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A Review on Applications of Biotechnology in Textile and Medical Industry

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Abstract

Our newspapers are filled with stories about ground-breaking discoveries in the field of biotechnology. Every single day new developments are emerging; the pace at which this field is evolving is astounding. When biological organisms and processes are used to create products that aid mankind, then the technology used to achieve this is called biotechnology. The advent of this field dates back thousands of years, when the farmers started to selectively breed their animals and crops, the use of yeast in the production of beer. Modern biotechnology however, took precedence in the late twentieth century due to breakthrough that the hereditary unit genes reside in the molecule called DNA (deoxyribonucleic acid). Watson and Crick along with Rosalind Franklin elucidated the structure of this miniature bio-molecule, initiating research into ways to manipulate it thereby creating molecular biology and genetic engineering, the modern day tools of biotechnology. Soon the genetic code and its relationship with proteins also known as the "Central dogma of life" was established; this is the basis of all the biotechnology research carried out today right from GM crops to transgenic animals. We have all heard about mystic marvel 'Dolly the Sheep' (2003) first ever genetically cloned mammal, she was created by somatic cell nucleus transfer, the technique where nucleus of a mature adult cell is transferred into an oocyte, followed by electric shock therapy that stimulates the cell of divide. This showed that adult somatic cells have the attribute of reverting to the embryonic stages. Thousands of such developments are emerging every day. This article gives a brief overview of the various applications of biotechnology in diverse fields and the current research being carried out in the same.

Introduction

Biotechnology as a discipline has found use in every sphere of life, be it medicine, agriculture, food technology, pharmaceutical industry or environmental science. It has managed to enrich the lives of mankind in various ways. Biotechnology has brought about a sea of change in the approach towards life, many exciting researches are being conducted worldwide and the results have been amazing. We all have had the oral polio vaccine as kids, but had never heard of vaccination via plants, this concept has been dwelled on for a long time and has become a success. Edible vaccines are pharmaceutical products manufactured by transgenic plants. Desired genes are introduced into plants and then these altered plants are induced to manufacture the encoded proteins. Oral delivery of vaccines reduces the cost of administration and the oral route many a times is more efficacious in nature. Edible vaccines for Hepatitis B have been developed and small scale clinical trials have also been carried out, these trials portrayed immunogenicity and safety. Biotechnology has played a crucial role in the bio-fuel industry. Bio-fuels are liquid or gaseous fuels derived from renewable biomass, they have great advantages as compared to fossil fuels and reduce pollution to a significant level and are a replenish able source of energy. Industrial biotechnology has played a key role in producing feedstock as well as in the conversion of biomass to biofuels. Various crops have been developed with increased biomass yield and prevent the losses from biotic and abiotic threats such as drought and salinity. Advanced biochemical biofuels have been developed by development of novel microorganisms and enzymes that aid in improving the efficiency of biomass breakdown and the release of sugar. Microorganisms that convert these sugars into biofuels have also been developed.

Biotechnology in Agriculture and food industry

Biotechnology has ample number of uses in agriculture; it is known as Agricultural biotechnology and involves the use of biotechnology in enhancement of crop productivity. For ages farmers have practiced the art of selective breeding to improve crop varieties; they used to select the best looking plants with desirable traits and breed them. Knowledge of cross breeding helped them create crops that improved qualities such as better yield, faster growth, larger seeds etc. An epitome of this would be the creation of disease resistant wheat produced by breeding different types of wheat till the desired trait was present in the new variety. However, in these conventional methods the crosses were done in an uncontrolled way, the farmers selected the crops and bred them but the recombination took place in a random manner leading to unpredictable results, also many unwanted traits were gained such as poor crop yield. Present day biotechnological practices in agriculture on the other hand are carried out in a more refined and controlled manner by using genetic engineering where specific sequences of DNA are transferred from one crop to the other with great precision. It is well known that plants reproduce sexually, the pollens from the same plant or another containing the male gamete fuses with the egg cell present in the flower, producing cells which have the ability to generate the entire plant. Unfortunately some plants take years to produce flowers and seeds, making plant improvement difficult. One of the methods developed to overcome this issue is tissue culture. Plant cells, tissues and organs are cultivated on a specialized media that provides all the nutrients and growth factors necessary for maintaining the cells. It is possible to generate an entire plant from a single cell, provided the right conditions are maintained. Depending on various explants used for the culture there are diverse types of

tissue culture such as anther culture, meristem culture, callus culture etc. Tissue culture is used for large scale plant propagation and disease elimination. In one recent study, virus free garlic plant was obtained by using meristem culture, this study compared shoot tip culture and meristem culture and used PCR to detect the viruses (2013). Along with genetic engineering tissue culture has been used to obtain a large amount of secondary metabolites, improved varieties and also crops that show resistance to salinity, draught and heat stress. Embryo culture is a new technique developed to avoid the problems associated with seed dormancy, production of haploid species and rare species. Excised embryos are cultivated to produce entire plants, thereby reducing long dormancy periods. Endangered species can be conserved; one recent example is that of development of an in-vitro method for propagating Khaya grandifoliola by using embryo culture. In plants one of the major hurdles is sexual incompatibility; this has been overcome by protoplast fusion. This technique allows for the creation of hybrids that have improved properties. Viable hybrid citrus plants were produced by fusing the cells of two different related citrinae species. Tremendous breakthroughs have been observed in agricultural biotechnology, major one would be the GM (Genetically Modified) crops or transgenic crops that are produced using recombinant DNA technology. This method involves cutting of a vector DNA, inserting the gene of interest, transforming the recombinant DNA molecule into the host such that the host can express the gene that was inserted and produce the required protein. Enzymes are used for cutting and ligating the DNA molecules and various methods have been developed to help transform the host cell. The most common traits that have been incorporated into these modified crops are insect resistance, herbicide resistance, reduction of spoilage, resistance to diseases and better yield. The famous "Bt crops" are transgenic crops that confer insect resistance; they include Bt cotton, Bt eggplant, Bt corn and many more. Not only has this technique generated crops with better qualities but it is also possible to incorporate more than one trait into a plant (stacked traits). There are currently corn, cotton, and soybean crops with both herbicide and insect tolerance traits. Transgenic crops with combined traits are also available commercially such as the herbicide tolerant and insect resistant maize and cotton. A recent study has shown that introduction of CRISPR/cas system in plants confers them resistance to Geminiviridae a family of DNA viruses that cause tremendous damage to plant varieties, until now there was very little success in this area. Functional foods are foods that offer health benefits apart from the basic nutrition. These foods contain biologically active substances such as antioxidants that may lower the risks from certain diseases associated with aging. Biotechnology is used to develop such functional foods. Carotenoids are plant pigments. Some carotenoids are converted by the body into vitamin A. It has a crucial role in normal growth and development, immune system function, and vision. Transgenic crops have been developed that produce increased amounts of these carotenoids. In today's world we are all susceptible to the evils of pollution. Pollution generates a large amount of free radicals in our body. These radicals damage the DNA and proteins eventually lead to degenerative diseases and cancer. Antioxidants are important biological compounds that can protect the body by neutralizing the activity of free radicals. Antioxidants occur in different forms, phenolic compounds such as flavonoids and tocopherols being the most common. They are naturally found in most fruits and vegetables and are also found in coffee, tea, and red wine. Transgenic potatoes have been developed by Lukaszewicz and colleagues to enhance the flavonoid content.

Biotechnology in Medicine:

21st century is the era of biotechnology. It is the basis of modern medicine. Today our market is filled with an array of biotechnology products. Diseases for which there was once no cure are now having a solution. Preventive vaccines for rare diseases are also available. Biotechnology has facilitated the prevention, diagnosis and treatment of diverse diseases. Various tools of biotechnology are employed to diagnose diseases at the gene level, thus facilitating targeted treatment, avoiding unnecessary tests and has also aided in personalized medicine. Prenatal screening and genetic counselling have taken precedence. Knowledge is power and this power is conferred upon us by biotechnology. Biopharmaceuticals are medicines that are derived from biological sources. They are large, complex proteins or nucleic acids, obtained from tiny micro-organisms or from animals including humans. The cells used for production of these biopharmaceuticals depend on the type of protein. DNA carrying the gene encoding the therapeutic protein is introduced into the microbes via Recombinant DNA technology. The transformed cells are made to express the genes. Large scale production is carried out by using fermentation. This class of products are called "biologics". A multitude of diverse biopharmaceutical products are in the market today, they include blood, blood components, vaccines, hormones, antibodies, therapeutic proteins, nucleic acids etc. The most common human derived therapeutics are blood components, organs, tissue transplants, stem cells and etc. Biopharmaceutical drugs mimic compounds found within the body. They cure diseases and have fewer side effects. The first biopharmaceutical substance approved for therapeutic use was biosynthetic human insulin made via recombinant DNA technology in 1982. More than 150 biotech drugs (human insulin, interferons, human growth hormones and monoclonal antibodies, as well as thirteen blockbuster drugs) are currently marketed around the world. Therapeutic products are used on a large scale for targeting diverse types of diseases such as malaria, diabetes, cardiovascular diseases and cancer. Treatment for high risk diseases such as HIV have also been developed. Diagnosis of any disease is as important as treating and curing it. Many a times treatment for diseases

are available but we fail to diagnose them at an earlier stage. Early detection can save someone's life. Conventional methods include microscopy, culture of specimen and testing. These methods lack specificity and are highly time consuming in nature. Novel methods and biosensors are now available to diagnose diseases. Biosensors using antibodies are now in the limelight. Antibodies are products of our immune system and are highly specific in their action. They were used earlier to determine our blood groups and were given to patients having a weak immune system. This is known as "passive immunity". Today, antibody screening is done. If blood contains the particular antigen for a disease, it will give a reaction. Immunological kits have been developed to test for diverse diseases. Monoclonal antibodies are currently used for this purpose. Monoclonal antibodies are a preparation of antibodies so that it is highly specific to a single epitope of an antigen. They are employed in immunological assays like ELISA, immuno PCR wherein Mab's specific for an antigen is attached with a marker and used for identification of specific antigen. Immuno diagnosis of protozoal and parasitic diseases has significantly been improved by MAb technology. MAbs of diagnostic value have also been developed against Trichomonas vaginalis, Leishmania donovani, Trypanosoma congolense, Babesia bovis. With improved sensitivity and specificity of the diagnostic test system, MAbs have also been developed against a number of animal viruses viz., bovine herpes virus, cervine herpes virus type I, pseudo rabies virus, calf strain RIT 4237 (sub-group I) and human strain 82-561 (sub group 3) of rotavirus. The possibilities of using MAbs to CEA in scintigraphic diagnosis of tumours have been reported by Steenbeck and Markwardt in 1985 and their use in diagnostics and therapy of allergic diseases by Becker and Schlaak in 1989. They are also used in the diagnosis of lymphoid and myeloid malignancies, tissue typing, enzyme linked immunosorbent assay, radio immunoassay, serotyping of microorganisms, immunological intervention with passive antibody. Along with antibodies, nucleic acids are also being used for diagnosis. Specificity is key to any diagnostic technique. Nucleic acid-based diagnostics detect specific nucleic acids (i.e. DNA or RNA). In the case of infectious diseases, these tests detect DNA or RNA from the infecting organism. For non-infectious diseases, nucleic acid-based diagnostics may be used to detect a specific gene or the expression of a gene associated with disease. Nucleic acid hybridization reactions have been used to detect a variety of microbial pathogens in assay formats using extracted nucleic acids or tissue sections. Immunoassays and these nucleic acid based tests usually employ radio-isotopic labels, dyes or enzymes to show that a reaction has occurred. Modern molecular biotech techniques employed are PCR, RT-PCR, FISH, ELISA, Immunoassays and many more are continuously been developed. The uses of biotechnology and molecular biology in medicine are endless. Recently normal genes are being introduced into cells in place of defective ones. This technology is known as "gene therapy" and the ultimate goal of gene therapy is to correct genetic disorders. Scientists all around the world are studying genes and many of them have identified genes responsible for the corresponding genetic disorders. Gene therapy is the application of this knowledge to cure the resulting disorder at the fundamental level. Genes are DNA molecules that code for various proteins, which are the building blocks of the body. Sometimes, these genes undergo a process called "mutation". Mutation is the change in the sequence of DNA. It could be due to addition, deletion, insertion or translocation of DNA. The outcome of a mutation is that the protein does not function normally, or at times it gets degraded, resulting in various genetic disorders. Gene therapy treats diseases by "repairing" dysfunctional genes or by providing copies of missing genes. This is achieved by introducing normal genes via vectors. Viral DNA sequences have shown success in human trials. The vector transforms target cells, normal genes are expressed resulting in restoration of function. The first gene therapy on humans was performed by researchers at the National Institutes of Health in 1990. It was carried out on a 4 year old boy suffering from ADA deficiency. ADA (Adenosine deaminase deficiency) is a rare genetic disorder in which the child is immuno-deficient and is prone to repeated infections. This therapy at NIH was a success. Since 1990, this approach has been tested for diseases like cystic fibrosis, SCID, Gaucher's disease, Canavan's disease etc. In 2003, more than 600 gene therapy clinical trials were under way in the United States, they have shown that this method holds promise but has issues in terms of efficiency of gene transfer. This approach is limited by our lack of knowledge in terms of pathophysiology of the diseases and the appropriate vectors that should be used. If we can gain a better understanding in these aspects, we can perfect it.

We have all heard the term "stem cells". Magazines, medical journals, and TV advertisements everywhere we have come across this term. These cells are the cells present in our body, they are special owing to their traits of being able to divide indefinitely and to differentiate into any other type of cell. These cells have varying potencies, some are totipotent and can form any kind of cell, some multipotent, pluripotent while others are unipotent. With the aid of biotechnology and its tools, these cells can be trained to form a particular cell type, thus opening an arena of applications. Today umbilical cord cell banks are there where these stem cells are preserved so that they can be used in the future. Stem cells are used to test the efficacy and safety of medicinal drugs. Cancer cell lines are used for checking the effects of anti-tumour drugs. One of the major applications of stem cells is in cell based therapies and regenerative medicine. For ages we have transplanted tissues and organs, and faced the problems of rejection. Stem cells are now used for this purpose, tissues of cells can be grown from the host stem cells and the same can be transplanted when needed, thus averting the problems associated with graft rejection. Artificial skin grafts are developed and transplanted. Stem cell therapy can be used to treat diseases including, osteoarthritis,

spinal cord injury, stroke, burns, heart disease, macular degeneration, diabetes, and rheumatoid arthritis. Various studies are being carried out with stem cells. In one study carried out at Wisconsin- Madison, it was seen that neurons from human embryonic cells can send as well as receive nerve impulses when transplanted into mouse brain. This brings the use of human embryonic stem cells in treatment of neurological disorders to the forefront and gives a very convincing evidence. It shows that if we use HESC's for treating ALS, epilepsy, Alzheimer's, Parkinson's etc. the cells can fully integrate and behave like normal neurons on transplantation in brain.

Biotechnology in Environmental science

We humans have made everything around us ours. We have invaded the forests, land, the oceans as well as the space. Our activities have led to pollution of the air, the water as well as the land. As the residents of this planet, it is our responsibility to pay for the damage that we have done, we depend on the environment for our basic necessities of food, water and oxygen. We are prone to the dangers of pollution and measures have to be taken to protect ourselves as well as our surrounding environment. Biotechnology has also found its applications in this sector. Commonly known as "environmental biotechnology". It involves the development, use and regulation of biological systems for remediation of environments that are contaminated. We use a wide range of hazardous chemicals such as pesticides, dyes, surfactants, wood preservatives, dioxins, heavy metals etc. for various purposes. These get accumulated the soil and groundwater over the years. These are all potentially hazardous in nature and their degradation is absolutely essential. Biotechnological methods are used to overcome these problems. Bioremediation and biotransformation is the use of micro-organisms to degrade noxious chemicals. Oil spills have severe hazardous effects, microorganisms have been used to degrade these products. Bioremediation of petroleum products is achieved by using the enzymatic capabilities of hydrocarbon- degrading microbial populations. Textile industries release a large amount of dyes into the river waters. These are harmful to the aquatic life as well as terrestrial life. Bioremediation of such dyes can help control the level of such pollutants. Aerobic degradation of a mixture of textile azodyes and individual azodyes has been done by using two isolated strains (BF1 and BF2) and a strain of Pseudomonas putida. These and many other methods of bioremediation have been developed for the treatment of wastewater, heavy metals and other contaminants.

Applications of biotechnology in textile processing

Another main area where biotechnology has spread its wings is the textile industry. Cloths are one of the basic necessities of our species. Textile is an interdisciplinary area between natural sciences and engineering sciences. It is constantly growing, coming up with new technologies to give us better quality and diverse products. It is always in demand and in order to grow new techniques are being developed. The potential of biotechnology in textile industry has been realised and many research initiatives in this area have been undertaken. Biotechnology can be used for development of bio fibres, biodegradable polymers and fibres and also in the treatment of waste water and industrial effluents. Biotechnology can be used to improve the quality of the natural fibres by incorporating modified properties in the existing ones. One of the areas in which research is being carried out extensively is the improvement of crop productivity and development of resistance to insecticides, herbicides and other pesticides. The other area of scientific interest is in incorporation of superior qualities in terms of length, strength, colour and appearance. Natural fibres that are of particular interest to the textile industry are cotton, wool and silk. Cotton is still predominant in the market, but the major problems faced is the protection of these crops from various insects. Monsanto scientists extracted a toxin gene from the soil bacteria called "Bacillus thuringiensis (Bt)". They inserted this gene into the cells of cotton plant and produced caterpillar resistant variety. More potent and active Bt cotton's have been developed recently. One of the major breakthroughs of biotechnology has been the development of cotton with natural polyester such as polyhydroxybutyrate (PHB) inside their hollow core. About 1% polyester has been achieved, thereby increasing the heat retention ability of these fibres. Biotechnological methods can add control and specificity in polymer synthesis. Molecular biology and genetic engineering are the tools that are being used for this purpose. Specific polyamide and polyesters have been developed. Biotechnological systems have the ability to produce protein polymers with specific properties. If the nature of the naturally occurring proteins having high tensile strength and other properties is understood, we can manufacture protein polymers that are biodegradable in nature. Spider dragline silk is apparently the toughest biopolymer on Earth. It has incredible strength and elasticity. As it is biodegradable in nature, it is of particular interest. Large-scale production of recombinant silks can have an array of applications in the textile, biomedical and material science industry. Extensive research is being carried out towards understanding the nature of the proteins as well as the production of recombinant spider silk. Enzymes have diverse applications in the textile industry. These enzymes are manufactured on a large scale by using micro-organisms. They are used to fade denims or woven fabrics, as bio-scouring, bio-polishing, silk degumming and peroxide removing agents. They are also used in the washing of reactive dyes. Amylases are used in the elimination of starch size. Enzymes have also found utility in various finishing processes. The effluents and waste released from the textile industry

contains a lot of hazardous chemicals including dyes, micro-organisms are being used for bioremediation of these wastes. A lot of time and energy can be saved by the use biotechnology and its multifarious tools in textile industry.

REFERENCES

[1]. Okere AU, Adegey A (2011) In vitro propagation of an endangered medicinal timber species Khaya grandifoliola C. Dc. Afr. J. Biotechnol. 10(17): 3335-3339.
[2]. Motomura T, Hidaka T, Akihama T, Omura M (1997) Protoplast fusion for production of hybrid plants between citrus and its related genera. J. Japan. Soc. Hort. Sci. 65: 685- 692.
[3]. Ason P. Weick, Yan Liu, and Su-Chun Zhang. Human embryonic stem cell-derived neurons adopt and regulate the activity of an established neural network, PNAS 2011 108 (50) 20189-20194.
[4]. Wang, W., Zhang, Z., Ni, H., Yang, X., Li, Q., & Li, L. (2012). Decolorization of industrial synthetic dyes using engineered Pseudomonas putida cells with surface-immobilized bacterial laccase. Microbial Cell Factories, 11, 75. http://doi.org/10.1186/1475-2859-11-75.
[5]. Lukaszewicz, M., Matysiak-Kata, I., Skala, J., Fecka, I., Cisowski, W., & Szopa, J. (2004). Antioxidant capacity manipulation in transgenic potato tuber by changes in phenolic compounds content. Journal of Agricultural and Food Chemistry, 52(6), 1526-1533.