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Review

The dynamic and ubiquitous nature of biotechnology

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The beneficial and multidisciplinary nature of biotechnology is highlighted. Contrary to the general belief that the impact of biotechnology is mainly limited to agricultural science in the area of animal, plant breeding, and tissue culture and the medical sciences in the area of gene therapy, production of bioactive products for the quick diagnosis and treatment of diseases, this paper discusses the use of biotechnology in other areas of human endeavours like computer science, physics, mathematics, law/legal studies, forensics, environmental sciences and toxicology, tourism, sociology and psychology, international relations, botany, technology and economics just to mention a few. In Nigeria and other developing countries where the application of biotechnology to our everyday living is still in the early stage, this paper aims to emphasize the fact that biotechnology can be beneficial to all fields of life. This will further encourage multidisciplinary approaches and research collaborations in biotechnology for the rapid development of our nation.

Key words: Dynamic, ubiquitous, biotechnology.

INTRODUCTION

Biotechnology is the technical applications of biological systems for the production of natural substances (antibiotics, biogas, enzymes, etc) and involves manipulation of living organisms for the benefit of man (Olasupo, 2005).This technology employs powerful but simple procedures to identify, isolate, purify and study the regulation of genes and their products. It also enables the transfer of genes from one organism to another and can design new genes (Osuntoki, 2005).

In agriculture, gene cloning, an aspect of biotechnology has provided new dimensions to crop breeding by enabling direct changes to be made to the genotype of a plant, circumventing the random processes inherent in conventional breeding (Brown, 1998).The two general strategies used are gene addition, in which cloning is used to alter the characteristics of a plant by providing it with one or more new genes and gene substraction, in which genetic engineering techniques are used to inactivate one or more plant's existing genes. All these have brought about the possibility of reducing the time between planting and harvesting of crops (food and cash), the manipulation of plants to produce their own insecticides which are more environmentally friendly, slowing down the ripening process of fruits like tomatoes so as to allow enough time to transport and market the crop before spoilage sets in.

In biochemistry and chemistry, biotechnology has enhanced the production and manipulation of enzymes for the benefit of mankind. Although enymes may cause deterioration of foods, they can also be used in food processing to produce particular products or to modify the characteristics of particular products (Ihekoronye and Ngoddy, 1985). Enzymes are used in bread making, cheese production, meat tenderizing, syrups and sugar production, confectionary, production of alcoholic drinks, tea, chocolate and coffee production, protein hydrosylates and condiments etc. Biotechnology techniques are also used to fix and immobilize enzymes because of the advantages it provides like capability of repeated use of the enzymes, ease of precise control, increased stability, reduction of product inhibition, control of proteolysis, reduced possibility of immunological reactions, operation of altered pH optima etc. Recombinant DNA technology offers a rational approach to the understanding of the molecular bases of a number of diseases like sickle cell disease, cystic fibrosis etc. (Murray et al., 2000).

Several phytomedicines have been uncovered in plants such as *Vernonia amygdalina, Allium sativum, Mormodica balsamina, Hyperidium spp, Occimum gratissimum* etc following preliminary studies which revealed their anti-bacterial, anti-fungal, anti-viral and anti-inflammatory properties (Iwalokun et al., 2001, 2004;

Smith et al., 2002). The phytomedicines occur as flavornoids, saponins, alkaloids and phenolic glycosides and are usually identified by chromatographic techniques. Chemical fingerprinting has been increasingly applied in the past few years to determine the ancestry of plants. Genotypic characterization of plant species and strains is useful as most plants, though belonging to the same genus and specieS, may show considerable variation between strains (Breighaupt, 2003). A good example of this is the fraudulent adulteration of chianti wines with inferior quality grapes. This is also the case with medicinal plants, where the amounts of active chemicals may vary from plant to plant. Herbal drugs are consumed in most developed nations in the form of ethnotherapeutics, nutraceuticals or are used as the primary source of medicinal compounds or their intermediates.

Additional motivation for using DNA fingerprinting on commercial herbal drugs is the availability of intact genomic DNA from plant samples after they are processed. Adulterants can be distinguished even in processed samples, enabling the authentication of the drugs (Milahov et al., 2001). Studies have reported the genotyping of several medicinal plants and have made available their DNA fingerprints (Milahov et al., 2001).

OTHER APPLICATIONS OF BIOTECHNOLOGY

Biotechnology and computer sciences/information sciences/mathematics/physics

Biotechnology is also found in the above specialty areas and related fields. Bioinformatics is the science of managing and analyzing biological information (Kaikabo and Kalshingi, 2007). Bioinformatics tools and algorithms have been developed because of the rapidly growing sequence of biological data. Bioinformatics is conceptualizing biology in terms of molecules (in the science of physical chemistry) and applying information techniques (derived from disciplines like computer science, mathematics and statistics) to understand and organize the information associated with the molecules on large scale. Bioinformatics is management information system for molecular biology and has many practical applications (Gerstein et al., 2001). Thus, bioinformatics is application of computational techniques to understand and organize the information associated with biological macromolecules (Kaikabo and Kalshingi, 2007). Bioinformatics tools are used to generate data for research, mining, retrieval and analyses of biological data, predict and identify protein in a sequence to produce and develop vaccines and also has laboratory applications (Kaikabo and Kalshingi, 2007).

Biotechnology and microbiology/immunology (bacteriology and virology)

Gene cloning is a technique whereby multiple copies of a plasmid or other cloning vehicles are produced by inserting the plasmid into a suitable host capable of producing multiple copies and growing in a bulk culture. The bacterium, *Escherichia coli* is often used as the host organism for this purpose (Coombs, 1992). Somatostatin, the first human protein to be synthesized was achieved using *E.coli* (Brown, 1998). Vehicles are central component of a gene cloning experiment, which transports the gene into the host cell and is responsible for its replication. Plasmids, which are small circles of DNA found in bacteria and some other organisms, which can replicate independently of the host cell chromosomes are used as vectors. Virus chromosomes, in particular, the chromosomes of bacteriophages, which are viruses that specifically infect bacteria, are also used as vectors in gene cloning. Restriction endonucleases, a key enzyme used in biotechnology are found in a wide range of bacterial species. More than 800 restriction endonucleases have been discovered in different bacterial species. Using biotechnological procedures, bacteria and viruses are used in the study of resistance of microorganisms to drugs. Chen et al. (2004) reported the characterization of multiple microbial resistant salmonella serovars isolated from retail meats purchased in the United States and China. A better understanding of the molecular mechanisms by which antimicrobial resistance emerges and spreads will enable scientists to design intervention strategies and reduce its progression and thus control the rapid spread of antimicrobial resistant bacteria (Chen et al., 2004).

Biotechnology and parasitology

The use of monoclonal antibody and genetic engineering technologies could provide the essential tools to help overcome the difficulties encountered in development of vaccines for protozoan and helminth parasites of livestock (Soetan and Abatan, 2007). The difficulties encountered are due to the inability to identify antigens which induce protective immune responses and in obtaining sufficient quantities of vaccine trials (Gamble and Zarlenga, 1986). Biotechnology is helping a lot in the control of malaria parasites and other infectious diseases through the discovery of their pathogenesis. Application of biotechnology to researches in veterinary parasitology provides promising avenues for significant breakthroughs in vaccine production.

Biotechnology and pharmaceutical sciences

In the pharmaceutical sciences, biotechnology is used in the production of recombinant pharmaceuticals. Gene cloning is used to obtain large amounts of recombinant human and animal proteins (Murray et al., 2000). Examples are production of recombinant insulin used in the management of diabetes, synthesis of human growth hor-

mones like somatostatin and somatotropin to manage growth disorders, production of recombinant factors VIII and IX to treat haemophilia and Christmas disease respectively, production of erythropoietin to control anaemia, relaxing to aid child birth, serum and albumin used as plasma supplement, interferon ∂,β,y and interleukins used in the management of cancers (Soetan and Abatan, 2007).

Biotechnology and genetics

Molecular biotechnology has brought advances in the knowledge of genetic predisposition to cancer and this will greatly assist in the prevention and management of cancer (Soetan and Abatan, 2007). Genetic counselling could inform parents of the potential of cancer development in their offspring. Individuals at high risk could also be followed through out their lives for early signs of cancer, thus assuring early diagnosis and maximizing chances for successful therapeutic intervention.

Pharmacogenetic studies has brought more light into the structure, function and regulation of cytochrome P450 gene super family and this has enhanced the use of drugs to solve diseases of animals and humans. Animal genetics can bring about quality of life (Adebambo, 2004). Biotechnology has great potentials for harnessing the genetic potential of animals and for enhancing their genetic performance. Changes in the virulence of certain infectious diseases have been demonstrated to be due to the acquisition of genetic elements (DNA or RNA) that code for the traits. DNA fingerprinting provides the basis for selection and validation of integration of vigour and nutritionally enhanced genes in germ plasm prior to crop development (Iwalokun, 2005).This technique has subsequently reduced the use of pesticides and minimize their associated toxicity.

Sustainable agriculture through integrated systems are now possible through incorporation of genes that mediate survival, tolerance, resilience, disease resistance and symbiotic association between biotic components in an ecosystem (Iwalokun, 2005). Permaculture, the cultivation of edible genetic engineered mushrooms e.g. (*Agaricus biospora*) with food crops are now practiced to ensure soil nutrient repletion and ecosystem sustenance.

Biotechnology and legal studies

Biotechnology has brought about faster proofs and evidences for crime detection through genetic fingerprinting, also called forensic science. In 1987, British legal history was made during a rape trial. This particular case was important because it was the first time that police had introduced a DNA fingerprint as evidence (Su, 1998). When the accused man was shown the results of the genetic tests, he changed his plea to guilt, and was sentenced to imprisonment. Similarly, a sample of blood found at the scene of a crime can be matched to a genetic fingerprint produced from the blood sample of a suspect. Screening of large numbers of suspects in this way has led to the conviction of several murderers. The legal intimacy of the technique is based on the fact that that the chances of two people coincidentally sharing the same genetic fingerprints is more than 40 million to one (Coombs, 1992). Genetic fingerprinting can also be used to identify a child's true father in contested palimony and immigration cases. DNA fingerprinting has been used to accurately trace offsprings to parents or genetic source.

Biotechnology and tourism/international relations

The import and export of embryos i.e. international sales of embryo through Multiple Ovulation and Embryo Transfer (MOET) technique has brought about international trade and relations among developed and developing countries. MOET has also been used in the conservation of native breeds, exotic and wild species of animals that are prone to extinction. Several hundred embryos from animal breeds in zoological gardens, game reserves and wild parks could be collected and stored in liquid nitrogen. This reduces the chances of complete extinction of such rare breeds of animals that serve as tourist attractions (Brem et al., 1989). Cryopreservation of genome and genes of endangered cattle breeds by means of modern biotechnological methods is reported to be much less expensive than maintaining unprofitable herds of cattle, and avoids problems of inbreeding that are typical of small, closed herds (Brem et al., 1989). Training in biotechnology has brought about exchange programmes among institutions from different countries and this has also enhanced international relationships among the participating countries.

Biotechnology and nutrition/food industries

Biotechnology offers benefits in understanding and controlling of food processing e.g. in the provision of starter cultures and enzymes .It also has a directly productive role in the production of biomass and transgenic plants for animal feeds and human foods (Hambleton, 1988). Application of genetic technology also increases the number of proteins used in food industry by supplying the required large quantities of molecules currently too scarce to be of use. This may facilitate the development of new manufacturing techniques and products (Daini, 2000). Others are large scale production of amino acids used in the fortification of animal and human diets, increases in the production rates of feedstuffs, use of organic chemicals as preservatives, precursors and texturizers etc.

DNA fingerprinting is used as a tracing tool for detecting poultry feed contamination with apovarcin, a growth promoting substance that has accelerated the evolution

of vancomycin-resistant staphylococci and enterococci (Iwalokun, 2005).

Biotechnology and environmental/toxicological studies

Environmental biotechnology can be defined as a discipline that studies the application of biotechnology to solve environmental problems. It involves the processes of portable water production, waste water purification, solid waste management and soil and sediment clean-up. It also includes newer developments such as the use of biopesticides, bioremediation of recalcitrant pollutants and biosensors for environmental monitoring. Biotechnology has provided improved efficiency to traditional sewage treatment processes. There is also potential for pollution control and toxic waste degradation (Hambleton, 1988). Other applications include microbial mineral leaching (bioleaching, which is the use of microorganisms in solution to recover metals from ores), metal concentration and enhanced oil recovery. There is likely to be considerable interest in these areas from regulatory authorities, since they may involve the deliberate release of genetically-manipulated organisms into the environment, and this may discourage rapid commercial exploitation. Using genetically engineered bacteria to clean up industrial waste is a good idea. In the petroleum industry, microorganisms can be genetically engineered to produce chemicals useful for enhanced oil recovery (Daini, 2000).

Biotechnology and electronics/electrical engineering

Biotechnology is dynamically expressed in the production of bioelectronics. Considerable effort is being put into the development of improved biosensors that use microbes, enzymes or monoclonal antibodies to detect specific substances (Hambleton, 1988). Sensors with improved stability and a wider range of sensing capabilities would find considerable use both in monitoring and control of industrial bioprocesses and in health care applications. It is also conceivable that new semi-conducting devices based on protein matrices (biochips) might one day supercede the silicon chip. All these bioelectronics have made estimations of biological parameters like blood, urine samples etc faster and more accurate and this aids in quicker diagnosis of diseases. This has helped medical and veterinary personnels to perform their duties faster in the area of giving correct prognosis and solutions to disease problems and accurately predict the risk of developing a given disease. This will greatly assist in reducing mortalities to the barest minimum.

Biotechnology and economic development

Global economic development is being accompanied by increased demand for milk, eggs, meat and other animal products. Sustainable development of more productive and efficient livestock herds and flocks will be required to meet these challenges (Adebambo, 2004). The commercial value of biotechnology lies in its potential to produce in almost unlimited quantities, products not previously available or are in short supply, costing less than those made by existing methods and safer products (Hambleton, 1988). Application of biotechnology is open to commercialization and biotechnology products offer opportunities for self-sufficiency and wealth. The world market in animal health care products is large.

The maize lines engineered for insect resistance (Bt maize) or herbicide tolerance (glyphosate) and herbicide tolerant soyabean will help save a lot of resources spent on chemicals. Herbicide-resistant soyabeans improve yield while reducing the need for chemical application as well as lowering production costs and reducing the need for soil tillage, which means less soil erosion. Insect-protected corn, cotton and potatoes result in better-quality crops with less reliance on insecticides. It is reported that in 1998, 3.5 million pounds less pesticide were applied to American-grown corn and cotton through the use of insect-protected varieties produced through biotechnology.

The goals of embryo transfer and related technologies are to make a profit by providing embryo transfer services, make a profit by selling animal products or breeding stock, increase the availability of animal products to consumers, improve the efficiency of animal agriculture (which also decreases pollution), manipulate the economy by creating new jobs or altering balances of trade among various sectors (Seidel and Seidel, 1992).

Possible barriers to successful commercialization of biotechnology products is the growth of national and international regulations attempting to control aspects of biotechnological application which are perceived as being unacceptable (Hambleton, 1988). Soetan and Abatan (2007) reviewed the issue of ethical questions and fears about biotechnology.

CONCLUSION

Biotechnology has brought about a faster means of discovering new facts in the scientific world. It has also encouraged research collaborations and multidisciplinary approach to research work. For example, the process of producing and developing a vaccine involves the services of several scientists from different fields like virology, bacteriology, immunology, biochemistry, pharmacology, physiology, parasitology, computer science (bioinformatics), statistics, pathology, public health and preventive medicine, research regulatory agencies, ethics and legal experts in the area of patents. The role of biotechnology as an essential tool to breakthrough in medical and veterinary research has been reviewed by Soetan and Abatan (2007). All the above points justify the dynamic

and ubiquitous nature of biotechnology and awareness of its importance to our everyday living should be increased.

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