Living on the Bark

Dipanjan Ghosh

Bark has different characteristics and functions depending on the species of tree. It provides trees with essential structural support, conducts nutrients from the leaves down to the roots, and offers protection from various animate and inanimate agents. Apart from harbouring a large number of living beings on the body, bark also supports our life on this planet.

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The bark is the outermost layer of the stem of a tree which transports nutrients from the leaves to the rest of the tree and also protects the tree from dehydration. It is a sort of blanket, enveloping the exposed surfaces of trunks, branches and roots. It protects the plants from insects and pathogens. The bark also functions as a medium for plant excretion and protects the plant from abrupt climatic changes. The bark is important from an ecological point of view too. The bark of a tropical tree species harbours countless microbes, insects and worms, and other groups of organisms along with a large number of lichens, algae and even higher plant species. Thus, bark serves as a platform for interaction among different species and with the environment.

Protective Shield for Plants

Plants are exposed to various pathogenic and parasitic forms especially fungi and bacteria. The first line of defence of plants against these organisms is their surface. The pathogen must penetrate the bark to infect the inner tissues. Increased thickness of bark enhances resistance to penetration by fungal hyphae. Moreover, the waxy nature of the suberized phellem or cork layer of bark provides a waterproof layer on which water drops containing fungal spores or bacteria cannot easily adhere to. However, in many cases, pathogens enter plants by penetrating the bark through openings which either exist naturally such as lenticels or appear on the bark as wounds created by various animate or inanimate

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Figure 1. Plants face innumerable attacks from insects throughout their lifetime and the resulting damages can be largely minimized by the bark.
(a) Marked portion shows the bark damaged due to insect attack.
(b) Termites causing damage to plants. Bark prevents to some extent the destruction of valuable wood.
(c) Shows the bark after termite activity.

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agents [1]. Certain saprobic wood rotting fungi also single out these damaged portions of the bark, as they obtain large amount of decaying matter for their nutrition.

The bark of a few tree species contain chemical compounds that defend the plant against attack from those fungi, insects, and parasitic plants which sometimes manage to breach the physical barrier (*Figure* 1). Most of the chemicals [2] present in plant bark, especially tannins and phenolic compounds, are natural antifungal substances. Certain other chemical compounds such as salicylic acid, jasmonic acid, oligogalacturonides, terpenoids and ethylene directly combat phytopathogens during infection. Hydrolytic enzymes such as glucanase and chitinase present in surface cells of plants may cause breakdown of pathogen cell wall components and thereby render resistance to infection. Saponins and simple phenylpropanoids exhibit strong antimicrobial activity against fungal pathogens [3].

The chemical nature of bark also offers protection from wood-boring insects, their larvae and even from bark-gnawing mammals such as rats, porcupines and squirrels. A large variety of defensive phytochemicals such as alkaloids, cyanogenic glycosides and some secondary metabolites are nitrogenous compounds. Active ingredients [4] extracted from the bark have opened up new vistas in the field of commercial biocides. For instance, the glycoside rotenone obtained from the root and stem bark of Indian tuber root (*Derris elliptica*) is used as an insecticide and a larvicide. The root bark of oriental bittersweet (*Celastrus angulatus*) possesses sesquiterpene polyolester compound, which is an active insecticide. Similarly, insecticidal compounds (recaglamide derivatives) have been isolated from *Aglaia oligophylla*, a native of the Indo-Malaysian rain forests. Strychnine, an alkaloid found in the bark (*Figure* 2a) as well as within the seeds, wood, leaves and root of the plant vishamusti or kuchila (*Strychnos nux-vomica*), is used as a rodenticide. The bark (*Figure* 2b) of kaner (*Nerium indicum*) is used in the manufacture of rat poison as it contains toxic glycosides rosaginin and nerlin. However, some non-nitrogenous secondary plant metabolites may also be used as commercial insect control agents. For instance, azadirachtin is extracted from the stem barks, leaves and fruits of the neem (*Azadirachta indica*) tree. As a complex limonoid (i.e., triterpene), azadirachtin exerts a variety of toxic effects on certain insects [5].

Certain phenolic compounds such as tannins are involved in plant protection. Tannins act as feeding repellents to mammals other than rodents and rabbits. They cause a sharp, astringent sensation in the mouth as a result of their binding with salivary proteins [3]. Hence, most mammals such as cattle, deer and primates rather than apes characteristically avoid plants with high tannin content in their bark.

Figure 2.
(a) Vishamusti (*Strychnos nux-vomica*) bark contains the poisonous alkaloid strychnine.
(b) Kaner (*Nerium indicum*) bark contains cardio-active glycosides which are also poisonous and used to kill rodents.

Preventing Nature's Rage

Bark also protects plants from several environmental and habitat factors. Plants are exposed to various ecological stressors ranging from high temperature to cool frost, salinity, high humidity to dry desiccated condition or calamities such as thunderstorms, forest fires, flood, drought, etc. The thick bark helps certain plants to cope with stresses caused by high temperatures as well as chilling and freezing injuries. The thick bark of larch (*Larix occidentalis*), pine (*Pinus palustris* and *P. ponderosa*) and bur oak (*Quercus macrocarpa*) help resist forest fire injuries [6]. Bark with rich tannin content enables mangroves to tolerate daily submersion in saline water. Suberized cork layers of bark provide a sort of insulation against highly humid to dry desiccating weather. However, bark is sensitive and can be susceptible to 'sunburn' or 'frost bite'. If a plant that has grown for many years in deep shade is suddenly exposed to the hot sun (when all the trees around it are cut down, for example), the bark may become red and flake off, injuring the plant. In temperate regions, a frost too late in the spring or too early in the fall can kill new bark tissue, besides leaves and new branches. However, the bark always keeps the inner tissues of the plant protected.

A Medium of Excretion

By-products of metabolic activities are called waste products or excretory materials. In plants, excretory products are far less active and are formed in lesser quantity than in animals. As a result, plants do not possess an excretory system. Excretory matter may remain accumulated somewhere in the plants, in special reservoirs or dead inactive tissues. The bark of perennial trees is an important medium for accumulating excretory materials which may be thrown out from time to time by abscission. Also certain insects such as termites help plants by devouring the outer bark which comprises a large array of excretory products.

Excretory materials of plants (*Figure* 3) are called as 'secondary metabolites'. They are often specific to a plant species or a taxonomically related group of species. Previously, these compounds (see *Table* 1) were thought to be functionless end products of metabolism, or metabolic wastes. More recently, they are considered to have important ecological functions as well in plants. Also, many of these substances are employed commercially as insecticides, fungicides, and pharmaceuticals, while others are used as fragrances, flavouring and industrial materials [3].

Figure 3. Excretory materials deposited on the bark have broad-spectrum economic uses.
(a) Gum excretion from drumstick (*Moringa oleifera*) trunk.
(**b)** Cinchona bark (*Cinchona officinalis*), the producer of commercial quinine.

Non-nitrogenous Compounds	Nitrogenous Compounds
A. Gums B. Latex C. Resins 1. Hardresins e.g., shellac 2. Oleoresins a. Terpenes i) Monoterpenes e.g., pyrethroids, essential oils ii) Sesquiterpenes e.g., sesquiterpene lactone, gossypol iii) Diterpenes e.g., abietic acid, phorbol iv) Triterpenes e.g., sterorids, limonoids, saponins v) Polyterpenes e.g., rubber 3. Gumresins e.g., asafoetida, dhuna D. Phenolic compounds 1. Lignin 2. Flavonoids a. Anthocyanins b. Flavones c. Flavonols d. Isoflavones 3. Tannins a. Condensed b. Hydrolysable	A. Alkaloids 1. Indole e.g., reserpine, strychnine 2. Isoquinoline e.g., morphine, codeine 3. Piperidine e.g., coniine 4. Pyrrolidine e.g., nicotine 5. Pyrrolizidine e.g., retrorsine 6. Quinolizidine e.g., lupinine 7. Tropane e.g., atropine, cocaine B. Cyanogenic Glycosides C. Glucosinolates

Table 1. Some compounds found in higher plants as excretory products (secondary metabolites).

Bark Dwellers

Several species of plants and animals live on trees. The diversity ranges from microscopic bacteria to large mammals. Only the bark of woody plants can harbour smaller creatures and tiny plants.

A plant species growing on other plants is technically termed as epiphyte or aerophyte. Many sub-aerial algae inhabiting tree bark are responsible for the variety of colours (*Figure* 4a) and textures of the bark surface. Genera such as *Nostoc*, *Phormidium, Scytonema, Stigonema* (of Cyanophyceae); *Chlorella*, *Cylindrocystis*,

Figure 4. Some aerophytic plant associations on tree bark.
(a) *Trentepohlia* (a green alga having haematochrome pigment).
(b) A crustose lichen.
(c) A bracket fungus (although nutritionally saprobic).
(d) Shows that mosses envelope the tree bark in a temperate forest like fur jackets.

Euglena, Mesotaenium, Physolinum, Pleurococcus, Trentepohlia (of Chlorophyceae); *Characiopsis, Chlorothesium, Ophiocytium* (of Xanthophyceae) and diatoms such as *Cymbella, Hantzschia, Navicula, Nitzschia* and *Pinnularia* are some examples of bark-dwelling algae [7]. These sub-aerial forms are usually associated with moss flora. They receive moisture either solely from the atmosphere or a fairly steady source of water seeping through the moss mats [8]. Lichens inhabiting tree trunks are known as corticolous lichens (*Figure* 4b). Many crustose (e.g., *Lecanora*), foliose (e.g., *Candelaria*, *Parmelia*, *Physcia* and *Xanthoria*) and fruticose (e.g., *Teloschistes* and *Usnea*) lichens prefer to grow on the surface of the bark.

Fungi are not true bark dwellers although various wood rotting or lignicolous fungi appear on the surface of the bark because fungal fruiting bodies receive nutrition from the humus pockets that are scattered throughout the bark and bark crevices. However, a true relationship between fungi and root bark (actually the inner bark layer) is seen in certain forest trees, in the form of ectotrophic mycorrhizal association. Genera such as *Amylascus*, *Armillaria*, *Cazia*, *Geastrum*, *Lactarius*, *Piloderma* and *Rhizopogon* are a few common examples of mycorrhizal fungi.

Among bryophytes, very luxuriant forms of mosses grow on the trees in wet tropical, subtropical and temperate forests [9]. In a dense forest they form a very lovely sight (*Figure* 4d). Most pleurocarpous mosses, such as *Hypnum*, *Orthotrichum*, *Taxithelium* and *Thuidium* are epixylic (growing on tree bark), and there are some acrocarpic[1] forms such as *Calymperes*, *Stereophyllum* and *Syrrhopodon*. In many genera of mosses the growth is so vigorous that after creeping on the bark of the branches, they hang down in pendulous forms, viz., *Meteoriopsis*, *Meteorium* and *Papillaria*. Certain foliose hepatics[2] such as *Lejeunea, Plagiochila* and *Porella* also grow on tree bark.

[1] 'Acrocarpic' refers to 'acrocarpous' (this word is botanically correct, i.e., more appropriate) which designates a group of true mosses having clustered upright stem axes (i.e., erect habit) and the reproductive parts/ sporophytes at the end of the axis.

Mosses actually support higher epiphytes (pteridophytes and angiosperms) by accumulating nutrients and moisture in the substratum. The profusely branched and ramifying pleurocarpic and densely packed acrocarpous mosses are generally more efficient absorbers and entrappers of metal particles. It is likely that these elements are obtained from wind blown materials lodged in the moss mats or from solutes[3] or rain water. A moss *Thelia asperella* growing on red cedar (*Juniperus virginiana*) bark is an excellent example. This particular species is so efficient an absorber that it contains eight essential elements not found in the supporting red cedar bark. However, the normal absorbing roots of higher epiphytes absorb water, minerals and organic nutrients from the humus (arising from denatured bark tissues, dead mosses and algal filaments) and dust that are accumulated on the surface of the bark of the supporting trees.

[2] 'Hepatics' or 'liverworts' refer to members of 'Hepaticopsida', i.e., thalloid bryophytes.

[3] The dissolved ions flowing within the tissues of mosses for preparation of carbohydrate food.

A large number of ferns (genera such as *Davallia, Drynaria, Leucostegia, Loxogramme, Microsorium, Monogramma, Platycerium, Pleopeltis* and *Polypodium*) are well-adapted to the tree bark enriched with inorganic and organic nutrients. Some non-fern pteridophytes such as *Ophioglossum pendulum, Psilotum flaccidum* and *Tmesipteris tannensis* are also found to share the same habitat. In tropical and subtropical forests, many epiphytic orchids, bromeliads, aroids, bo trees[4] and even cacti are found on the bark of other woody angiosperms.

[4] 'Bo trees' refer to fig trees – *Ficus religiosa* (peepal) or *Ficus benghalensis* (banyan) – that usually share bark crevices or trunk-hollows.

Interestingly, some epiphytes show specificity in the selection of their supporting plants. *Tortula pagorum*, an epiphytic moss, is peculiar in the sense that it grows on the tree trunk within urban limits [9]. Host specificity is quite common in certain mosses,

Figure 5. Some insects permanently live on tree bark. **(a)** and **(b)** show two spider species waiting for their prey on the tree bark.

ferns and flowering plants. However, some lichens show preference for certain trees based mostly on the nature of bark and its microclimatic and chemical conditions. Some macrolichens, for instance, *Cladonia cartilaginea*, *Collema auriculatum* and *Sticta praetextata* show specificity to particular host trees such as tiger's milk spruce (*Sapium insigne*), Chinese banyan (*Ficus microcarpa*) and Indian laurel (*Litsea floribunda*), respectively [10]. Astonishingly, there are a few examples of host-specific (more precisely substratum-specific) saprobic fungi. For instance, the polypore fungi *Phellinus robiniae* and *Navisporus floccosus* are specific to black locust (*Robinia pseudoacacia*) and peepal (*Ficus religiosa*), respectively.

Animals are more advanced than plants in respect of thriving on the bark of trees and using it for their needs. Smaller animals, mostly insects, worms and snails are closely associated with tree bark (*Figure* 5). Many insects such as mites, lice, aphids, wood borers, beetles, wasps, etc., are found living under loose bark on trees. Social huntsman spider (*Delena*) and common huntsman spider (*Isopeda*) can be seen in groups under the bark of trees and stumps [11]. A large number of insects and spiders also utilize bark as breeding and hatching places (*Figure* 6). They lay eggs individually in bark crevices. Larvae that are hatched from eggs live in those crevices. Sometimes, larvae make tunnels under the bark. The Southern pine beetle (*Dendroctonus frontalis*) is a

Figure 6. Various insects and their larvae reside on the bark and in the bark crevices.

Figure 7 (left). An unusual visitor of tree bark. Bark is often used as a resting place by certain nocturnal and diurnal creatures especially insects.

Figure 8 (right). a) An ant mimic spider is waiting for its prey. **b)** Oriental garden lizard (*Calotes versicolor*) shows its best camouflaging ability on the exposed bark surface.

primary pest of pine forests. Larvae of this insect make tunnels or galleries beneath the bark in patterns resembling the letter 'S' [11]. Certain arboreal ants such as *Dilobocondyla*, *Formica* and *Tapinoma* nest in bark crevices. Some animals and a few nocturnal creatures, especially insects (*Figure* 7), often use bark as a resting place.

Many insects use the tree bark as a hiding place too, either to catch prey or to escape from predators. Some of these creatures resort to mimicry (*Figure* 8a) as well as adopt alternate colours (*Figure* 8b). The hiding incidence of peppered moths on the oak bark is an outstanding observation in the field of evolutionary biology (*Box* 1).

Box 1. Peppered Moth and Industrial Melanism

The light colouration of peppered moths (*Biston betularia*) of Lepidoptera had camouflaged them properly against the light-coloured tree-bark and lichens on which they rested (*Figure* a). However, after the industrial revolution in England, many of the lichens died out due to massive pollution. The trees upon which the peppered moths rested were blackened by soot exposing the light-coloured moths to predators. At the same time, the dark coloured melanic moths (*B. betularia* morpha *carbonaria*) flourished because of their ability to hide on the darkened tree-bark (*Figure* b). This phenomenon is known as 'industrial melanism' and was first observed on the bark of trees.

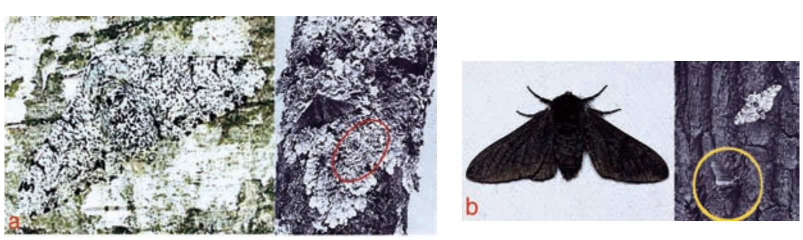


Figure A. a) White night-flying peppered moth *(Biston betularia*) and its camouflaging on the tree trunk teemed with lichens. **b)** The Melanic black moth (*B. betularia* morpha *carbonaria*) and its appearance on a tree trunk after industrial melanism.

The Bark-Eaters

Many insects and pests such as mites, mealybugs, zorapterans and bark-lice are voracious bark eaters. They usually feed on bark of inhabiting trees. It is known that butterfly caterpillars eat gluttonously. Prior to their metamorphosis, these caterpillars remain crowded (*Figure* 9) on the tree bark of drumstick (*Moringa oleifera*), coral jasmine (*Nyctanthes arbor-tristis)* and some other plants.

Some insects depend on the juices and exudates secreted from the bark of flowering trees. Aphids suck juices of the inner bark layer. Nutritive fluids (chiefly carbohydrates) flowing through the underlying phloem tissues (living bark involved in translocation[5]) of trees such as eucalyptus (*Eucalyptus rostrata*), mango (*Mangifera indica*), sisham (*Dalbergia sissoo*) and neem sometimes seep out from wounds and are stored within the crevices of bark. In addition, gums (denatured cell wall substances) are deposited on the surfaces of bark in the case of drumstick, mango, otaheite apple (*Spondias dulcis*), silk flower (*Albizzia lebbeck*), etc. These exudates attract various types of wood ants (*Figure* 10) belonging to genera such as *Camponotus, Crematogaster, Dilobocondyla, Formica, Tapinoma* and *Technomyrmex* which use these materials as a food source. Such availability of food sometimes gives rise to myrmecophily, a symbiotic association between the plant and ants. The ants benefit by obtaining food and

[5] 'Translocation' means the bidirectional movement of synthesized food to the growing regions and also to the storage organs of the plant through phloem tissues.

Figure 9 (left).
(a) Congregation of butterfly caterpillars on the bark.
(b) The exposed bark after the dispersion of caterpillars.
Figure 10 (right). Arboreal ants nest in wood crevices showing myrmecophilous association.

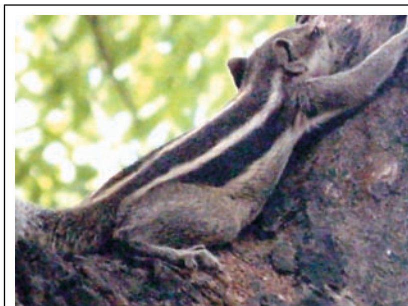
nesting sites while plants benefit by receiving protection and means of seed dispersal. It is also seen that termites consume the dried gum of certain gum-exuding trees during their routine etching of the bark.

The bark is not very nutritious and thus largely ignored by higher animals in seasons of plentiful sustenance. However, when food is scarce, animals often turn to tree branches and consume bark as their main diet. Thus, the bark itself becomes a food source in winter, attracting various animals such as rodents, larger mammals and even deer.

Smaller animals feast on bark. In the temperate forests of North America and Europe, some rabbits (mainly *Lepus californicus*, *Oryetolagus cuniculus* and *Sylvilagus floridanus)* and porcupines (*Atherurus macrourus* and *Erethiozon dorsatum*) eat the bark of lower branches, sometimes leaving individual teeth marks in the wood. Grey squirrel (*Sciurus carolinensis* and *S. griseus*), red squirrel (*S. vulgaris* and *Tamiasciurus hudsonicus*) and fox squirrel (*Sciurus niger*) may gnaw bark at the trunk bases of sumac (*Rhus copallina*), crab apple (*Malus floribunda*) and certain shrubby species of roses (e.g., *Rosa californica*, *R. gallica*, *R. virginiana*). Beavers (*Castor canadensis*) are great tree pruners. Beavers are the only animals that actually chew away large chips of wood in order to fell trees. However, they do not really chew and digest wood; they only consume the inner bark [13].

In the tropical forests of our country, animals (*Figure* 11) such as striped squirrels (*Funambulus palmarum* and *F. pennanti*), small flying squirrel (*Hylopetes fimbriatus*), crested porcupine (*Hystrix indica*) and hispid hare (*Carprolagus hispidus*) rely largely on tree bark during food scarcity. The Malabar giant squirrel (*Ratufa indica*) feeds on the bark of teak (*Tectona grandis*), laurel (*Terminalia tomentosa*), dhaman (*Grewia tiliifolia*), ben-teak (*Lagerstroemia lanceolata*) and mango. About 6.5% to 36% of bark (making up the bulk of the diet) is consumed annually by this particular species [14].

Figure 11. Striped squirrel (*Fanumbulus pennanti*), a familiar face of our neighbourhood, is a great devourer of tree bark.



Deer sometimes eat the bark of tree branches. Unlike other animals, they can easily reach the higher branches. Deer usually bite off twigs and chew bark which they rip off in strips [14].

Securing Human Desiderata

Apart from its necessity to the plant, bark provides raw materials for some basic requirements of human life such as medicine, clothing, cordage, paper, dyes, etc.

Plant bark may be the most extensively used materials in the preparation of medicines since times immemorial. 'Aspirin' was originally derived from the bark of willow tree (*Salix alba*). An extract of pau d'arco (*Tabebuia avellanedae*) bark, a native of Argentina, is used for its antibacterial, antifungal and immunostimulant properties. Essential oil present in the bark decoction of Brazilian pepper tree (*Schinus molle*) possesses an antifungal principle which is effective against skin diseases. 'Pygeum', a substance used primarily to combat prostate problems, is derived from the bark of African prune or pygeum tree (*Pygeum africanum*). Yohimbe tree (*Pausinystalia yohimbe*) bark is believed to have beneficial effects in relieving anxiety disorders. Glossy buckthorn (*Rhamnus frangula*) bark provides the purgative 'frangula'. The bark (*Figure* 12) of Arjun tree (*Terminalia arjuna*) is used in Indian traditional medicine for its curative properties. It has a pungent taste due to the high tannin and alkaloid content. Today, the best-known tree bark medicine is 'tamoxifen', which is derived from the Pacific yew tree (*Taxus brevifolia*). It was originally used to treat ovarian cancer, but is now the main weapon in the prevention of the recurrence of breast cancer.

Figure 12. Arjun tree bark.

Moreover, ayurvedic application [15] of various tree barks is quite an ancient practice in India and there is voluminous literature available on this subject. For instance, decoction of nishinde (*Vitex negundo*) bark gives relief from asthma. The infusion of the bargad (*Ficus benghalensis*) bark is used to cure bleeding of nose, inflammation of skin, dysentery, diarrhoea, and to control diabetes and obesity. Kadamb (*Anthocephalus cadamba*) bark is used as a febrifuge. Its composition is similar to that of cinchona [16]. A drink prepared from the bark ash of imli (*Tamarindus indica*) is used to stop nausea and vomiting. Bakul or bullet-wood bark (*Mimusops elengi*) is effective against toothache, caries of teeth and in the treatment of vitiligo. The root bark of devil's cotton (*Abroma angustum*) is useful in treatment of gynaecological ailments. Walnut (*Juglans regia*) bark, very rich in zinc content, is used to treat paradontosis. The bark (*Figure* 13) of kurchi (*Holarrhena anti-dysenterica*) is useful in treatment of amoebic dysentery. Oak bark has considerable medicinal value [17]. Decoction of white oak (*Quercus alba*) bark is used to cure sinus and chronic mucous discharge. The paste of the inner bark of red oak (*Q. rubra*) and black oak (*Q. nigra*) provides a wash that is good for sore eyes. The bark of bur oak (*Q. macrocarpa*) tree can be used as primitive bandages to hold broken bones in place and also as a mild medicine for children with intestinal problems.

Figure 13. Kurchi bark is used as ayurvedic medicine in India from time immemorial.

Plant bark yields good quality fibres which are used in making ropes, cordage, coir mats, carpets and even attires in different countries [18]. For instance, the bark of buttercup tree (*Cochlospermum vitifolium*), lasora (*Cordia dichotoma*) and lal keonti (*Ventilago denticulata*) is used in making ropes and cordage. The bark of bastard cedar (*Guazuma ulmifolia*), screw tree (*Helicteres isora*) and gulu (*Sterculia urens*) yields good quality fibres. 'Madras hemp' is derived from the fibres of the bark of Deccan-hemp (*Hibiscus cannabinus*). The stem bark of tossa jute (*Corchorus olitorius*) and white jute (*C. capsularis*) produces 'jute' of commerce. The bark of zulu fig (*Ficus nekbudu*) of Mozambique serves as a source of 'mutshu cloth'. Paper mulberry (*Broussonetia papyrifera*) is largely cultivated throughout Polynesia for making 'tapa cloth'. The bark of ogiovu (*Antiaris toxicaria*) tree is used in making garments and sacks. The lace-like inner bark of lace bark tree (*Lagetta lintearia*) is suitable for making dresses. The bark of flax plant (*Linum usitatissimum*) yields a fine fibre for weaving into linen cloth.

Figure 14. The bark of *Casuarina* yields dye of commercial importance.

Fibres of certain plant bark are largely used for producing paper pulp [18]. The fibrous inner bark of jui hsiang (*Daphne cannabina*) is utilized for preparing 'Nepal paper'. Inner bark of paper mulberry provides good fibres for manufacturing paper. Bark of pteroceltis (*Pteroceltis tatarinowii*) is the main raw material for manufacturing 'Xuan paper'.

Of late, the demand for natural dyes is gradually increasing for their utility in making inks, paints, staining of polymers, beverages, food items as well as in textile industries. Also they do not cause adverse side effects. Various natural dyes are produced by different plant barks [19]. For instance, dull red to red dyes are obtained from the root bark of peach (*Prunus persica*) and stem bark of babul (*Acacia nilotica*) and amaltas (*Cassia fistula*). A reddish-yellow dye is produced by the stem bark of mahua (*Madhuca indica*), whereas a light reddish dye is produced by casuarina (*Casuarina equisetifolia*) bark (*Figure* 14). A purple dye is extracted from the bark of devakanchan (*Bauhinia purpurea*), a purplish black dye from spur mangrove (*Ceriops tagal*) bark, a light brown dye from arjun and a brownish red dye is extracted from the bark of Indian kino (*Pterocarpus marsupium*) trees. Generally, the colour is extracted by powdering the dried bark, followed by boiling in water. The bark of lodhra (*Symplocos racemosa*) is used for dyeing; sometimes it is powdered to prepare *gulal*, a material used in the Holi festival.

Another useful aspect of plant bark is its effectiveness in preparation of cork. Normally, cork consists of irregularly shaped, thin-walled, wax-coated cells from the outer bark of a tree. But, commercial cork is produced only from the bark of cork oak (*Quercus suber*). Cork is obtained from the new outer sheath of the bark that forms after the original rough outer bark has been removed. This outer sheath can be stripped repeatedly without injuring the tree. Cork is unique because it is made of air-filled, water-tight cells that are remarkably effective as an insulating medium. Cork has different uses although it is exclusively used in bottles for medicine and wine or champagne, instead of rubber.

Endnote

Miniature biota with plenty of biological diversity have found an ecological niche in bark crevices: Some live there unworried, some make a meal of them, some live there comfortably in symbiotic association with others while some have predator–prey relationships. This struggle for existence on the bark surfaces of tropical and temperate forest trees is truly amazing!

Acknowledgements

After publication of ‘Bark is the hallmark’ in *Resonance* [2], an email from renowned Prof. Ramesh Maheshwari, sent after critical reading of my article, encouraged me to write this account. Besides, readers’ reactions published in *Resonance* in due course, equally encouraged me in my quest for more information. I personally thank all those readers of *Resonance*. I am also indebted to three of my students, viz., Subham Paul, Ayan Mondal and Arnab Banik for their painstaking efforts in taking photographs.

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