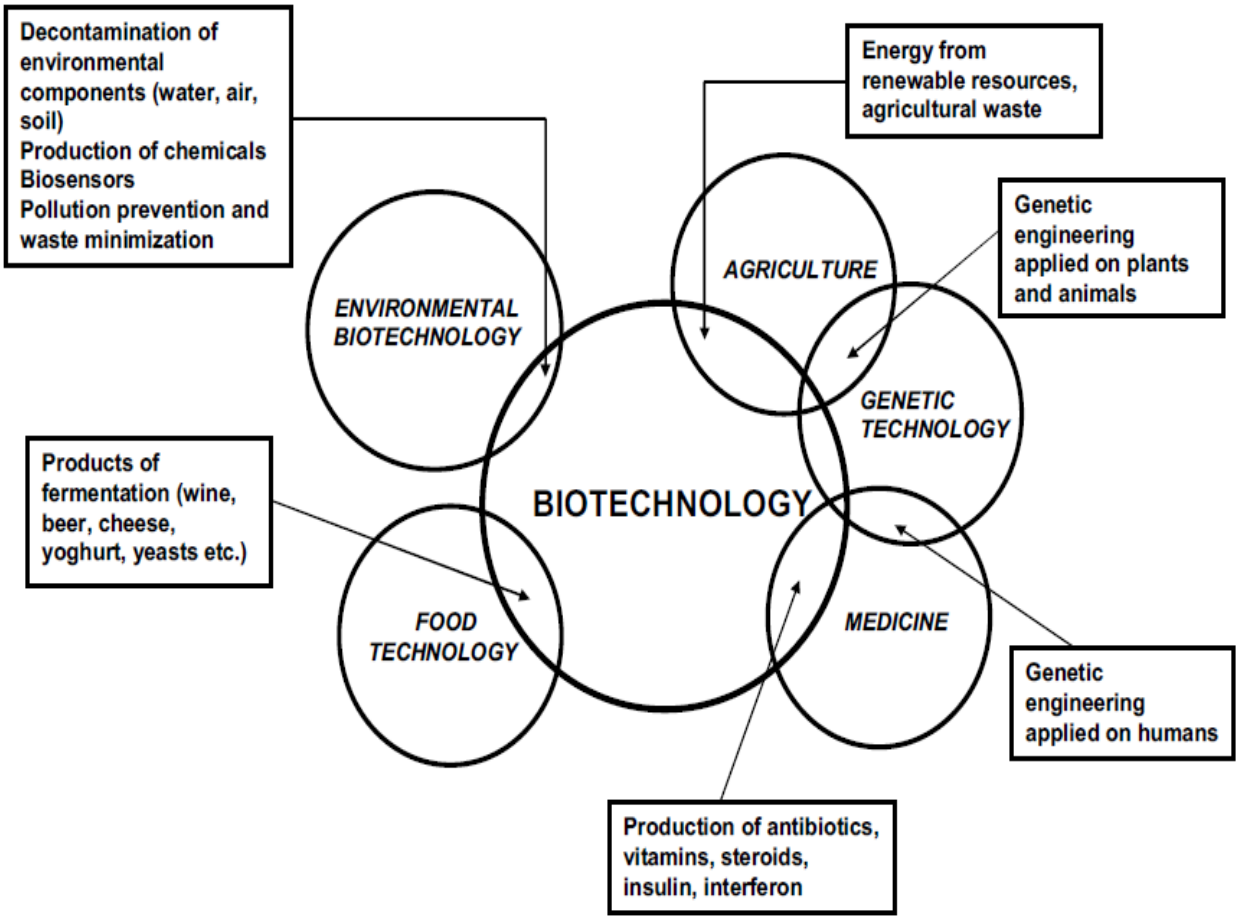
- Fundamental issues in biotechnology
- Status of biotechnology in Ghana
- Applications of biotechnology (Agriculture, Industry, Health and Environment)
- Recommendations

FUNDAMENTALS OF BIOTECHNOLOGY

In the year 1919, Hungarian agricultural engineer ***Karl Ereky*** foresaw a time when biology could be used for turning raw materials into useful products. He coined the term biotechnology to describe that merging of biology and technology. Ereky's vision culminated in what is now referred to as ***Biotechnology***. As an academic discipline and technological platform, many scholars and connoisseurs abound in the field of biotechnology hence the several definitions that one may have to contend with.

The Convention on Biological Diversity defines biotechnology as "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific uses". Van Beuzekom and Arundel, (2006) define biotechnology as the integration of natural sciences and engineering in order to achieve the application of organisms, cells, parts thereof and molecular analogues for products and services. They appreciate biotechnology as a versatile and key area which has greatly impacted various technologies based on the application of biological processes in *manufacturing, agriculture, food processing, medicine, environmental protection and natural resource conservation.* Van Beuzekom and Arundel, (2006) also identified biotechnology as the new wave of technology that accounts for

the dramatic improvements in various sectors of national economies, including production of drugs, vitamins, steroids, interferon, products of fermentation used as food or drink, energy from renewable resources and waste, as well as genetic engineering applied on plants, animals and humans. Indeed, biotechnology provides novel opportunity for sustainable production of existing and new products and services. The figure below highlights the resourcefulness of applications of biotechnology.



(Adapted from Sukumaran Nair 2006)

BIOTECHNOLOGY IN MEDICINE AND HEALTH

A variety of biotechnological techniques are used in modern drug development and medical treatment. In some cases, for example, genetic engineering is the basis for both the process and the product. In others, gene technology is used simply as one tool in the development of new products such as pharmaceuticals. Biotechnology enables scientists to understand genetic variability in humans and this leads to healthcare benefits for individuals who are genetically susceptible to certain diseases. Genetic screening and analysis, for example, makes it possible for tailor- made treatment of diseases. Gene therapy involves the genetic engineering of a patient's genetic code to remove or replace a mutant gene that is causing disease and this contributes substantially to modern health delivery across the world. According to a 2002 UNCTAD report addressing Key Issues in Biotechnology, the first biotechnology product approved for human health care was synthetic human insulin, which came onto the market in the United States in 1982. Since then, more than 170 biotechnologies related drugs and vaccines have been approved by the United States Food and Drug Administration, of which 113 are currently on the market. Another 350 biotechnology medicines, together targeting over 200 diseases, are in the later stages of development. Amongst those approved during 2000 are medicines to treat pneumococcal diseases in children, diabetes, cancer and hemophilia. Keener et al from the North Carolina State University, Food science Department in their undated publication in Biotechnology and its applications reported that biotechnical methods are now used to produce many proteins for pharmaceutical and other specialized purposes. A harmless strain of Escherichia coli bacteria, given a copy of the gene for human insulin, can make insulin. As these genetically modified (GM) bacterial cells age, they produce human insulin, which can be purified and used to treat diabetes in humans. Microorganisms can also be modified to produce digestive enzymes. In the future, these microorganisms could be colonized in the intestinal tract of persons with digestive enzyme insufficiencies. Products of modern biotechnology include artificial blood vessels from collagen tubes coated with a layer of the anticoagulant heparin.

AGRICULTURAL BIOTECHNOLOGY

The field of agriculture is one with largest impact of biotechnology. The following paragraphs discuss some of the monumental impact on agriculture resulting from the use of biotechnology.

Bioferlizers: These are substances which make use of microorganisms to fertilize the soil. These fertilizers are not harmful to crops or other plants like the chemical fertilizers. They are taken from animal wastes along with microbial mixtures. Micro-organisms are used to increase the level of nutrients the plants. They let the plant grow in a healthy environment and protect them from getting any disease. They are also environment friendly and do not cause pollution in any sort. They are not costly and even poor farmers can make use of them.

Biotechnology advances allow for specific changes to be made quickly in plants and animals breeding which enhances their traits to get new and different varieties to them through traditional methods like cross-pollination, cross-breeding and grafting. Similar changes are made in crops like cold resistant enhancements of tropical plants breeds so that they can grow in the cold or polar regions. Technology advances also allow agriculturist and botanists to develop plants and animals that are resistant to pest and diseases.

Nutrients supplementation: In an effort to improve human health particularly in under developed countries, scientist, creating genetically altered foods that contain nutrients know to help fight disease malnourishment. An example of this is Golden rice, which contain beta-carotene, the precursor for vitamin A production in our bodies. Similar efforts are also made to improve like stock feed by improving nutrient content and also improve the digestibility of low quality animal feed by using efficient food additives. It is also used to improve the nutritional value of animal feed such as low protein amino acid or deficiency of certain minerals by adding the efficient feeding additive. In conclusion, agricultural biotechnology is the best way to grow healthier plants and rear healthier animals for ensuring food security.

GENETIC ENGINEERING

Genetic engineering generally refers to the use of recombinant DNA techniques to introduce new characteristics or traits into an organism. It entails producing a piece of DNA (the recombinant DNA or rDNA construct) and introducing it into an organism so that new or altered traits can be imparted to that organism. The genes and other segments of DNA that are part of the rDNA construct may be obtained from other organisms, or synthesized from scratch in a laboratory.

Genetic engineering enables people to introduce a much wider range of new traits into an organism than is possible by conventional breeding. It has been widely used to make crops

resistant to certain pests or herbicides, Cross breeding of different species of animals and cloning of organisms.

The use of genetic engineering as a tool to improve crop plants for human use is an idea that should be irreproachable. Genetic engineering is one way by which we may be able to boost the production of food to needed levels. Food crops with built-in insecticides, such as the Bt toxin, should be easier, safer and cheaper to grow, and produce higher yields. Those crops that are tailored nutritionally should be able to eliminate some serious chronic deficiencies in diets in some parts of the world. Fruits and vegetables that ripen when needed should make it possible to get more produce to market at the optimum time, minimizing waste. In medicine, for example it is used to develop microbes that can be produce in pharmaceuticals for human or animal use, and in food to produce microorganisms that aid in baking, brewing, and cheese-making. In human and animals genetic engineering can be in the form of cloning of the species in the laboratory to produce exact own kind. Genetic cross breeding is widely accepted in animals, and animals about to be extinct in future can be genetically bred.

ENVIRONMENTAL BIOTECHNOLOGY

Since the 1980s, environmental biotechnology gained importance through the environmental laws being passed by many countries. Environmental biotechnology concerns the application of biotechnology as an emerging technology in the context of environmental protection, since rapid industrialization, urbanization and other developments have resulted in a threatened clean environment and depleted natural resources.

Human activities in modern development have amplified air pollution (with CO_2, NO_x, SO_2, greenhouse gasses, etc.), water pollution (with chemical and biological pollutant materials, nutrients, leachate, oil spills, etc.), and soil pollution (due to hazardous waste, spreading of pesticides and the use of non-biodegradable materials (Gavrilescu, M. 2010). In the case of Ghana, several researches by experts and institutions confirm the findings of Gavrilescu. Indeed, the Environmental Protection agency in its 2004 report on the State of the Environment- Ghana tabulated a tall list of these categories of pollution. The World Bank Development Data Group in its 2013 World Development Indicators reports that as at 2012, Ghana's CO_2 emissions from manufacturing industries and construction was 1.4 million metric tons.

Nonetheless, biotechnology offers a platform that has enabled many countries to tackle their environmental challenges. Olguin (1999) posited that advance technologies are now available to treat waste and degrade pollutants assisted by living organisms and to develop products as well as processes that generate less waste and preserve natural non-renewable resources. Gavrilescu identified the following as the opportunities offered by biotechnology in relation to the environment conservation;

- *Improved treatments for solid waste and wastewater*
- *Bioremediation: cleaning up contamination and phytoremediation*
- *Ensuring the health of the environment through bio-monitoring*
- *Cleaner production: manufacturing with less pollution or less raw materials*
- *Energy from biomass*
- *Genetic engineering for environmental protection and control.*

Government of Ghana puts a high priority on modern biotechnology as a key tool both in the research and development agenda and also in environmental management. This focus has led to the development of a management system, the National Biosafety Framework (NBF), which encapsulates the national position of maximizing the use of modern biotechnology with the appropriate safety mechanisms in place. The eventual passage into law and full operation of the biosafety act will help Ghana make higher strides in the case of environmental biotechnology.

INDUSTRY AND FOOD BIOTECHNOLOGY

As far back as 6000 B.C., people produced beer, wine and bread using fermentation, a natural process in which the biological activity of one-celled organisms plays a critical role. By 4000 B.C., the Chinese were using lactic-acid-producing bacteria for making yogurt, molds for making cheese and acetic acid bacteria for making wine vinegar. Biotechnology brought industry and agriculture together at the beginning of the 20th century. Fermentation processes were developed that produced acetone from starch and paint solvents to be used on automobiles. Between 1930 and 1952, researchers focused their effort on the relationship of genes and proteins. They found a direct relationship between mutations of a gene and the sequence of amino acids in a protein.

Biotechnology has a long history of use in food production and processing. For ten thousand years fermentation, a form of biotechnology has been used to produce wine, beer and bread. Selective breeding of animals such as horses and dogs has been going on for centuries. Selective breeding of essential foods such as rice, corn and wheat have created thousands of local varieties with improved yield compared to their wild ancestors.

CONCERNS ABOUT BIOTECHNOLOGY

As biotechnology has become widely used, questions and concerns have also been raised. The most vocal opposition has come from western countries. One of the main areas of concern is the safety of genetically engineered food. In assessing the benefits and risks involved in the use of modern biotechnology, there are a series of issues to be addressed so that informed decisions can be made. In making value judgments about risks and benefits in the use of biotechnology, it is important to distinguish between technology-inherent risks and technology-transcending risks. The former includes assessing any risks associated with food safety and the behavior of a biotechnology-based product in the environment. The latter involve the political and social context in which the technology is used, including how these uses may benefit or harm the interests of different groups in society. The health effects of foods grown from genetically engineered crop depend on the composition of the food itself. Any new product may have either beneficial or occasional harmful effects on human health. For example, a biotech-derived food with a higher content of digestible iron is likely to have a positive effect if consumed by iron-deficient individuals. Alternatively, the transfer of genes from one species to another may also transfer the risk for exposure to allergens. Therefore in our view, as nations legislate on Biosafety and Bioethics, such laws and standards must address national concerns adequately.

STATUS OF BIOTECHNOLOGY IN GHANA

The Biosafety Law in Ghana was passed in December 2011, signed into law by the late President Prof. Evans Atta Mills with Government assent to the Biosafety Act 831 of 2011. Leading Institutions involved in biotechnology in Ghana are CSIR, University of Ghana, Kwame Nkrumah University of Science and Technology, BNARI of the Ghana Atomic Energy Commission (GAEC) and Cocoa Research Institute of Ghana (CRIG). These institutions are

involved in research and development activities in plant pathology, molecular breeding, conventional breeding and tissue culture.

SUMMARY

Our study of the literature in the field confirms that the applications of biotechnology are so broad, and the advantages so compelling, that virtually every industry is using this technology. Developments are underway in areas as diverse as pharmaceuticals, diagnostics, textiles, aquaculture, forestry, chemicals, household products, environmental cleanup, food processing and forensics to name a few. Biotechnology is enabling industries to make new or better products, often with greater speed, efficiency and flexibility. Biotechnology holds significant promise to the future but certain amount of risk is associated with any area. Biotechnology must continue to be carefully regulated so that the maximum benefits are received with the least risk.

IMPLICATIONS FOR GHANA

Ghana has made significant efforts in the area of establishing research institutions. The passing of a Biosafety Act is another milestone in Ghana's efforts towards modern biotechnology. It is however crucial that the following recommendations are speedily implemented.

- Invest in science and technology education and research.
- Develop institutions with the capacity to adopt and develop the know-how required for successful application of modern biotechnology.
- Create of necessary infrastructure for the transfer of relevant technologies
- Build capacity to understand our own ecosystems and to select, acquire, manage and further develop those modern biotechnologies that are most appropriate for our national needs.
- Enforce biosaftey and bioethics standards as enshrined in the legislation

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