Sticky Stuff from Plants (hydrogels, elastic latexes and resins)

Confusing terminology

- •chewing gum is really a latex
- •pine pitch or pine gum is a resin

Hydrogels--water-modifying substances, prevent water molecules from moving freely therefore you get a thick solution

Gums--are harvested from wounded plants, extracted from seeds, wood, algae or bacteria or are synthetic

- Primarily exudates of material in response to injury or wounding
  - •may come from the breakdown of compounds in injured cells
  - •seal wounds and help prevent invasion by fungi and bacteria
- Harvested from algae
  - •agar
  - •alginin
  - •agarose
- May also be produced synthetically from cellulose
- Gums are polysaccharides composed of salts of sugars
  - •arabinose, fucose, galactose, mannose, rhamnose and xylose
  - •calcium, magnesium and potassium ions of the salts cause the gum molecules to associate with water
- Gums are only partially digested by humans and mostly have no adverse effects when eaten
  - •considered inert
  - •well suited for use in foods, diet products and medicines
  - •also used in paper, textile cosmetic and petroleum industries
- Gums are used in foods to texturize products (i.e. provide body and improve the feel)
  - •most dairy products use gums to disperse fat and protein molecules evenly in a water base (i.e. ice cream, whipped toppings, frostings and cream fillings)
  - •in frozen foods gums help prevent the formation of ice crystals
  - •in sauces and syrups they produce a thick, rich consistency
  - •increase the shelf lives of products by preventing solid particles from settling out of suspension and by helping bakery goods to stay moist
  - •drink "crystals" are sprayed with a thin film of gum to prevent water absorption before use, help disperse the particles in water, and help thicken the drink
  - •gums are added to meat particles and fibers to bind them into lunch meats
- Gums are used in medicine
  - •to hold tablets together
  - •act as laxatives
  - •make toothpaste a "paste" or "gel"
  - •allow fats and oils in hand and body lotions to stay smooth and creamy
- Gums are used as sizing agents in paper and textile industries
  - •primary use of many gums
  - •fill in the pores and irregularities and make the material stiff or smooth
  - •are usually washed out of textiles into streams and rivers (minor effects?)

Gums used by the petroleum industry

- create a drilling lubricant when mixed with the water-soil mixture surrounding the bit
- gums added to the brine is pumped into the ground to maintain enough pressure to keep gas and oil rising to the surface (water alone would seep into the ground)

Exudate Gums

Gum Arabic

- from wounded trees of *Acacia senegal* (Fabaceae), native to northeastern Africa
- 90% still obtained from wild trees that are slashed or punctured. Natives then collect the dried beads of gum that exude from the wounds in the dry season
- name derived from ports in Arabia where it was shipped to Europe
- used since Egyptian times
- ubiquitous in our daily lives
  - –added to beer to stabilize the foam
  - –water soluble glue on postage stamps and envelopes
  - –coating to flavor particles and drinks
  - –added to candies with high sugar content to prevent crystallization
  - –emulsifies fats in foods, hand lotions and liquid soaps
  - –most important gum in the manufacture of ink

Gum tragacanth

- from wounded *Astragalus gummifer* and *Astragalus* spp., native to Near East and Asia
- name derived from the Greek term for "goat horn" from the way the exuded gum forms ribbons
- one of the earliest emulsifiers
- does not degrade in acid solutions
- can emulsify oil without a surfactant (wetting agent)
- may cause allergic reaction in some people
- still used in mayonnaise, spreads, and prepared milkshakes
- used in medicine to make pastes, lotions, as a binder for tablets and for suspending oral penicillin

Gum karaya (sterculia gum)

- Collected from *Sterculia urens* (Sterculiaceae), native tree from the rocky hills of India
- unique because it can form a strongly adhesive gel when mixed with only small quantities of water
- least soluble commercial gum
- resistant to bacterial and enzymatic breakdown
- used as a dental adhesive
- used as a binder for fibers of bologna and other lunch meats
- salad dressings, ice cream, cheese spreads, whipped toppings
- hair setting gels
- replaces gum arabic in the tissue paper industry
- formerly used in drilling operations

Ghatti

- harvested from trees of *Anogeissus latifolia* (Combretaceae)
- named because it was brought to Indian ports across mountain pass (ghats)
- inferior grades are powdered and used as a stabilizer in whitewash
- better oil emulsifier than either gum arabic or karaya gum
- used in liquid and paste waxes and for fat soluble vitamins
- drilling operations

Extractive Gums

Come from the endosperm of seeds of some legume species or extracted from the wood of others

Importance has risen in the US because of the availability and price more reliable than exudate gums

Locust gum (locust bean gum or carob gum)

- extracted from seeds (endosperm) of *Ceratonia siliqua* (Fabaceae)
- used by the Egyptians as an adhesive for mummy bindings
- chocolate substitute
- used almost exclusively by the food industry
  - –ice creams
  - –salad dressings
  - –pie fillings

Guar gum

- extracted from the seeds of *Cyamopsis tetragonolobu*s (Fabaceae), known only as a cultivated plant
- Guar is an herbaceous perennial that can be used as cattle food
- the only commercially exploited source of gum that lends itself to mechanical agriculture
- used mostly in the paper industry
- formerly used in drilling operations
- water with guar gum flows faster than does regular water, and it is used mixed with water in fire hoses

Larch gum

- extracted from wood chips from *Larix occidentalis* (Pinaceae)
- behavior similar to gum arabic
- used in lithographic operations
- it has been approved for use in foods, but to this point it is not used much

Semisynthetic Gums

cellulose gum (carboxymethylcellulose)

- purified cellulose reacts in a strong alkaline with a compound that adds acetyl to the cellulose backbone
- used in more diverse ways than any other water-soluble polymer
  – detergents-provides a whitening and brightening effect by binding with the dirt in the washing machine, preventing redeposition (reduces graying)
- important in the paper industry
- major replacement for starch in the textile industry
- small quantities in latex paints to give the paint proper viscosity and flow
- used in many foods to add texture, stabilize, and thicken

Rubber producing latex

Elastic latex come mostly from new world plants. As far as we know, rubber was used in preindustrial times only in Central and South America

Latex--any mixture of organic compounds produced in laticifers
--emulsion of a variety of compounds
--long-chain hydrocarbons predominate in elastic latexes
•alkaloids
•resins
•phenolics
•terpenes
•proteins
•sugars

--latex in some plants not elastic
ex. opium poppy, papaya

The name rubber derives from the discovery that it can be used for rubbing errors from a pencil-written page

Rubber is now specifically defined as terpenoid polymers with elastic properties

Laticifers are single cells or strings of cells that form tubes, canals, or networks in various plant organs.
the cellular organelles have usually disintegrated in mature laticifers
not known in gymnosperms but occur sporadically throughout the angiosperms (dicots)

Function of latex in plants not known
--antiherbivore
--may be waste material storage
--may supply surrounding cells with compounds for further synthesis

Plants with latex
C*astilla elastic*a (*Moraceae, fig family)*
--*Azte*cs made balls and figurines out of latex from this plant (it represented blood since it flowed from the "veins" of the tree)

Hevea brasiliensis (Euphorbiaceae)
Amazon Indians dipped their feet in the latex from this tree, and smoked them in a fire to coagulate the rubber--first tennis shoes
Spaniards began to dip their hats and cloaks and smoke them to render them waterproof
Charles Macintosh discovered that hevea rubber is soluble in hexane and that when the hexane evaporated a thin film of rubber was left
•the famous rainwear was devised in this way
•problems with the cold (cracked) and hot (became sticky)
Vulcanization--addition of sulfur with lead oxide to rubber
•caused cross linking of the molecules of isoprene
•makes the latex impervious to weather
•you can also vulcanize rubber by irradiating the latex with cobalt 60.

Until the 1880s all hevea rubber was extracted from wild trees, now mostly plantations
- •in 1876 seeds from a highly productive population of hevea known to produce large quantities of latex were taken to Kew Gardens
- •from there seeds were used to establish plantations in SE Asia

World War II--fighting cut off supply of rubber to the United States
- •US began serious experimentation with other sources of rubber
- •discovered a synthetic substitute; we now have several
  - –styrene butadiene
  - –polybutadiene
  - –polyisoprene (similar to natural rubber)
- •by the end of World War II synthetic rubber accounted for 75% of the market; the basic compound were from petroleum

The demand for natural rubber has increased because its properties are still superior to synthetics
- •radial tires are made from a mixture of natural and synthetic rubber

Guayule (*Parthenium argentatum*)

Shrub native to the Chihuahuan desert of Texas and Mexico

Latex occurs in individual cells dispersed throughout the cortical and ray tissues of the stems and roots

Guayule was among the plants studied during World War II as a source of rubber
- •high hopes--rubber is identical to hevea rubber
- •plants grow naturally in semiarid regions with little economic alternatives
- •but, its rubber cannot be harvested until the plants are 7 years old
- •Mexico has a functional guayule production plant

Chicle (*Manilkara zapota*, Saponaceae)

Historically provided the base for chewing gum--inadvertently invented by Antonio Lopez Santa Anna (the Mexico general who defeated the Alamo)

milky-white exudate from the Sapodilla tree

most chewing gum today is made with synthetic vinyl as the base

Many other potential rubber sources

Ceara rubber	*Manihot glaziovii* (Euphorbiaceae)
Panama or caucho rubber	*Castilla elastica* (Moraceae), trees felled
Gutta-gum	*Couma macrocarpa* (Apocynaceae), trees felled
Gutta-percha rubber	*Palaquium gutta* (Sapotaceae)
Indian fig or bambong	*Ficus elastica* (Moraceae)
African rubber	*Funtumia elastica* (Apocynaceae)
landolphia rubber	*Landolphia gummifera* (Apocynaceae)

Resins

Played a role in the history of many cultures--most are native to the old world

Early paints, incense for religious services caulking for ships came from resins

Most resins now synthetically produced, but demand for resins provided the impetus for development of synthetic replacements

Resins are synthesized and secreted into specialized canals or ducts

--the ducts are simple intercellular spaces or canals formed by the disintegration of a series of adjacent cells

--Resin canals occur in the xylem, phloem and bark of many gymnosperms and some dicots

--Chemically natural resins are a heterogeneous group of compounds

- •all are polymerized terpenes that generally are mixed with volatile oils
- •all are insoluble in water

--resins deter herbivory by many insects

--some have antibacterial properties

ex. Pinesol

Incense

--common in the earliest writings for religious purposes

--releases volatile oils that diffuse outward in the sweet smelling smoke

--two important incenses

Frankincense--*Boswellia sacra* (Burseraceae)

Myrrh--*Commiphora abyssinica* (Burseraceae)

- •native to Ethiopia
- •harvested much like exuded gums by wounding the plant
- •used in embalming

Mastic--*Pistacia lentiscus* (Anacardiaceae)

--sealing material

--masticant to sweeten the breath

--adhesive for dental caps

Lacquer--*Rhus verniciflua* (Anacardiaceae)

--collected by tapping the trunks of trees that are native to China and Japan

--liquid resin is filtered and kept in a dark, tightly closed container

--the use of lacquers was developed into an art form in China during the Ming Dynasty

- •wooden surfaces smoothed, coated with thin layer of lacquer, hand rubbed and polished
- •up to 300 layers of lacquer were applied and smoothed this way
- •the process took months

Copal--recent or fossilized resin from *Copaifera* or *Hymenaea* (Fabaceae) or *Agathis* (Araucariaceae)

Dammars--exudate of *Shorea* (Dipterocarpaceae)
- --harvested like a exudate gum
- --soluble in nonpolar solvents
- --lustrous and transparent when dry
- --used in many paints and varnishes
- --now almost all restricted to artists "oil" paints

Naval Stores--pitch, turpentine and rosin
- --made from pines (*Pinus pinaster*, *P. sylvestris*, *P. palustris* and *P. elliottii* (all Pinaceae)
- --Pine pitch
  - •effective sealant
    - ex. Grecian urns were sealed with pine pitch to prevent leakage. This gave a pine flavoring to the wine and now they put pine flavoring in retsina wine

- --Rosin
  - •When the liquid resin is collected, the rosin precipitates from the crude resin
  - •brittle and friable dry, but sticky when heated
    - ex. used on bows of stringed instruments to increase friction with the strings
    - ex. rosin bag on pitchers mound
  - •also used in printer's ink, paten coatings, varnishes and sealants

Turpentine
- •distilled from crude liquid resin
- •solvent and cleaning agent for oil-based paints
- •source of organic compounds for further synthesis
- •deodorants, shaving lotions and some medicines contain turpentine or chemicals derived from it
- •Limonene is a lemon flavoring made from turpentine

Amber--only jewel of plant origin
- --fossilized terpenoid resin