



Purdue University Forestry and Natural Resources

Why Do Animals Eat the Bark and Wood of Trees and Shrubs?

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Animals gnawing the bark and wood of trees and shrubs is not a malicious act or evidence of a neurotic condition. Instead, it is the normal means by which some animals acquire a nutritious food source. The ability to consume this seemingly unpalatable food supply and derive nourishment from it requires specialized feeding habits and digestive systems.



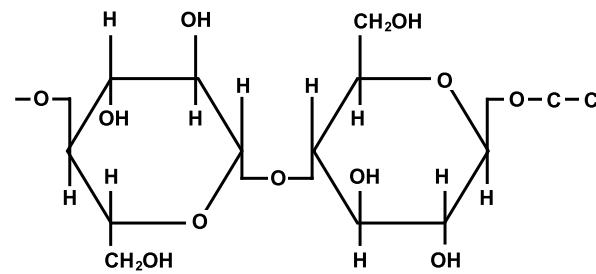
The most consummate wood feeders are the billions of termites throughout the world that literally devour thousands of tons of woody debris every year in forests as well as lumber in buildings. Many of our most serious and damaging insect pests are the bark beetles and wood borers that feed on the parts of trees for which they are named. Even mammals ranging in size from mice to elephants consume bark and woody branches. They all have specialized digestive systems that allow them to extract nourishment from this material, something humans cannot do. To understand how bark and wood can serve as food for these critters requires knowledge of cell wall structure, bark and wood

anatomy, movement and storage of food in trees, and the variations in digestive systems among animals.

Constituents of Plant Cell Walls

Unlike animals, plants have cells with rigid cell walls composed of cellulose, hemicellulose, and lignins. Pectins help hold the individual cells together in tissues. All of these substances are potential sources of food for animals.

Cellulose



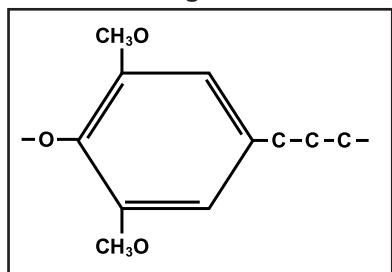
A principal component of cell walls is cellulose, which consists of 5,000 to 10,000 glucose molecules joined by a so-called beta linkage to form straight chain polymers of pure sugar. The long chains of cellulose are combined first into microfibrils and then further into macrofibrils to create a mesh-like matrix of cell wall material, much like fibers twisted to make thread are used to weave cloth.

Although cellulose is a pure carbohydrate, it is not a source of food for humans or most other organisms because they lack the enzymes necessary to digest it. Starch, which many animals including humans can metabolize

because they produce amylase enzymes, is similar to cellulose except the long chains of glucose are linked in an alpha configuration. Cellulose has as much food value as starch, but only animals that maintain colonies of microorganisms in their gut that produce the enzyme cellulase are capable of digesting it.

A second important constituent of plant cell walls is hemicellulose, which bonds cellulose fibrils together. Hemicellulose also is a polymer, but it's more complex than cellulose because the molecule is highly branched instead of straight-chained and consists of a mixture of several kinds of sugars. Only animals with microorganisms in their gut that produce hemicellulase enzyme can use this substance as food.

Lignin



Lignin, occurring within the cell wall matrix formed by cellulose and hemicellulose, serves as a binding agent to hold the cells

together and imparts rigidity to tissues. The soft nature of cotton, practically pure cellulose, is an indication of how flexible wood would be without a stiffening ingredient like lignin. Lignin is a complex polymer built of phenylpropane units. Due to its phenolic nature (phenols are often used as disinfectants), lignin tends to make wood less digestible even for animals adapted to feeding on woody tissues.

The middle lamella located between cells functions somewhat as a cementing material to hold adjacent cells together. It consists of pectins and pectic acids that upon breakdown yield galacturonic acid and the sugars arabinose and galactose.

All of these cell wall materials are potential sources of food if the proper enzymes are available to digest them into their basic sugar and organic acid components.

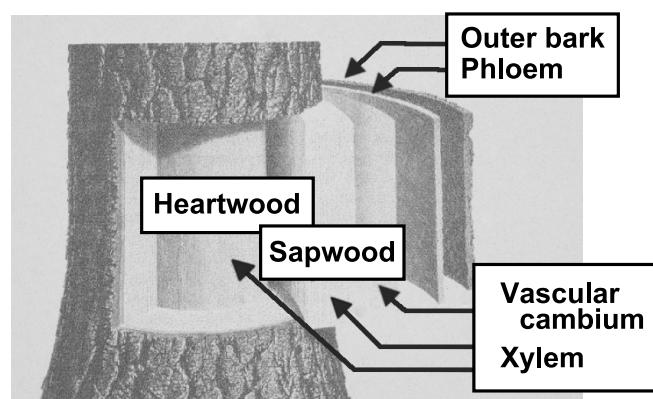
Bark Anatomy

Bark consists of accumulations of crushed, dead cells of the outer bark and the inner bark of living cork cambium and functional phloem tissues that transport sugars throughout trees. The thickness and appearance of bark varies widely among different kinds of trees and depends on the relative activity of cork cambium and the amount of fibers produced in the phloem. The dead outer bark, regardless of its thickness, is the least palatable because the cell walls are high in lignin, phenols, and the waxy substance suberin.

The inner bark, in contrast, has living cells with nutrient laden cell sap, organelles, and stored starch. Most importantly, the phloem cells with their sugary contents are located here. The inner bark is the chief target for animals that feed on bark. Young twigs and branches are preferred because they have a higher proportion of inner to outer bark and lower concentrations of anti-digestion compounds such as lignin and phenols. There are considerable differences among species of trees, but all barks contain sugars, starch, cellulose, hemicellulose, and mineral elements.

Wood Structure

The functional xylem or wood of trees extends from near the tips of twigs to near the tips of roots. When mature, the water conducting xylem vessels and tracheids are dead and hollow. The only nutritional value of these cells is in the lignified cell walls. The xylem also contains parenchyma cells that constitute the vascular rays as well as being located around vessels, at the boundaries between annual rings, or just scattered among the vessels and tracheids. In the functional



Relative position of bark and xylem tissues in a tree trunk

part of the xylem, the sapwood, parenchyma cells are alive and used for storage of starch. The heartwood, in contrast, has no living cells and the starch is replaced with resins and phenols that deter fungal decay and insect feeding. Hence, the sapwood is the most appealing and digestible part of the xylem for wood feeders with its stored starch and water conducting cells containing only small amounts of anti-digestion compounds.

The vascular cambium is the lateral meristem from which both new xylem and phloem cells arise. The succulent, expanding new xylem and phloem cells produced by the vascular cambium become a sink for sugars and amino acids, making them particularly attractive as a food source.

Movement and Storage of Food in Trees

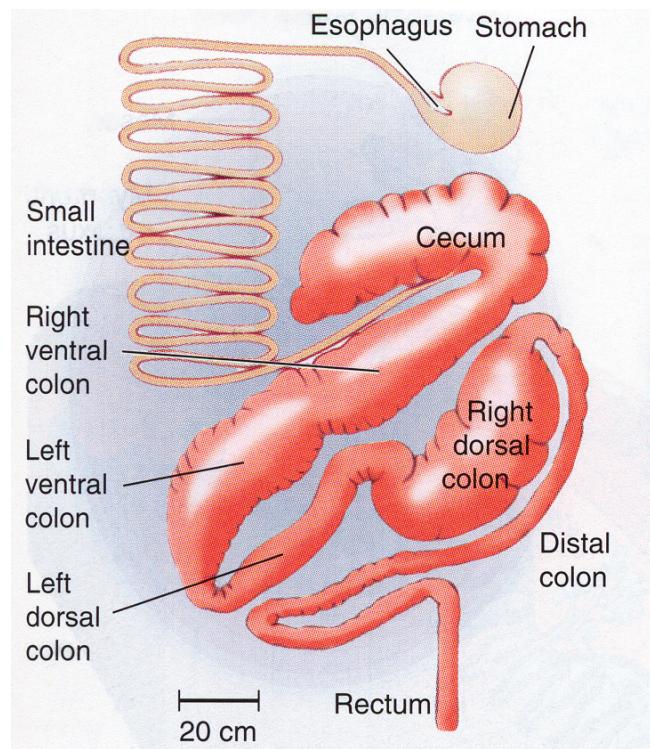
Some of the sugar produced by photosynthesis is used for growth at its site of synthesis, but most is transported via the phloem to other sites to sustain growth or for storage in the branches, trunk, fruits, and roots. The phloem, located in the inner bark, extends throughout trees from the small twigs in the crown to the fine roots. Analysis of the watery sap coursing through the cells of the phloem reveals that sucrose is the principal form in which photosynthate is translocated, but sorbitol, mannitol, raffinose, stachyose, verbascose, and even amino acids also occur. Surplus quantities of these sugars are stored in living parenchyma cells in the roots and in the sapwood of the branches and trunk of trees, usually as starch. Renewal of tree growth in the spring is dependent on this stored food, which at the same time can also be a rich source of easily digestible food for consumers of the bark and wood.

Digestive Systems

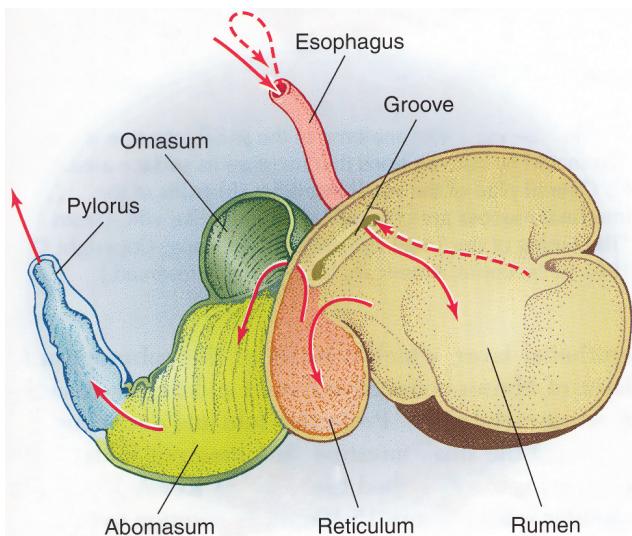
To use bark and wood as food, organisms must possess specialized digestive systems and the necessary enzymes. The function of these adaptations is to break down huge macromolecules (proteins, fats, starch, cellulose, and hemicellulose) into smaller molecules (amino acids, fatty acids, and sugars) that can be absorbed into the circulatory system.

For carnivores and omnivores adapted to eating meat as well as fruits and nuts with their concentrated food value, the digestive system is relatively simple. Strict herbivores have a big challenge since the vegetation they consume is a far less concentrated food, more difficult to digest, and often protected by defensive compounds. In addition, the rigid cell walls of plant material must be broken down to gain access to proteins and carbohydrates inside living cells.

For animals, the breakdown of foodstuffs is accomplished through a combination of mechanical grinding and enzymatic processes beginning in the mouth. To further degrade ingested food, the digestion system of herbivores is uniquely modified. It varies considerably among species, but in all cases depends on microorganisms that inhabit special compartments of the stomach (rumen), intestines (cecum, an outpocketing of the terminal portion of the small intestine where it joins the large intestine), an exceptionally long intestine, or an enlarged colon. Protozoa and bacteria that function similarly to microorganisms that degrade woody debris in the outside environment by secreting digestive



Hindgut fermenter with cecum



Stomach of foregut fermenter

enzymes are brought “indoors” to the protection of the gut. There they basically conduct the same fermentation processes. The cellulases, hemicellulases, and other enzymes that they produce, release sugars, organic acids, and amino acids from woody materials, nourishing both the host animal and the millions of microorganisms living in its digestive system.

The stomach of herbivorous animals can be a single saclike compartment (monogastric) or complexly subdivided into various chambers (digastric). In monogastric herbivores such as horses, rhinoceroses, rodents, and rabbits, protein is digested and absorbed in the single-chambered stomach. Cellulosic material is digested by microorganism-aided fermentation in the intestine, often modified to have either a cecum or enlarged colon. In these animals the intestine is very long, often 25 times the body length, to insure adequate time for digestion and absorption. Monogastric animals that have the ability to digest cellulosic materials are referred to as hindgut fermenters.

In digastric animals like deer, antelope, moose, camels, sheep, goats, and cattle, the stomach is divided into four chambers, the first being the rumen which contains the symbiotic microorganisms. Digastric animals only partially chew their food as they quickly gather it. Later when resting and watchful for predators, they regurgitate and re-chew it. This cycle is repeated

until the mechanical and chemical breakdown of the food is adequate for it to pass to the next chamber of the stomach. Digastric animals are called foregut fermenters.

Several hindgut fermenters (rodents, rabbits, and others) increase the digestion of their food by eating 25 to 60 percent of their feces. This practice, known as coprophagy, is important for small mammalian species with relatively high metabolic rates and sustained caloric needs. The first pass of food through the digestive tract does not provide enough opportunity for microorganisms to digest the coarse food particles. Coprophagy is somewhat analogous to a ruminant animal chewing its cud, the difference being the point in the digestion process at which the food is rechewed. Animals that practice coprophagy usually consume their feces when resting.

Examples of Animals that Eat Bark and Wood

Beavers are a good example of a hindgut fermenter. They are primarily bark-eaters, ingesting the bark of young twigs and sapwood of branches and small tree trunks. In the spring and fall, about half of the beaver’s food is woody vegetation, but in winter it feeds on woody vegetation almost exclusively. They actively cut trees and shrubs in the summer, storing sections of the wood under water as a winter food supply beneath the ice.

Beavers have many adaptations for their woody diet. Large jaw muscles power sharp



Trees cut by beavers for food and dam construction

incisors that slice through wood and flat molars grind the fibrous bark. Their large cecum contains bacteria and fungi that aid in digesting about 30 percent of the dietary cellulose. To improve the extraction of nourishment from wood and bark, beavers practice coprophagy, thereby running food through their digestive system several times.

Rabbits have a simple stomach, but an enlarged cecum and colon inhabited by symbiotic microorganisms allow digestion of their herbivorous diet. Particularly in winter when other sources of food are scarce, rabbits may gnaw the bark of trees, creating consternation for homeowners, foresters, nurseryman, and Christmas tree growers. Rabbits practice coprophagy, allowing them to meet their nutritional requirements in spite of the fast transit time of food through their digestive system. Coprophagy increases protein digestibility from 50 percent in one pass through their digestive system to 75 to 80 percent upon re-ingestion. Cellulose digestion is increased from 14 percent in one pass through their digestive system to two or three times that amount when the feces is re-ingested.

In summer, porcupines feed on ground vegetation, but in the winter, they spend most of their time in trees eating the inner bark and twigs from a great variety of species, making themselves a pest in the opinion of most tree



Bark stripped from sapling by porcupine

and shrub owners. Much of the damage is due to girdling the base of seedlings and saplings, as well as from deforming the growth of young trees by randomly pruning branches as they feed.

To digest the high percentage of fiber in their diet, porcupines are equipped with a cecum housing cellulase- and hemicellulase-producing microorganisms. In addition, porcupines have 20 teeth to reduce their food to dust-like consistency for efficient breakdown. The large intestine also is extremely long, resulting in a slow passage time and more absorption of the fermented products of the cecum.

Ruminants with chambered stomachs and foregut fermentation are represented by a large number of animals that dominate woodlands and prairies. Deer and moose are just a couple of examples.

The herbaceous diet of deer frequently includes the foliage and twigs of woody plants that they chew just enough to swallow. After a deer fills its rumen, the first chamber of its stomach, it lies down in a secluded place to regurgitate and chew its cud, re-swallowing the food for further microbial fermentation and eventual passage to the second portion of the stomach, the reticulum. After about 16 hours, food passes to the third chamber, the omasum, where intensive digestion and absorption take place. The last compartment, the abomasum, produces acid to break down food pieces for easier absorption of nutrients in the intestines.

The diet of moose includes leaves of trees and shrubs and both terrestrial and aquatic plants when available. During the winter months their food becomes even more woody, consisting almost solely of 30 to 45 lbs of twigs and shrubs each day. As food becomes scarce in late winter, moose will strip bark from trees, especially poplars. Like deer, the ruminant digestive system of moose extracts sustenance from these woody tissues.

It should now be apparent that tree bark and wood are important sources of food for many animals with feeding habits and digestive systems adapted to capitalize on their food value.



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