Evolution of Allelochemics: Plant Protection

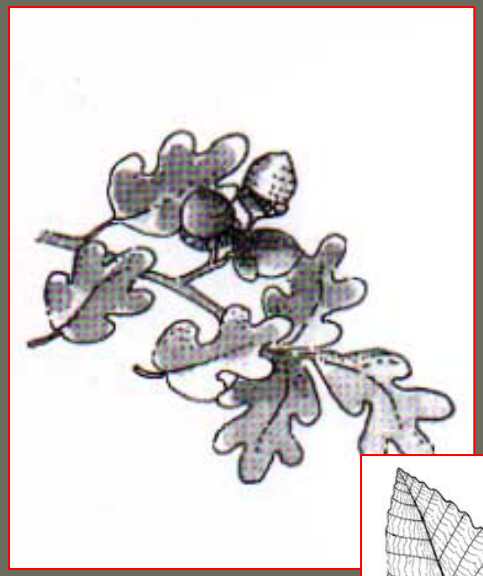
Evolution of Allelochemics

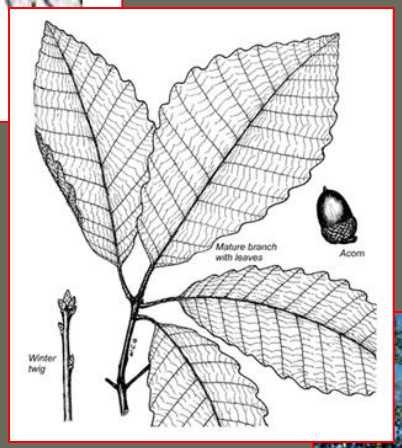
There are plant or tree resources that can be termed:

- **Predictable or apparent**
- **Unpredictable or unapparent**

Predictable - Apparent

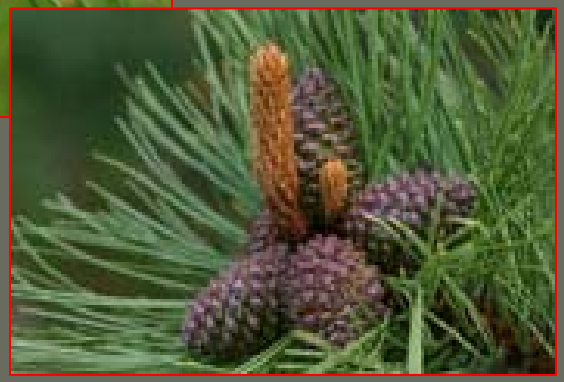
Stems, trunks, woody tissues in general.





Predictable - Apparent

Mature leaves, climax trees



Unpredictable – Unapparent

Flowers, buds and tender tissues

Unpredictable – Unapparent

Flowers, buds, tender tissues and pioneer-seral plants

UNPREDICTABLE

Annuals, biennials, deciduous trees, new foliage etc.

Short generation times, rapid growth rates, many seeds, juvenile plants and seeds etc.

Available as food for short time periods: unpredictable in time and space

Lower commitment to defensive chemistry

PREDICTABLE

Evergreens, long lived woody perennials, mature leaves, heart wood of trees.

Long generation times, slow growth, few large seeds, mature trees, climax trees

Stable food source over long time periods: predictable in time and space.

Complicated, well developed defensive chemistry and plant morphology to store chemicals etc.

The Unpredictable:

Have qualitative defenses! → **Cheap and toxic**

The Predictable:

Have quantitative defenses! → **Expensive, sophisticated, but lots of it (them)**

EXPECTED DEFENSIVE CHEMICAL TYPES BASED ON FUNCTION

Qual. Defenses – Toxins

- Alkaloids, cyanide compounds, glycosides etc.
- Highly active in low concentrations against insect physiological systems.

- Low concentrations ±1%
- Stored in plant tissues, often in inactive form.

Unpredictable Plants

Quant. Defenses: Sophisticated

- Tannins, enzyme inhibitors, resins, silica compounds etc.
- Form complexes with nutrients needed by insects.
- Relatively high concentrations; can be 5%-50%
- Stored in vacuoles to reduce long term auto-toxicity.
- Expensive to produce

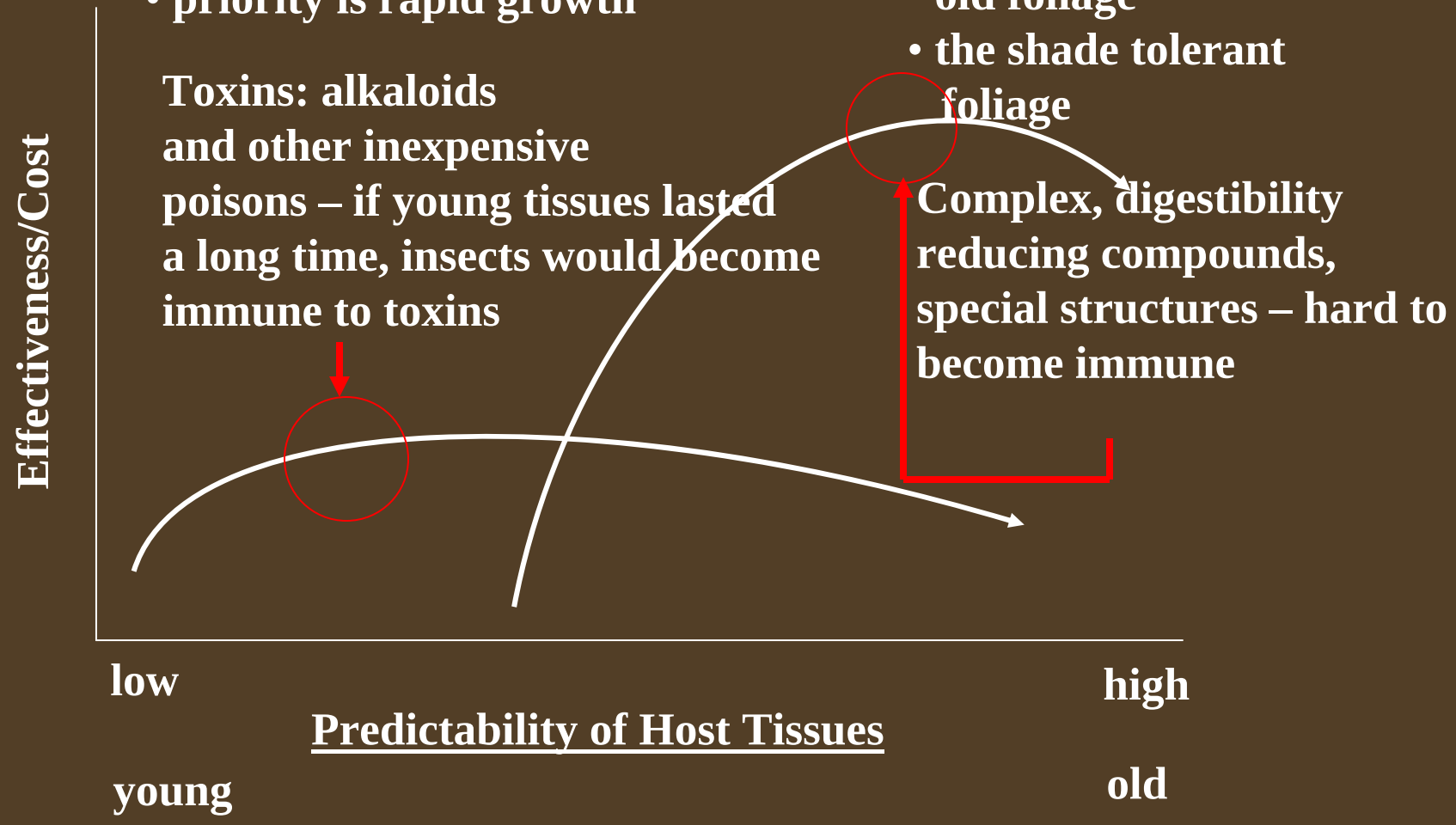
Predictable Plants

Unapparent Trees

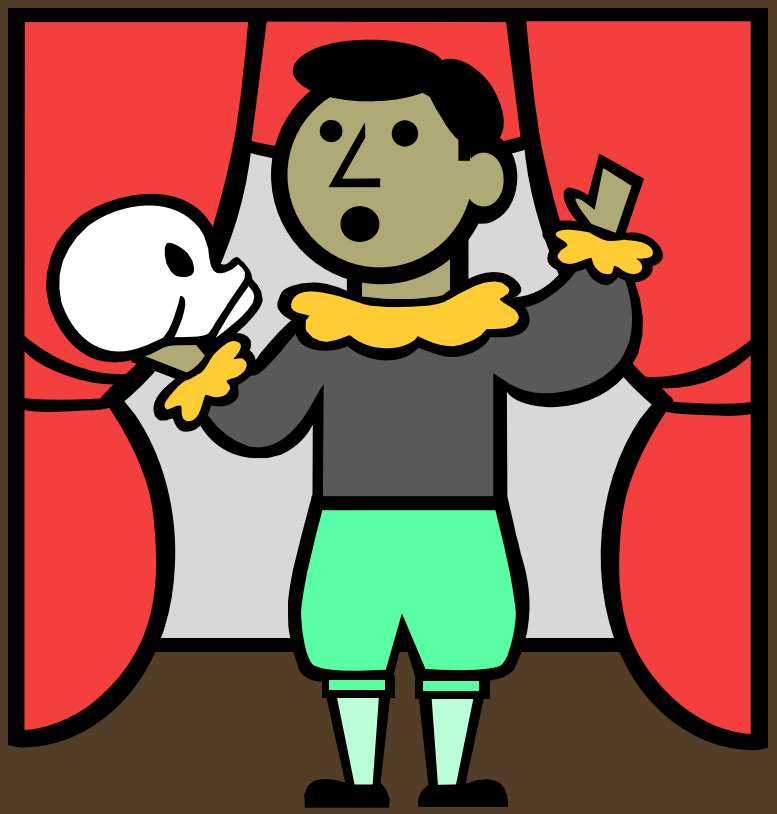
- young trees
- new foliage
- important meristems (growing tips)
- priority is rapid growth

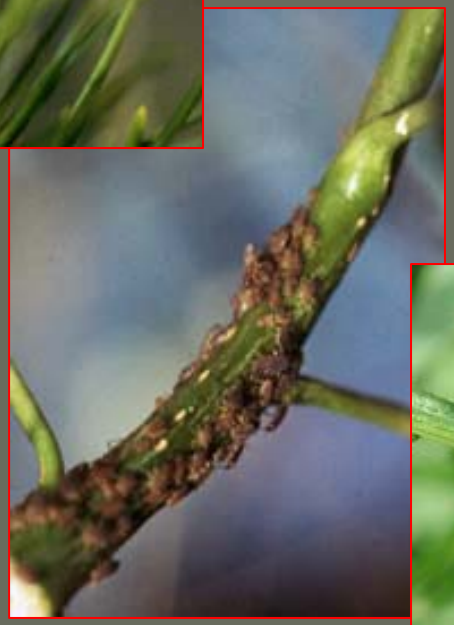
Apparent Trees

- maintenance of structure
- they are there a long time
- old foliage
- the shade tolerant foliage



Alas, I know I've talked about this, but review from another direction is a great learning tool.





Why Aphids on young foliage, growing tips and reproduction?

Piercing-sucking mouth parts wiggle their way past the toxic plant cells and plug into the vascular bundles – the phloem.

How does the pioneering Douglas-fir defend itself?

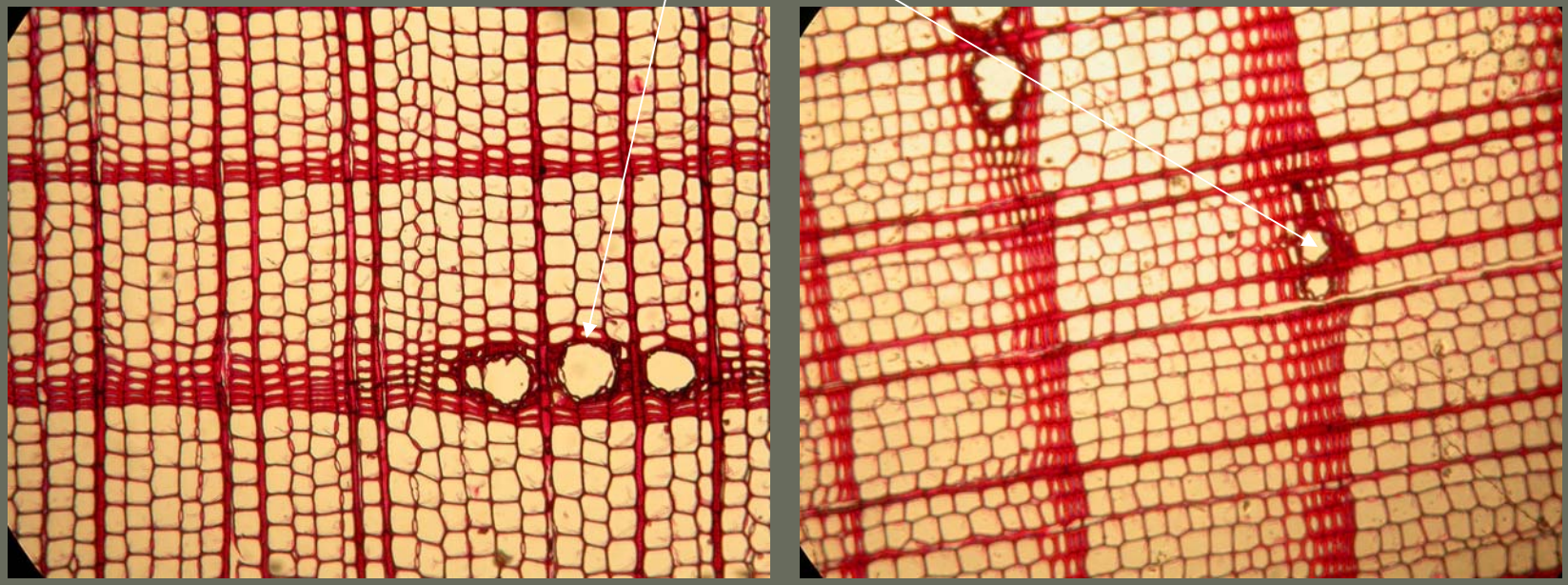
Douglas-fir, the pioneer, defends itself with a series of morphologically and chemically based strategies.

- **cheap toxicants in young foliage**
- **resin canals as tree matures**
- **non-crystallizing resin**

On the other hand, Douglas-fir main energy allocations involve growing fast to firmly establish stand dominance.

Douglas-fir (*Pseudotsuga menziesii* Mirb Franco), **Cross-section**, low magnification

Abrupt EW to LW transition
Scattered groups of 2-3 small resin canals
Groups often well spaced



Western hemlock regeneration:

- **a late successional species;**
- **even though this is regeneration, the foliage has to be defended for a long time.**

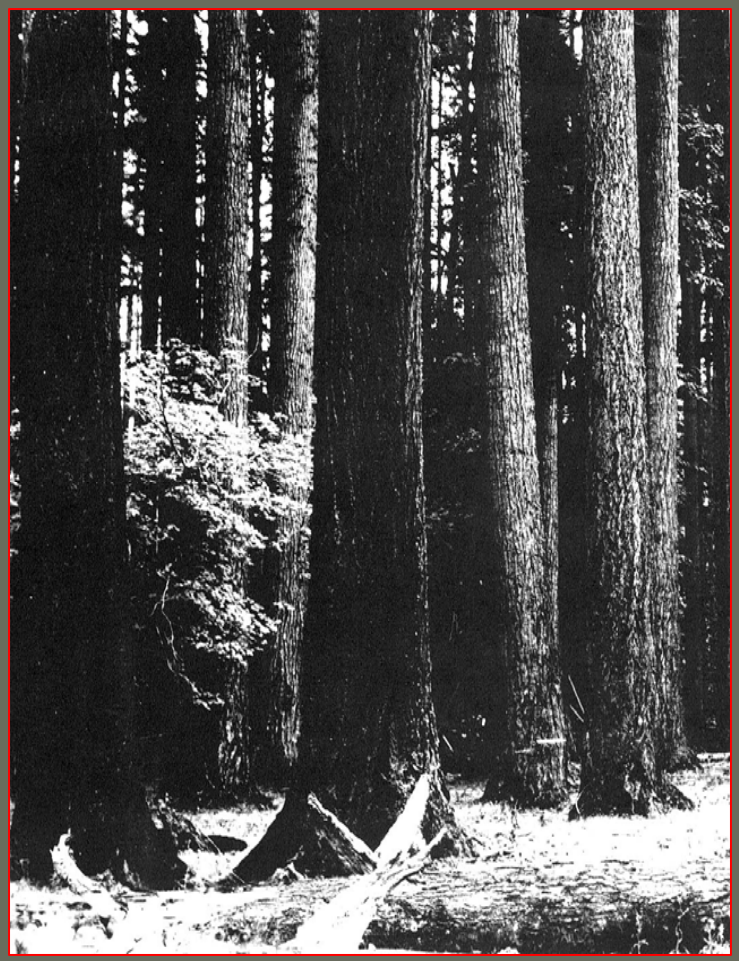
- **late successional species defend leaves and growing tips with complex tannins and other expensive products.**

What happens as the old-growth forest develops? Old western hemlocks?

The ultimate dominant is western hemlock -- its defense strategies are for absolute defense of its foliage.

Expensive chemicals locked away in special foliar structures (vacuoles).

Chemicals that affect the ability of herbivores to digest the foliage.

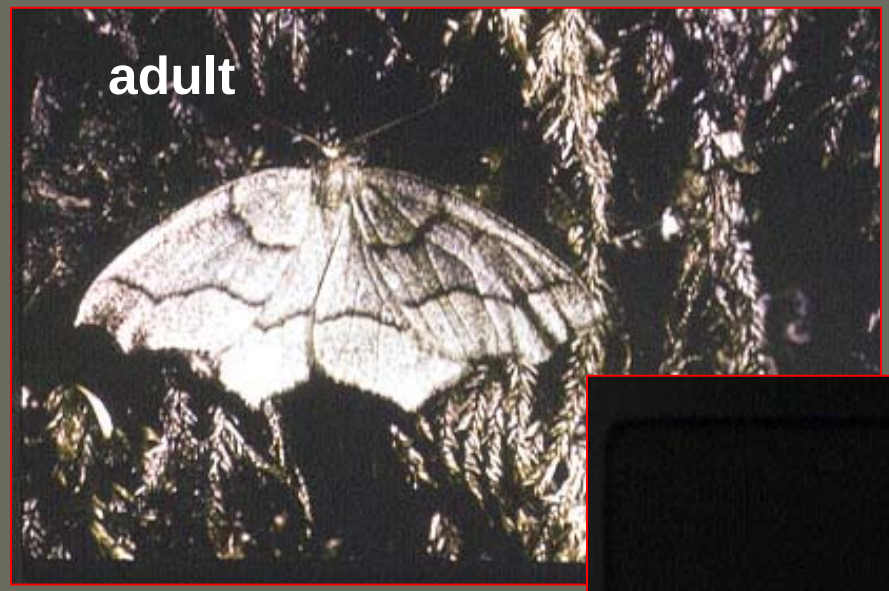


The western hemlocks are mature and:

- the crowns have to support a huge biomass;
- the crown to stem ratio is small;
- there is a limited supply of photosynthates (energy);

- there comes a time that there is just enough energy to simply maintain the biomass -- none for defense!

The hemlock looper, an old-growth agent of disturbance!



Outbreaks of the hemlock looper -- last one in 1960

Now, let's do a bit of analysis. At times, what we read, doesn't make sense.

So, what's wrong with these conclusions?

TABLE 6.1. Mean arthropod densities in a young (10-year-old) Douglas-fir and old-growth (450-year-old) Douglas fir-western hemlock stand. Numbers of species are in parentheses. One interpretation of these data is that greater plant and arthropod diversity of old-growth forests limits pest populations; old-growth forest have over 100 times as many predators as young forests (adapted from Schowalter 1989).

Arthropod type	*Young Douglas-fir*	*Old-growth Douglas-fir*	*Old-growth hemlock*
	No. of individuals/kg		
Folivores			
Gall aphids	29,000 (1)	48 (1)	28 (1)
Aphids	100 (1)	0	0
Scale insects	2 (1)	49 (2)	110 (3)
Budmoths	0	1 (7)	0
Other folivores	2 (2)	1 (7)	2 (5)
Pollen and seed feeders			
Seed bugs	0	1 (1)	12 (3)
Thrips		3 (2)	1 (2)
Detritivores			
Oribatid mites		17 (5)	50 (5)
Insects	0	1 (4)	12 (4)
Predators			
Ants	2 (1)	1 (2)	0
Aphid predators	9 (1)	3 (5)	1 (4)
Parasitic wasps	8 (4)	2 (5)	1 (4)
Other insects	3 (2)	2 (3)	0
Spiders	19 (3)	14 (15)	15 (15)
Other arachnids	0	5 (2)	7 (2)
	Predators: folivore		
Predator: Herbivore →	0.0014	0.26	0.18

Why aphids?

Predators: herbivores?