# BIODIVERSITY

The term **biodiversity** or **biological diversity** may be defined as the variety and variability of living organisms and the ecological complexes in which they exist, including the diversity within and between species and ecosystems.

In other words, biodiversity refers to the totality of genes, species and ecosystem of a region. It differs from place to place. The primary reason of concern is that, the biologically rich and unique habitats are being destroyed, fragmented and degraded even before their actual size is known. The loss of biodiversity would check the evolutionary capabilities of biota to cope with the environmental changes.

**MAGNITUDE OF BIODIVERSITY:**

The known and described number of species of all organisms on the earth is between 1.7 and 1.8 million, which is fewer than 15% of the actual number. The predicted number of total species varies from 5 to 50 million and averages at 14 million. Out of the total known species, about 60% are insects, about 16% are higher plants and only about 0.3% are mammals. There are many more species that have not yet been described, especially in the tropics. Information about bacteria, viruses, protists and Archaea is just fragmentary. However, new species are being discovered faster than ever before due to the efforts of projects like Global Biodiversity Information Facility and The Species 2000. The approximate numbers of species of different taxonomic groups, which have been identified and described from all over the world, are given in Table below:

| **Group** | **Number of species** |
|---|---|
| Higher plants | 270000 |
| Algae | 40000 |
| Fungi | 72000 |
| Bacteria (including Cyanobacteria) | 4000 |
| Viruses | 1550 |
| Mammals | 4650 |

| | |
|---|---|
| Birds | 9700 |
| Reptiles | 7150 |
| Fish | 26959 |
| Amphibians | 4780 |
| Insects | 1025 |
| Crustaceans | 43000 |
| Molluscs | 70000 |
| Nematodes and worms | 25000 |
| Protozoa | 40000 |
| Others | 110000 |

**BIODIVERSITY OF INDIA:**

With 2.4 per cent of the world's land, India contributes 8 per cent to the world diversity. It has, therefore, been designated as one of the 12 megadiversity regions of the world. India is recognized as a country uniquely rich in biodiversity because of its tropical location, varied physical features and climate. Indian biodiversity is estimated to be over 45,000 plant species contributing 8 per cent of the world's flora and about 80,000 animal species constituting 7 percent of the world's fauna of which 33 per cent flora and 62 per cent fauna are endemic (found nowhere else in the world) to India. Among the plant species, the flowering plants have a much higher degree of endemism, a third of these are not found elsewhere in the world. Of the estimated 45,000 species of plants about 5,000 species of algae, 20,000 of fungi, 1,600 of lichens, 2,700 of bryophytes, 600 of pteridophytes and 15,000 of flowering plants have been identified and described so far. Indian flowering plants represent 15 per cent of the flowering plants of the world. Among flowering plants orchids have high species diversity (1,082) found mainly in North-eastern Himalaya.

Apart from the high biological diversity in Indian wild plants there is also great diversity of cultivated crops. The traditional cultivar includes 30,000 to 50,000 varieties of rice and a number of cereals, vegetables and fruits. The highest diversity of cultivars is concentrated in high rainfall areas of the Western Ghats, Eastern Ghats, Northern Himalayas and the North-Eastern hills.

As far as faunal diversity is concerned, India is home for 67,000 species of insects (including 13,000 butterflies and moths), 4,000 of molluscs, 6,500 other invertebrates 2,000 of fishes, 1,200 of birds, 540 of reptiles, 200 of ambhibians, and 500 of mammals, in which 62 per cent ambhibians and 32 per cent reptiles are endemic to India. Among lizards, of the 153 species recorded 50 per cent are endemic.

Among the larger animals 79 mammals, 44 birds, 15 reptiles and 3 amphibians are threatened today and 1,500 plant species belong to endangered category (the species which are in danger of extinction).

Indian sub-continent alone has given the world nearly 320 species of wild animals, whose centre of origin lies in India. Livestock diversity is also high i.e. 27 breeds of cattle, 40 breeds of sheep, 22 breeds of goats and 8 breeds of buffaloes are available in the country. However, today many of these are standing on the verge of extinction due to the increased use of exotic breeds. Jersey and Holsteins have largely replaced indigenous breeds of cattle.

India has contributed 167 species of cultivated plants along with their 320 species of wild relatives and land races and several domestic animals. Rice, sugarcane, jute, jackfruit, ginger, turmeric, black pepper, bamboos, camel, mithun and water buffalo have originated in India.

India is extremely rich in Ecosystem diversity as well. According to Wildlife Institute of India the country has 10 biographic zones: (i) Trans-Himalayas (ii) Himalayas (iii) Desert (iv) Semi-arid (v) Western Ghats (vi) Deccan (vii) Gangetic Plain (viii) North-East India (ix) Islands; and (x) Coasts.

The North-East, the Western Ghats, Western and North-Western Himalayas are rich in endemism. At least 200 endemic species are found in the Andaman and Nicobar islands.

Hot spots are the regions of high biodiversity with massive threat to flora and fauna due to high biotic pressure. Of the 18 biodiversity hot spots of the world 2 belong to India. Western Ghats and Eastern-Himalayas are the hot spots of biodiversity in India.

The Andaman and Nicobar islands are extremely rich in species, and many subspecies of different animals and birds have evolved here. The islands alone have as many as 2,200 species of flowering plants and 120 species of ferns. Out of 135 genera of land mammals in India 85 (63%) are found in the north-east. The north-eastern states also have 1,500 endemic plant species.

A major proportion of amphibian and reptile species, especially snakes, is concentrated in Western Ghats, which is also habitat for 1,500 endemic plant species. The Coral reefs around the Andaman and Nicobar Islands, the Lakshadweep islands and the Gulf areas of Gujarat and Tamil Nadu are biologically diverse ecosystems and are often called 'tropical rain forest' of the ocean.

**TYPES / LEVELS OF BIODIVERSITY:**

There are three interrelated hierarchical levels of biodiversity namely, genetic diversity, species diversity and community or ecosystem diversity.

1. **Genetic diversity:**

   Each species, varying from bacteria to higher plants and animals, stores an immense amount of genetic information. For example, the number of genes is about 450-700 in Mycoplasma, 4000 in a bacterium (*Escherichia coli*), 13000 in fruit fly (*Drosophila melanogaster*), 32000-50000 in rice (*Oryza sativa*) and 35000 to 45000 in human being (*Homo sapiens*).

   Genetic diversity refers to the variation of genes within species; the differences could be in alleles (different variants of same genes), in entire genes (the traits determining particular characteristics) or in chromosomal structures. The genetic diversity enables a population to adapt to its environment and to respond to natural selection. If a species has more genetic diversity, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to uniformity, as is the case with large monocultures of genetically similar crop plants. This has advantage when increased crop production is a consideration, but can be a problem when an insect or a fungal disease attacks the field and poses a threat to the whole crop.

   The amount of genetic variation is the basis of speciation (evolution of new species). It has a key role in the maintenance of diversity at species and community levels. The total genetic diversity of a community will be greater if there are many species as compared to a situation where there are only a few species. Genetic diversity within a species often increases with environmental variability.

2. **Species diversity:**

   Species diversity refers to the variety of species within a region. Simplest measure of species diversity is species richness, i.e. the number of species per unit area. The number of species increases with the area of the site. Generally, greater the species richness greater is the species diversity. However, number of individuals among the species may also vary resulting into differences in evenness, or equitability, and consequently in diversity.

3. **Community or ecosystem diversity:**

   Ecosystem diversity can be described for a specific geographical region. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures. An ecosystem is referred to as 'natural' when it is relatively undisturbed by human activities or 'modified' when it is changed to other types of uses, such as farmland or urban areas. Ecosystems are most natural in wilderness areas. If natural ecosystems are overused or misused their productivity eventually decreases and they are then said to be degraded. India is exceptionally rich in its ecosystem diversity.

**MEASURING BIODIVERSITY:**

Species richness is a method often employed to understand the biodiversity of community. If the number of species is known, the diversity could be measured. There are several mathematical indices of biodiversity measurement. Some of them are:

1. **Alpha diversity (within community diversity):** refers to the diversity of organisms sharing the same community/habitat. A combination of species richness and equitability / evenness is used to represent diversity within a community or habitat.
2. **Beta diversity (between-community diversity):** Species frequently change when habitat or community changes. The rate of replacement of species along a gradient of habitats or communities is called beta diversity. Species composition of communities may vary along environmental gradients, e.g. altitudinal gradient, moisture gradient, etc. Higher the

heterogeneity in the habitats in a region or greater the dissimilarity between communities, higher is the beta diversity.

3. **Gamma diversity (Overall diversity):** Diversity of the habitats over the total landscape or geographical area is called gamma diversity. It includes both α and β diversities. The relationship is as follows:

$$\gamma = \alpha + \boldsymbol{\beta} + Q$$

where, Q = Total number of habitats or communities,

α = Average value of α diversities

**β** = Average value of β diversities

## IMPORTANCE OF BIODIVERSITY:

The living organisms on earth are of great diversity, living in diverse habitats and possessing diverse qualities and are vital to human existence providing food, shelter, clothing's, medicines etc.

**1. Productive values:** Biodiversity produces a number of products harvested from nature and sold in commercial markets. Indirectly it provides economic benefits to people, which include water quality soil protection, equalization of climate, environmental monitoring, scientific research, recreation etc.

**2. Consumptive value:** The consumptive value can be assigned to goods such as fuel woods, leaves, forest products etc. which may be consumed locally and do not figure in national and international market.

**3. Social value:** The loss of biodiversity directly influences the social life of the country possibly through influencing ecosystem functions (energy flow and biogeochemical cycle). This can be easily understood by observing detrimental effects of global warming and acid rain which cause an unfavorable alteration in logical processes.

**4. Aesthetic value:** Aesthetic values such as refreshing fragrance of the flowers, taste of berries, softness of mosses, melodious songs of birds, etc. compel the human beings to preserve them. The earth's natural beauty with its colour and hues, thick forest, and graceful beasts has inspired the human beings from their date of birth to take necessary steps for its maintenance. Similarly botanical and zoological gardens are the means of biodiversity conservation and are of aesthetic values.

**5. Legal values:** Since earth is homeland of all living organisms, all have equal right to coexist on the surface of earth with all benefits. Unless some legal value is attached to biodiversity, it will not be possible to protect the rapid extinction of species.

**6. Ethical value:** Biodiversity must be seen in the light of holding ethical value. Since man is the most intelligent amongst the living organisms, it should be prime responsibility and moral obligation of man to preserve and conserve other organisms which will directly or indirectly favour the existence of the man.

**7. Ecological value:** Biodiversity holds great ecological value because it is indispensable to maintain the ecological balance. Any disturbance in the delicately fabricated ecological balance maintained by different organisms, will lead to severe problems, which may threaten the survival of human beings.

**8. Economic value:** Biodiversity has great economic value because economic development depends upon efficient and economic management of biotic resources.

In the day to day life, human beings are maintaining their lifestyle at the sacrifice of surrounding species which come from diversity of plants and animals struggling for their existence.

So, it is highly essential for the human beings to take care of their surrounding species and make optimum use of their service, for better economic development. Thus, it is rightly told, survival of the man depends upon the survival of the biosphere.

## USES OF BIODIVERSITY:

Biodiversity has the following uses for the development humanity:

(i) It provides food of all types.

(ii) It provides fibers, sources for the preparation of clothes.

(iii) It provides different types of oil seeds for the preparation of oils.

(iv) It provides new varieties of rice, potato etc. through the process of hybridization.

(v) It provides different drugs and medicines which are based on different plant products.

(vi) It is very essential for natural pest control, maintenance of population of various species, pollination by insects and birds, nutrient cycling, conservation and purification of water, formation of soil etc. All these services together are valued 16.54 trillion dollars per year.

## THREATS TO BIODIVERSITY:

Biodiversity is considered as a reservoir of resources to be used for the manufacture of food, medicine, industrial products, etc. But with an increased demand of rapid population growth, biodiversity is gradually depleting. A number of plants" and animal species have already become extinct and many are endangered.

**The different factors responsible for causing threat to biodiversity are as follows:**

### 1. Habitat destruction:

The primary cause of loss of biodiversity is habitat loss or destruction which is resulted due to the large industrial and commercial activities associated with agriculture, irrigation, construction of dams, mining, fishing etc.

**2. Habitat fragmentation:**

With increased population, the habitats are fragmented into pieces by roads, fields, canals, power lines, towns etc. The isolated fragment of habitats restricts the potential of species for dispersal and colonization. In addition, the habitat fragmentation also brings about microclimatic changes in light, temperature, wind etc.

**3. Pollution:**

The most dreaded factor inducing loss of biodiversity is environmental pollution which include air pollution, Water pollution, industrial pollution, pollution due to chemical Pastes, pesticides radioactive materials etc.

**4. Over exploitation:**

The natural resources are over exploited to meet growing rural poverty, intensive technological growth and globalization of economy. All these factors together may be responsible for the extinction of a number of species.

**5. Introduction of exotic species:**

**The introduction of exotic species are due to:**

(i) horticulture

(ii) agriculture;

(iii) European colonisation and

(iv) accidental transport.

It is seen that some exotic species may kill or eat the native species thereby causing its extinction.

**6. Diseases:**

Since the animals are more vulnerable to infection, the anthropological activities may increase the incidence of diseases in wild species, leading to their extinction.

**7. Shifting or Jhum cultivation:**

The shifting or Jhum cultivation by poor tribal people greatly affects the forest structure which is a store house of biodiversity.

**8. Poaching of wild life:**

A number of wildlife species are becoming extinct due to poaching and hunting.

**Endangered and Endemic Species of India**

| Category | Enlisted species | Highly endangered Species |
|---|---|---|
| 1. Higher plants | 15,000 | 135 |
| 2. Mammals | 372 | 69 |
| 3. Reptiles and amphibians | 580 | 22 |
| 4. Birds | 1175 | 40 |
| 5. Fishes | 1693 | — |

**CONSERVATION OF BIODIVERSITY:**

Biodiversity is being depleted by the loss of habitat, fragmentation of habitat, over exploitation of resources, human sponsored ecosystems, climatic changes, pollution invasive exotic species, diseases, shifting cultivation, poaching of wild life etc.

Since the human beings are enjoying all the benefits from biodiversity, they should take proper care for the preservation of biodiversity in all its form and good health for the future generation i.e., the human being should prevent the degradation and destruction of the habitats thereby maintaining the biodiversity at its optimum level.

Conservation of biodiversity is protection, upliftment and scientific management of biodiversity so as to maintain it at its threshold level and derive sustainable benefits for the present and future generation. In other words, conservation of bio-diversity is the proper management of the biosphere by human beings in such a way that it gives maximum benefits for the present generation and also develops its potential so as to meet the needs of the future generations.

**Mainly the conservation of biodiversity has three basic objectives:**

(a) To maintain essential ecological processes and life supporting systems.

(b) To preserve the diversity of species.

(c) To make sustainable utilization of species and ecosystems.

**Important aspects of biodiversity conservation:**

(1) All the possible varieties (old or new) of food, forage and timber plants, live stock, agriculture animals and microbes should be conserved.

(2) All the economically important organisms in protected areas should be identified and conserved.

(3) Critical habitats for each species should be identified and safeguarded.

(4) Priority should be given to preserve unique ecosystems.

(5) There should be sustainable utilisation of resources.

(6) International trade in wild life should be highly regulated.

(7) The poaching and hunting of wildlife should be prevented as far as practicable.

(8) Care should be taken for the development of reserves and protected areas.

(9) Efforts should be made to reduce the level of pollutants in the environment.

(10) Public awareness should be created regarding biodiversity and its importance for the living organisms.

(11) Priority should be given in wildlife conservation programme to endangered species over vulnerable species and to vulnerable species over rare species.

(12) The habitats of migratory birds should be protected by bilateral and multilateral agreement.

(13) The over exploitation of useful products of wild life should be prevented.

(14) The useful animals, plants and their wild relatives should be protected both in their natural habitat (in-situ) and in zoological botanical gardens (ex-situ)

(15) Efforts should be made for setting up of National parks and wild life sanctuaries to safeguard the genetic diversity and their continuing evolution.

(16) Environmental laws should be strictly followed.

# BIODIVERSITY CONSERVATION STRATEGIES

Biodiversity is an irreplaceable resource, because of which there is no possibility of recreation of extinct plants and animals. Therefore, it is important to generate awareness for the conservation and sustainable utilization of biodiversity, for the benefit of mankind and for their survival. Several methods are being used for the conservation of biodiversity which falls under two broad categories:

I. In-situ conservation strategy
II. Ex-situ conservation strategy

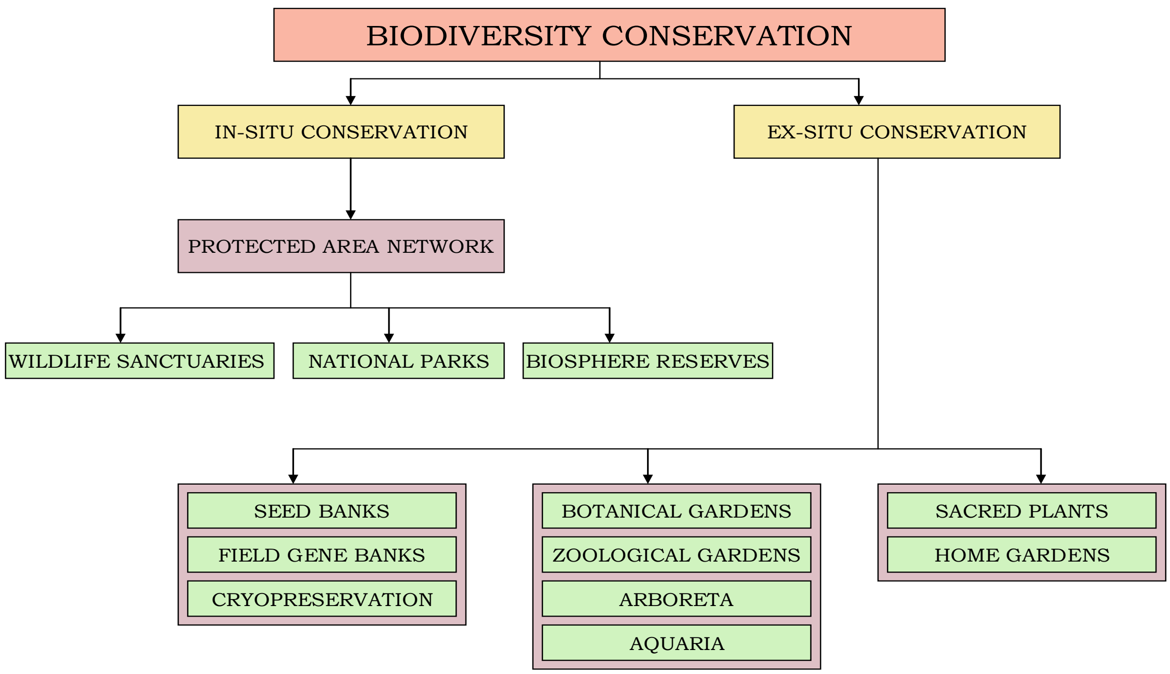


Figure: Schematic view of insitu and exsitu approaches for conservation of biodiversity

## I. In situ conservation strategy:

The conservation of species in their natural habitat or natural ecosystem is known as in situ conservation. In the process, the natural surrounding or ecosystem is protected and maintained so that all the constituent species (known or unknown) are conserved and benefited. The factors which are detrimental to the existence of species concerned are eliminated by suitable mechanism. The protection and management of biodiversity through in situ conservation involve certain specific areas known as protected areas which include national parks, wildlife sanctuaries, biosphere reserves etc.

**1. Protected areas:**

The protected areas are biogeographical regions where biological diversity along with natural and cultural resources are protected, maintained and managed through legal and administrative measures. The demarcation of biodiversity in each area is determined on the basis of climatic and physiological conditions.

In these areas, hunting, firewood collection, timber harvesting etc. are prohibited so that the wild plants and animals can grow and multiply freely without any hindrance. Some protected areas are: Cold desert (Ladakh and Spiti), Hot desert (Thar), Saline Swampy area (Sunderban and Rann of Kutch), Tropical moist deciduous forest (Western Ghats and north East) etc. Protected areas include national parks, sanctuaries and biosphere reserves. There are about 37,000 protected areas throughout the world. As per World Conservation Monitoring Centre, India has 870 protected areas i.e. 156,700 square kilometres, roughly 4.95% of the total surface area.

**(i) National parks:**

National park (IUCN Category II protected area) is similar to a wilderness area in its size and its main objective is protecting and functioning of ecosystems. However, national parks tend to be more lenient with human visitation and its supporting infrastructure. National parks are managed in a way that may contribute to local economies through promoting educational and recreational tourism on a scale that will not reduce the effectiveness of conservation efforts. The surrounding areas of a national park may be for consumptive or non-consumptive use but should nevertheless act as a barrier for the defence of the protected area's native species and communities to enable them to sustain themselves in the long term.

At present, there are about 104 national parks in India encompassing an area of 40,501.13 $km^2$, i.e. 1.23% of India's total surface area (Source: National Wildlife Database, Wildlife Institute of India, May, 2019).

## List of National Parks in India

| State | S.No. | Name of State/ Protected Area | Year of Establishment | Area ($km^2$) |
|---|---|---|---|---|
| Andaman & Nicobar Islands | 1 | Campbell Bay NP | 1992 | 426.23 |
| Andaman & Nicobar Islands | 2 | Galathea Bay NP | 1992 | 110 |
| Andaman & Nicobar Islands | 3 | Mahatama Gandhi Marine (Wandoor) NP | 1983 | 281.5 |
| Andaman & Nicobar Islands | 4 | Middle Button Island NP | 1987 | 0.44 |
| Andaman & Nicobar Islands | 5 | Mount Harriett NP | 1987 | 46.62 |
| Andaman & Nicobar Islands | 6 | North Button Island NP | 1987 | 0.44 |
| Andaman & Nicobar Islands | 7 | Rani Jhansi Marine NP | 1996 | 256.14 |
| Andaman & Nicobar Islands | 8 | Saddle Peak NP | 1987 | 32.54 |
| Andaman & Nicobar Islands | 9 | South Button Island NP | 1987 | 0.03 |
| Andhra Pradesh | 1 | Papikonda NP | 2008 | 1012.86 |
| Andhra Pradesh | 2 | Rajiv Gandhi (Rameswaram) NP | 2005 | 2.4 |
| Andhra Pradesh | 3 | Sri Venkateswara NP | 1989 | 353.62 |
| Arunachal Pradesh | 1 | Mouling NP | 1986 | 483 |
| Arunachal Pradesh | 2 | Namdapha NP | 1983 | 1807.82 |
| Assam | 1 | Dibru-Saikhowa NP | 1999 | 340 |
| Assam | 2 | Kaziranga NP | 1974 | 858.98 |
| Assam | 3 | Manas NP | 1990 | 500 |
| Assam | 4 | Nameri NP | 1998 | 200 |
| Assam | 5 | Rajiv Gandhi Orang NP | 1999 | 78.81 |
| Bihar | 1 | Valmiki NP | 1989 | 335.65 |
| Chhattisgarh | 1 | Guru Ghasidas (Sanjay) NP | 1981 | 1440.705 |
| Chhattisgarh | 2 | Indravati (Kutru) NP | 1982 | 1258.37 |
| Chhattisgarh | 3 | Kanger Valley NP | 1982 | 200 |
| Goa | 1 | Mollem NP | 1992 | 107 |
| Gujarat | 1 | Vansda NP | 1979 | 23.99 |
| Gujarat | 2 | Blackbuck (Velavadar) NP | 1976 | 34.53 |
| Gujarat | 3 | Gir NP | 1975 | 258.71 |
| Gujarat | 4 | Marine (Gulf of Kachchh) NP | 1982 | 162.89 |
| Haryana | 1 | Kalesar NP | 2003 | 46.82 |
| Haryana | 2 | Sultanpur NP | 1989 | 1.43 |
| Himachal Pradesh | 1 | Great Himalayan NP | 1984 | 754.4 |
| Himachal Pradesh | 2 | Inderkilla NP | 2010 | 104 |
| Himachal Pradesh | 3 | Khirganga NP | 2010 | 710 |
| Himachal Pradesh | 4 | Pin Valley NP | 1987 | 675 |

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|---|---|---|---|---|
| Himachal Pradesh | 5 | Simbalbara NP | 2010 | 27.88 |
| Jammu & Kashmir | 1 | City Forest (Salim Ali) NP | 1992 | 9 |
| Jammu & Kashmir | 2 | Dachigam NP | 1981 | 141 |
| Jammu & Kashmir | 3 | Hemis NP | 1981 | 3350 |
| Jammu & Kashmir | 4 | Kishtwar NP | 1981 | 425 |
| Jharkhand | 1 | Betla NP | 1986 | 226.33 |
| Karnataka | 1 | Anshi NP | 1987 | 417.34 |
| Karnataka | 2 | Bandipur NP | 1974 | 874.2 |
| Karnataka | 3 | Bannerghatta NP | 1974 | 260.51 |
| Karnataka | 4 | Kudremukh NP | 1987 | 600.32 |
| Karnataka | 5 | Nagarahole (Rajiv Gandhi) NP | 1988 | 643.39 |
| Kerala | 1 | Anamudi Shola NP | 2003 | 7.5 |
| Kerala | 2 | Eravikulam NP | 1978 | 97 |
| Kerala | 3 | Mathikettan Shola NP | 2003 | 12.82 |
| Kerala | 4 | Pambadum Shola NP | 2003 | 1.318 |
| Kerala | 5 | Periyar NP | 1982 | 350 |
| Kerala | 6 | Silent Valley NP | 1984 | 89.52 |
| Madhya Pradesh | 1 | Bandhavgarh NP | 1968 | 448.85 |
| Madhya Pradesh | 2 | Dinosaur Fossils NP | 2011 | 0.8974 |
| Madhya Pradesh | 3 | Fossil NP | 1983 | 0.27 |
| Madhya Pradesh | 4 | Indira Priyadarshini Pench NP | 1975 | 292.85 |
| Madhya Pradesh | 5 | Kanha NP | 1955 | 940 |
| Madhya Pradesh | 6 | Madhav NP | 1959 | 375.22 |
| Madhya Pradesh | 7 | Panna NP | 1981 | 542.67 |
| Madhya Pradesh | 8 | Sanjay NP | 1981 | 466.88 |
| Madhya Pradesh | 9 | Satpura NP | 1981 | 585.17 |
| Madhya Pradesh | 10 | Van Vihar NP | 1979 | 4.45 |
| Maharashtra | 1 | Chandoli NP | 2004 | 317.67 |
| Maharashtra | 2 | Gugamal NP | 1975 | 361.28 |
| Maharashtra | 3 | Nawegaon NP | 1975 | 133.88 |
| Maharashtra | 4 | Pench (Jawaharlal Nehru) NP | 1975 | 257.26 |
| Maharashtra | 5 | Sanjay Gandhi (Borivilli) NP | 1983 | 86.96 |
| Maharashtra | 6 | Tadoba NP | 1955 | 116.55 |
| Manipur | 1 | Keibul-Lamjao NP | 1977 | 40 |
| Meghalaya | 1 | Balphakram NP | 1985 | 220 |
| Meghalaya | 2 | Nokrek Ridge NP | 1986 | 47.48 |
| Mizoram | 1 | Murlen NP | 1991 | 100 |

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|---|---|---|---|---|
| Mizoram | 2 | Phawngpui Blue Mountain NP | 1992 | 50 |
| Nagaland | 1 | Intanki NP | 1993 | 202.02 |
| Odisha | 1 | Bhitarkanika NP | 1988 | 145 |
| Odisha | 2 | Simlipal NP | 1980 | 845.7 |
| Rajasthan | 1 | Desert NP | 1992 | 3162 |
| Rajasthan | 2 | Keoladeo Ghana NP | 1981 | 28.73 |
| Rajasthan | 3 | Mukundra Hills NP | 2006 | 200.54 |
| Rajasthan | 4 | Ranthambhore NP | 1980 | 282 |
| Rajasthan | 5 | Sariska NP | 1992 | 273.8 |
| Sikkim | 1 | Khangchendzonga NP | 1977 | 1784 |
| Tamil Nadu | 1 | Guindy NP | 1976 | 2.82 |
| Tamil Nadu | 2 | Gulf of Mannar Marine NP | 1980 | 6.23 |
| Tamil Nadu | 3 | Indira Gandhi (Annamalai) NP | 1989 | 117.1 |
| Tamil Nadu | 4 | Mudumalai NP | 1990 | 103.23 |
| Tamil Nadu | 5 | Mukurthi NP | 1990 | 78.46 |
| Telangana | 1 | Kasu Brahmananda Reddy NP | 1994 | 1.43 |
| Telangana | 2 | Mahaveer Harina Vanasthali NP | 1994 | 14.59 |
| Telangana | 3 | Mrugavani NP | 1994 | 3.6 |
| Tripura | 1 | Clouded Leopard NP | 2007 | 5.08 |
| Tripura | 2 | Bison (Rajbari) NP | 2007 | 31.63 |
| Uttar Pradesh | 1 | Dudhwa NP | 1977 | 490 |
| Uttarakhand | 1 | Corbett NP | 1936 | 520.82 |
| Uttarakhand | 2 | Gangotri NP | 1989 | 2390.02 |
| Uttarakhand | 3 | Govind NP | 1990 | 472.08 |
| Uttarakhand | 4 | Nanda Devi NP | 1982 | 624.6 |
| Uttarakhand | 5 | Rajaji NP | 1983 | 820 |
| Uttarakhand | 6 | Valley of Flowers NP | 1982 | 87.5 |
| West Bengal | 1 | Buxa NP | 1992 | 117.1 |
| West Bengal | 2 | Gorumara NP | 1992 | 79.45 |
| West Bengal | 3 | Jaldapara NP | 2014 | 216.51 |
| West Bengal | 4 | Neora Valley NP | 1986 | 159.89 |
| West Bengal | 5 | Singalila NP | 1986 | 78.6 |
| West Bengal | 6 | Sunderban NP | 1984 | 1330.1 |

**Source: National Wildlife Database, Wildlife Institute of India (May, 2019)**

**(ii) Wildlife Sanctuaries:**

Wildlife sanctuaries (IUCN Category IV protected area) focus on more specific areas of conservation (though size is not necessarily a distinguishing feature), like an identifiable species or habitat that requires continuous protection rather than that of a natural feature. These protected areas will be sufficiently controlled to ensure the maintenance, conservation, and restoration of particular species and habitats, possibly through traditional means and public education of such areas is widely encouraged as part of the management objectives.

Habitat or species management areas may exist as a fraction of a wider ecosystem or protected area and may require varying levels of active protection. Management measures may include (but are not limited to) the prevention of poaching, creation of artificial habitats, halting natural succession, and supplementary feeding practices.

At present there are about 551 existing wildlife sanctuaries in India covering an area of 119775.80 $km^2$, which is 3.64 % of the geographical area of the country (National Wildlife Database, May, 2019).

**List of some important wildlife sanctuaries in India**

| S.N. | Wildlife Sanctuaries | State |
|---|---|---|
| 1 | Bhitarkanika Wildlife Sanctuary, 1975 | Odisha |
| 2 | Barren Island Wildlife Sanctuary | Andaman and Nicobar Islands |
| 3 | Nelapattu Bird Sanctuary, 1976 | Andhra Pradesh |
| 4 | Gir Wildlife Sanctuary, 1965 | Gujarat |
| 5 | Wild Ass Wildlife Sanctuary, 1973 | Gujarat |
| 6 | Periyar Wildlife Sanctuary, 1982 | Kerala |
| 7 | Ken Gharial Sanctuary | Madhya Pradesh |
| 8 | Sariska Tiger Reserve | Rajasthan |
| 9 | Dalma Wildlife Sanctuary, 1976 | Jharkhand |
| 10 | Udhwa Lake Wildlife Sanctuary | Jharkhand |

### (iii) Biosphere reserves:

The Indian government has established 18 biosphere reserves in India (categories roughly corresponding to IUCN Category V Protected areas), which protect larger areas of natural habitat than a typical national park or wildlife sanctuary, and often include one or more national parks or reserves, along with buffer zones that are open to some economic uses. Protection is granted not only to the flora and fauna of the protected region, but also to the human communities who inhabit these regions, and their ways of life.

### List of biosphere reserves in India

**Biosphere reserves of India**

| | Year | Name | Location | State | Type | Key fauna | Area ($km^2$) |
|---|---|---|---|---|---|---|---|
| 1 | 1986 | Nilgiri Biosphere Reserve | Part of Waynad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley | Tamil Nadu, Kerala and Karnataka | Western Ghats | Nilgiri tahr, tiger, lion-tailed macaque | 5520 |
| 2 | 1988 | Nanda Devi Biosphere Reserve | Parts of Chamoli District, Pithoragarh District & Bageshwar District | Uttarakhand | Western Himalayas | Snow leopard, Himalayan black bear | 5860 |
| 3 | 1989 | Gulf of Mannar | Indian part of Gulf of Mannar extending from Rameswaram island in the north to Kanyakumari in the south of Tamil Nadu and Sri Lanka | Tamil Nadu | Coasts | Dugong | 10500 |
| 4 | 1988 | Nokrek | In west Garo Hills | Meghalaya | Eastern hills | Red panda | 820.00 |
| 5 | 1989 | Sundarbans | Part of delta of Ganges and Brahmaputra river system | West Bengal | Gangetic Delta | Royal Bengal tiger | 9630 |
| 6 | 1989 | Manas | Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang Districts | Assam | Eastern Hills | Asiatic elephant, tiger, Assam roofed turtle, hispid hare, golden langur, pygmy hog | 2837 |
| 7 | 1994 | Simlipal | Part of Mayurbhanj district | Odisha | Deccan Peninsula | Gaur, royal Bengal tiger, Asian elephant | 4374 |
| 8 | 1998 | Dihang-Dibang | Part of Siang and Dibang Valley | Arunachal Pradesh | Eastern Himalaya | Mishmi takin, musk deer | 5112 |
| 9 | 1999 | Pachmarhi Biosphere Reserve | Parts of Betul District, Hoshangabad District and Chhindwara District | Madhya Pradesh | Semi-Arid | Giant squirrel, flying squirrel | 4981.72 |
| 10 | 2005 | Achanakmar-Amarkantak Biosphere Reserve | Part of Annupur, Dindori and Bilaspur districts | Madhya Pradesh, Chhattisgarh | Maikala Hills | Four-horned antelope, Indian wild dog, sarus crane, white-rumped vulture, sacred grove bush frog | 3835 |
| 11 | 2008 | Great Rann of Kutch | Part of Kutch, Morbi, Surendranagar and Patan districts; the largest biosphere | Gujarat | Desert | Indian wild ass | 12454 |

**Biosphere reserves of India**

| | Year | Name | Location | State | Type | Key fauna | Area (km²) |
|---|---|---|---|---|---|---|---|
| | | | reserve in India. | | | | |
| 12 | 2009 | Cold Desert | Pin Valley National Park and surroundings; Chandratal and Sarchu & Kibber Wildlife Sanctuary | Himachal Pradesh | Western Himalayas | Snow leopard | 7770 |
| 13 | 2000 | Khangchendzonga | Parts of Kangchenjunga | Sikkim | East Himalayas | Snow leopard, red panda | 2620 |
| 14 | 2001 | Agasthyamalai Biosphere Reserve | Neyyar, Peppara and Shenduruny Wildlife Sanctuary and their adjoining areas | Kerala, Tamil Nadu | Western Ghats | Nilgiri tahr, Asian elephant | 3500.08 |
| 15 | 1989 | Great Nicobar | Southernmost of the Andaman and Nicobar Islands | Andaman and Nicobar Islands | Islands | Saltwater crocodile | 885 |
| 16 | 1997 | Dibru-Saikhowa | Part of Dibrugarh and Tinsukia districts | Assam | Eastern Hills | White-winged wood duck, water buffalo, black-breasted parrotbill, tiger, capped langur | 765 |
| 17 | 2010 | Seshachalam Hills | Seshachalam Hill Ranges covering parts of Chittoor and Kadapa districts | Andhra Pradesh | Eastern Ghats | Slender loris | 4755 |
| 18 | 2011 | Panna | Part of Panna District and Chhatarpur District | Madhya Pradesh | Catchment Area of the Ken River | Tiger, chital, chinkara, sambhar and sloth bear | 2998.98 |

Eleven of the eighteen biosphere reserves are a part of the World Network of Biosphere Reserves (WNBR), based on the UNESCO Man and the Biosphere (MAB) Programme list.

| # | Name | States/ UT | Year |
|---|---|---|---|
| 1 | Nilgiri Biosphere Reserve | Tamil Nadu, Kerala and Karnataka | 2000 |
| 2 | Gulf of Mannar Biosphere Reserve | Tamil Nadu | 2001 |
| 3 | Sundarbans Biosphere Reserve | West Bengal | 2001 |
| 4 | Nanda Devi Biosphere Reserve | Uttarakhand | 2004 |
| 5 | Nokrek Biosphere Reserve | Meghalaya | 2009 |
| 6 | Pachmarhi Biosphere Reserve | Madhya Pradesh | 2009 |
| 7 | Simlipal Biosphere Reserve | Odisha | 2009 |
| 8 | Great Nicobar Biosphere Reserve | Andaman & Nicobar Islands | 2013 |
| 9 | Achanakmar-Amarkantak Biosphere Reserve | Chhattisgarh, Madhya Pradesh | 2012[ |
| 10 | Agasthyamalai Biosphere Reserve | Kerala and Tamil Nadu | 2016 |
| 11 | Khangchendzonga National Park | Sikkim | 2018 |

## II. Ex-situ conservation strategy:

It is the process of protecting an endangered species, variety or breed, of plant or animal outside its natural habitat; by removing part of the population from a threatened habitat and placing it in a new location within the care of humans, like in zoos, botanical gardens, nurseries etc. or as a parts like, cells, sperms, pollens, seeds etc. Various methods involved under ex-situ conservation strategies include:

1. Seed banks
2. Field gene banks
3. Cryopreservation
4. Tissue culture
5. Botanical garden
6. Zoos

**1. Seed Banks:** Seed banks are vast refrigerators where the seed samples are stored under controlled humidity and temperature conditions. Conventional storage protocols involve drying seeds to about 20% relative humidity, sealing seeds in high quality moisture-proof containers, and storing seeds at −20° Celsius. Seeds from species like corn, wheat, rice, soybean, pea, tomato, broccoli, melon, sunflower, etc. can be stored in this way.

Under controlled storage conditions, some seeds may remain viable for hundreds and even thousands of years. Regular checking of seeds for viability and damage is most essential and the seed samples are grown out before the seeds begin to deteriorate so that a fresh generation of seeds can be obtained for continued storage. The oldest carbon-14-dated seed that has grown into a viable plant was a Judean date palm seed about 2,000 years old, recovered from excavations at the palace of Herod the Great in Israel. In February 2012, Russian scientists announced they had regenerated a narrow leaf campion (*Silene stenophylla*) from a 32,000-year-old seed. The seed was found in a burrow 124 feet (38 m) under Siberian permafrost along with 800,000 other seeds. Seed tissue was grown in test tubes until it could be transplanted to soil. This exemplifies the long-term viability of DNA under proper conditions.

There are about 6 million accessions, or samples of a particular population, stored as seeds in about 1,300 genebanks throughout the world as of 2006. This amount represents a small fraction of the world's biodiversity, and many regions of the world have not been fully explored. Some important seed banks around the world are:

- The Svalbard Global Seed Vault has been built inside a sandstone mountain in a man-made tunnel on the frozen Norwegian island of Spitsbergen, which is part of the Svalbard archipelago, about 1,307 kilometres (812 mi) from the North Pole. It is designed to survive catastrophes such as nuclear war and world war. It is operated by the Global Crop Diversity Trust. The area's permafrost will keep the vault below the freezing point of water, and the seeds are protected by 1-metre thick walls of steel-reinforced concrete. There are two airlocks and two blast-proof doors. The vault accepted the first seeds on 26 February 2008.
- The Millennium Seed Bank housed at the Wellcome Trust Millennium Building (WTMB), located in the grounds of Wakehurst Place in West Sussex, near London, in England, UK. It is the largest seed bank in the world (longterm, at least 100 times bigger than Svalbard Global Seed Vault), providing space for the storage of billions of seed samples in a nuclear bomb proof multi-story underground vault. Its ultimate aim being to store every plant species possible, it reached its first milestone of 10% in 2009, with the next 25% milestone aimed to be reached by 2020. Importantly they also distribute seeds to other key locations around the world, do germination tests on each species every 10 years, and other important research.
- The Australian Grains Genebank (AGG) is a national center for storing genetic material for Plant breeding and research. The Genebank is in collaboration with the Australian Seed Bank Partnership on an Australian Crop Wild Relatives project. It is located at Grains Innovation Park, in Horsham, Victoria, Australia, and was officially opened in March, 2014 The primary reason for the bank to be created was the extreme temperatures in the area, up to 40 degrees Celsius (104 degrees Fahrenheit) in the summer time. Because of that they had to ensure the protection of the grains all year around. The Genebank aims to collect and conserve the seeds of Australian crop wild species, that are not yet adequately represented in existing collections.
- Nikolai Vavilov (1887–1943) was a Russian geneticist and botanist who, through botanic-agronomic expeditions, collected seeds from all over the world. He set up one of

the first seed banks, in Leningrad (now St Petersburg), which survived the 28-month Siege of Leningrad in World War II. It is now known as the Vavilov Institute of Plant Industry. Several botanists starved to death rather than eat the collected seeds.

- Navdanya is a research-based initiative founded by Dr. Vandana Shiva, a world-renowned scientist and environmentalist. Navdanya, meaning "nine seeds" in Hindi, saves endangered seed varieties through its seed vault, and provides support for local farmers. They also conduct research on sustainable farming practices at their own organic farm in Uttarakhand, North India. Navdanya has collected roughly 5,000 crop varieties, primarily staples such as rice, wheat, millet, kidney beans, and medicinal plants. Navdanya's outreach program has established 111 additional seed banks in 17 Indian states. Navdanya has also created a learning center, Bija Vidyapeeth in Doon Valley, Uttarakhand. Bija Vidyapeeth offers courses on biodiversity protection, agroecological practices, water conservation, and more.

**2. Field gene banks:** In field genebanks the plant genetic resources are kept as live plants that undergo continuous growth and require continuous maintenance. They are often used when the germplasm is either difficult or impossible to conserve as seeds (i.e. when no seeds are formed, seeds are recalcitrant or seed production takes many years, as for many tree species) or the crop is reproduced vegetatively. Field gene banks are commonly used for conserving such species as cocoa (*Theobroma),* rubber *(Hevea),* banana *(Musa),* cassava *(Manihot),* mango *(Mangifera),* coffee *(Coffea),* coconut *(Cocos),* sweet potato *(Ipomoea)* and yam *(Dioscorea).*

Although some of the crops conserved in this way are sexually fertile, it is often not convenient to propagate them commercially from seed because of high levels of genetic heterozygosity, and breeders and horticulturalists commonly require uniform clones. Many vegetatively-propagated crops are, however, sexually sterile, or at the very least have reduced fertility which precludes the possibility of seed storage. For instance, garlic *(Allium sativum)* rarely produces seeds, whilst the seeds of cocoa *(Theobroma cacao)* and its wild relatives from the western slopes of the northern Andes of South America can be stored only for very short periods. The seeds of apples and pears cannot be stored either, for a long time and of course do not breed true to the parental genotype. These also need to be conserved in field gene banks unless tissue culture storage can be used.

**3. Cryopreservation:** Cryopreservation is a technique of preserving sperms, eggs, animal cells, tissues and embryos at very low temperature of around -196 degree centigrade in liquid nitrogen. By cryopreservation, the reproductive parts of rare species can be preserved. Dry Ice and liquid nitrogen are generally used in this method of preservation. At these subzero temperatures, all the biological activities of cells, tissues and other biological materials cease or effectively stopped and are presumed to provide indefinite longevity to cells. Cryopreservation is a long-term storage technique, which is mainly used for preserving the biological material without decline or decaying the biological samples for an extended period of time at least for several thousands of years. This method of preservation is widely used in different sectors including cryosurgery, molecular biology, ecology, food science, plant physiology, and in different medical applications. Other applications of cryopreservation process are in seed bank, gene bank, blood transfusion, in vitro fertilization, organ transplantation, artificial insemination, freezing of cell cultures, storage of rare germplasm, conservation of biodiversity, conservation of endangered and disease free plant species etc.

The cryopreservation of plant cell culture followed by the regeneration of plants broadly involves the following stages

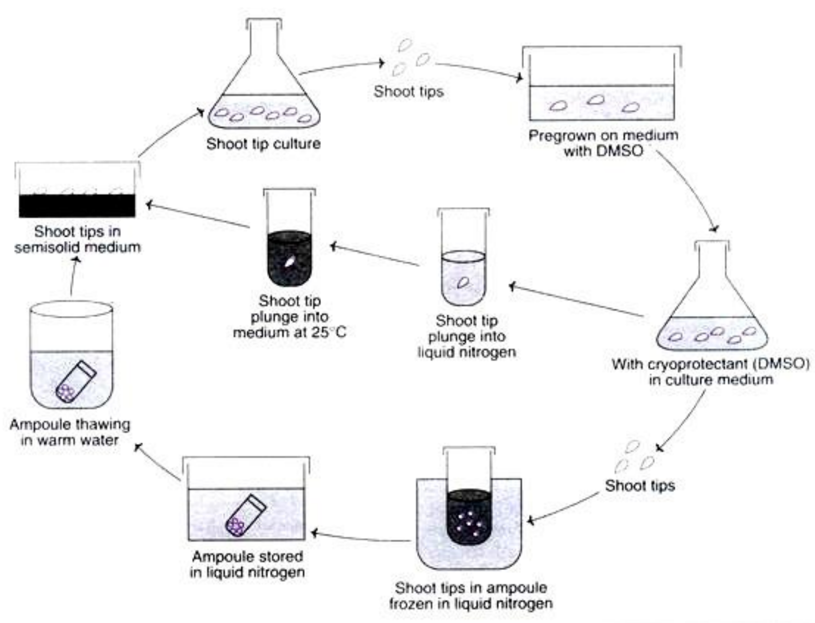



*Fig. 48.1 : An outline of the protocol for cryopreservation of shoot tip (DMSO–Dimethyl sulfoxide).*

**Development of sterile tissue culture:**

The selection of plant species and the tissues with particular reference to the morphological and physiological characters largely influence the ability of the explant to survive in cryopreservation. Any tissue from a plant can be used for cryopreservation e.g. meristems, embryos, endosperms, ovules, seeds, cultured plant cells, protoplasts, calluses. Among these, meristematic cells and suspension cell cultures, in the late lag phase or log phase are most suitable.

**Addition of cryoprotectants and pretreatment:**

Cryoprotectants are the compounds that can prevent the damage caused to cells by freezing or thawing. The freezing point and super-cooling point of water are reduced by the presence of cryoprotectants. As a result, the ice crystal formation is retarded during the process of cryopreservation.

There are several cryoprotectants which include dimethyl sulfoxide (DMSO), glycerol, ethylene, propylene, sucrose, mannose, glucose, proline and acetamide. Among these, DMSO, sucrose and glycerol are most widely used. Generally, a mixture of cryoprotectants instead of a single one is used for more effective cryopreservation without damage to cells/tissues.

**Freezing:**

The sensitivity of the cells to low temperature is variable and largely depends on the plant species.

**Four different types of freezing methods are used:**

**1. Slow-freezing method:**

The tissue or the requisite plant material is slowly frozen at slow cooling rates of 0.5-5°C/min from 0°C to -100°C, and then transferred to liquid nitrogen. The advantage of slow-freezing method is that some amount of water flows from the cells to the outside. This promotes extracellular ice formation rather than intracellular freezing. As a result of this, the plant cells are partially dehydrated and survive better. The slow-freezing procedure is successfully used for the cryopreservation of suspension cultures.

**2. Rapid freezing method:**

This technique is quite simple and involves plunging of the vial containing plant material into liquid nitrogen. During rapid freezing, a decrease in temperature -300° to -1000°C/min occurs. The freezing process is carried out so quickly that small ice crystals are formed within the cells. Further, the growth of intracellular ice crystals is also minimal. Rapid freezing technique is used for the cryopreservation of shoot tips and somatic embryos.

**3. Stepwise freezing method:**

This is a combination of slow and rapid freezing procedures (with the advantages of both), and is carried out in a stepwise manner. The plant material is first cooled to an intermediate temperature and maintained there for about 30 minutes and then rapidly cooled by plunging it into liquid nitrogen. Stepwise freezing method has been successfully used for cryopreservation of suspension cultures, shoot apices and buds.

**4. Dry freezing method:**

Some workers have reported that the non-germinated dry seeds can survive freezing at very low temperature in contrast to water-imbibing seeds which are susceptible to cryogenic injuries. In a similar fashion, dehydrated cells are found to have a better survival rate after cryopreservation.

**Storage:**

Maintenance of the frozen cultures at the specific temperature is as important as freezing. In general, the frozen cells/tissues are kept for storage at temperatures in the range of -70 to -196°C. However, with temperatures above -130°C, ice crystal growth may occur inside the cells which reduces viability of cells. Storage is ideally done in liquid nitrogen refrigerator — at 1 50°C in the vapour phase, or at -196°C in the liquid phase.

The ultimate objective of storage is to stop all the cellular metabolic activities and maintain their viability. For long term storage, temperature at -196°C in liquid nitrogen is ideal. A regular and constant supply of liquid nitrogen to the liquid nitrogen refrigerator is essential. It is necessary to check the viability of the germplasm periodically in some samples. Proper documentation of the germplasm storage has to be done.

**The documented information must be comprehensive with the following particulars:**

i. Taxonomic classification of the material

ii. History of culture

iii. Morphogenic potential

iv. Genetic manipulations done

v. Somaclonal variations

vi. Culture medium

vii. Growth kinetics

**Thawing:**

Thawing is usually carried out by plunging the frozen samples in ampoules into a warm water (temperature 37-45°C) bath with vigorous swirling. By this approach, rapid thawing (at the rate of 500- 750°C $min^{-1}$) occurs, and this protects the cells from the damaging effects ice crystal formation.

As the thawing occurs (ice completely melts) the ampoules are quickly transferred to a water bath at temperature 20-25°C. This transfer is necessary since the cells get damaged if left for long in warm (37-45°C) water bath. For the cryopreserved material (cells/tissues) where the water content has been reduced to an optimal level before freezing, the process of thowing becomes less critical.

**Re-culture:**

In general, thawed germplasm is washed several times to remove cryoprotectants. This material is then re-cultured in a fresh medium following standard procedures. Some workers prefer to directly culture the thawed material without washing. This is because certain vital substances, released from the cells during freezing, are believed to promote in vitro cultures.

**Measurement of survival/viability:**

The viability/survival of the frozen cells can be measured at any stage of cryopreservation or after thawing or re-culture.

The techniques employed to determine viability of cryopreserved cells are the same as used for cell cultures .Staining techniques using triphenyl tetrazolium chloride (TTC), Evan's blue and fluorescein diacetate (FDA) are commonly used.

The best indicator to measure the viability of cryopreserved cells is their entry into cell division and regrowth in culture. This can be evaluated by the following expression.

$$\frac{No. of\ cells/organs\ growing}{No. of\ cells/organs\ thawed} \times 100$$

**Plant regeneration:**

The ultimate purpose of cryopreservation of germplasm is to regenerate the desired plant. For appropriate plant growth and regeneration, the cryopreserved cells/tissues have to be carefully nursed, and grown. Addition of certain growth promoting substances, besides maintenance of appropriate environmental conditions is often necessary for successful plant regeneration.

A selected list of plants (in various forms) that have been successfully used for cryopreservation is given in Table 48.1.

**Table 48.1 A selected list of plants in various forms that are successfully cryopreserved**

| *Plant material* | *Plant species* |
|---|---|
| Cell suspensions | *Oryza sativa* |
| | *Glycine max* |
| | *Zea mays* |
| | *Nicotiana tabacum* |
| | *Capsicum annum* |
| Callus | *Oryza sativa* |
| | *Capsicum annum* |
| | *Saccharum* sp |
| Protoplast | *Zea mays* |
| | *Nicotiana tabacum* |
| Meristems | *Solanum tuberosum* |
| | *Cicer arietinum* |
| Zygotic embryos | *Zea mays* |
| | *Hordeum vulgare* |
| | *Manihot esculenta* |
| Somatic embryos | *Citrus sinensis* |
| | *Daucus carota* |
| | *Coffea arabica* |
| Pollen embryos | *Nicotiana tabacum* |
| | *Citrus* sp |
| | *Atropa belladona* |

**Cold Storage:**

Cold storage basically involves germplasm conservation at a low and non-freezing temperatures (1-9°C) The growth of the plant material is slowed down in cold storage in contrast to complete stoppage in cryopreservation. Hence, cold storage is regarded as a slow growth germplasm conservation method. The major advantage of this approach is that the plant material (cells/tissues) is not subjected to cryogenic injuries.

Long-term cold storage is simple, cost-effective and yields germplasm with good survival rate. Many in vitro developed shoots/plants of fruit tree species have been successfully stored by this approach e.g. grape plants, strawberry plants.

Virus- free strawberry plants could be preserved at 10°C for about 6 years, with the addition of a few drops of medium periodically (once in 2-3 months). Several grape plants have been stored for over 15 years by cold storage (at around 9°C) by transferring them yearly to a fresh medium.

**Low-Pressure and Low-Oxygen Storage:**

As alternatives to cryopreservation and cold storage, low-pressure storage (LPS) and low-oxygen storage (LOS) have been developed for germplasm conservation. A graphic representation of tissue culture storage under normal atmospheric pressure, low-pressure and low-oxygen is depicted in Fig. 48.2.

**Low-Pressure Storage (LPS):**

In low-pressure storage, the atmospheric pressure surrounding the plant material is reduced. This results in a partial decrease of the pressure exerted by the gases around the germplasm. The lowered partial pressure reduces the in vitro growth of plants (of organized or unorganized tissues). Low-pressure storage systems are useful for short-term and long-term storage of plant materials.

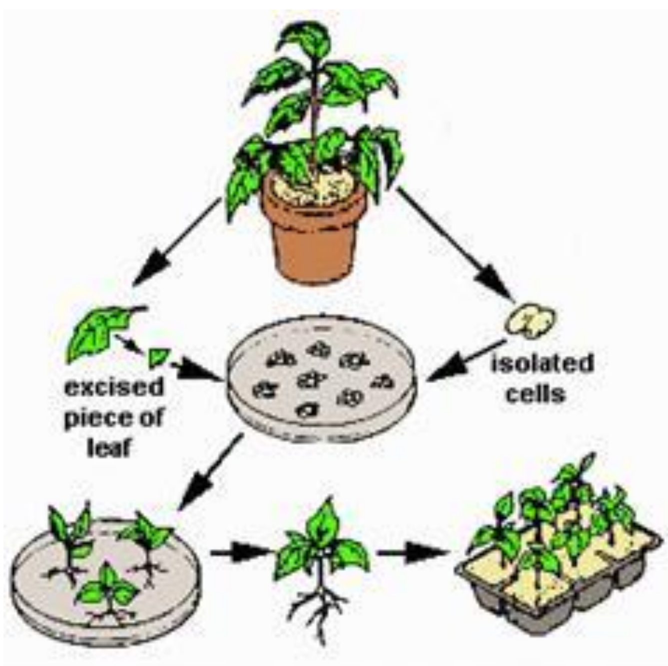
The short-term storage is particularly useful to increase the shelf life of many plant materials e.g. fruits, vegetables, cut flowers, plant cuttings. The germplasm grown in cultures can be stored for long term under low pressure. Besides germplasm preservation, LPS reduces the activity of pathogenic organisms and inhibits spore germination in the plant culture systems.

**Low-Oxygen Storage (LOS):**

In the low-oxygen storage, the oxygen concentration is reduced, but the atmospheric pressure (260 mm Hg) is maintained by the addition of inert gases (particularly nitrogen). The partial pressure of oxygen below 50 mm Hg reduces plant tissue growth (organized or unorganized tissue). This is due to the fact that with reduced availability of $O_2$, the production of $CO_2$ is low. As a consequence, the photosynthetic activity is reduced, thereby inhibiting the plant tissue growth and dimension.

**4. Tissue culture:** Plant tissue culture techniques have also helped in large- scale production of plants through micropropagation or clonal propagation of plant species. Small amounts of tissue can be used to raise hundreds or thousands of plants in a continuous process. This is being utilized by industries in India for commercial production of mainly ornamental plants like orchids and fruit trees, e.g., banana. Using this method, millions of genetically identical plants can be obtained from a single bud. This method has, therefore, become an alternative to vegetative propagation. Shoot tip propagation is exploited intensively in horticulture and the nurseries for rapid clonal propagation of many dicots, monocots and gymnosperms.

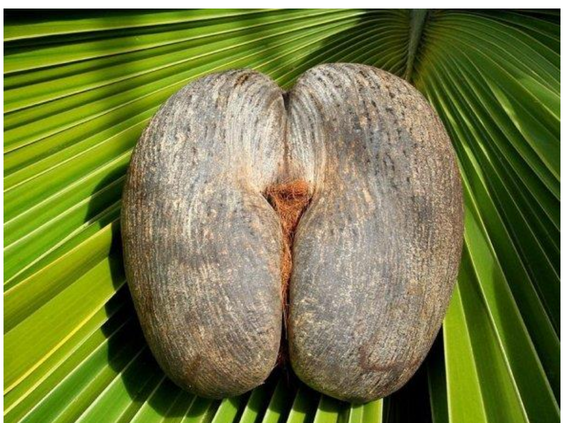
Clonal propagation refers to the process of asexual reproduction by multiplication of genetically identical copies of individual plants. The vegetative propagation of plants is labour-intensive, low in productivity and seasonal. The tissue culture methods of plant propagation, known as 'micropropagation' utilizes the culture of apical shoots, axillary buds and meristems on suitable nutrient medium.The regeneration of plantlets in cultured tissue was described by Murashige in 1974. The micropropagation is rapid and has been adopted for commercialization of important plants such as banana, apple, pears, strawberry, cardamom, many ornamentals (e.g. Orchids) and other plants




Overview of the Tissue Culture Process

**5. Botanical gardens:** Botanical gardens are institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education. They generally conserved species of rare wild plants. More than 80,000 species are represented in collections of botanical gardens all over the world, nearly a third of all known plant species. Over time, they have become indispensable databases for taxonomy and studying biodiversity. In fact, the first biodiversity database was published by a botanical garden.

Scientists at the 232-year-old Acharya Jagadish Chandra Bose Indian Botanic Garden in Howrah are trying to save India's only double-coconut tree (*Lodoicea maldivica*) near Kolkata. A 125-year-old female double coconut tree, the lone specimen planted by the British in India in 1894, is dying scientists fear. It is now in a virtual botanical intensive care unit. Double-coconut trees are found only on two islands of the Seychelles, are rare and globally threatened species of plam. They were planted by the British in countries including India, Sri Lanka and Thailand. They can live up to 1,200 years and bear the largest fruits (weighing up to 25 kg) and leaves in the entire plant kingdom.



*Lodoicea maldivica*

**6. Zoos:** Zoological gardens or Zoos are the conservation sites which provide protection for endangered species that are no longer present in the wild, free from the pressures of habitat loss, starvation and predators. One of the most important modern functions of zoos is supporting international breeding programmes, particularly for endangered species. In the wild, some of the rarest species have difficulty in finding mates and breeding, and they might also be threatened by poachers, loss of their habitat and predators. The zoos enable these species to live and breed in a secure environment. There are 39 animal species currently listed by the IUCN as Extinct in the Wild. These species would have vanished totally, if not kept in captive conditions in zoos. The Amur leopard, for example: There are perhaps 35-65 left in the wild, a species teetering right on the brink. But fortunately there is a long running breeding program with over 200 surviving in captivity. Amongst the most well known and successful reintroductions are:

- The Scimitar-Horned Oryx, having become extinct in Africa in the 1980s, zoos around the world maintained a captive population and at last this year, a reintroduction led by the Sahara Conservation Fund has begun.

- The Californian Condor, only 23 existed in the wild in the early 1980s. The last of the wild population was taken into captivity in a last ditched attempt to save the species, with chicks being reared at San Diego zoo. It worked. There are now more than 400 in the wild.

- The Golden Lion Tamarin, perhaps the most famous of all reintroductions. In 2003, the Golden Lion Tamarin was downlisted from Critically Endangered to Endangered after thirty years of tireless conservation efforts involving the Smithsonian National Zoological Park and the Associação Mico-Leao-Dourado in Rio de Janeiro. More than one-third of the wild populations are descendants of the reintroduction program which has contributed significantly not only to the numbers of living in the wild, but also to the protection 3,100 ha of forests within their range.