UNIT 2 EX-SITU CONSERVATION

Structure

5.0 INTRODUCTION

For much of the time man lived in a hunter-gather society and thus depended entirely on biodiversity for sustenance. But, with the increased dependence on agriculture and industrialisation, the emphasis on biodiversity has decreased. Indeed, the biodiversity, in wild and domesticated forms, is the sources for most of humanity food, medicine, clothing and housing, much of the cultural diversity and most of the intellectual and spiritual inspiration. It is, without doubt, the very basis of life. Further that, a quarter of the earth's total biological diversity amounting to a million species, which might be useful to mankind in one way or other, is in serious risk of extinction over the next 2-3 decades. On realisation that the erosion of biodiversity may threaten the very extinction of life has awaked man to take steps to conserve it.

During the last decade, the IUCN have developed strategies for Conservation of Nature and Natural Resources with hold up from World Bank and other institutions. On the whole, the conservation plan has a holistic approach and encompasses whole spectrum of biota and activities ranging from ecosystems at the macro level (*in-situ* conservation) to DNA libraries at the molecular level (*ex-situ* conservation).

Definiton

Ex-situ conservation literally means, "off-site conservation". It is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans. While *ex-situ* conservation comprises some of the oldest and best known conservation methods, it also involves newer, sometimes controversial laboratory methods.

Ex situ conservation, using sample populations, is done through establishment of gene banks, whih include genetic resources centres, zoo's, botanical gardens, cultue collections etc.

5.1 ADVANATAGES OF *EX-SITU* CONSERVATION

The conservation of biodiversity can be achieved through an integrated approach balancing *in situ* and *ex situ* conservation strategies. The preservation of species *in situ* offers all the advantages of allowing natural selection to act, which cannot be recreated *ex situ*. The maintenance of viable and self-sustainable populations of wild species in their natural state represents the ultimate goal, but habitat destruction is inevitable and endangered species need to be preserved before they become extinct. *Ex situ* conservation provide the opportunity to study the biology of, and understand the threats to, endangered species in order to eventually consider successful species recovery programmes, which would include restoration and reintroduction. It also has the advantage of preserving plant

material and making it available for research purposes, without damaging the natural populations. Their conservation *ex situ* is therefore complementary to *in situ* conservation and can act as an "insurance policy" when species are threatened in their natural habitats It is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans.

Ex-situ conservation has several purposes:

- Rescue threatened germplasm.
- Produce material for conservation biology research.
- Bulk up germplasm for storage in various forms of ex situ facility.
- Supply material for various purposes to remove or reduce pressure from wild collecting.
- Grow those species with recalcitrant seeds that cannot be maintained in a seed store.
- Make available material for conservation education and display.
- Produce material for reintroduction, reinforcement, habitat restoration and management.

5.2 OBJECTIVE

The main obective of this unit is to give you a picture of present scenario of ex-situ conervation of biological resources and recently development in this field. The major objectives of present study are:

a. To understad the varioous components of *ex-situ* conservation of biological diversity;
b. To stuy the mechanism of *ex-situ* conservation and strategies for conservation of plants, animals and micro-organisms;
c. To study the conservation process of threatened species;
d. To study the institutional mechanism of *ex-situ* conservation in India.

5.3 PRINCIPLES AND PRACTICES

Ex-situ conservation is the chief mode for preservation of genetic resources, which may include both cultivated and wild material. Generally seeds or *in-vitro* maintained plant cells, tissue and organs are preserved under appropriate conditions for long term' storage as gene bank. This requires considerable knowledge of the genetic structure of population sampling techniques, methods of regeneration and maintenance of variety of gene pools, particularly in cross-pollinated plants.

These *ex-situ* collections of living organisms (living collections, seed banks, pollen, vegetative propagules, tissue or cell cultures) need to be managed according to strict scientific and horticultural standards to maximise their value for conservation purposes. Thus they need to be correctly identified, documented and managed and an efficient information management system put in place. Integrated conservation management can also ensure that *ex-situ* collections can support *in-situ* conservation, through habitat restoration and species recovery.

There are two ways or modes of *Ex-situ* conservation.

1. Conventional methods
2. Biotechnological aspects.

5.4 CONVENTIONAL METHODS OF EX-SITU CONSERVATION

5.4.1 Gene Banks

Plant genetic resources gene banks store, maintain and reproduce living samples of the world's huge diversity of crop varieties and their wild relatives. They ensure that the varieties and landraces of the crops and their wild relatives that underpin our food supply are both secure in the long term and available for use by farmers, plant breeders and researchers.

Gene banks conserve genetic resources. The most fundamental activity in a gene bank is to treat a new sample in a way that will prolong its viability as long as possible while ensuring its quality. The samples (or accessions as they are called) are monitored to ensure that they are not losing viability. A cornerstone of gene bank operations is the reproduction-called regeneration-of its plant material. Plant samples must periodically be grown out, regenerated, and new seed harvested because, even under the best of conservation conditions, samples will eventually die.

To conserve and regenerate genetic resources, gene banks first must collect genetic resources. But gene banks aren't built just to conserve genetic resources; they are intended to ensure that these resources are used, whether it is in farmers' fields, breeding programmes or in research institutions. This means making sure the collections are properly characterized and documented; and that the documentation is available to those who need it. The information systems used by gene banks are becoming increasingly important tools for researchers and breeders seeking data on the distribution of crops and their wild relatives.

5.4.2 Community seed banks

Seed banks don't have to be high-tech and managed by governments or businesses. Germplasm conservation in the form of seed inmost convenient since seeds occupy a relatively small space. Their transport to various introduction centers and gene banks is also economical but the draw backs in conservation by seed are :

1. Loss of viability over passage of time and susceptibility to insect or pathogen attack.
2. Inability to maintain distinct clones except for inbreed and apomicts species.
3. Non-applicability to vegetatively propagated crop e.g. *Dioscorea, Ipomoea, potato* etc.

In many developing countries, farmers rely on informal seed systems based on local growers retention of seed from previous harvests, storage, treatment and exchange of this seed within and between communities. The informal seed sector is typically based on indigenous structures for information flow and exchange of seed. Seed banks managed within this local seed system operate on a small scale at the community level with few resources.

These community seed banks and the institutions that support them are extremely important in the preservation of local varieties and for agricultural production. Much could be gained from learning more about these seed banks and working with communities to improve them. In spite of this, informal seed banks have until now received little attention or support from the scientific community or the state.

5.4.3 Seed Banks

Undeniably, the most cost-effective method of providing plant genetic resources for long-term *ex situ* conservation is through the storage of seeds under very specific conditions, following techniques well developed for crop plants by organisations such as the International Plant Genetic Resources Institute (IPGRI), previously the International Board of Plant Genetic Resources (IBPGR) and the Food and Agricultural Organisation of the United Nations (FAO). The main advantage of seed banking is that it allows large populations to be preserved and genetic erosion to be minimised by providing optimum conditions and reducing the need for regeneration (Given, 1987).

Endangered plants may also be preserved in part through seedbanks or germplasm banks. The term seedbank sometimes refers to a cryogenic laboratory facility in which the seeds of certain species can be preserved for up to a century or more without losing their fertility. It can also be used to refer to a special type of arboretum where seeds are harvested and the crop is rotated. For plants that cannot be preserved in seedbanks, the only other option for preserving germplasm is in-vitro storage, where cuttings of plants are kept under strict conditions in glass tubes and vessels.

However, when a natural population still exists, it may be advisable to re-collect rather than regenerate a new supply from the previous collection as damage can occur such as mutations associated with the loss of viability during storage. The success of long-term conservation of seeds is dependant on continuous viability monitoring and regeneration or re-collection when the viability of the sample drops below a minimum level (Eberhart, Roos & Towill, 1991). It is important to realize that however much care is taken during seed collection, regeneration and storage, natural selection cannot be simulated and some artificial selection will be unavoidable, which inevitably leads to unpredictable genetic changes (Ashton, 1988).

The recommended preferred standards for long-term seed storage of orthodox species recommended by IPGRI is to dry the seeds to a moisture content of below 7% and seal the dried seeds in a moisture-proof container such as laminated foil bags, aluminium cans or glass jars for storage at a low temperature of -18ºC. Clearly this is only applied to true orthodox species of crops and their relatives. However because less is known about wild species, a temperature of -4ºC and moisture content of 7-8% is advisable to begin with. The activities in seed banks should take the following sequence: collection, seed preparation, seed drying, packaging, storage, periodic germination tests, seed regeneration, re-storage and documentation at each stage of activity.

When plant species are recalcitrant or long-term conservation cannot be achieved through seed banking, different methods have been developed with their respective merits, such as field gene banks, in vitro germplasm collections, pollen and DNA banks. This is in many cases the main problem faced by botanic gardens dealing with many different species of which, a great proportion are be recalcitrant. They need to develop complementary conservation techniques and adopt different methods.

Example

1. Indian clover, *Trifolium amoenum*, is an example of a species that was thought to be extinct, but was rediscovered in 1993 by Peter Connors in the form of a single plant a site in western Sonoma County. Connors harvested seeds and grew specimens of this critically endangered species in a controlled environment.
2. A tank of liquid nitrogen, used to supply a cryogenic freezer (for storing laboratory samples at a temperature of about −150 degrees Celsius).
3. The Wollemi Pine is an another example of a plant that is being preserved via *Ex-situ* conservation, as they are being grown in nurseries to be sold to the general public.

Ex-situ conservation of plant genetic resources can be achieved through different methods such as seed banks, field gene banks, *in vitro* storage methods, pollen banks and DNA banks. The major consideration for long-term conservation of germplasm collections is the determination of the seed behavior of each individual species to be

preserved during storage under dry conditions and cold temperatures. If the seeds can be dried to a low percentage humidity such as below 8%, in the majority of cases, the seeds will then withstand very cold temperatures of below 20ºC. When the seeds tolerate these conditions and remain viable after many years of storage, they are classified as orthodox (desiccation tolerant) as opposed to recalcitrant (desiccation intolerant) when they do not. However, there might be many other reasons why a particular species cannot be preserved in seed banks, such as a very low production of seed or long-life cycle species, such as trees and perennials. Their conservation as seeds would make the study of their biology difficult.

5.4.4 Botanical gardens

Botanical gardens and zoos are the most conventional methods of ex-situ conservation, all of which house whole, protected specimens for breeding and reintroduction into the wild when necessary and possible. These facilities provide not only housing and care for specimens of endangered species, but also have an educational value. They inform the public of the threatened status of endangered species and of those factors which cause the threat, with the hope of creating public interest in stopping and reversing those factors which jeopardize a species' survival in the first place. They are the most publicly visited ex-situ conservation sites.

The history of botanic gardens can be traced as far back as the Hanging Gardens of Babylon, built by Nebuchadnezzar in 570 BC as a gift to his wife. Early botanic gardens were designed mainly for the purpose of recreation. By the 16th Century, however, they had also become important centers for research. They promoted the study of taxonomy and became a focal point for the study of aromatic and medicinal plants. More recently, they have taken on significant conservation responsibilities and they often have conservation facilities, such as seed banks and tissue culture units.

Botanical gardens hold living collections. Indeed botanical garden conservation could be considered as field gene bank or seed gene bank or both, depending on the conservation method being used. However, they tend to focus their conservation efforts on wild, ornamental, rare and endangered species. Most of the germplasm conserved in botanical gardens do not belong to the plant genetic resources for food and agriculture.

A botanic garden which wishes to start a small seed bank /gene bank would be advised to start with collecting germplasm that is very well documented from their living plant collection. This would allow them to experiment with a wide range of species and find suitable facilities and techniques for their particular needs. Once the set up is organised and functional, it would be advisable to collect accessions directly from the wild in order to distribute a wider genetic variability and to reduce the effect of domestication on the genetic make up of the accessions.

Last two hundred years, efforts of botanic gardens in collecting plant material, and the great efforts on crop germplasm collection during the 1970s and the 1980s, there are a large number of gene banks and germplasm collections around the world. According to the FAO and World Information & Early Warning System (WIEWS) database, it is estimated that there are now more than 2000 botanic gardens known around the world in over 150 countries. Together, they maintain more than 6 million accessions in their living collections and 142 million herbaria specimens in the botanic garden herbaria. 60% of the total numbers of accessions are known to be stored in medium-term or long-term facilities, 8% in short-term facilities and 10% in field gene banks, in vitro and under cryopreservation. Clearly, seed storage is the predominant form of plant genetic resource conservation, accounting for about 90% of the total accessions held *ex situ*.

It is very difficult to give an estimate of the type of collections stored around the world as such information is known for only a third of the accessions in the WIEWS database. However, it has been estimated that 48% of all accessions are advanced cultivars or breeders' lines, while over a third are landraces or old cultivars and about 15% are wild or weedy plants or crop relatives.

Some famous botanic gardens/ research centers/ institutes

International

1. **Royal Botanical Garden, Kew, England :** Largest botanical garden in world and its herbarium is also largest in world, having 6 million specimen.
2. **CIAT :** International Center for Tropical Agriculture located at Palmira, Columbia
3. **ICARDA :** International Center for Agriculture Research in Dry Areas located at Allepo, Syria
4. **ICRISAT :** International Center for Agriculture Research for Semi Arid Tropics located at Patencheru, (Hyderabad) India.
5. **IRRI :** International Rice Research Institute located at Manila, Philippines.
6. **CITES :** Convention on International Trade in Endangered Species of Wild Fauna and Flora.

National

1. **Indian Botanical Garden, Calcutta :** Largest Botanical Garden in India and its herbarium is largest in India, having 1 million specimen
2. **NBRI :** National Botanical Research Institute located at Lucknow (UP) formally known as National Botanical Garden.
3. **BSI** : Botanical Survey of India started working in 1890 and is connected with plant exploration and writing up of regional floras and also preparation of flora of India.

4. **IARI** : Indian Agricultural Research Institute or **Pusa Institute** located at New Delhi. It was initially established at village Pusa in Darbhanga District of Bihar in 1905 under the name **Imperial Agricultural Research Institute**. After a severe earthquake, this institute was shifted to New Delhi in 1936 under the same name. But after independence, it was renamed as Indian Agricultural Research Institute.
5. **FRI** : Forest Research Institute located at Dehradun (Uttarakhand), established in 1906 under name Imperial Forest Research Institute (IFRI), but after independence, name was changed to FI. This institute is connected with researchers on different aspects of forest trees and also provides training to forest officers.

5.4.5 Field Gene banks

Field gene banks or living collections are the main conservation strategy for long-lived perennials, recalcitrant species and vegetatively propagated species. Their main limitation is that they take a great deal of space and are difficult to maintain and protect from natural disasters. They are susceptible to the spread of diseases and may suffer from neglect. Furthermore, out-breeders require controlled pollination for regeneration from seed. In many circumstances they are the only available option for the conservation of important germplasm. When displayed, the plants have an important educational value and can easily be accessed for research purposes.

The conservation of germplasm in field gene banks involves the collecting of materials and planting in the orchard or field in another location. Field gene banks have traditionally been used for perennial plants, including:

- species producing recalcitrant seeds;
- species producing little or no seeds;
- species that are preferably stored as clonal material; and
- species that have a long life cycle to generate breeding and/or planting material.

Field gene banks are commonly used for such species as cocoa, rubber, coconut, coffee, sugarcane, banana, tuber crops, tropical and temperate fruits, vegetatively propagated crops, such as wild onion and garlic, and forage grasses.

5.5 BIOTECHNOLOGY METHOD OF EX-SITU CONSERVATION

Biotechnology is the *third wave* in biological sciences and represents such an interface of basic and applied sciences, where gradual and subtle transformation of science into technology can be witness. Biotechnology is also defined as the applications of scientific and engineering principles to the processing of material by biological agents to provide goods and services. United States Congress's office of Technology Assessment defined biotechnology as any technique that used living organisms to make or modify a product,

to improve plants or animals or to develop microorganisms for specific used. The document focuses on the development and application of modern biotechnology based on new enabling techniques or recombinant-DNA technology, often referred to as genetic engineering.

Since biotechnology involves the use of all life forms for human welfare. Therefore, extinction of wild species and destruction of ecosystems has been a major concern of policy markers and environmentalists. A discussion on biotechnology involving biodiversity is relevant, because biodiversity is being utilized to provide genes from wild species for biotechnological exercises.

Several biotechnological tools are now available to tackle various specific problems and to enhance the potentials of grass covers such as feeding value, propagation and persistence. Basically, in range grasses, several tools of biotechnology, comprising endosperm and anther culture, somaclonal variation protoplast culture and fusion, transformation, etc., can address breaking the apomictic barrier for recombination for recombination of desired traits. The grass biotechnologists are actively engaged to achieve this goal. Besides, the mapping of genes, isolation, cloning and characterization of important genes/ traits in range species as well as in other crops can ultimately improves the value of grass cover through genetic transformation in the pasture species. It is envisaged that by following these approaches anti-quality factors can be suppressed and the digestibility of allows even tracking the genes for polyphonic traits and the metric traits like seed production; the biomass would also be hopefully improved. The current certainly go a long way in adding to the fertility and diversity of grass covers. Propagation of specific genotypes of endangered but useful species on a large scale in a short time frame is possible through the modern biotechnological approaches.

5.5.1 *In-vitro* Conservation

Conservation *in-vitro* is wholly dependent upon the techniques of plant cell, tissue and organ culture, and is appropriate in situations where conventional seed storage cannot or is not to be employed.

In particular *in-vitro* conservation used for vegetatively propagated material species with recalcitrant seed and material biology. This later material may have been costly and limited in quantity and have characteristics whose stability during repeated mitotic divisions and following meiosis are unknown. It is, therefore prudent to conserve stocks of this material to ensure consistency in subsequent experimentation of production processes, and as definitive source of reference material.

The material stored *in vitro* may be protoplast, isolated cells grown in suspension or on semi-solid medium, meristem cultures at various stages of development or organized plantlet. It can be assumed that genetic stability within the in-vitro systems increase as the complexity of the cultured material, with completely differentiated plantlets in culture

having the least risk of genetic alteration during an in-vitro excursion (Karp, 1989). Consequently, if the storage conditions are to permit some level of growth and metabolic activity then organized plantlets are the conservation material of choice, but where growth is to be completely inhabited as in cryopreservation excersied shoot meristems may be the more suitable explains (Ford-Lloyd and Jackson, 1986; Wihters, 1987) where cell or protoplast cultures are to be maintained and there is no choice as to a preferred level of organization then care must be taken to ensure the maximum genetic stability, preferable by opting for cryopreservation.

At the simplest level conservation *in-vitro* is achieved by repeated sub-culture continuing the protection from adverse environmental conditions and pathogens that is inherent in the in-vitro systems. This is expensive both in terms of labour and the basic material of the culture process and whilst least demanding in terms of the level of available technology, has a considerable risk of material loss due to human error or the failure in-vitro security e.g. the invasion of pathogen during transfer.

Mode of propagation

There is large number of threatened/ rare/ endangered plant species on which in-vitro propagation of threatened plants could be achieved by the following methods.

1. Clonal propagation
2. Somatic embryogenesis
3. Organogenesis
4. Callus differentiation

Table : In-vitro regeneration of threatened/ rare/ endangered plant species

Name of Plants	Explant Used	Medium	Mode of Regeneration
Aconitum carmichaeli	Shoot tips & axillary buds	MS	Clonal multiplication
Aconitum nepellus	Nodal shoot	MS	Axillary shoot proliferation
Aconitum noveboraacense	Nodal shoot	MS	Axillary shoot proliferation
Anogeissus sericea	Nodal segment (seedling explant)	MS	Axillary shoot proliferation
Caralluma edulis	Shoot segments	MS	Clonal multiplication
Commiphora wightii	Shoot segments	MS	Axillary shoot proliferation
Coptis teeta	Hypocotyl segment	MS	Callus culture

Feronia limonia	Axillary branching	MS	Axillary shoot proliferation
Gerbera aurantiaca	Axillary bud	MS	Axillary shoot proliferation
Nepenthes khasiana	Mature nodal segment	MS	Axillary shoot proliferation
Nepenthes khasiana	Axillary bud	MS or wood pt. medium	Axillary shoot proliferation
Ocotea catharinensis	Zygotic embryos	MS	Somatic embryogenesis
Oncidium catharinensis	Seedling	Knudson medium	Root tip culture
Picorrhiza kurroa	Axillary bud	MS	Axillary shoot proliferation
Podophyllum hexandrum	Zygotic embryos	MS	Somatic embryogenesis
Rauvolfia serpentine	Low temperature	MS	Storage
Rheum embodi	Axillary bud	liquid	Axillary shoot proliferation
Rumex acetosella	Axillary bud	MS	Somatic embryogenesis
Santalum album	Zygotic embryos	MS	Somatic embryogenesis
Trichopus zeyanicus	Axillary bud	MS	Axillary shoot proliferation
Valeriana wallichii	Axillary bud	MS	Callus culture
Wrightia tomentosa	Axillary bud	MS	Axillary shoot proliferation

5.5.2 *In-Vitro* Storage of Germplasm and Cryopreservation

Assuming that differentiated plantlets are to be stored in-vitro, with all that this implies for genetic stability and then lowering growth temperature to slow metabolism and development has previously reduced the labour and expense for repeated subculture. The security of the culture is also improved as the frequency of the physical interventions of subculture is also reduced. Similarly, the use of osmotic stress and the addition of growth retardant to the culture medium have effectively prolonged the interval between culture transfers (Wither 1987; Prithcard et al., 1986).

The greatest genetic stability is achieved by storage of propagules, capable of regeneration in-vitro liquid nitrogen i.e. **cryopreservation** (kartha 1985) where possible

these propagules will be excised meristems, capable of direct regeneration into plantlets, but they amy, of necessary, by isolated cells or protoplasts.

Cryopreservation

In this system stability is imposed by ultra low temperature and storage is at, or close to -196^{0}C using liquid Nitrogen (or the vapour immediately above it), as practical and convenient oxygen. At such temperature normal cellular chemical reactions do not occur as energy level are too low to allow sufficient molecular motion to complete the reaction. Water exists either in a crystalline or glassy state under these conditions and such high viscosity (> 1013 poises) that rates of diffusion are insignificant over time spans measured at least as decades. The majority of the chemical changes that might occur in a cell are therefore; effectively prevented and so the cell is stabilized the maximum extent that is practically possible.

Unfortunately, that is not to say that biological material successfully cooled to -196^{0}C is in state of complete suspended animation. Certain type of chemical reaction can still occur at these temperatures, such as the formation of the free radicals and macromolecular damage due to ionizing radiation. The only real threat to genetic stability comes from such reactions, especially those that damage nucleic acids. Any damage that does occur will necessarily be cumulative as enzyme repair mechanisms are also totally inhibited at these low temperatures.

While there are as yet few quantitative data on genetic stability at ultra low temperature for higher organisms, studied by Ashwood, Smith and Grant (1977) indicate that to reach a D10 level (where D10 is the readiation dose resulting in 90% mortality of the population) a frozen cell population would have to be exposed to back ground radiation for some 32,000 years. It is also noteworthy that dimethyl sulphoxide, probably the most commonly used cryoprotectant in-vitro preservation and may aid in radiation damage.

The potential of conservation system for in-vitro material based upon cryogenic storage is therefore, clear and the technique has become relatively widely used.

5.5.3 Other Methods

Cold storage

Germplasm conservation by storing material in cultures at low and no-freezing temperature the ageing of plant material is slow but not completely stopped as in freezes prevention.

Low Pressure and Low Oxygen Storage

Attempts have been made to development Low Pressure Storage (LPS) and Low Oxygen Storage (LOS) as feasible techniques for future conservation of cultured plant materials. In LPS, the atmospheric pressure surrounding the tissue cultures is reduced resulting in partial decrease of the pressure created by gases in contact with the plant material. On the other hand, in LOS, the atmospheric pressure (760 mm Hg) is not reduced but the inert gases (particularly nitrogen) are combined with oxygen to create low oxygen pressure.

These are found useful in both short term and long term storage. There is also belated recognition that nature is infinitely more tough tests of survival for millions of years. An effort is now onto revive culturing of plant in-vitro. A biotechnology firm in USA, *Phytera*, has for example set up and stored plant cell cultures of 5,000 spp in glass vials.

5.5.4 Germplasm Facilities in India

Recognizing the need for sophisticated facilities for research and development and providing services, the following additional germplasm facilities have been set up :

1. The National Facility for Microbial Type Culture Collection at the Institute of Microbial Technology, Chandigarh, with over 1,600 cultures in its stock.
2. The National Facility on Blue-green Algal Collection at the Indian Agricultural Research Institute, with over 500 strains and several pure culture as well as soil-based cultures, which have been supplied to farmers for production of bio-fertilizers.
3. The National Facility for marine Cyanobacteria at the Bharatidasan University, Tiruchirapalli, which is coordinating extensive surveys on the southern coast.
4. The National Facility for Plant Tissue Culture Respository at NBPGR, New Delhi, which has undertaken in vitro conservation of germplasm (Cell, Tissue, organ), for medium and long term, particularly for those species for which conventional methods are inadequate. It has 850 accessions of crop species and employes molecular methods of characterization and classification.
5. The National Facility for Laboratory Animals at Central Drug Research Institute, Lucknow and the National Institute of Nutrition, Hyderabad have made available quality animals for biomedical research and industry in the country.
6. The National Facility for Animal Tissue and Cell Culture, Pune, and autonomous institutions under Department of Biotechnology (DBT) has 1127 stock cultures comprising 594 different cell strains. The facility has supplied 401 culture consignments to 84 insttutions throughout the country. It also has 50 rectors, plasmids and genomic libraries.
7. Three National Gene Bank for Medicinal and Aromatic Plants at the Central Institute of Medicinal and Aromatic Plants, Lucknow and NBPGR, New Delhi, for the northern region; and the Tropical Botanical Garden and Research Institute,

Trivendrum, for peninsular India have been established. These banks will conserve important species of proven medicinal value, which are categorized as endangered, threatened or rare and are used extensively in traditional systems of medicine, difficult to propagate, have significance for research and developmet for the future, and are of commercial values. India is the regional coordinator for Asia and also the overall coordinator for the establishment of Gene banks of Medicinal and Aromatic Plants among G-15 countries.

5.6 GENERAL ACCONT OF IMPORTANT INSTITTIONS

5.6.1 Botanical Survey of India

Botanical Survey of India (BSI) was established in 1890 with the basic objectives of carrying out floristic surveys of the Indian empire. It was reviewed and reorganised in 1954. During the successive plan periods its functions have been gradually expanded. After reorganisation and establishment of 10 different regional centres throughout the country, the aims and objectives of the Survey were redefined in 1976 with a view to encourage taxonomic research and to accelerate the scientific expertise for the preparation of a comprehensive flora of the country. The objectives and perspectives of BSI were thoroughly reviewed in 2002 by the subcommittee constituted by Programme Advisory Committee for BSI & ZSI. Activities like survey and exploration of plant resources, listing of endangered species, publication of national flora, preparation of national Data Bank on herbarium and live collection, plant distribution and nomenclature were strengthened.

History

The British East India Company had established botanical gardens at Sibpur, Poona, Saharanpur and Madras as centres for improving botanical knowledge and experimentation under the local Governments. For example, the Saharanpur botanical garden, which dates from before 1750, was acquired by the East India Company in 1817 for growing medicinal plants. Most of the EIC botanical gardens' work was for the cultivation of plants of interest in commerce and trade.

The Botanical Survey was formally instituted on February 13, 1890 under the direction of Sir George King, who had been superintendent of Royal Botanic Garden, Calcutta since 1871. King became the first ex-officio Director of BSI. The Calcutta Garden became the headquarters of the Survey and was given regional responsibility for Bengal, Assam, North East, Burma, and the Andaman and Nicobar Islands.

Objective

The prime objectives of the Survey were:

- To undertake intensive floristic surveys and collect accurate and detailed information on the occurrence, distribution, ecology and economic utility of plants in the country.
- To collect, identify and distribute materials which may be of use to educational and research institutions and,
- To act as custodian of authentic collections in well planned herbaria and to document the plant resources in the form of local, District, State and National Flora.

Research Center/ Circle

To cope up with this enormous task assigned to the Survey, the following 4 circles were established after independence, in different Botanical regions to cover the vast stretches of the country :

1. Botanical Survey of India, **Southern Circle** at Coimbatore on 10th October 1955.
2. Botanical Survey of India, **Eastern Circle** at Shillong on 1st April 1956.
3. Botanical Survey of India, **Western Circle** at Pune on 12th December 1955.
4. Botanical Survey of India, **Northern Circle** at Dehra Dun on 1st August 1956.

Simultaneously, a Central Botanical Laboratory at Lucknow was established in December, 1957 for studying the various aspects of plant biology like – cytology, plant physiology, plant chemistry, seed biology, ecology, etc.- in order to provide multidisciplinary approach to conventional taxonomy.

During the same year (1957), the Herbarium belonging to "Royal Botanic Garden", Calcutta, which was renamed as the "Indian Botanic Garden" in 1950, was transferred to Botanical Survey of India and soon this herbarium shot into fame as the "Central National Herbarium" (CAL).

In order to further strengthen the Survey for carrying out its assigned mandate more effectively and expeditiously, a number of new Circles in different phytogeographical regions were opened as follows:-

5. Botanical Survey of India, **Central Circle** at Allahabad in 1962
6. Botanical Survey of India, **Arid Zone Circle** at Jodhpur in 1972
7. Botanical Survey of India, **Andaman & Nicobar Circle** at Port Blair in 1972
8. Botanical Survey of India, **Arunachal Pradesh Circle** at Itanagar in 1977
9. Botanical Survey of India, **Sikkim Himalayan Circle** at Gangtok in 1979
10. **Botanic Garden of Indian Republic** at Noida in 2002

11. Botanical Survey of India, **Deccan Circle** at Hyderabad in 2005

Mandate

During the successive five year plan periods, the functions of Botanical Survey of India were further diversified to include various new areas such as assessment and inventorisation of endemic, rare and threatened plant species; evolving conservation strategies; studies on fragile ecosystems and protected areas like Sanctuaries, National Parks and Biosphere Reserves; monitoring of changes in floristic components; ex-situ conservation, multiplication and maintenance of germplasm of plant genetic resources, endemic and threatened species, wild ornamentals, etc.; ethnobotanical and geobotanical studies and the development of National Database on Herbarium (including Type specimens) live collections, plant genetic resources, plant distribution and nomenclature. The aims and objective of the department were redefined, reviewed during the year 1987 and survey and exploration of plant resources and inventorisation of threatened species, publication of National and State Floras and development of National database were given top priority.

After the ratification of the Convention on Biological Diversity by the Govt. of India in February, 1994 a greater role for Botanical Survey of India was envisaged, particularly with reference to the article – 7, 8, 12, 16 of the Convention on Biological Diversity (CBD). Following which the objectives and strategies of the Botanical Survey of India were further diversified.

Following are the main functions of Botanical Survey of India:

Primary Functions

- Exploration, inventorisation and documentation of phytodiversity (including non-flowering plants) in general and protected areas, hotspots, fragile ecosystems, wetlands, sacred groves in particular; publication of National, State and District Floras.
- Identification of Red list species and species rich areas needing conservation; ex-situ conservation of critically threatened taxa in the Botanical Gardens.
- Survey and documentation of traditional knowledge (ethnobotany) associated with plants
- Develop a national database of Indian plants including herbarium specimens, live specimens, Botanical paintings /illustrations etc.

Secondary Functions

- Revisionary/Monographic studies on selected plant groups.

- Qualitative analysis of nutritive value of ethno-food plants and other economically useful species.
- Capacity building in plant taxonomy through refresher courses and post M.Sc. certificate course.
- Environmental Impact Assessment of areas assigned to BSI for study.
- Develop and maintain Botanical Gardens, Musea and Herbaria.
- Preparation of Seed, Pollen and Spore Atlas of Indian Plants.
- Recently, the Survey has also extended its activities to Antarctica from 16th expedition (1996 – 97) onwards for the study of Bryophytes, Fungi and Algae (except the blue-green).

5.6.2 The National Bureau of Plant Genetic Resources (NBPGR)

The National Bureau of Plant Genetic Resources has its Headquarters at New Delhi, located at latitude of 28° 35' N, longitude of 70° 18' E and an altitude of 226 m above mean sea level. NBPGR functions under the administrative control of the Crop Science Division of the ICAR. The Bureau draws guidelines from the Crop Science Division of ICAR, Bureau's Management Committee, Research Advisory Committee and Germplasm Advisory Committees.

The Bureau has four Divisions, two units, three cells and an experimental farm at its Headquarters in New Delhi and 10 regional/ base stations located in different phyto-geographical zones of India. Besides this, a National Research Centre on DNA fingerprinting and an All India Coordinated Research Project on Under-utilized Crops are also located at the Bureau.

Plant Exploration and Collection Division has the objectives to plan, coordinate and conduct explorations for collecting germplasm. Germplasm Evaluation Division is entrusted with the prime responsibility of characterization and evaluation of all the indigenous and exotic germplasm collections for their field performance and other important traits like resistance to biotic/ abiotic stresses and phytochemical attributes along with maintenance and regeneration. This division has an experimental farm located at Issapur about 45 km from the main campus covering an area of 40 ha. Germplasm Conservation Division is vested with the task of conservation of germplasm of various crop plants, and to undertake basic research on various aspects of seed storage and longevity. Plant Quarantine Division has the power vested by Plant Protection Advisor to the Government of India, under the Plant Quarantine (Regulation of Import into India) Order 2003 under the Destructive Insects and Pests Act (1914), to carry out quarantine of the plant germplasm imported for research purposes. It also undertakes the quarantine of material under export and issues the phytosanitary certificate. Germplasm Exchange Unit has the responsibility of introducing genetic resources of diverse crop plants and their wild relatives and distributing the same within the country, and also exports the

germplasm. There is also a Tissue Culture and Cryopreservation Unit, with the main objective to conserve economic plants, for which conventional methods of storage are unsuccessful or inadequate, through in vitro and cryopreservation techniques. In addition, the Bureau has three cells, namely PGR Policy, Agriculture Research Information System and Technical Cell.

The NRCDF has facilities for molecular fingerprinting of released varieties and genetic stocks of crop plants of India. It has the objectives of standardization of molecular marker systems for DNA profiling and their application in variety identification. The NBPGR Headquarters, along with the network of 11 regional /base/ satellite stations covering different agro-climatic regions, and the linkages with 59 National Active Germplasm Sites constitute the Indian Plant Genetic Resource Management System.

Mandate

To act as nodal institute at national level for acquisition and management of indigenous and exotic plant genetic resources for food and agriculture, and to carry out related research and human resource development, for sustainable growth of agriculture.

Objectives of NBPGR

- To plan, organize, conduct and coordinate exploration and collection of indigenous and exotic plant genetic resources.
- To undertake introduction, exchange and quarantine of plant genetic resources.
- To characterize, evaluate, document and conserve crop genetic resources and promote their use, in collaboration with other national organizations.
- To develop information network on plant genetic resources.
- To conduct research, undertake teaching and training, develop guidelines and create public awareness on plant genetic resources.

Regional station of NBPGR

Regional Station, Akola

The Regional Station was established at Akola in 1977 to cater to the needs of Plant Genetic Resources activities in central-peninsular India, especially Maharashtra, Goa, Daman and Diu and parts of Southern districts of Madhya Pradesh and parts of northern Karnataka. This region is a vast plateau comprising hilly tract of Satpura, Gawilgarh and Maikala ranges, plain cotton belt of erstwhile Berar, undulating Western Ghats and coastal regions (now referred to as Central Indian Region, Zone IX under NATP-PB). The experimental farm of 20 hactares is located in university campus. Amravati centre now is working as satellite centre of Akola station.

Regional Station, Bhowali

The Regional Station was initially established at Almora as an exploration base centre for germplasm collection activities in Kumaon and Garhwal hills. Mandate area of the regional station is now referred to at Central Himalayan Region, Zone V under NATP-PB). The centre was shifted to Bhowali in April 1986 and designate NBPGR Regional Station when Wheat Research Station (of Vivekanand Parvatiya Krishi Anushandhan Shala VPKAS) was merged with it. Earlier to shifting, this station has a long history. The Imperial Potato Research Station established in 1943, for potato seed multiplication and brown rot (Pseudomonas solanacearum) test was known as hot spot for the development of plant diseases. In 1956, with the commencement of wheat improvement scheme under PL-480, it was transferred to Indian Agricultural Research Institute (IARI) and name was changed as Wheat Research Station, Bhowali. In 1984 it was again transferred to VPKAS, till shifted NBPGR. Year of establishment: 1986

Exploration Base Center, Cuttack

This Base Centre was established in the campus of Central Rice Research Institute with the objective of exploration and collection of indigenous crops from Orissa, West Bengal and adjoining areas in parts of Jharkhand and Chhattisgarh (now referred to as Humid/Moist Tropical East Coastal Region, Zone III under NATP-PB). Climatically, the area is sub-humid to humid in eastern and south-eastern plains. Northern plateau is an extension of Chhotanagpur plateau and spreads upto Mayurbhanj and Keonjhar districts and districts of Ganjam, Kalahandi, Phulbani and Koraput in the southern portion. The whole area is potential for collecting. Year of establishment: 1986

Regional Station, Hyderabad

This Regional Station was established initially as Plant Quarantine Station in ARI campus of Acharya N G Ranga Agricultural University at Rajendranagar, Hyderabad to cater to the needs of Plant Quarantine clearance work particularly on five mandate crops of ICRISAT and paddy international trial material received from IRRI, Philippines meant for research organizations in south India. A modest beginning was made in 1977, by taking possession of 16 acres of land that was provided by the University. Central Plant Protection and Trainging Institute in collaboration with Directorate of Rice Research was authorized to take up the plant quarantine clearance work until the establishment of PQRS of NBPGR in 1985.

Regional Station, Jodhpur

This Regional Station was established in 1965 as a sub-station of erstwhile Plant Introduction Division of Indian Agricultural Research Institute in the campus of Central Arid Zone Research Institute at Jodhpur, Rajasthan (now referred to as Arid Region, Zone I under NATP-PB). The main task assigned was to acclimatize the genetic

resources of tropical plants procured from abroad on a systematic basis and to collect the indigenous germplasm suited to arid/semi-arid conditions. With the creation of NBPGR in 1976, the substation was transferred to it. It has a farm area of about 6 ha with irrigation facility. The station is entrusted with the responsibility to carry out Plant Genetic Resources (PGR) activities in the states of Rajasthan, Gujarat and adjoining areas in Haryana.

Regional Station, Shillong

This Regional Station was established in 1978 as the northeastern region of India at Shillong, Meghalaya representing the humid, subtropical to sub temperate ecology and climate. It is surrounded by Tibet, China in the north, Bangladesh in southwest, Myanmar in the east and Bhutan and Nepal in the north-west. The jurisdiction of this station for collection activities encompass all the eight states, namely, Assam, Meghalaya, Manipur, Nagaland, Tripura, Sikkim, Arunachal Pradesh and Mizoram (now referred to as Northeastern Region, Zone IV under NATP-PB). The station was under the administrative control of ICAR Research complex for NEH region for some period (Feburary 1983 to September 1985). Since 1986 it is again under administrative control of NBPGR. The office cum laboratory building and experimental farm at Umiam (1000m altitude) in district Ribohi are situated 20kms away from Shillong City.

Exploration Base Center, Ranchi

This Base centre was established in 1988 to carry out systematic exploration for germplasm collection in the states of Bihar, parts of Jharkhand and adjoining areas in Uttar Pradesh and West Bengal (now referred to as Sub-tropical/sub-humid Region, Zone V under NATP-PB). The tribal belt of Chhotanagpur and adjoining region is a potential area for germplasm collection. It is fast developing as a centre for evaluation and maintenance of germplasm of tropical fruits and other field crops suited to the region.

Regional Station, Shimla

This Regional Station was established as Plant Introduction Station under Botany Division of IARI in 1960. Since 1976, it came under the control of NBPGR. Apart from the office building and laboratories, it has 7 hectares of farmland. The station has the major responsibility for the conservation and management of plant genetic resources of western Himalayas comprising Himachal Pradesh and Jammu and Kashmir (now referred to as Northwest sub-Himalayan and high attitude Himalayan Region, Zone VI under NATP-PB). A field genebank of temperate fruits and newly introduced fruit plants, and largest germplasm collection of french bean, amaranth, buckwheat is being maintained at the station. The station has also a facility of medium-term storage for conserving orthodox seeds where seeds can be stored up 12-15 years without losing viability. This station also acts as National Active Germplasm Site (NAGs) for amaranth, french bean, buckwheat and temperate fruits. It has strong linkages with State Agriculture Universities

of Himachal Pradesh and Jammu and Kashmir as well as Himachal Pradesh University, Shimla.

Regional Station, Srinagar

This Regional Station was established in 1988 to carry out systematic exploration for germplasm collection in Jammu and Kashmir. This area has a potential for the collection of temperate fruits, vegetables, rice, millets, medicinal and aromatic plants and temperate tribal food.

NBPGR Regional Station, Thrissur, Kerala

This station was established in 1977 in the Kerala Agricultural University campus near Pineapple Research Station on the Mannuthy-Chirakkakode road with a farm area of 10.4 ha. Thrissur is well connected by road, rail and air. Nearest airport is Kochi International Airport at Nedumbassery (60 km). The area of jurisdiction for exploration and collection by the station is southern India comprising Kerala, Karnataka, Tamil Nadu, Pondicherry, Goa and Andaman & Nicobar Islands.

5.6.3 Indian Agricultural Research Institute (IARI)

Agriculture in India is the means of livelihood of almost two thirds of the workforce in the country. It employs nearly 62% of the country's total population and occupies 42% of its total geographical area. From a nation dependent on food imports to feed its population, India today is not only self-sufficient in grain production, but also has a substantial reserve. The progress made by agriculture in the last four decades has been one of the biggest success stories of free India. Agriculture and allied activities constitute one of the main contributors to the Gross Domestic Product of the nation. The increase in agricultural production has been brought about by bringing additional area under cultivation, extension of irrigation facilities, the use of seed of improved high yielding varieties, better production technologies evolved through agricultural research, water management, and plant protection through judicious use of fertilizers, pesticides and cropping practices.

The Indian Agricultural Research Institute (IARI), a centenarian, is the country's premier national Institute for agricultural research, education and extension. It has served the country by developing appropriate technologies through basic, strategic and need-based research resulting in crop improvement and agricultural productivity in harmony with the environment leading to the Green Revolution and served as a centre for academic excellence in the area of postgraduate education and human resource development in agricultural sciences.

Originally established in 1905 at Pusa (Bihar) with the financial assistance of an American Philanthropist, Mr Henry Phipps, the Indian Agricultural Research Institute

(IARI) started functioning from New Delhi since 1936 when it was shifted to its present site after a major earthquake damaged the Institute's building at Pusa (Bihar). The Institute's popular name 'Pusa Institute' traces its origin to the establishment of the Institute at Pusa.

The Indian Agricultural Research Institute is the country's premier national Institute for agricultural research, education and extension. It has the status of a 'Deemed-to-be-University' under the UGC Act of 1956, and awards M. Sc. and Ph. D. degrees in various agricultural disciplines.

The growth of India's agriculture during the past 100 years is closely linked with the researches done and technologies generated by the Institute. The Green Revolution stemmed from the fields of IARI. Development of high yielding varieties of all major crops which occupy vast areas throughout the country, generation and standardization of their production techniques, integrated pest management and integrated soil-water-nutrient management have been the hallmarks of the Institute's research. The Institute has researched and developed a large number of agrochemicals which have been patented and licensed and are being widely used in the country. Over the years, IARI has excelled as a centre of higher education and training in agricultural sciences at national and international levels.

Function

The Indian Agricultural Research Institute (IARI) is India's premier institution in the field of agricultural research, higher education in agriculture (post-graduate programme) and extension education. The primary functions of the Institute are

(i) Basic and applied research in the various branches of agricultural sciences,

(ii) Teaching at the post-graduate level and organisation of special short-term training programmes in several aspects of agricultural sciences, both at the national and international levels and

(iii) Extension advisory work for improving farm productivity and socio-economic conditions of the farming community.

Mandate

To realize the mission laid down by the Institute, i.e., to explore new frontiers of science and knowledge, to develop human resources and policy guidance to create a vibrant, responsive and resilient agriculture, the mandate of the institute is as follows:

- To conduct basic and strategic research with a view to understanding the processes, in all their complexity, and to undertake need-based research that leads to crop

improvement and sustained agricultural productivity in harmony with the environment.

- To serve as a centre for academic excellence in the area of post-graduate education and human resources development in agricultural sciences.
- To provide national leadership in agricultural research, extension, and technology assessment and transfer by developing new concepts and approaches and serving as a national referral point for quality and standards.
- To develop information systems, add value to information, share the information nationally and internationally, and serve as a national agricultural library and database.

Growth

IARI is India's premier national institute for research and higher education in agricultural sciences. The Institute received the status of a "Deemed University" in 1958 under the UGC Act of 1956 and was empowered to award M. Sc. and Ph.D. degrees. Headquartered at New Delhi, it is the largest and most prestigious of the research institutes financed and administered by the Indian Council of Agricultural Research (ICAR).

The administrative and technical head of IARI is its Director. The Board of Management, with the Director as its chairman, served by four councils, namely, Research Advisory Council, Academic Council, Extension Council and Executive Council, provides the overall management direction. The Director is assisted by a Joint Director (Research), a Dean & Joint Director (Education) and a Joint Director (Extension) who are equivalent to the Directors of ICAR institutes, which are not deemed universities. A Joint Director (Administration) looks after the day-to-day administrative work. The Chief Finance and Accounts Officer has overall charge of the audit and accounts matters.

Centers

Presently the research, education, and extension activities of the Institute are carried out through a network of 20 discipline-based divisions, 5 multidisciplinary centers situated in Delhi, 8 regional stations, 2 off-season nurseries, 10 centres of All India Coordinated Research Projects and a common set of service units. The Institute also serves as the headquarters of 3 All India Coordinated Research Projects. In addition, some of the institutes like National Research Centre on Plant Biotechnology, NCIPM and Directorate of Maize Research are located in the campus.

5.6.4 Council of Scientific and Industrial Research (CSIR)

The **Council of Scientific & Industrial Research** (**CSIR**) is the premier industrial research and development (R&D) organization in India. It was founded on 26 September

1942, by a resolution of the then Central Legislative Assembly. It is funded mainly by the India Ministry of Science and Technology and it is one of the world's largest publicly funded (R&D) organisations, having linkages to academia, other R&D organisations and industry.

Although CSIR is mainly funded by Science and Technology Ministry, it operates as an autonomous body registered under the Registration of Societies Act of 1860.

The R & D activities of CSIR includes various fields such as aerospace engineering, Structural engineering, ocean sciences, molecular biology, metallurgy, chemicals, mining, food, petroleum, leather, and environment. The Director General of CSIR Dr. Raghunath A. Mashelkar retired in December 2006. After that Dr. M. K. Bhan had taken the additional charge, but he was relieved on March 7, 2007. After that Dr. T. Ramasami had the additional charge of director general of CSIR.

Presently **Prof. Samir K. Brahmachari** is the Director-General of CSIR since November 13, 2007.

CSIR Achievements

- Achieved the first breakthrough of flowering of Bamboo within weeks as against twenty years in nature.
- First to analyze genetic diversity of the indigenous tribes of Andaman and to establish their origin out of Africa 60,000 years ago.
- Developed the first transgenic Drosophila model for drug screening for Human Cancer.
- First to introduce DNA fingerprinting in India.
- Helped India to be the first Pioneer Investor under the UN law of Sea Treaty.
- Invented the first ever only once a week non-steroidal family planning pill in the world by the name of *Saheli*.
- Designed India's first ever parallel processing computer Flosolver.
- Partnered more than 50,000 companies with turnover ranging from Rs 5 lakhs to Rs 500,000 crores.
- Rejuvenated India's one hundred year old refinery at Digboi using the most modern molecular distillation technology.
- Provided the critical technology for the NMP Lube Extraction Plant of capacity of 2,50,000 tonnes per year.
- Development of a versatile portable PC-based software 'Bio-Suite' for bioinformatics.
- Design of 14 seater plane 'SARAS'.

- Established first ever in the world 'Traditional Knowledge Digital Library' accessible in 8 international languages.
- Remained in Top 3 in the list of PCT patent applications amongst all developing countries.
- Topped list of USA patents holders.
- Successfully challenged the grant of patent in the USA for use of haldi (turmeric) for wound healing and neem as insecticide.

Research Laboratories under CSIR

1. C-MMACS - CSIR Centre for Mathematical Modelling and Computer Simulation, Bangalore
2. CBRI - Central Building Research Institute, Roorkee
3. CCMB- Centre for Cellular and Molecular Biology, Hyderabad
4. CDRI - Central Drug Research Institute, Lucknow
5. CECRI- Central Electro Chemical Research Institute, Karaikudi
6. CEERI - Central Electronics Engineering Research Institute, Pilani
7. CFRI - Central Fuel Research Institute, Dhanbad
8. CFTRI - Central Food Technological Research Institute, Mysore
9. CGCRI - Central Glass and Ceramic research Institute, Calcutta
10. CIMAP - Central Institute of Medicinal and Aromatic Plants, Lucknow
11. CLRI - Central Leather Research Institute, Chennai
12. CMERI - Central Mechanical Engineering Research Institute, Durgapur
13. CMRI - Central Mining Research Institute, Dhanbad
14. CRRI - Central Road Research Institute, New Delhi
15. CSIO - Central Scientific Instruments Organisation, Chandigarh
16. CSMCRI - Central Salt and Marine Chemicals Research Institute, Bhavnagar
17. IGIB - Institute of Genomics and Integrative Biology, Delhi
18. IHBT - Institute of Himalayan Bioresource Technology, Palampur
19. IICB - Indian Institute of Chemical Biology, Calcutta
20. IICT - Indian Institute of Chemical Technology, Hyderabad
21. IIP - Indian Institute of Petroleum, Dehradun
22. IMT - Institute of Microbial Technology, Chandigarh

23. IITR - Indian Institute of Toxicology Research, Lucknow (Formerly known as Industrial Toxicology Research Centre)
24. NAL - National Aerospace Laboratories, Bangalore
25. NBRI - National Botanical Research Institute, Lucknow
26. NCL - National Chemical Laboratory, Pune
27. NEERI - National Environmental Engineering Research Institute, Nagpur
28. NGRI - National Geophysical Research Institute, Hyderabad
29. NIO - National Institute of Oceanography, Goa
30. NISCAIR - National Institute of Science Communication and Information Resources, New Delhi
31. NISTADS - National Institute of Science, Technology and Development Studies, New Delhi
32. NML - National Mettalurgical Laboratory, Jamshedpur
33. NPL - National Physical Laboratory, New Delhi
34. RRL, Bhopal - Regional Research Laboratory, Bhopal
35. RRL, Bhubaneshwar - Regional Research Laboratory, Bhubaneshwar
36. RRL, Jammu - Regional Research Laboratory, Jammu
37. NEIST (RRL), Jorhat - North East Institute of Science and Technology, Jorhat , Jorhat
38. National Institute for Interdisciplinary Science and Technology - Thiruvananthapuram
39. SERC, M - Structural Engineering Research Centre, Chennai

5.6.5 Department of Biotechnology (DBT)

The setting up of a separate Department of Biotechnology (DBT)**,** under the Ministry of Science and Technology in 1986 gave a new impetus to the development of the field of modern biology and biotechnology in India. In more than a decade of its existence, the department has promoted and accelerated the pace of development of biotechnology in the country. Through several Research & Development projects, demonstrations and creation of infrastructural facilities a clear visible impact of this field has been seen. The department has made significant achievements in the growth and application of biotechnology in the broad areas of agriculture, health care, animal sciences, environment, and industry.

The impact of the biotechnology related developments in agriculture, health care, environment and industry, has already been visible and the efforts are now culminating into products and processes. More than 5000 research publications, 4000 post-doctoral

students, several technologies transferred to industries and patents filed including US patents, can be considered as a modest beginning. Department of Biotechnology (DBT) has been interacting with more than 5,000 scientists per year in order to utilise the existing expertise of the universities and other national laboratories. A very strong peer reviewing and monitoring mechanism has been developed. There has been close interaction with the State Governments particularly through State S & T Councils for developing biotechnology application projects, demonstration of proven technologies, and training of human resource in States and Union Territories. Programmes with the states of Gujarat, Rajasthan, Madhya Pradesh, Orissa, West Bengal, Haryana, Punjab, Jammu & Kashmir, Mizoram, Andhra Pradesh and Uttar Pradesh have been evolved. Biotechnology Application Centres in Madhya Pradesh and West Bengal have already been started.

A unique feature of the department has been the deep involvement of the scientific community of the country through a number of technical task forces, advisory committees and individual experts in identification, formulation, implementation and monitoring of various programmes and activities.

In India, more than a decade of concerted effort in research and development in identified areas of modern biology and biotechnology have given rich dividends. The proven technologies at the laboratory level have been scaled up and demonstrated in field. Patenting of innovations, technology transfer to industries and close interaction with them have given a new direction to biotechnology research. Initiatives have been taken to promote transgenic research in plants with emphasis on pest and disease resistance, nutritional quality, silk-worm genome analysis, molecular biology of human genetic disorders, brain research, plant genome research, development, validation and commercialisation of diagnostic kits and vaccines for communicable diseases, food biotechnology, biodiversity conservation and bioprospecting, setting up of micropropagation parks and biotechnology based development for SC/ST, rural areas, women and for different States.

Necessary guidelines for transgenic plants, recombinant vaccines and drugs have also been evolved. A strong base of indigenous capabilities has been created. The field of biotechnology both for new innovations and applications would form a major research and commercial endeavor for socio-economic development in the next millennium.

Mandate

- Promote large scale use of Biotechnology
- Support R&D and manufacturing in Biology
- Responsibility for Autonomous Institutions
- Promote University and Industry Interaction

- Identify and Set up Centres of Excellence for R&D
- Integrated Programme for Human Resource Development
- To serve as Nodal Point for specific International Collaborations
- Establishment of Infrastructure Facilities to support R&D and production
- Evolve Bio Safety Guidelines, manufacture and application of cell based vaccines
- Serve as nodal point for the collection and dissemination of information relating to biotechnology.

The Department of Biotechnology (DBT) since its inception has been working for the creation of a strong and indigenous base of modern biology. Biotechnology has made incredible progress in the last two decades all over the world. Rapid advances have been achieved in the fields of recombinant DNA techniques, cell and tissue culture, immunology, enzymology, bioprocess engineering and vaccinology. Availability of new biotechnological tools and production of microbes, plants and animals with improved traits have opened up great opportunities for better products and processes. These applications have great potential in developing countries for providing opportunities for employment through value added products, and for generation of non-polluting and environmentally friendly technologies.

Areas where biotechnology plays a significant role are agriculture, health, environment and industry. In order to expedite field evaluation of technologies and products generated through R&D efforts, DBT has evolved a system for contract research through which such programmes will bring forth either a product or a new process in a time bound format for field testing and subsequent large scale production. Special programmes have been launched for the welfare of the poorer sections of society in terms of generation of employment and improvement in the living standards, nutrition and health etc.

Manpower Development

The Department has formulated an Integrated Programme of Manpower Development to generate a critical mass of well trained scientific personnel for the many biotechnological research, teaching and industrial activities in the country. These include Post-Graduate Teaching and Post-Doctoral Programme; Biotechnology Associateship (Overseas and National); Short-term Training Courses for Mid-Career scientists and Industrial R & D scientists; Technician Training and School Teachers Training Programmes; Programmes for Biology Teaching in Schools. DBT scholarship in biology and schemes like biotechnology publications, popular lectures by renowned scientists, support to seminar/symposia, film production etc., aimed at the popularisation of biotechnology in the country, are in full flow.

Infrastructural Facilities

To provide scientists working in the field of biotechnology adequate assistance and support, the Department had set up facilities such as, germplasm banks (microbial type culture collection, blue green algal collection, marine cyanobacteria and plant tissue culture repository), animal house facilities, biochemical engineering research and process development, genetic engineering units, oligonucleotide synthesis etc. The animal house facilities at Central Drug Research Institute, Lucknow and National Institute of Nutrition (NIN), Hyderabad have supplied over two lakh laboratory animals of around 20 species to several scientists in the field of biomedical research. The biomedical engineering research and process development facility has a computer controlled fermentation system ranging 30 ltr to 1,500 ltr capacity. The operational facilities are available to research personnel and industry to upgrade their processes and products. The National Facility for Marine Cyanobacteria at Tiruchinapally, is developing a technology for aquaculture feed and for the production of natural colorant. Genetic Engineering Unit at MKU, Madurai has tied up with industries to work on several industrial products.

Immunodiagnostics

A number of programmes have been adopted to develop simple, inexpensive but sensitive diagnostic kits for early detection of a variety of communicable and non-communicable diseases. The technology transfer of eight products that has taken place so far are amoebic liver abscess, hepatitis-B, blood grouping, typhoid (blood test) pregnancy detection (all developed by the National Institute of Immunology, an autonomous body under DBT), typhoid (urine test) (developed by AIIMS, New Delhi) filariasis (developed by Mahatma Institute of Medical Sciences, Wardha) and leishmaniasis (developed by CDRI, Lucknow), technology for diagnosis of leishmaniasis in another format aspergillosis, a quantitative test for typhoid fever as well as reproductive hormones are ready for transfer to industry.To accelerate the development of immuno-diagnostics a pilot plant has been established at the National Institute of Immunology, New Delhi. A recombinant DNA based AIDS detection kit with merely one drop of blood has reached at an advanced stage of development.

Vaccine Production

The Department of Biotechnology has promoted a R&D cum manufacturing unit, Bharat Immunologicals and Biological Cooperation Limited (BIBCOL) at Bulandshahr, Uttar Pradesh.Manufacturing activities are divided into two phases, Phase I involving the formulation, packaging and distribution from imported bulk of OPV and Phase II involving the indigenous production of vaccine. Phase I has already been completed. Manufacturing licence has been obtained from competent authorities.

Immunological Approaches to Fertility Control

A composite programme of Immunological Approaches to Fertility Control is being undertaken in National Institute of Immunology (NII), New Delhi; Post Graduate

Institute of Medical Education and Research, Chandigarh; IISc, Bangalore; CDRI, Lucknow; Institute for Research in Reproduction, Bombay and National Institute of Health and Family Welfare (NIH&FW), New Delhi with the objective of developing safe, cost-effective, durable and reversible contraceptive vaccines for controlling fertility in men and women. Two projects, one at Indian Institute of Science, Bangalore and the other at Institute of Research in Reproduction, Bombay have carried out research to demonstrate the termination of pregnancy by interrupting vitamin carrier protein through antibodies.

Crop Biotechnology

Genetic engineering for gene isolation, transformation, transgenic plants and molecular maps based on RFLP/RAPD are the emerging areas of research to facilitate agricultural productivity. Consequently, the Department has made a concerted effort to support specific priority crops like, rice, rape mustard, chickpea, pigeonpea and wheat by R&D projects and has also set up six centres for plant molecular biology all over the country. Some of the important achievements of these programmes are :

i) To improve the nutritional quality of cereals and to study the regulation of seed storage protein gene, a gene encoding for a protein of high lysine and sulphur containing amino acid from Amarantus has been cloned and sequenced. ii) Nuclear coded male sterile genetic lines as well as their restorers are under trial in mustard. iii) Two molecular marker technologies - RFLP and RAPD have been utilised for tagging genes responsible for blast resistance in rice. iv) Plant regeneration from mesophyll protoplast has been achieved. v) Two multi-institutional projects on development of cotton and quality improvement of wheat by molecule transgenic techniques were successfully launched.

Animal Biotechnology

The main areas of research in the sphere of animal biotechnology are embryo transfer technology, health care and diagnostics, nutrition, genetic resource conservation, leather biotechnology and development of bio-products. Research programmes in upstream areas of embryo transfer technology (ETT) have been funded. Significant progress has been recorded in the fields of in-vitro fertilisation, in-vitro maturation, splitting and cloning of embryos. Development of indigenous hormones and biologicals is another rapidly emerging potential area of research. A major programme on down-stream activities of ETT, principally to take the various technologies developed to the grass-root level, has been put into action. Diagnostics and vaccines are being developed for animals including poultry. Projects involving genetic resource conservation attempts to conserve invaluable indigenous breeds have also been launched.

Aquaculture

Projects in the field of aquaculture revolve around feed development, production of transgenic fish, extraction of bio-active compounds, cryopreservation of embryos and development of disease diagnostics. A production of 8 to 10 tonnes in two crops per year has been demonstrated in a semi-intensive system for tiger shrimp. Carp production upto 15 tonnes per hectare per year has been demonstrated. A mission-mode programme on shrimp aquaculture under different agroclimatic zones has been launched.

Biomass, Horticulture and Plantation Crops

Research and Development projects have commenced on selected forest tree species for developing and standardising protocols for plantlet regeneration using tissue culture techniques from ex-plants collected from elite genotypes. Nationally important forest tree species requiring immediate attention for development of tissue culture protocol have been identified as a priority for conducting such studies during the Eighth Plan.

Protocols have been standardised for plantlet regeneration via tissue culture technology for Eucalyptus camaldulensis, E. tereticornis, Dendrocalamus strictus, Tectona grandis, Bambusa tulda, Populus deltoides and Anogeissus pendula. These protocols have now been adopted for large scale production. Research programmes have been initiated on horticulture and plantation crops of economic importance - mango, citrus, banana, tea, coffee, rubber, cashew and spices. Protocols have been developed for pepper, rubber and cocoa. Large scale production of elite forest trees is under process at the Culture Pilot Plant units at NCL, Pune and TERI, New Delhi. Approximately 6.67 lakh plantlets have been produced, of which five lakh have been field planted covering an area of 150 ha in nine different states. Preliminary field data collected indicates an initial survival of 90-95 per cent.

Biological Control of Plant Pests, Diseases and Weeds

The biocontrol network programme is under implementation with 29 research and development projects at various institutions/universities throughout the country for the control of serious insects, pests and diseases affecting cotton, sugarcane, pulses, oilseeds and vegetables. The principal objective has been achieved by laying greater emphasis on development of better formulations and cost effective commercially viable pilot scale technology for the production of biocontrol agents to be used under IPM of key pests and diseases. The target of 11.600 ha has been crossed in the fields of cotton, chickpea, sugarcane, tobacco, oilseeds and vegetables. With a view to promote commercialisation of biopesticides, two biocontrol pilot plants (BCPP) have been set up at two centres, TNAU and MKU. Each BCPP aims to produce sufficient quantity of biocontrol agents to cater to the requirements of 10,000 ha of chickpea, groundnut, cotton, sunflower, tobacco, castor, sugarcane, blackgram and green gram. The targets of the BCPPs have been achieved as per schedule. Sufficient quantities of NPV of H.armigera, S.litura, GV of C.infuscatellus, Trichogramma, Trichoderma have been produced to cover an area of 18,000 ha in the fields of the crops mentioned above. These two BCPPs serve as a model

unit for private entrepeneurs taking up such a venture. The Department also supports some projects on breeding varieties resistant to biotic stresses through biotechnology in crops such as chickpea, sugarcane, rice and tobacco.

For popularising biopesticides and ensuring their large scale adaptation by the farmers, the Department arranged field days, workshops-cum-farmers melas under the Biocontrol Network Programme. During 1994-95, 10 more production units were set up in several states.

Biofertilizers

The project on Technology Development and Demonstration of Biofertilizers has resulted in technology packages like polyalkene bioreactor designs to optimise the biomass production of blue green algae, specific media components, their concentration and simple bioassay method and 136 tonnes of high quality soil based innoculum was produced.

Biotechnology Information System

A national network of distributed information centres (DICs) and distributed information sub-centres (DISCs) in specialised areas of Biotechnology under its Biotechnology Information System (BTIS) Programme has been set up. The network provides a complete information source on a) genetic material as hard data. (eg. protein and nucleic acid sequences, gene bank etc.); b) soft information (eg. bibliographic reference through CDROM etc.) and management information. Ten distributed information centres and 23 distributed information sub-centres in selected areas have been established under this system to meet the end user's information requirements. These centres are equipped with international networks like Internet, bitnet, ICGEB net etc., for accessing several biological information resources.

Industrial Biotechnology

Steps are being taken to develop products and processes with specific need based inputs in order to transform semi-finished R&D results into industrially usable products. The Task Force on Industrial Biotechnology helps in identifying such projects. At present, 30 product oriented projects are in operation which include development of diagnostic kits, liposome intercalated drug delivery system, biotechnological methods for enrichment of ores, gathering field data on efficacies of bio-pesticides, gene cloning and gene expression of epidermal growth factor in E.coli, optimisation of process parameters for the production of enzymes and carbohydrates, standardisation of production process for edible mushrooms and process development of high fructose syrup. The areas of development include agriculture, forestry, human and animal health, as well as industrial products.

The Biotech Consortium India Limited (BVIL) has played a crucial role in bridging the gap between R&D industrial and financial institutions. A new programme, Farmers Agricultural Resource Management (FARM), a UNDP-FAO-UNIDO supported activity, was implemented. DBT will coordinate the Asian Biodiversity and Biotechnology Sub-Programme.

International Collaboration

International research and development cooperation progammes have been signed with Germany, Switzerland, USA, UK, Sweden and Russia. A programme of cooperation in biotechnology has been developed among the members of SAARC countries in the fields of health care, agriculture, animal sciences and environment. India has also been handed the overall responsibility for coordinating the activities of the G-15 nations for the establishment of gene banks for medicinal and aromatic plants. Under the aegis of this programme, a network of three national gene banks at Tropical Botanical Garden and research Institute, Thiruvananthapuram; Central Institute of Medicinal and Aromatic Plants, Lucknow; and National Bureau of Plant Genetic Resources, New Delhi have been set up for the conservation of medicinal and aromatic plants.

Autonomous Institutions

The Department of Biotechnology has set up two autonomous institutions, National Institute of Immunology (NII), New Delhi and National Facilities for Animal Tissue and Cell Culture (NFATCC), Pune.

NII has been working on the mechanisms of the immune system so as to work out comprehensive solutions to a plethora of health problems. Till now the focus has been on the control of fertility and the diagnosis and control of communicable diseases. The main areas of research are birth control vaccines; vaccine for communicable diseases; immunodiagnostics kit development alongwith DNA probe for communicable diseases; drug delivery system to deliver all doses of vaccine at a single point; animal related biotechnology for reproduction of genetically superior animals of economic value; predetermination of sex of embryos; preservation of genes of rare species of animals; aquaculture biotechnology; induced breeding of major Indian crops; transgenic animals and recombinant products. So far, the Institute has delivered eight products to the industry.

Since its inception, the NFATCC has been actively involved in cell repository and supply of cell lines. The principal objectives of the Facility are to identify, maintain, store, propagate and supply of human and animal cell lines, establishment of technology for collection, maintenance and supply of various human organs like cornea, skin and bone marrow. Presently, the Facility holds a stock of 1,500 different cell lines. The technology that maintains human cornea for an extended period has been standardised, and the procedures for preservation of heart valves are being developed. The Facility has

successfully developed cell culture from human foetal tissues. Studies on screening antimalarials against chloroquine resistant malaria parasite strains have been carried out. The cell biology laboratory is functional to screen anti-cancer drugs using cell lines. The technology for maintenance and cultivation of skin as organ culture and 3D epithelia from human keratinocytes and its subsequent grafting to burns, nevi and vitiligo cases has been standardised and the results are promising. Newer approaches towards cryopreservation of tissues are being developed at the institute.

5.7 LET US SUM UP

After going through this unit, you would have achieved the objectives stated earlier in the unit. Let us recall what we have discussed so far.

1. India is one of the 12-megadiversity countries in the world. Around 1,27,000 species of microorganisms, plants and animals have been described in the country till date.
2. India has had a long history of conservation and sustainable use of natural resources. National strategies and plans for the conservation, sustainable and equitable use of biological diversity are rooted in the long and rich spiritual and cultural traditions of the country.
3. Institutionalized ex-situ conservation of biological diversity in India started with the establishment of Botanic and Zoological Gardens.
4. India has a number of gene banks for the ex-situ conservation for plants and animals.
5. Systemic surveys of flora and fauna of the country covering all the ecosystems started with the establishment of Botanical Survey of India in 1890 and the Zoological Survey of India in 1916.
6. Institutional support in the assessment of biological diversity in, little known agricultural crops & their wild relatives, and floristic surveys are provided by BSI, IARI and NBPGR.
7. CSIR and DBT have involved in conservation and sustainable use of medicinal plants, industries development in the conservation and sustainable use of biological diversity.
8. India has taken important steps in developing new strategies and further strengthening the existing strategies for effective conservation and sustainable use of its biological diversity. Various systems and approaches for the conservation and sustainable use of biological diversity have been evolved by Government, Non-Government Organizations and local communities.

5.8 CHECK YOUR PROGRESS AND THE KEY

Tick the correct answer :

1. Most active centreof biodiversity studies in India is :

(a) Chennai (b) New Delhi

(c) Allahabad (d) Varanasi

2. IBP stands for

(a) International Biological Programme

(b) Indian Biology Programme

(c) International Botanical Programme

(d) None of the above

3. Silent valley, which contains vary rare species of plants and animals is in :

(a) Mumbai (b) Rajasthan

(c) Kerala (d) J & K

4. The organisation which protects the trade in endangered species at international level :

(a) IBWL (b) CITES

(c) WHO (d) WWF

5. Largest Botanical Garden in India is in :

(a) Lucknow (b) Mumbai

(c) Hyderabad (d) Calcutta

Key :

1. (b) New Delhi
2. (a) International Biological Programme
3. (c) Kerala
4. (b) CITES
5. (d) Calcutta

5.9 ASSIGNMENTS/ ACTIVITIES

It is compulsory for every student to complete an assignment/ activity/ project work from any known prospects of conservation of biological diversity. It may be an extension of project work from previous chapter or a completely new topic, possibly in collaboration with the *ex-situ* conservation. Explain the following (any one):

a. Biological diversity in India
b. Strategy for conservation of biological diversity with special reference to India
c. Institutional mechanism and modalities for conservation of biodiversity
d. India's national plant genetic resources system
e. Future strategy for the conservation of biological diversity
f. In-vitro conservation and its applications and limitations
g. Recent development in in-vitro conservation.

5.10 REFERENCES/ FURTHER READING

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