40TH SIR ALBERT CHARLES SEWARD MEMORIAL LECTURE

Some environmental aspects of present distribution of plants

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In the earth's history of what is estimated as 4.6 billion years, it is believed that the first rocks were formed only a few million years after its origin. Scientists at the Australian National University have recently claimed to have found four billion years old rocks, the oldest ever found. Earlier, a sequence of metamorphosed, highly deformed igneous rocks had been found on the west coast of Greenland and radio-active dating measurements made at Oxford indicated that the rocks crystallized 3.75 billion years ago (Moorbath, 1977). Not long thereafter, the first cell may have appeared and this, in the course of the next two billion years or so, under the influence of a varied environment and other factors, evolved into the extremely diversified manifestation of life that featured the early phase of life on earth. These early plants were aquatic in habit and of simple structural organization. These evolved into more complicated forms and, in due course, moved over to the land. Once the plants occupied the land, they diversified occupying a variety of habitats, developed structural modifications in adaptation to the environmental needs and, in course of time, assumed gigantic dimensions as was characteristic of the luxuriant Lycopod forests of the Carboniferous Period, a good 4.3 billion years from the time of origin of the earth. The early periods of earth's history and plant evolution have been extensively studied and documented. A summarized account of this was presented by Venkatachala (1993) in his Birbal Sahni Memorial Award Lecture at the Aurangabad Session of the Indian Botanical Society in 1992. The rise of the first land plants has also been reviewed by W.G. Chaloner (1970). Professor Seward himself has described the entire scenario of *Plant life through the ages* in his masterly book of that title (1931, 1966).

The Late Carboniferous and Early Permian periods (365-245 m yrs) witnessed glaciation on a large scale and this also triggered in its aftermath the appearance of newer forms of plant life like the Glossopteris Flora which spread out over the southern super-continent. It should be remembered that over the billion years, the earth has seen cataclysmic changes in its land contours, movement of continents, periodic glaciation and other geophysical trauma. It has been stated that about 500 m years ago there were four large continents which moved towards each other and in subsequent epochs formed a giant super-continent, the Pangea by Permian (250 m yrs). This began to split and drift in subsequent millenia. The oceans also opened up by Eocene (50 m yrs) and eventually by Pleistocene (40,000 yrs), the continents had come to occupy almost their present position.

There have also been mass extinctions of life in various periods in the world. Till recently the earliest mass extinction was considered to be the one that occurred 450 m years ago when many shell-covered marine animals disappeared. According to a recent study for the NSF by a biologist at Harvard and a geologist at Lund, something happened 650 m yrs ago which wiped out much of life on earth, at that time, mostly one-celled plants and animals. It is speculated that these mass extinctions are the result of extreme environmental changes.

The Early Mesozoic Era (200 m yrs) saw the appearance of seed plants like the Bennettitales, Cycadales and Ginkgoales which attained rapid development and spread during Jurassic. The remarkable survivor from these times, the maidenhair tree, *Ginkgo biloba* of the present day flora has no parallel in the history of the plant world. This is the only living representative of the Order Ginkgoales which had as many as fifteen genera in the past. Extinct genera such as *Ginkgoites* and *Baiera* are known from fossilized leaves which are similar to those of the present day tree. As if this was not the only such instance another equally fascinating

gymnosperm tree with a fossil record was found in a living state in eastern Sczechwan Province of China. This is the Dawn Cypress, *Metasequoia glyptostroboides* of the family Taxodiaceae. The genus *Taxodium* was not believed to exist in Asia, though the fossil remains of *Metasequoia* were known from Japan Further search revealed the existence of many living trees of Dawn Cypress. Seeds were collected from these trees in China about 50 years ago and plantings were commenced the world over. Dawn Cypress is a member of the same family to which the well known Swamp Cypress of SE United States of America belongs.

A significant extinction of plant life seems to have occurred at the end of the Mesozoic (see Dale A Russel in *Sci. Amer.*: January, 1982). While most of the Cycads were eliminated, scattered representatives are seen in the present day flora. Among them are nine genera, viz., *Cycas, Zamia, Dioon, Encephalartos, Macrozamia, Microcycas, Ceratozamia, Stangeria* and *Bowenia*. A tenth genus, *Lepidozamia* has been recently added from Australia and perhaps there is an eleventh also. Their distribution in the present day flora is of particular interest. While the monotypic *Stangeria* is restricted to Natal, *Bowenia* is endemic in Queensland. *Encephalartos* with 10 species is African. One of them, *E. woodii* at present in cultivation at the Royal Botanic Garden, Kew is stated to be the rarest plant in their collection. A single male plant was found in Zululand and two stems were taken to Durban in 1907 and then brought to Kew in 1917. *Macrozamia* is represented by 11 species in Australia (New South Wales) and one of them, *M. communis* is prominent in the understory of coastal *Eucalyptus* forests along with tree ferns. The conifers which survived the extinction of most gymnosperms at the end of the Mesozoic, assumed prominence in the subsequent era and they form a conspicuous element in the present day northern temperate flora and on mountain tops at more southern latitudes of the Northern Hemisphere. The firs (*Abies*), spruces (*Picea*), cedars (*Cedrus*), cypresses (*Cupressus*) and junipers (*Juniperus*) constitute the dominant genera among them and only the pines (*Pinus*) extend to the tropical zone. At more northern latitudes, approaching the arctic circle and at higher elevations on mountains, the conifers gradually become stunted and assume a reclined posture. Beyond the tree line in the north temperate region lies a stretch of treeless plains towards the North Pole. This inhospitable zone is referred to as the Tundra and it harbours only a few shrubs, sedges and lichens.

Along the western coast of North America the magnificent redwoods (*Sequoia*) present a spectacular feature of the landscape. The giant redwoods reach enormous height and girth. Further north, along the western coast of North America, the Douglas Fir (*Pseudotsuga menziesii*) becomes conspicuous.

The genus *Cedrus* with its three prominent species — *C. atlantica* of the Atlas Mt in NW Africa, *C. libani* of the Middle East and *C. deodara* (Deodar) of Western Himalaya, shows a disjunct distribution. In Himalaya, Deodar has an exclusive western Himalayan distribution, extending from Afghanistan to about 83 ^{O} E Longitude in Nepal.

Juniperus is another genus characteristically found in the more northern latitudes and on mountain tops, often beyond the tree line. They form low bushes and are generally associated with other low bushes of willows, Rhododendrons, birches and other broad-leaved members, often exhibiting the 'Krummholz' habit. In the central Asian Highlands, some slow growing junipers, viz., *Juniperus oxycedrus, J. semiglobosa* and *J. zeravschanica* are seen. The first named is frequently attacked by the Loranthaceous parasite, *Arceuthobium oxycedri*. It is interesting that this parasite is also found on *Juniperus macropoda* in Lahul in Western Himalaya. Another species of this parasite *A. minutissima* causes extensive damage to the Blue Pine (*Pinus wallichiana*).

In the Southern Hemisphere, the conifers are represented by only a few genera, the podocarps and the araucarias. W. Lobb, a well known professional collector in South America, found this tree in the temperate forests of Chile. This tree had already been introduced into England by Menzies, the Scottish Surgeon on Capt. Vancouver's Voyage of Survey and Exploration and had called it the Chilean Pine. Lobb, a gardener, saw the potentiality of this as an ornamental for European gardens and named it *Araucaria* as a tribute to the local tribals of that name who use the edible kernels of the tree (Whittle 1970). *Callitris*, the

southern pine is unique in the Australian flora. It turns a beautiful yellow in the Australian autumn.

A remarkable genus of the gymnosperms in Africa is *Welwitschia* of unknown affinity. Whittle (1970), in an interesting account of this plant, writes that Africa had a great fascination for Joseph Hooker and when this strange plant collected by Dr Welwitsch arrived at Kew, "it stole his (Hooker's) heart away. The mishappen plant devoured all Hooker's interest and spare moments for months. He lectured on it, talked about it, wrote about it and no doubt dreamt of it". This unique plant was discovered by Baines in Damaraland and later by Dr Welwitsch in Mossamedes along the western coast of Angola in West Africa. Joseph Hooker named it for Dr Welwitsch. Pollen grains similar to those of *Ephedra* and *Welwitschia* have been found as early as the Permian and on the basis of fossil pollen both these genera appear to have had more species in former times than they have now, suggesting that the genera declined since Early Mesozoic (Scagel *et al.*, 1965). *Ephedra,* the other aberrant genus is now found in the cold temperate as well as in warm desert areas.

The dominant group of plants of the present day, the flowering plants or Angiosperms are considered to have attained this dominance by Late Cretaceous (65 m yrs). The origin of Angiosperms is still shrouded in mystery. A report in *Science* (May, 1984) referred to the discovery of 94 m yr old fossil flowers, the earliest known bisexual flowers discovered, from the Dakota Formation in Nebraska. The report stated that 50 wholly or partially preserved flowers in different stages of development allowed an accurate reconstruction of floral structure and reproductive biology. A Swedish Palaeobotanist has recently claimed that perfectly preserved fossils of flowers which were 75 m yrs old have been found in southern Sweden and that three-dimensional flower fossils have never been found previously anywhere in the world. Though the exact time and form in which the flowering plants evolved and their ancestry is still a matter of speculation, suggestions have been made that they arose from herbaceous ancestors rather than from tree forms. Chloranthaceae and Piperaceae have been mentioned in this regard. Chloranthaceae, as originally defined by Bentham and Hooker included some disparate elements whose relationships have been redefined by subsequent investigators. *Sarcandra* has already been segregated on account of its vesselless character and *Circaeaster* likewise on anatomical grounds. *Hedyosmum,* another anomalous genus has been recently interpreted as possessing a male flower that bears up to several hundred stamens spirally arranged along an axis, extraordinary for an angiosperm, a cone-like (strobiloid) structure. This is also associated with other primitive characters, particularly pollen that bears a resemblance to the monosulcate type known from the Lower Cretaceous. It is claimed that this new discovery has implication for the origin of Angiosperms (John F. LeRoy in *Taxon* 32: 169-175, 1983).

Whatever be their origin, the rapid spread of the Angiosperms is attributed to the efficiency of the group's reproductive biology. The close association of insects and flowering plants had an important role in this spread (Mulcahy, 1979). With specialization of floral structure and efficiency of fruit and seed dispersal, flowering plants are so widespread that, in the present day world, they occupy even the most unlikely places for the occurrence of plants. In the Arctic region, on mountain tops even at altitudes above 6,000 m, in the hottest deserts, in the densest jungles on tree tops, on rocks in rapids and in rushing water (Podostemaceae), angiosperms have adopted appropriate modifications to suit the environment. Some have curious nutritional adaptations as in the case of parasites, saprophytes and insectivores.

A region of great phytogeographical interest in the present day world is the Great Himalayan Mountain System. The Himalaya arose as a consequence of collision of the Indian Peninsula which had broken off from the African landmass more than 70 m yrs ago. Its northward drift brought it in collision with the Asian landmass about 40 m yrs ago; it is said this northward movement is still continuing. The freshly exposed heights of this vast mountain system stretching over length of nearly 3,000 km NW to SE, came in contact with the floristically rich areas of the northwestern and central Asian Highlands on west and the mountain slopes and lush valleys of SW China in the east with the famed peaks of Nanga Parbat (8,126 m) and Namcha Barwa (7,756 m) standing as sentinels at either end. This enormous topographical

feature provided a great opportunity for the mixing of floras, migrations and other phenomena with evolutionary implications. There were also many extinctions of elements which could not adjust to the pressure of environmental change. The influence of climate, altitudinal zonation, the great riverain valleys with their corresponding multidirectional mountain slopes and the complex edaphic factors contributed to the evolution of a flora of considerable diversity. Carl Troll (1967) has given its graphic account based on his own observations supported by the extensive documentation provided by Schweinfurth (1957) in his book on the subject. At the extreme northwest, in Ladakh, Karakoram and in the environs of Nanga Parbat along the Indus Valley alpine heights arise from desert-like valleys and the topoclimatic conditions are intimately associated with the vegetation cover. The alpine steppes characteristic of central Asian Highlands find their southern limits here. The associations met with include the alpine scrubs which often show the 'Krummholz' habit and the constituent elements include the birch, dwarf willows, astragali and others. Then there are the steppes with *Artemisia*, dwarf junipers and others. On exposed slopes are found spinescent cushions of *Caragana, Cousinia, Acantholimon, Astragalus, Oxytropis*, and others. Rock-like mounds of the curious *Thylacospermum* are also seen as also *Ephedra*. Some of the spectacular species of *Eremurus* (Liliaceae) and *Morina* (Dipsacaceae) which are largely represented in the central Asian flora reach their southern limit in north-western Himalaya with a few species, among them, *Eremurus himalaicus* and *Morina coulteriana* with yellow flowers being prominent on the bleak heights in Lahul (north-west Himalaya).

In the moist coniferous zone in western Himalaya extending from Indus Himalaya to Garhwal Himalaya, forests of blue-pine, firs, birches and oaks are seen. At lower elevations are found pine forests along with oaks and, in Garhwal Himalaya, sub-tropical forests of *Shorea*.

The Himalayan heights are also the migratory path for many northern elements which have entered from the northwest, north and northeast. They have spread to varying extent within the mountain system. William Stearn (1960) is of the opinion that the zone of transition between the western and eastern Himalayan botanical provinces lies at 83°-84° E Longitude, based on a phytogeographical analysis of the distribution of some key genera. The western Himalayan flora is related to the flora of northwestern Tibet, central Asia and mountain systems further west and the eastern Himalayan flora has affinity with the flora of neighbouring Szechwan and Yunnan Provinces of China.

At high altitudes in the Himalaya a fascinating alpine flora is seen. The highest altitude known for the occurrence of a flowering plant is claimed by a little Crucifer, *Christolea* (*Ermania*) *himalayensis* which was collected by Gurdial Singh on Mt. Kamet. Many curious saussureas occur here. *Saussurea* has a large representation in Central Asia and in Himalaya many species have been recorded. The most curious of them are the woolly *S. gossypiphora* and *S. simpsoniana*. *Corydalis crassissima* of the Fumariaceae is a herb with an interesting habit and distribution. It is found in northwest Himalaya and neighbouring Karakoram and Hindukush Mts (Per Wendelbo, personal communication). It is particularly seen on gravel in the Panchtarni Valley on the way to the holy shrine of Amarnath in Kashmir.

Circaeaster agrestis formerly included under the Chloranthaceae but now treated as a unigeneric member of the Circaeasteraceae is another curious plant of the Himalaya. It was so named by Maximovicz based on a collection of Prezewalski in his travels in China. This curious herb had been collected earlier by Strachey and Winterbottom in the Kumaon Himalaya but before they could be described the specimens were lost in the Kew Herbarium. Joseph Hooker considered them to be so unique that he wrote to Duthie who was on collecting assignment in Kumaon to look for this saying "It would be well worth a pilgrimage to look for this as I know nothing like this." Duthie succeeded in collecting this and till recently these were the only known specimens at Kew and in the Indian Herbaria. At the Botanical Survey of India in Dehradun we succeeded in collecting this in a new locality in Garhwal Himalaya. Ripe fruits were also collected and sent to Kew and Berkeley where living colonies were established. Based on this new material Professor Adriance Foster made a life long study of this curious plant and its open dichotomous venation of its leaves.

The genus *Saxifraga* has one of its main centres of distribution in the Himalaya. One of them, the *Saxifraga flagellaris* complex, with the curious surculi, has a wide distribution in the world being found in high arctic as well at altitudes nearly 5,000 m in the Himalaya. Several sub-species are recognized based on their present disjunct distribution. They perhaps represent the survivors of Pleistocene glaciation which eliminated them from many intermediate locations. These sub-species are now recognized from the Caucasus, north-west Himalaya, Pamirs, Tien Shan Mts and south-west China (Hulten, 1964).

Cassiope, the Ericacean genus of wide arctic distribution is represented by a single species, *C. fastigiata* in the alpine zone of Himalaya. A little Polygonaceous herb, *Oxyria digyna*, has an even more interesting distribution being found in the north Arctic and sub-arctic regions, in the Himalaya and even on East African Mountains.

The primulas are extremely pretty herbs distributed widely in cold temperate and alpine habitats. The Himalaya is an important centre for its occurrence, some exclusively found in the western Himalaya (e.g., *P. rosea, P. denticulata*). *P. prolifera* of eastern Himalaya and Khasya Hills is strangely found on a volcanic peak in West Java of Indonesia. At the source of the River Subansiri in Arunachal Pradesh of northeast India, Kingdon-Ward "saw the greatest multitude of *Primula* he had ever seen or imagined". Kingdon-Ward in his *Pilgrimage for Plants* (1960) has given a delightful account of his travels in the floristically rich territory at the meeting place of South-west China, North-east India and North Burma. One of the primulas, *P. magellanica* is found at the extreme southern tip of the South American continent.

The eastern Himalaya, i.e., the territory lying east of 83° E Longitude has many Chinese elements represented in its flora. The attractive *Magnolia campbellii* has entered the Himalaya from the east where Magnolias are well represented in the western Chinese flora. In its hexaploid form, *M. campbellii* has extended westward as far as 83° E Longitude. Several polyploid Rhododendrons of the dwarf habit are also found in eastern Himalaya.

Tetracentron, a vesselless dicotyledon of the Trochodendraceae known from China and Upper Burma was collected in the eastern Himalaya by the Japanese botanists in recent decades.

At the eastern end of the Himalaya, the famed peak of Namcha Barwa and its slopes have been recently explored by scientists of the Chinese Academy of Sciences. They discovered many interesting plants including *Podocarpus* and some tree ferns which are regarded as relicts from the past ages. This great mountain also presents the characteristic altitudinal zonation of vegetation. In the tropical zone *Cyathea spinulosa*, a near extinct plant (China Pictorial Aug, 1984), was found.

In the eastern Himalaya and further south in the lush rain-concentrated regions, the vegetation is rich. Here one finds a rich orchid flora in Sikkim and the neighbouring territories of West Bengal and Assam. The Blue Vanda (*Vanda coerulea*) and the slipper orchids (*Paphiopedilum*) are rare and highly prized. An orchid belt is also seen further west in Kumaon Himalaya. Venezuela in South America, Thailand, Malaysia, Singapore and some islands of the east are among the countries presenting a rich variety of orchids which are also commercially exploited.

In eastern India, some years ago a remarkable parasite of the Rafflesiaceae, *Mitrastemon yamamotoi* was discovered in the Mowsmai forest of Khasia and Jaintia Hills (Rao, 1974). This was originally described from Japan. A mention may be made here of the unique *Rafflesia arnoldii*, reputed to have the largest flower known in flowering plants, which is found in the forests of Sumatra in Indonesia. The Khasya Hill is also the home of the famed insectivore, *Nepenthes khasyana*.

Then there are the extensive desert regions in various parts of the present day world. These deserts harbour their own characteristic flora adapted to the harsh environment. They include the dendroid, succulent and cactoid forms. The Saguaro of Arizona, the Yuccas, Aloes and various other Cactaceae of the Mexican and other desert areas of the world are well known. There is a remarkable instance of a little *Boerhaavia* from Mali in Saharan West Africa which completes its lifecycle in just 10-12 days. The seeds remain buried in sand and when a little moisture appears, they germinate, flower and fruit all within a short span of 10-12 days and the seeds again get buried in sand till the next favourable chance for them

to germinate. This short life-span of a seed plant is in contrast to those of some of the tree forms which live for several thousands of years, as for example, some redwoods, junipers, etc. The well known Dragon Tree of Teneriffe in the Canaries (*Dracaena draco*) is said to have been 6,000 years old when it was struck down by a storm in 1868. It had attained by then a height of 70 ft and girth of 45 ft (Willis 1931). Another Dragon Tree (*Dracaena cinnabari*) is a native of Socotra.

It is when we come to the Southern Hemisphere that we come across many interesting and intriguing plant occurrences. Many of them can be attributed to past land connections. Instances of endemism, isolation, strange insular floras and disjunct distributions are numerous. In an attempt to explain such distributions, it may not always be prudent to attribute specific causes/evolutionary past of many of these aberrant elements. It is best to describe them as they are because even a staid, straightforward account of the plants/their locations are themselves of considerable interest. Taking the flora of Juan Fernandez Island in the Pacific off the Chilean coast in the South American continent, it harbours a unique family of flowering plants, the Lactoridaceae (Piperales E & P). Its only member *Lactoris fernandesiana* is highly endemic in the Island. Another classic example of high endemism is insular flora of St. Helena in South Atlantic where all but one of the extant species are endemic.

In the Indian Ocean, Seychelles has the unique double coconut, *Lodoicea* and another endemic palm, *Phoenicophorium*. The double coconut weighing 50 to 60 pounds is suspended for 6 to 7 years during the course of its ripening (Corner, 1964).

Calvaria majus (Sapotaceae) in Mauritius is on the verge of extinction. It has not germinated for more than a century. It is said that this tree in the course of evolution became so dependent on the bird Dodo that when the bird became extinct the tree has failed to perpetuate itself as the outer shell of the fruit could be softened only when it passed through the alimentary system of the bird (RM May in *Nature* 27, pp. 204-205, 1977).

In the Mauritian Island of Rodriguez, a specimen of *Ramosmania heterophylla* (Rubiaceae) known to be the only surviving member of the species has been successfully rehabilitated in the Royal Botanic Garden at Kew after the IUCN mounted a rescue operation.

Madagascar has some very strange plants. The family Didieraceae with succulent habit includes four genera whose species resemble the cactus-like euphorbias. The family is exclusively Madagascarean and is of doubtful affinity, though it is now placed among the Centrospermae.

In the wake of the breaking up of the Supercontinent, Pangea and the drifting of the fragments which began during the Late Permian, the Australian landmass has travelled a long way for more than 200 m yrs in reaching its present position carrying with it its own flora and fauna. During this long period of isolation and lack of contact with other continents, Australia has developed its own characteristic flora and fauna. One finds in the present day flora some highly endemic and unique elements. The visitor to the vast continent will not fail to notice the Kangaroo and other marsupials among the animals and *Eucalyptus* among the plants as unique apart from others of exclusive distribution here. The phanerogamic flora of this vast continent is estimated at 15 to 20,000 species. The southern Beech, *Nothofagus* with antarctic connection is found here as also the fern *Dicksonia antarctica* of such affinity. *Nothofagus* is regarded as a 'key genus of plant geography in time and space' (van Steenis, 1971). It has an ample fossil record and a wide distribution at present with its range extending from the southern half of the Pacific in South America and occurring further in New Zealand, Tasmania, E. Australia, New Caledonia and New Guinea. There are evergreen as well as deciduous species among them. In Argentina, *Nothofagus* forms an evergreen forest in the Magellan District where it is associated with another interesting plant *Drimys winteri* of Winteraceae (Garcia, 1962). In New Zealand, *Nothofagus* forms low forests on the sides of alpine ridges connecting rather low mountain masses (Philipson & Hearn, 1962). Except for a small number of *Eucalyptus* spp. which are native to land outside the Australian continent, the vast majority of the nearly 500 species of the genus is exclusively Australian. These occupy vast stretches of various habitats, cool mountain forests in the interior, montane forests of the coastal range where they attain

great heights. Among them are the Shining Gum (*E. nitens*), Alpine Ash (*E. delegatensis*). The tall eucalypts may attain a height of more than 90 m. A specimen of *E. regnans* is reputed to be the tallest tree in the world (97.3 m) though there are some giant sequoias to challenge this claim. In the sub-alpine and alpine regions, low open forests or woodlands of the Snow Gum (*E. pauciflora*) are seen. Several low growing Australian eucalypts especially *E. dumosa* and *E. oleosa* form thickets in some parts of the continent. This formation is called locally as 'Mallee' country. One of them, a very colourful one, *E caesia* subsp. *magna* popularly known as 'Silver Princess' is rare and endangered. This is now only in cultivation. A fine specimen is seen at the entrance to the Gift Shop in the Sydney Botanical Garden. Myrtaceae is one of the families with a strong Australian flavour; other genera of the family, viz., *Callistemon* (12 spp.), *Melaleuca, Phymatocarpus, Darwinia* (35 spp.) are well represented in the continent.

When Joseph Banks went with James Cook on his first voyage in 1768-69 and Cook, after sailing around New Zealand, went to explore the east coast of Australia, making the first sighting of land at Port Hicks and first landing at Botany Bay, Banks collected specimens of a tree "that would cause much revelation back home". These specimens represented a group then unknown to science and were promptly named after Banks as *Banksia* and included under the Proteaceae. Banks later took control of the Kew Garden and sent plant collectors around. The genus *Banksia* is now represented by about 50 species, all Australian and these are spectacular trees and shrubs with brightly coloured cylindrical or globose inflorescences. Proteaceae is well represented in the Australian flora. The other common genera are *Grevillea* (190 spp., extending to E. Malaysia, New Hebrides, New Caledonia), *Hakea* (100 spp.), *Dryandra* (50 spp.) named for Dryander, the librarian at Kew under Banks, *Persoonia* (60 spp. extending to New Zealand), *Stenocarpus* (25 spp. also in New Caledonia), *Macadamia* (Queensland Nut) and others. The Proteaceae are also indicators of the southern connection of the past, though the family is not well represented in South Africa. *Protea curvata* in Barberton, Transvaal is rare and endangered, perhaps the rarest tree in South Africa.

Among the endemic trees of Australia, are the bottle-trees of *Brachychiton* (Sterculiaceae) of Queensland (trees with such bloated stems are also known in the Apocynaceous genera, *Adenium* of Socotra and *Pachypodium* of East Africa and Madagascar). The giant Nettle Tree, *Dendrocnide excelsa* with very large leaves armed with stinging hairs is endemic as also the Loranthaceous, *Nuytsia*, a small tree with an exclusive West Australian distribution. Other endemics of the continent include *Correa* (11 spp.) of Rutaceae, *Westringia* (12 spp.) of Lamiaceae, *Xanthorrhoea* (15 spp.) of Xanthorrhoeaceae which are popularly known as the Grass-Trees or Black-Boys, *Anigozanthos* (10 spp.) of Haemodoraceae; of them *A. flavida* is the well known Kangaroo Paw and *Doryanthes* (3 spp.) of the Amaryllidaceae. The remarkable insectivore, *Cephalotes follicularis* in swamps in SW Australia, the Lycopod, *Phylloglossum drummondii* of damp sandy areas are other exclusively Australian species.

There are other families and genera which are seen in Australia but are also found in other countries as well in the Southern Hemisphere. *Hibbertia* of the Dilleniaceae has 100 species in Australia and New Caledonia. Goodeniaceae is chiefly Australian but extends to New Zealand and some islands in the Pacific. *Scaevola* of this family is one of the coastal shrubs in the tropics and is also found along the Indian coast.

Easter Island in the South Pacific Ocean lying about 3,200 km west of Chile, famed for its 'Men of Stone' has a unique tree, *Sophora toromiro* (Leguminosae) in its flora, the only tree species in the Island. Thor Heyerdahl, the explorer of Kontiki fame who visited this Island collected seeds from the last specimen of this tree and these finally landed up in the Botanical Garden at Gothenburg in Sweden, where they germinated. On a revisit to the Island, the tree had disappeared. Three small plants from the Gothenburg Garden were sent back to the Island where they were planted (Per Wendelbo, in a personal communication). Recently it was reported that a fossil of the endocarp of a palm fruit was found in the Island belonging to an extinct palm. Earlier fossil pollen of the palm had been discovered in the Island (Dransfield, 1984 in *Nature* 312, p. 750).

In addition to the instances of disjunct distribution referred to earlier, the distribution of some families and genera in the present day flora deserve consideration as they have a bearing on the past land connections and the southern flora. Among them are the Byblidaceae (Rosales), Epacridaceae (Ericales), Eucryphiaceae (Guttiferales), Rapateaceae (Commelinales), Restionaceae (Commelinales) and the genus *Exocarpus* (Santalaceae) (see also Good, 1953).

Byblidaceae occur in the southwest corner of South Africa and in the north and southwest corner of Australia. The Epacridaceae form the southern counterpart of families of ericoid habit of other continents and these occupy similar habitats in heaths, moors, etc. The genera, *Epacris* and *Richea* are particularly characteristic. *Richea* occupies extensive tracts in the moist alpine zone on the way to Mt Kosciusko, the highest point in the Australian Continent. Eucryphiaceae found in Chile, Australia, Tasmania and New Caledonia has some shrubs with attractive flowers. Rapateaceae is a family with a very interesting disjunct distribution and is found in the northeastern corner of the South American continent and in the corresponding northwestern tip of Africa. This is illustrative of the past land connection. Restionaceae are represented in South America (Chilean coast), South Africa (Nyasaland), Madagascar, Malaysia, Australia and New Zealand. The Restionaceae are mostly xerophytic and with a general juncoid appearance. The genus *Exocarpus* of the Santalaceae with trees of timber value is found in Malaysia and Madagascar besides its chief centre in Australia.

There are many other rare and intriguing groups of plants in the Island groups around Australia and in the Pacific Ocean. The family Degeneriaceae known for its vesselless species is exclusive to the Fiji Island. Winteraceae with its vesselless genera is found in New Guinea, Fiji, New Caledonia and East Australia. The family also extends to Madagascar and Juan Fernandez Island, *Pseudowintera*, the endemic and sole New Zealand genus of the family has its three species distributed in the subtropical and sub-Antarctic rain forests where one of them is reduced to an alpine scrub (Philipson & Hearn, 1962). New Caledonia has the monotypic, endemic vesselless *Amborella trichopoda* of uncertain affinity. Among the other members of the vesselless dicotyledons, *Cercidiphyllum* which had an extensive distribution in the world during Late Cretaceous and Tertiary Periods as per the fossil record is now confined to a limited area in China. The genera *Trochodendron* and *Tetracentron* now placed in separate families have restricted distribution, *Trochodendron* in Japan and *Tetracentron* in China, Upper Burma and eastern Himalaya.

Having given a fleeting glimpse of facets of plant distribution of the present day world, drawing particular attention to some rare and strange members among them, it may be stated that our knowledge of the present day distribution of plants particularly the angiosperms has been built up over the past several hundred years largely due to the pioneering efforts and adventurous forays into the remote and inaccessible, inhospitable areas in several continents by dedicated plant hunters and explorers who had to face innumerable, hardships, hostile elements, natural as well as human. Many of them sacrificed their lives in this great effort for acquisition of knowledge. Prezewalski, a famed Russsian explorer, died of typhoid during his travels, the missionary Soulie was murdered and a young lady plant collector from Kew fell from the cliff while collecting flowers and died. There is a simple marble tablet in memory of this lady, Joan Margaret Legge in the Valley of Flowers in Garhwal Himalaya where she died. E. H. Wilson, the famed plant collector in south-west China once faced certain death if he had slipped when photographing the curious 'handkerchief' tree or Dove tree (*Davidia involucrata* — Davidiaceae of Cornales) which was growing on a steep rocky declivity in the Yangtze gorge. Wilson had to climb up a slender branch of a tree to get a good view of the plant for his bulky plate camera. The tree was *Tetracentron* with extremely brittle wood and it was growing on cliff overlooking a drop of a couple of hundred feet below (Whittle, 1970). The lure of plant hunting is irresistible. That there is still scope for momentous discoveries by such adventurous efforts is illustrated by the discovery some years ago in a remote tropical forest area of the Cameroons in West Africa of a remarkable dicotyledonous tree. When the specimens reached Kew the experts could not reach

any conclusion about its relationships. The plant was named as a new genus by Brenan at Kew (1952) and it had to be accommodated in a new family and even a new Order with its basionym *Medusandra*. It was only after an exhaustive study of its morphology, anatomy, pollen and other attributes that it is now considered to have a Santalalean affinity. The field is still open for such discoveries and there lies the hope for the avid plant hunter.

In conclusion it may be stated that in the present day world man has made a significant impact through the introduction of many useful plants of economic value, ornamentals and various others to newer lands where many of them have thoroughly acclimatised and naturalized among the local flora. Incidentally, man has also been responsible for introduction of many weeds and pests which have run wild in their new environment in many parts of the world.

I wish to express my gratitude to the Chairman and Members of the Governing Council and the Director of the Birbal Sahni Institute of Palaeobotany for asking me to deliver the 40th Sir Albert Charles Seward Lecture. With deep reverence I offer my respects to the memory of two of the most distinguished Botanists of the present Century, Professor AC Seward and Professor Birbal Sahni.

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