1 Introduction
1.1 General introduction

Forests have come to play a dominant role in the development of several forest based industries in the world. Although wood is the major raw material of the forest, a great variety of other products from trees and associated vegetation have permitted the establishment of many highly specialized industries. These 'minor forest products' which include gums and resins contribute about 30% of total revenue of Forest Department of India (Anonymous, 1976a). It is noted that while the total income from our forest land is dismally low when compared
to other countries of the world, India fares better when we separately consider the case of minor forest products (Thapar, 1975). Gums and resins are among the few forest raw materials, the export of which exceeds import. Some of the well known gums of international market such as "karaya", "ghatti" and "katira" are totally indigenous to India (Farooqui, 1976). Potentiality of these products to contribute to the economy of the nation becomes evident when we consider the fact that during 1974-75, the country earned an amount of about Rs.32 crores solely by the export of indigenous gums (Farooqui, 1976).

Leaving aside the seed gums, the gums and resins of commercial importance are the exudates of certain trees. They ooze out of the plant body through wounds and injuries, and may solidify on the plant surface from where it is picked by man. In some plants the production of gums and resins is a part and parcel of their normal metabolism, and such plants have specific tissue systems in their body for their synthesis and storage. But some other plants develop the system and exude gum or resin only as a response to stresses of various kinds. In this case the induced gum or resin exudation is thus of traumatic origin. The stress which induces the exudation may be mechanical injury, wounding by insects and pathogens, aging, drought or the application of certain chemicals (Ghosh and Purkayastha, 1962; Skene, 1965; Whistler, 1973; Hillis, 1977; Agrios, 1978; Fahn et al., 1979; Greenwood
The common secretory products of plant origin are resin, latex, essential oils, gum, mucilage and wax. Even though, in their general physico-chemical properties of solubility, melting points and structure, together with their sites of secretion, these groups of compounds are reasonably distinct, there is always some overlap in chemical properties of most of these groups (Dell and McComb, 1978a).

Gums are regarded as neutral salts of complex polysaccharides, and are always highly branched. These polysaccharides are made of a β-D galactan core, heavily substituted by outer chains containing L-arabinofuranosyl, D-glucopyranuronosyl and L-rhamnopyranol groups (Stephen, 1980). Other sugars such as D-mannose, D-xylose, L-fucose, D-galacturonic acid and 3-O-methyl-L-rhamnose are also found linked as substitutes in the gums of certain plants.

The gum is soluble in cold or hot water (or at least it swells to form a gel), but insoluble in organic solvents. Resin on the other hand is insoluble in water but soluble in organic solvents. Resins are mixtures of compounds, typically including flavonoids, terpenoids and fatty substances (Dell and McComb, 1978a). Some plant exudations consist of both gum and resin components and hence they are referred to as gum-resins.
Gums and resins have been used by human beings from time immemorial. Gums are amongst the oldest drugs known to mankind. Today the gums and resins find a prominent place in some of the world's largest industries of foods, pharmaceuticals, medicines, beverages, cosmetics, paints, paper, ink, photography, confectionaries, ceramics etc. (Farooqui, 1963, 1976, 1979a, b). Vegetable gums and related compounds continue to hold their dominance over the synthetic substitutes owing to their easy availability and low costs.

In spite of its importance in commerce and its potency of absorbing lakhs of unemployed weaker section, the gum industry has not been developed in an organized manner in our country. In order to meet the ever increasing demand of gums and resins, their production should be streamlined either by finding new sources or by a better exploitation of the existing natural sources. The industry suffers from lack of scientific knowledge in several problems connected with it. The production is largely uncontrolled and unsystematic. Tapping and collection are mostly done by tribals in crude ways and hence the yield is by odds and the life span of the tree is considerably reduced. Scientific methodology for a rational exploitation of these natural resources is badly in need. The pressing need is to find scientific methods for an organized and well planned collection of the exudates and to find out useful and economic means to aggravate the yield.
Study of the structure and distribution of the secretory system is significant to derive precise tapping methods which yield maximum exudate causing minimum tissue damage. Research in our laboratory in recent years has given a basic knowledge on the distribution and structure of the secretory systems and the process of gum and gum-resin secretion in several tropical trees (Setia, 1976; Subrahmanyan, 1981; Venkaiah, 1982). Still several aspects associated with the process remain to be known. The exact role of the gums or gum-resins in the plants' life is still not completely known. Further, the significance of the specific distribution pattern of gum or gum-resin producing system in different tissues and organs of the plant is yet to be understood.

In the present investigation, the distribution, structure and development of normal gum-resin producing systems in various organs of Vateria indica, Garcinia cambogia, and induced gum/gum-resin producing systems in the secondary xylem of Bombax ceiba, Sterculia urens and Lilanthus excelsa are described. The significance of characteristic distribution pattern of gum/gum-resin producing system in different tissues is correlated with their proposed function. Ultrastructure of pith ducts in V. indica and A. excelsa is studied with an intention to extend and examine the existing knowledge on the process of secretion in more uninvestigated genera.

Ethephon, an ethylene releasing chemical has been known to induce gummosis, resinosis and gum-resinosis in several
plants (Bradely et al., 1969; Abeles, 1973; Hillis, 1975; Greenwood and Morey, 1979; Nair et al., 1980, 1985; Bhatt and Shah, 1985). In the present study ethephon was administered to B. ceiba, S. urens, and A. excelsa. The optimum concentration of ethephon for maximum yield of the exudate without visible adverse effect on the plant is worked out in B. ceiba and S. urens. Histology of the exuding part of the plants has been studied to understand the factors contributing to the enhanced exudation.

Plants may produce gums and resins as a response to microbial attack (Agrios, 1978; Mehrotra, 1980). Involvement of bacteria is doubted in the gum exudation of Acacia senegal (Gosh and Purkayastha, 1962). Recently, Gedalovich and Fahn (1985) observed traumatic development of gum ducts in the secondary xylem of Citrus upon artificial inoculation of fungus. But how the pathogens lead to the development of traumatic secretory system and induce exudation is still unknown.

Bombax ceiba was known to exude gum only as a response to infection or some functional diseases (Dymock et al., 1890; Anonymous, 1972), and artificial injuries made on the stem do not exude gum. Similarly A. excelsa which has normal gum-resin ducts only in pith, develops cavities in the xylem and exude gum-resin in response to fungal infection. Distribution, structure and development of disease-induced and ethephon-induced cavities are compared in A. excelsa and a possible role of ethylene in disease-induced exudation is discussed.
In many plants, development of gum ducts in the secondary xylem is associated with blockage of xylem vessels by tyloses or gummy occlusions (Gosh and Purkayastha, 1959; Parups and Molnar, 1972; Hillis, 1977; Greenwood and Morey, 1979; Olien and Bukovac, 1982). Much is known about tyloses, but there is no consistency of opinion on the origin and chemical nature of gummy occlusions. The occluding material may arise by the swelling of preformed wall structures (Robb et al., 1975; Vander Molen et al., 1977; Cooper and Wood, 1980). It may be contributed by the parenchyma cells adjacent to the vessel (Rickard et al., 1979) or by the pathogen itself (Oullette, 1978). Despite the close association of the vascular occlusions with gum producing system in several plants, our knowledge about the comparative chemical nature of occluding gum and exuding gum is almost nil. Hence the origin of the vascular occlusion in A. excelsa is investigated in detail, and the composition of the occluding substance and the exudate is histochemically examined.

1.2 Introduction to the new genera investigated

1.2.1 Vateria indica L.

Family : Dipterocarpaceae


It is a large evergreen tree indigenous to the evergreen forests of the western ghats from North Kanara to Kerala. The tree is valued for its timber, 'resin' and tallow of the seeds.
The exudate of the tree is known as piney resin, white dammar or dhupa and is commercially important. It is obtained by tapping the tree by making semicircular incisions on the stem through the cork cambium, upto the surface of the sapwood. The resin starts oozing out from the incision in 3-4 days and continues for 60-90 days.

The essential oil in the resin shows marked antibacterial activity and hence this resin finds extensive use in Indian medicine. It is also credited with tonic, carminative and expectorant properties and is used for the treatment of several diseases such as throat troubles, chronic bronchitis, piles, diarrhea, rheumatism, tubercular glands, syphilis, gonorrhea, ulcers, boils etc. It forms a good emollient for plasters and ointment bases.

The resin also finds use in the preparation of varnish, candles, torches, incense and as a substitute for amber in photographer's varnish.

1.2.2 *Garcinia cambogia* Desr.

Family : Guttiferae


It is a small or medium-sized tree with rounded crown and horizontal or drooping branches. The tree is found commonly in the evergreen forests of western ghats from Konkan southwards to Travancore, and in the Sholar forests of Nilgiris upto an altitude of 1,800 m.
The tree is mainly valued for its fruits. The dried rind of fruit is used in Travancore-Cochin and Malabar as a condiment for flavouring curries. It is a superior substitute for tamarind and lime.

The tree yields a translucent yellow exudate which is variously described as resin (Anonymous, 1956) and as gum-resin (Howes, 1949; Schery, 1954). The exudate, known as 'gamboge' possesses purgative properties. It is also used as a water paint pigment and in "spirit" varnishes for metal.

In the literature, the terms gum, resin and gum-resin are rather vaguely used. Based upon their positive reaction with the histochemical tests for both polysaccharides and lipids, the exudates of V. indica and G. cambogia will be hereafter referred as gum-resin in this thesis.

The normal gum/gum-resin producing systems of B. ceiba, S. urens and A. excelsa have been previously studied (Setia, 1976; Subrahmanyan, 1981; Venkaiah, 1982).