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Development of Biotechnology Research in India

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The Department of Biotechnology (DBT) is the nodal agency supporting research and it's applications in life sciences, promotes and accelerates the pace of development and large scale use of biotechnology in the country. The setting up of DBT in 1986 gave a new impetus to the development in the field of modern biology and biotechnology in India. In more than three decades of its existence the department has promoted and accelerated the developments in agriculture, health care, animal sciences, environment and industry. It has achieved significant milestones in biotechnology encompassing vaccine production, genetic engineering. Pharmaceuticals, bioinformatics, bioprocessing and stem cell research. These accomplishments have far reaching implications for uplifting the devastated sections of Indian society. The biopharmaceutical, bio agriculture, bio IT and bio services are the biggest successful sectors suppliers of low cost drugs, agricultural inputs and services worldwide. It also leads to biosimilars with the most number of biosimilars approved in the domestic market.

The DBT developed Biotechnology Strategy Document, outlines India's strength and confidence in delivering a knowledge driven bio economy. It has a mission to make India globally competitive in biotechnology research, innovation, translation, entrepreneurship development and industrial growth with an expectation of USD 150 billion bio economy by 2025. India among the top 12 destinations of biotechnology development countries sharing with approximately 3 percent share in the global biotechnology industry. It also ranked 52nd according to the global innovation index report 2019.

In India, Bangalore is widely recognized as India's leading biotechnology hub with some of the largest companies in the country. As of 2023, there are about 160 biotechnology companies in India engaged in development and production of various products and processes. These industries valued at over 92 billion dollars and expected to reach a market value of 300 billion dollars by 2030. The growth of industry would be driven by increasing demand for vaccines and pharmaceuticals in the domestic and international markets. Biotechnology has many regulatory and ethical issues to be addressed seriously. Therefore with the rapid expansion of biotechnology industry and its expansion in the vast range of fields, a color coded system has been developed to easily identify the primary areas of biotechnological research. There are four major area of biotechnology represented as white, green, blue and red. The white biotechnology revolves primarily around the use of biocatalysts for the industrial scale production and processing of products; involving the production and processing of products, biodegradable polymers and renewable fuel to encourage a more sustainable system.

Red biotechnology covers application of biotechnology related to clinical trials, vaccine development, disease research, antibiotic production, drug development and molecular diagnostics. The future of red biotechnology is likely to involve the expansion of genetics- focused areas such as gene therapy and regeneration medicine.

Green biotechnology plays a key role in increased production of food to meet the demand of an increasing population as well as developing less environmentally damaged fertilizers and bio pesticides. The genetic modification of plants and advancements in the field of agriculture is allowing the production of crops that can tolerate to the range of adverse environmental conditions, show resistance to insects, pests and herbicides, as well as produce increased yields.

Blue biotechnology applies to oceans and seas aims to utilize develop new products to benefit the society and the environment. It has important roles in the production of many enzymes and proteins that have been used in numerous applications from biodegradable plastics to medical products.

For thousands of **years** man has been involved in such activities as brewing, food preservation and modification of food by fermentation (cheese vinegar etc.), the manufacture of perfumes from aromatic powers

and invention of primitive medications. The discovery of genetic engineering techniques via recombinant DNA technology, is responsible for the current biotechnology boom. Ago, scientists have isolated and manipulated genes and have cloned to create life itself. The work of several brilliant scientists around 1950 led to the acceptance of a chemical compound deoxyribonucleic acid (DNA) as the magic substance of the gene which controls all characters of an organism. The unravelling of the DNA double helix was one of the great events in science comparable to the splitting of the atom or the publication of Darwin's 'Origin of Species'. It also marked the coming of age of a bold new science, Molecular Biology. At present, this has become one of the most active, exciting and productive arenas of science that has cornered much of the limelight focused on scientific developments and, naturally, has attracted some of the best talents.

Science of Molecular Biology entered Indian laboratories as early as 1960s, when basic training was being imparted on understanding of DNA structure and mechanism of its action in test tubes, mostly using bacterial system. The Indian biotechnology industry felt essential to have a wide range of career opportunities including pharmaceuticals, agriculture, environmental science and many others. The first Indian biotechnology company to be established was Biocon which was founded by Kiran Majumdar- Shaw in 1978. This has created awareness and need to boost the biotechnology in the country with growing demand of biotechnology engineers and professionals having great scope for research, development and innovation offering a promising rewarding career path.

Plant genetic engineering is important area in biotechnology, which has progressed to a great extent in India. Inserting and expressing useful foreign genes have genetically transformed several plant species. Genetic engineering requires development of tissue culture techniques for regenerating a complete plant from a single cell or a protoplast or a group of tissues as well as cloning, sequencing and developing of proper techniques of gene targeting in the plant. Scientists at several laboratories in India such as in JNU, New Delhi, Bose Institute, Calcutta, National Botanical Research Institute, Luck now, have cloned and sequenced many useful genes, which are involved in providing resistance to diseases as well as stress conditions. Besides storage, protein genes and genes involved in amino acid biosynthesis have also been cloned in JNU and inserted in legumes, rice and potato.

Department of Biotechnology has developed seven centers of Plant Molecular Biology for generating improved varieties of plants through unconventional breeding techniques. These are at the JNU, New Delhi; South Campus, Delhi University; NBRI, Lucknow; MKU-Coimbatore and Bose Institute - Calcutta. All the centers have produced excellent results within a span of seven years. In plant tissue culture, India has always been at the forefront as compared to the rest of the world. A novel technique of test-tube fertilization was developed in Delhi University to overcome incomparability in plants, which is exhibited during wide crossing. This technique developed are being employed in many laboratories in all parts of the world. Another landmark research in plant breeding and genetics was the production of haploids through another culture of Datura achieved for the first time, again at Delhi University. Many countries especially China, employed the technique of another culture developed by the Indian scientists on a war footing to improve the crop plants. NCL scientists demonstrated flowering of bamboo, which is a rare phenomenon, in the 1980s. Development of triploid plants through endosperm culture was also first reported from Delhi University in the 1970s. Triploid plants produce seedless juicy fruits, an example of which is juicy triploid watermelon. Protocols have been developed for clonal multiplication of hundreds of plant species, which include trees, medicinal and aromatic plants, and endangered species, from several laboratories across the country. Department of Biotechnology has established two major Tissue Culture Pilot Plants - one in Haryana and the other in Maharashtra. Over 12 lakh plantlets of forest trees have been produced for field trials.

For more accurate diagnosis of diseases and vaccination DBT took up in 1987 the task of producing immune-diagnostic kits and vaccines for both communicable as well as non-communicable diseases. A number of detection kits developed by scientists of various institutions have been purchased by industries. This has resulted in continuous interaction between the institutes and the industry, which is of great advantage to the society. Researches on vaccine production are also showing excellent progress. Under the Indo-US Vaccine Action Programme, the project on Hepatitis C and Rota Viral diarrhea for development of a diagnostic kit and a candidate vaccine strain has shown impressive results.

Biotechnological research has now become a very important factor for increasing the productivity and profitability of farming systems, as modern agriculture depends heavily on fertilizers and pesticides, particularly in high yielding crop varieties. Various technologies for large-scale production of bio fertilizers, which utilize blue green algae and nitrogen fixing bacteria, have been developed in several research institutes. Bio fertilizers

do not lead to pollution of soil and ground water. It will not be out of place to mention must an outstanding research on in vitro fertilization for producing a human baby in Calcutta in 1978. This research resulted in India's first and the world's second test-tube baby. There was no modern biotech products (rDNA based) manufactured or imported in India before the establishment of DBT. The country having an established fermentation based products such as ethyl alcohol production from molasses and few number of antibiotics like penicillin, streptomycin, tetracycline's products of conventional nature were available. Also some bio fertilizers based formulations and natural isolates of microbes, composting and biogas production facilities including vermicomposting production etc. The manpower generated through skill development helped use microbes and the microbiologist in promotion of conventional biotechnology. Role of chemical and biochemical engineers and technologists were in the forefront of biotechnology industry promotion. In agriculture, animal husbandry and fisheries sector, there were no rDNA based products or substances and production of hybrid seeds as well as high yielding planting materials by tissue culture were considered as agricultural activities. It was difficult to obtain monitory support from financial institutions as well as from banks for pursuing agriculture based activities.

DBT played a pivotal role in recommending such activities to be included as industrial activities and there was no modern biotech products (rDNA based) manufactured or imported in India before the establishment of DBT. The country having an established fermentation based products such as ethyl alcohol production from molasses and few number of antibiotics like penicillin, streptomycin, tetracycline's products of conventional nature were available. Also some bio fertilizers based formulations and natural isolates of microbes, composting and biogas production facilities including vermicomposting production etc. The manpower generated through skill development helped use microbes and the microbiologist in promotion of conventional biotechnology. Role of chemical and biochemical engineers and technologists were in the forefront of biotechnology industry promotion. In agriculture, animal husbandry and fisheries sector, there were no rDNA based products or substances and production of hybrid seeds as well as high yielding planting materials by tissue culture were considered as agricultural activities. It was difficult to obtain monitory support from financial institutions as well as from banks for pursuing agriculture based activities.

The recommendations were accepted by Ministry of Industry in its new licensing policies. In order to assess and control the new developments of biotechnology and to handle the accompanying ethical issues, environmental concerns, human health and potential physical damages, DBT in 2013, has established Biotechnology Regulatory Authority of India(BRAI). This body improves the regulations of biotechnology products including genetically modified organisms (GMOs) and the biotech products/ process development with an ultimate objective to oversee and govern biotechnology in India. With these establishments DBT setting up of a strong modern biotech industry and skill development suitable to high class R& D, institutional infrastructure, pilot plants and the establishments of biotech parks and incubators within the country. Biotechnology is offering solutions to address global challenges such as combating the spread of infectious diseases, reducing hunger, climate change and remediating environmental degradation, green fuel development etc. Initially, DBT didn't have institutions like ICAR, ICMR or CSIR but in nineties it has done well to support the institutions by allocation of funds to several biotechnology research based activities. As such DBT has set up 14 autonomous institutions to pursue research in various interdisciplinary areas of biotechnology for persuasion of R&D and product/ process development under the research mandate of the Institute. These institutes also supports joint ventures national and international research collaborations. With the change of time, now DBT has merged its institutions into an apex body called the Biotechnology Research and Innovation Council (BRIC) with an aim of streamlining governance and outcome in related research activities.

India holds a fairly good share of global biotech market and has all the capabilities to dominant player in biotech industry. Consumption of biotech products is expected to quadruple in the next decade. India has rich human capital for this knowledge based industry and has competency in various areas of biotechnology. India being a significant player on the global arena projected to capture good biotech market share from its 3 percent to its much higher level. The biotech strategy of India covers small business incubation research funding. Human research development, establishment of regional technology centers and Centers of Excellence & Innovation. Technology transfer with academic- industry linkages through public- private partnership strengthening the biotechnology development in the country. Also collaborations among Indian institutions as well as international agencies, including bilateral and multilateral promoted shown promising leads. It is now quite apparent that India has made big strides in the realm of biotechnology and holds out great promise for a better future.