

Current Advances in Biotechnology, their Potential Applications, Economic, Social, and Ethical Implications in Sub-Saharan Africa.

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Key words: Biotechnology, Genetically Modified Foods, Africa

Abstract:

The study of biotechnology has greatly expanded in recent years with the sequencing of the human genome however biotechnology has been around for years. In fact, the food industry has used biotechnology to make bread, cheese, yogurt, and drinks for decades. Medical research and pharmaceutical industry have used biotechnology to produce medicines and vaccines to cure or prevent the most devastating diseases threatening humanity.

This presentation aims to give an update on current advances in Biotechnology and their potential applications in Sub-Saharan Africa. It will also analyze the economic, social, and ethical implications of this technology, especially the ethical issues in the use of agricultural biotechnology.

Introduction

Of the vast numbers of scientific findings made over the last century, perhaps none has improved human health and longevity more than the developments that have occurred through biomedical research using Biotechnology.

Biotechnology is broadly defined as using living organisms, or products of living organisms, for human benefit to make a product or solve a problem. Classic examples of biotechnology include domestication of animals such as sheep and cattle for use as livestock, the use of microorganisms to make antibiotics, vaccines, bread, cheese, yogurt, and alcoholic beverages such as beer and wine.

Humans have been manipulating genes for hundreds of years without realizing it. Selective breeding has been used for thousands of years to improve the production of crops and livestock. Exciting innovations and applications in biotechnology were possible due to our understanding of genetics and molecular biology.

The ability to identify and reproduce a gene of interest through gene cloning and the manipulation of DNA through genetic engineering and recombinant DNA technology have led to the production of proteins of medical importance including insulin, human growth hormone, and blood-clotting factors. These technologies have also allowed the development of disease-resistant crops and plants that produce greater yields of fruits and vegetables, genetically engineered bacteria capable of degrading environmental pollutants and identification of thousands of genes involved in human genetic disease conditions. A new field called Bioinformatics also applies computer science to the study of DNA and protein data to analyze the tremendous amount of DNA sequence data generated by genome projects.

Types of biotechnology:

Microbial Biotechnology:

This type of biotechnology relies on the use of yeast for beer and wine production, the use of bacteria and yeast to create better enzymes and organisms for making many foods, simplifying manufacturing and production processes, and

making decontamination processes more efficient for removal of industrial waste products. It allows the production of important proteins used in human medicine including insulin and growth hormone.

Agricultural Biotechnology:

This type of Biotechnology also called "Ag-biotech" allows the production of genetically engineered pest resistant plants, foods with higher protein or vitamin content, and drugs developed and grown as plant products. Agricultural biotechnology is already a big business with an estimated \$6 billion market in the USA in 2005.

Recent estimates indicate that 500,000 children, most of them in the developing world, will become blind because of a vitamin A deficiency. One potential solution is Golden Rice, which is a rice that has been genetically modified to produce large amount of beta carotene, a provitamin that the body converts to vitamin A.

Animal Biotechnology:

Animals such as goats, sheep, cattle, and chickens are sources of medically valuable proteins such as antibodies (protective proteins defending the body against pathogens). Transgenic animals can be used to produce therapeutic proteins in their biological secretions such as milk. Gene knock-out and cloning can be used to study gene function, test drugs, and genetic therapies in animals which can lead to novel treatment strategies in humans.

Forensic Biotechnology:

This is a powerful tool for law enforcement that can lead to inclusion or exclusion of a person from a crime, based on DNA evidence. This technology uses DNA fingerprinting which has many other applications such as paternity testing, identification of human remains and endangered species, and the tracking of diseases such as AIDS, meningitis, West Nile Virus, and tuberculosis.

Bioremediation:

This procedure relies on the use of biotechnology to clean up many environmental hazards that have been caused by industrial progress such as oil spill. The treatments of domestic and industrial sewage and the recovery of valuable metals also use this technology which relies heavily on Microbial Biotechnology.

Aquatic Biotechnology:

From using aquaculture to raise fish for human consumption to isolating biologically valuable molecules from marine organisms for medical applications, aquatic biotechnology has the potential for a wide range of applications.

Medical Biotechnology:

Many biotechnology products such as drugs, vaccines, and other recombinant proteins are being manufactured for human medical applications. Gene therapy approaches have the potential to treat genetic diseases and stem cell technologies which might be used in transplantation to replace damaged tissues or failing tissues and organs such as the liver, pancreas, and retina. This type of approach called Regenerative Medicine is the medicine of the future.

Regulatory Biotechnology:

Quality assurance and quality control are two important aspects of the regulatory process that govern the biotechnology industry, to regulate the final quality of the product and to ensure that biotechnology products meet strict standards for purity and performance.

Current Advances in Biotechnology

Regenerative Medicine

The ability to maintain stem cell lines in culture and direct their development into specific cell types holds the potential to save or improve many lives by controlling cancer, re-establishing function in stroke victims, curing diabetes, regenerating damaged spinal cord or brain tissue, and successfully treating many diseases associated with aging.

With the aid of this technology, scientists someday may be able to generate replacement neurons to heal diseases of the brain; replace pancreatic islet cells to cure juvenile diabetes; to repair skin, cartilage and bone for accident victims and the casualties of war; and to make cells for the treatment of liver and heart disease.

Cloning

"Cloning" is a generic term for the replication, in a laboratory, of genes and cells or organisms from a single original entity. As a result of this process, exact genetic copies of the original gene, cell or organism can be produced. Somatic cell nuclear transfer (SCNT or therapeutic cloning) uses cloning technology to generate new stem cells. It is an extension of basic embryonic stem cell research aimed at generating replacement cells, tissues and organs. Genetically matched cellular and tissue transplants could address some of humanity's most devastating disorders, such as Alzheimer's and Parkinson's diseases, kidney failures and heart disease. SCNT could also be used to create new stem cell lines for research purposes.

Global Health

Infectious diseases are a global concern. According to the World Health Organization/UNAIDS, there are more than 40 million HIV-infected people in the world of whom about 30 million are in sub-Saharan Africa with 3.1 million new infections in 2004 and 2.3 million deaths. As of 2003, there are 300 million infections from malaria each year, a third of the world's population already carries the TB bacteria, and 42 million people are living with AIDS. The numbers continue to grow, but very little research is directed toward the diseases that overwhelmingly afflict the poor throughout the world. Scientists using biomedical technologies are exploring how to improve the way we diagnose, prevent, treat and control infectious diseases prevalent in the developing world. To prevent malaria, scientists are bioengineering mosquitoes by transferring into these insects an effector gene that prevents the parasite causing malaria from traversing the midgut thus disrupting its life cycle. Other scientists have developed an antibody that prevents the parasite from entering the mosquito's salivary gland, a step required for the parasite to develop and spread. Future release of these mosquitoes (after approval) could be a solution to the problem of insecticide-resistant mosquitoes and drug-resistant parasites that have hampered decades of attempts to control malaria in developing countries.

Plants and Animals

Biotechnology is used to modify plants and animals to meet consumer demand for more healthful, nutritious foods and to produce food in more environmentally sustainable ways. One of the main advantages is reduction in pesticide residues most of which are pollutants. Crops and animals also are being modified to provide new, plentiful and safer sources of medicines for treatment of human diseases. Biotechnology can help in the development of alternative testing methods that will actively encourage reduction in use of animals.

Biotechnology advocates strongly believe that advances in biotechnology have helped people all over the world by increasing crop yields, lowering prices for consumers, and providing a safe and nutritious food supply. In the United States, biotech crops generated \$27.5 billion of gross revenues for farmers in 2003-04.

"New biotech plant varieties are currently being developed to produce crops high in essential vitamins and minerals, as well as crops with higher conversion rates for renewable fuels, like ethanol. Cold and drought-tolerant plants such as peanuts are already developed. Today, more than 80 percent of cotton bales harvested in the U.S. are from varieties with one or more biotechnology traits. Some people believe that farmers in developing countries can also benefit from this technology. The argument is that for the world's growing population to be fed with nutritious foods and clothed with natural performance fibers, we will depend on biotechnology's ever growing benefits.

Ethical Issues, Economic, Social, and Environmental Impacts of Biotechnology:

The applications and promise of Biotechnology raise many ethical, economic, social, and environmental concerns around the world including Africa. For instance the use of genetically modified plants in agriculture and genetically

modified foods for human consumption faces strong resistance by certain groups of people who worried about the potential health effects, the economic, environmental, and social impacts of this technology. There are worries about genetic "pollution" of and eventual disappearance of local seed varieties if genetically modified (GM) seeds are introduced. This would increase debt and dependence for many farmers. Most African farmers including cotton farmers indicate that the problem is the low price of their crops not production. Many African countries are working on bio-safety legislation and countries like Zambia have refused genetically modified aid. In some European countries there is widespread public opposition to GM crops.

Several other issues are on the table such as stem cell research, cloning, global health, use of genetic information, medical records confidentiality, and protection of human subjects. People may avoid genetic tests out of fear that they will be discriminated against, including regards to health insurance, employment and education, as well as discrimination based on predictive genetic information.

As biotechnology reaches toward such benefits as treatments for intractable diseases such as cancer, Alzheimer's and Parkinson's; abundant, nutritious food; industrial sustainability; and a cleaner world, public discussion of the ethical, legal and social implications of biotechnology research should be encouraged. A strong protection of the confidentiality of medical information, including genetic information should be applied.

There should be strong policy of opposing the use of biotechnology to develop weapons of any sort that contain pathogens or toxins aimed at killing or injuring humans, crops or livestock. There should also be policy supporting the conservation of biological diversity.

Conclusion:

Because of biotechnology there is an increase of our understanding of the complexity of human genetics, human evolution and human disease. Ground-breaking discoveries are being made to fight diseases, improve food production, clean up the environment, and make manufacturing more efficient and profitable. Supporters of Biotechnology strongly believe that the ability to produce the food that is needed to feed a human population that is doubling every 45 years, from about 2% of the total land and surface of the world, cannot occur without advancements in technology. Most of the changes in agriculture in the last few decades have been delivered by Biotechnology. In the near future, genes may be routinely introduced into humans, as gene therapy approaches are employed, to treat and cure human disease conditions.

Healthier lives and increase in human lifespan will be possible with the modern advances in medicine driven by new knowledge from the Human Genome Project. There is no doubt that Sub-Saharan Africa will benefit immensely from Biotechnology if it can be used to find cures or to prevent such diseases as HIV/AIDS, malaria, cholera, yellow fever, and other devastating diseases plaguing Africa.

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