



# PLANTS VERSUS ANIMALS: Who gets the leaf?

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Image: Japanese barberry, picture Leslie J. Merhoff, Bugwood database. Please contact me via my website with questions and corrections: [www.felkerquinn.com](http://www.felkerquinn.com).

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## Producers versus Consumers

- PRODUCERS can make food from the air and sunlight.
  - PLANTS are producers. They make food using PHOTOSYNTHESIS.
- CONSUMERS cannot make food from the air and sunlight, they have to get their food by eating other plants or animals.
  - ANIMALS are consumers.
  - WHAT DO Animals need to CONSUME (eat) in order to survive?

## A leaf is designed for photosynthesis

**PROTEINS:** the conveyor belt of photosynthesis. They move carbon around as it is built from small carbon dioxide (a gas) into sugars.

**WIDE and THIN:** to allow the sunlight (energy) to reach the chloroplasts.



**SUGARS, STARCHES, FATS:** food! Storage for energy.

**FIBER:** the skeleton of the leaf, holding it up.

**WATER:** allows the leaf to 'breathe' and get carbon dioxide from the air. The leaf loses water and gains carbon dioxide through stomata.

## A leaf is the perfect package of food for consumers!

PROTEINS: to  
build muscles to  
move us around

WIDE and THIN:  
Easy to chew and  
swallow!



SUGARS, STARCHES, FATS:  
to give us energy

FIBER: helps us  
digest our food.

WATER: allows the  
movement of other  
chemicals through  
the body (humans  
are 65% water)

For more on water: <http://www.npr.org/blogs/krulwich/2013/11/25/247212488/born-wet-human-babies-are-75-percent-water-then-comes-drying>



*Both require the nutrients, energy, and water in leaves to survive...*

**PLANTS**



versus  
*in*  
**COMPETITION**  
*for the*

**LEAF**



**ANIMALS!**



## Plants and animals use traits to compete

- A TRAIT is a

- Chemical
- Color
- Shape
- Structure
- Texture
- Taste
- Behavior



## What TRAITS allow mammal herbivores to eat?

Most mammals do not have fingers or hands like we do.

They use their tongues to pull leaves and stems into their mouths, and then their teeth break the plants into smaller pieces.



Watch a deer eat here!

<http://www.arkive.org/white-tailed-deer/odocoileus-virginianus/video-08a.html#src=portletV3>

## What TRAITS allow insects to eat?



Beetle picture by Darren Yeo

Instead of teeth inside their mouth, insects have **MANDIBLES** which cut up leaves in front of their face (this is a bit like having scissors where your nose is).

Instead of a tongue to pull food into their mouths, they have **PALPS** which act like arms to move the food from mandibles to mouth.

Watch a beetle use its mandibles and palps to eat!

<http://www.arkive.org/oil-beetle/meloe-proscarabaeus/video-00.html#src=portletV3>

While deer put their food in their mouth and then chew it, insects chew their food with their mandibles **IN FRONT OF** their faces and then put it in their mouth with their palps. (Note that this beetle probably eats other insects, which is why its mandibles are so toothy)

## Plants use defense TRAITS to try and keep herbivores from eating their leaves

Physical Defenses that make it DIFFICULT to reach the leaves:

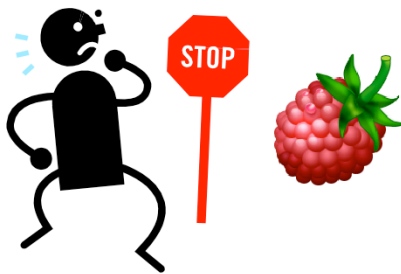
- Thorns, spines
- Leaf Hairs (trichomes)
- Wax

Chemical Defenses that make it DISGUSTING to taste and swallow the leaves:

- Tannins
- Latex
- Poisons

## Physical Defenses

- These make it DIFFICULT for animals to eat the nutritious leaves
- They form a barrier between the animal's mouth and the leaf
- The animal cannot reach the leaf (or sometimes the fruit)



## THORNS and SPINES

- A sharp, pointy projection from the leaf or stem of a plant.
- Large enough for you to see.



From left to right: thorns of the honeylocust tree, picture DE Herman, USDA Plants database. Spines of a Rose stem, picture JJ Harrison, Wikipedia. Prickles of *Solanum viarum*, picture Clyde Dowler, Bugwood database.

## Leaf Hairs

- Often so small you can only see them with magnification.



Humans are very big compared to most leaf hairs, so plants with leaf hairs often feel soft, fuzzy, or velvety when we touch them with our hands.

Hairs or trichomes on rukutu pepper (*Capsicum pubescens*), picture Luciano Roth Coelho, Wikipedia. Rukutu pepper plant, picture Adam McKenna, Wikipedia. Paper mulberry leaf stem, Karen A Rawlins, Bugwood.



## Wax



- Makes the leaf too slippery for insects to walk on or to grab with their mandibles
- Also forms a barrier against water so that the leaf doesn't dry out
- Found on leaves and fruits
- Has the waxy covering ever kept you from eating a blueberry?



Answer to question: wax stops insects, not mammals. The powdery blue substance on blueberries which you can rub off with your fingers is wax. On leaves, wax makes a leaf look shiny, and feel smooth if you touch it lightly, or a little sticky if you rub it hard (it rubs off onto your fingers)

Sweetbay magnolia, picture Richard Webb, Bugwood database. Blueberry bush and fruit, picture Caleb Slemmons, Bugwood database

## BIG versus SMALL herbivores

What are some mammals that eat plants?

These herbivores are mostly BIGGER than leaves.

What are some bugs that eat plants?

These herbivores are mostly SMALLER than leaves.

Will thorns stop big or small herbivores?

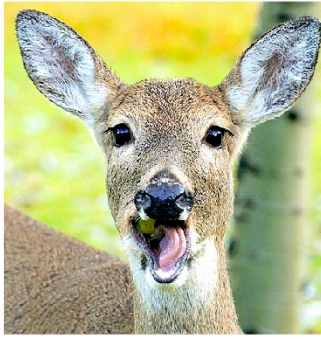
Will leaf hairs stop big or small herbivores?

Mammals that eat plants? (horses, cows, deer, squirrels, rabbits, mice, hamsters)

Bugs that eat plants? (caterpillars, beetles, flies, moths, butterflies)

To answer leaf and thorns, use the big versus small exercise

## Big versus Small activity



Deer



Raspberry Stem

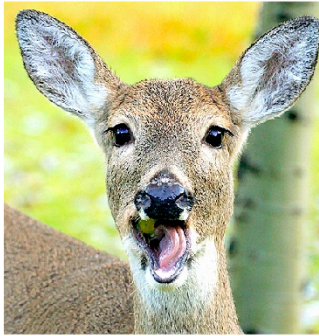


Beetle

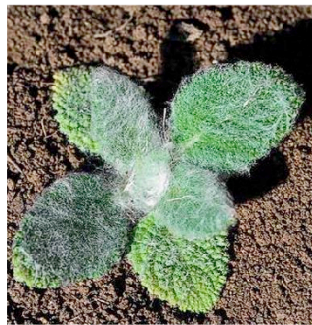


Whitetail deer, picture Bern Krause, Natural Moments Blog. Raspberry Stem, Robert Vidéki, Doronicum Kft., Bugwood.org. Japanese beetle face, picture Pest and Diseases Image Library, Bugwood database. Entire Japanese beetle, picture Susan Ellis, Bugwood database

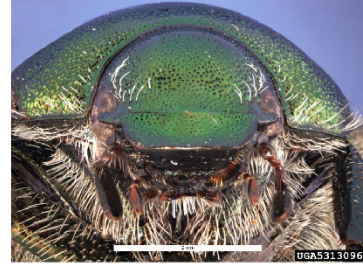
## Big versus Small activity



Deer



Sage leaves

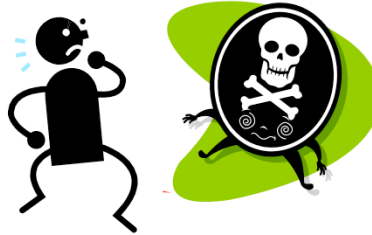


Beetle

Sage plant, Joseph M. DiTomaso, University of California - Davis, Bugwood.org

## Chemical Defenses

- These make it DISGUSTING for animals to eat the nutritious leaves
- The animal can take a bite of the leaf, but gets sick afterward
- Unless the animal has a special ADAPTATION for dealing with the chemical defense, they may die.
- Plants developed many different kinds of chemical defenses, and humans use a lot of these to flavor our foods and make our medicines.



Painkillers like aspirin and opiates are derived from plant chemicals; mint, sage, oregano, are flavors that prevent insect herbivory.

# Tannins

- Very large amounts of tannins in trees (leaves, seeds, and bark of trees).
- Many people like the taste of tannins in small amounts, like in black tea and in the skin of grapes—they have a bitter taste.
- Tannins can slow digestion.
- Insects have to eat large amounts of leaves quickly in order to survive—high tannins slow them down enough that they starve to death even as they eat.



## Who is ADAPTED to eat plants with tannins?



**Deer** have 4 stomachs.

Their food moves very slowly through their body.

This ADAPTATION allows them to get nutrition from slow-digesting high-tannin plants.

Ruminants have 4 stomachs, cow, deer, elk, etc.

# Latex

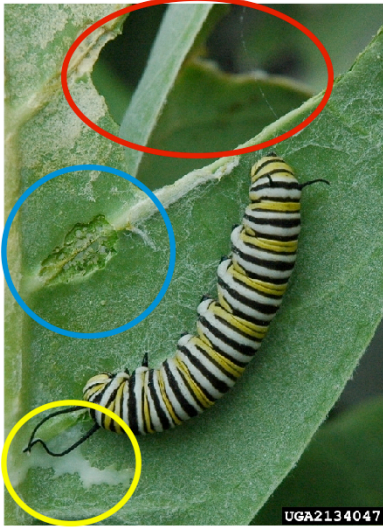
- Latex is a milk-colored fluid
- Many plants have special tubes full of latex at the leaf and bark surface
- When the leaf is chewed or cut open, the latex shoots out and quickly dries, turning sticky
- The latex can glue an insect's mouth shut or trap it on the leaf
- Lettuces and sweet potatoes contain latex that is easily digested by humans.
- Not all latex is safe for all people. Some plants dump additional irritating chemicals in their latex—latex from the rubber plant is a common allergy



leafy spurge dripping latex, Photo by Norman E. Rees, Bugwood database. Sweet potato oozing latex, Photo by Gerald Holmes, Bugwood database. rubber tree harvesting, photo by David Cappaert, Bugwood database.



## Who is ADAPTED to eat plants with latex?



**Monarch butterfly caterpillars** have a BEHAVIOR adaptation. They bite a hole in the stem to let the latex drip out (yellow circle), and then go eat another part of the leaf (red circle).

Monarchs, unlike beetles, can handle leaf hairs. They chew them off, spit them out, and eat the delicious part of the milkweed leaf (blue circle).

Watch a small monarch caterpillar almost get trapped by latex!  
<http://www.arkive.org/monarch-butterfly/danaus-plexippus/video-09b.html#src=portletV3>  
See how cutting the leaf drains the latex to let insects eat!  
<https://www.youtube.com/watch?v=SbB5DnWWqF4>

Monarch larva, William M. Ciesla, Forest Health Management International, Bugwood.

## Poisons

- Hypericin is a chemical made by the plant St. John's Wort
- Eating the plant or getting its juice on your skin can block your skin's defense against the sun—you get a sunburn (like this horse).
- This plant is phototoxic—it is more poisonous to mammals and bugs when they eat it or touch it in sunlight. In large amounts, it can blind or kill grazing animals like deer, horses, or cows.
- It is used as a medicine. In small amounts, it might help depression or cancer, although research is still ongoing on these claims.



Sunburned horse, <http://extension.udel.edu/equine/tag/sunburn/>.

## Who is ADAPTED to eat plants with hypericin?



The St. Johnswort beetle actually tastes plants looking for hypericin, and won't eat plants without hypericin.

It avoids sun damage by staying in the shade. The adult spends its feeding time under the leaves, and its larval stages live underground.

The advantage of eating a plant poisonous to everyone else is you always have plenty of food.

St. Johnswort beetle, *Chrysolina hyperici*, Photo by Norman E. Rees, Bugwood

## Why don't all plants use ALL the defensive traits?

Each defensive TRAIT requires energy to make

Making all the defensive TRAITS would use up all the plant's energy; it would have none left to grow, flower, or make seeds.

Many plants combine defenses to make even stronger defensive TRAITS:

**Milkweed:** latex + poisons in the latex that can stop a mammal's heart

**Stinging nettle:** leaf hairs + chemicals that cause a rash in mammals (formic acid like in a fire ant bite)



Top, milkweed: *Asclepias syriaca*, Photo by Rob Routledge, Bugwood. Bottom, stinging nettle, *Urtica dioica* ssp. *Holosericea*, Photo by Joseph M. DiTomaso, Bugwood

## Why don't all animals use ALL adaptations?

- It can take a lot of time for new behaviors or shapes to become common in a single animal species.
- For many animals, it takes less energy to beat one plant's trait than to try different strategies for dealing with all the plant defenses out there.



## Are all plant-animal interactions competitive?

NO!

- Plants depend on animals to carry pollen between flowers to make new seeds. As a reward, many plants feed their pollinators, providing nectar or making extra pollen so that the animals can eat.
- For example, the monarch butterfly eats milkweed leaves as a caterpillar, but it can pollinate milkweed flowers as an adult butterfly.



An interaction where both parties benefit is called a MUTUALISM.

90% of the plants that we eat require insect pollination to make fruit and seeds!

More on monarch butterfly pollination: <http://www.fs.fed.us/wildflowers/pollinators/animals/butterflies.shtml>

Monarch picture: *Danaus plexippus*, Life Cycle , Photo by Rob Routledge, Bugwood