

# Invisible Connections: Introduction to Parasitic Plants

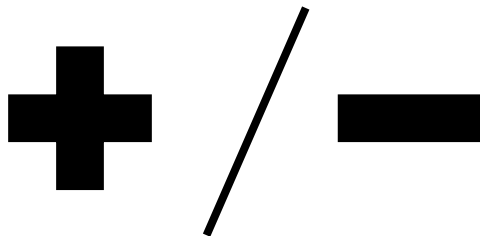
Dr. Vanessa Beauchamp

Towson University

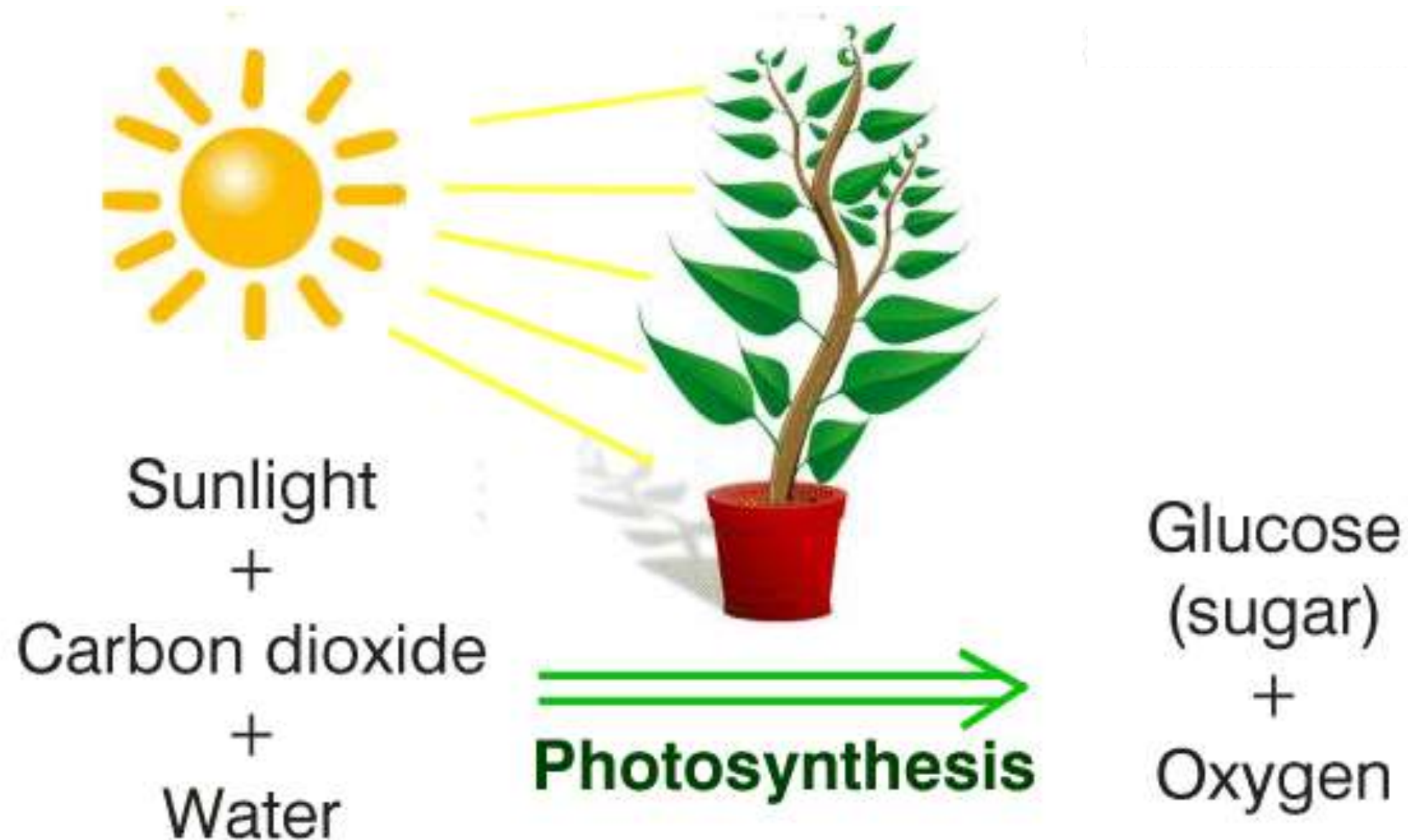
# What is a parasite?

- An organism that lives in or on an organism of another species (its host) and benefits by deriving nutrients at the other's expense.

Symbiosis



# Food acquisition in plants: Autotrophy



# Heterotrophs (“different feeding”)

- True parasites: obtain carbon compounds from host plants through haustoria.
- Myco-heterotrophs: obtain carbon compounds from host plants via mycorrhizal fungal connection.
- Carnivorous plants (not parasitic): obtain nutrients (phosphorus, nitrogen) from trapped insects.



Image Credit: Flickr User wackybadger, via CC



[https://commons.wikimedia.org/wiki/File:Pink\\_indian\\_pipes.jpg](https://commons.wikimedia.org/wiki/File:Pink_indian_pipes.jpg)



<http://www.welivealot.com/venus-flytrap-facts-for-kids/>



# Parasite vs. Epiphyte



<https://chatham.ces.ncsu.edu/2014/12/does-mistletoe-harm-trees-2/>



By © Hans Hillewaert /, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=6289695>



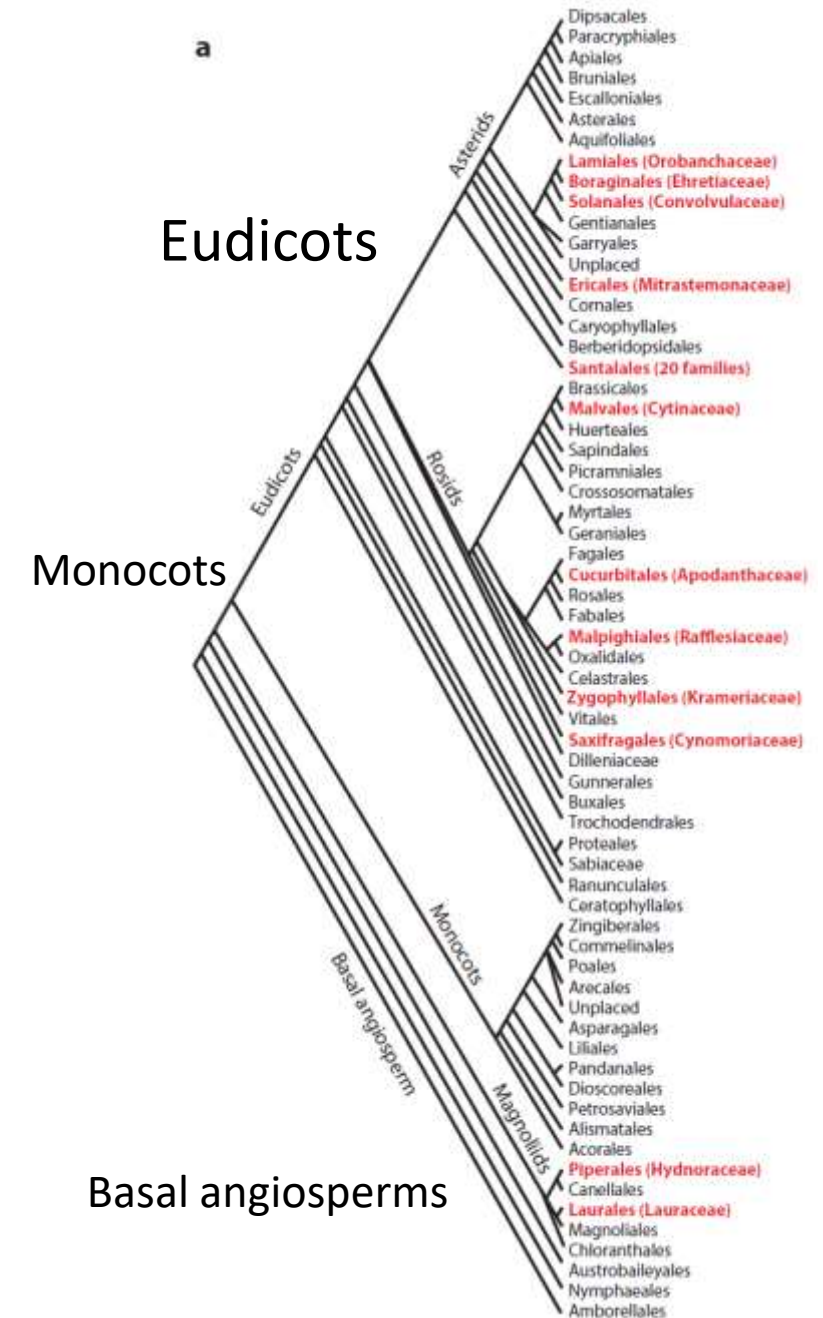
# True Parasitic Plants

- Gains all or part of its nutrition from another plant (the host).
- Does not contribute to the benefit of the host and, in some cases, causing extreme damage to the host.
- Specialized peg-like root (haustorium) to penetrate host plants.



# Diversity of parasitic plants

- Parasitism has evolved independently at least 12 times within the plant kingdom.
- Approximately 4,500 parasitic species in 28 families.
- Found in eudicots and basal angiosperms
  - 1% of the dicot angiosperm species
  - No monocot angiosperm species

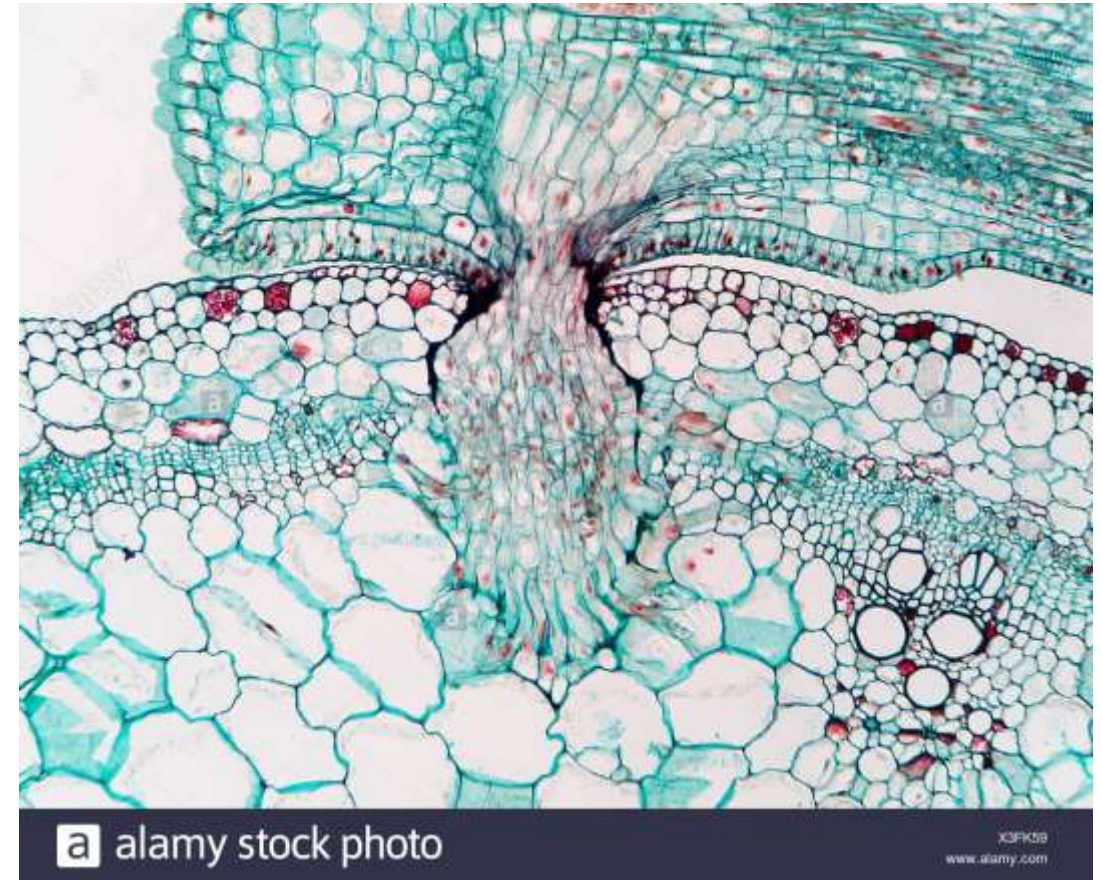




# True Parasitic Plants



<https://www.gettyimages.com/detail/news-photo/mistletoe-plant-with-haustoria-in-the-trunk-of-the-host-news-photo/857129812>



a alamy stock photo

X3FK09  
www.alamy.com

<https://www.alamy.com/parasitic-dodder-plant-cuscuta-showing-penetration-parasitic-haustor>

The defining structural feature of a parasitic plant is the haustorium.

<https://www.britannica.com/plant/parasitic-plant>

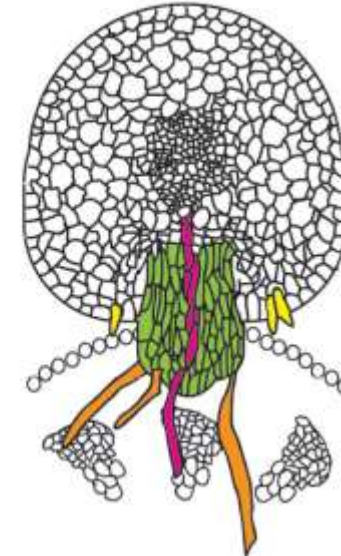
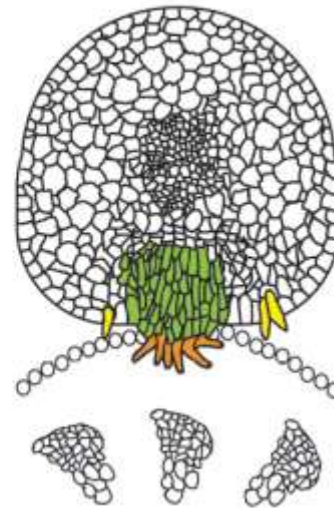
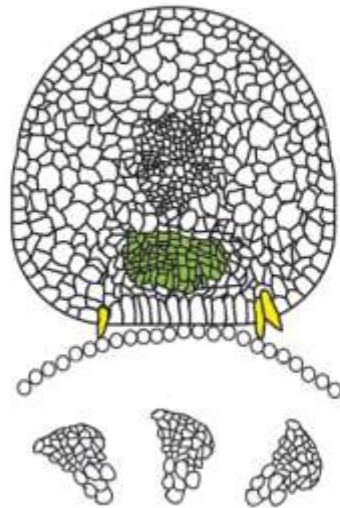
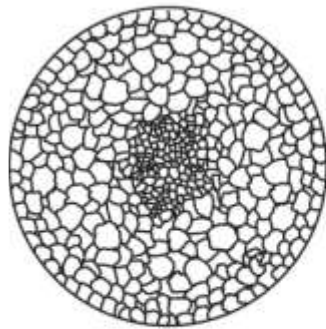
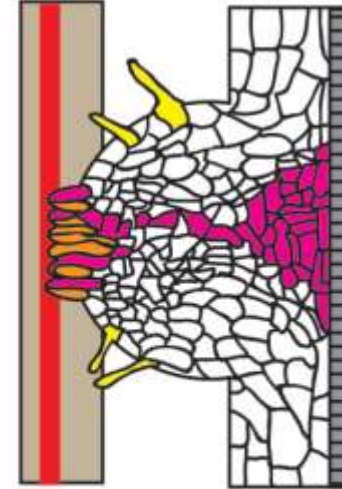
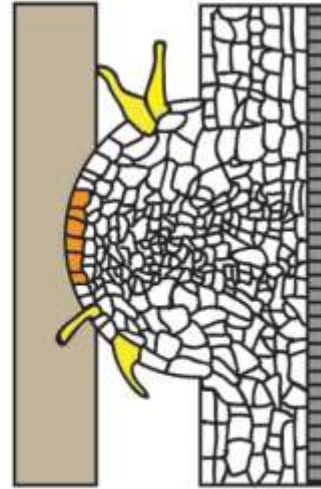
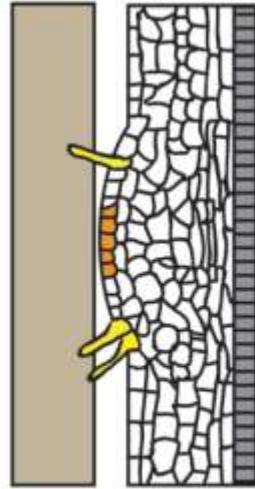
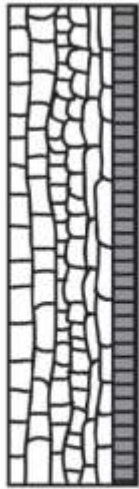


**i** Root/stem

**ii** (Pre)haustorium formation

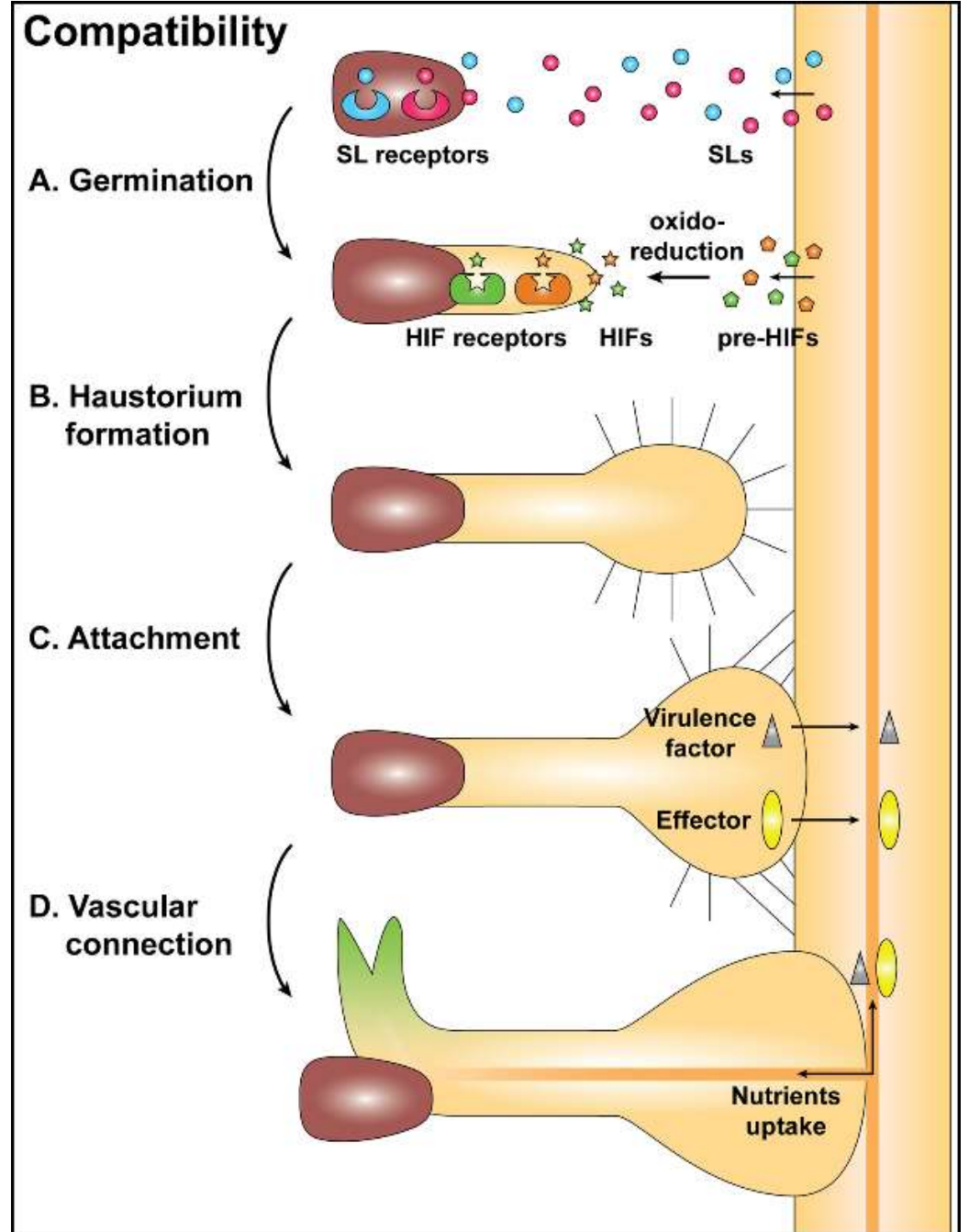
**iii** Invasion

**iv** Host connection

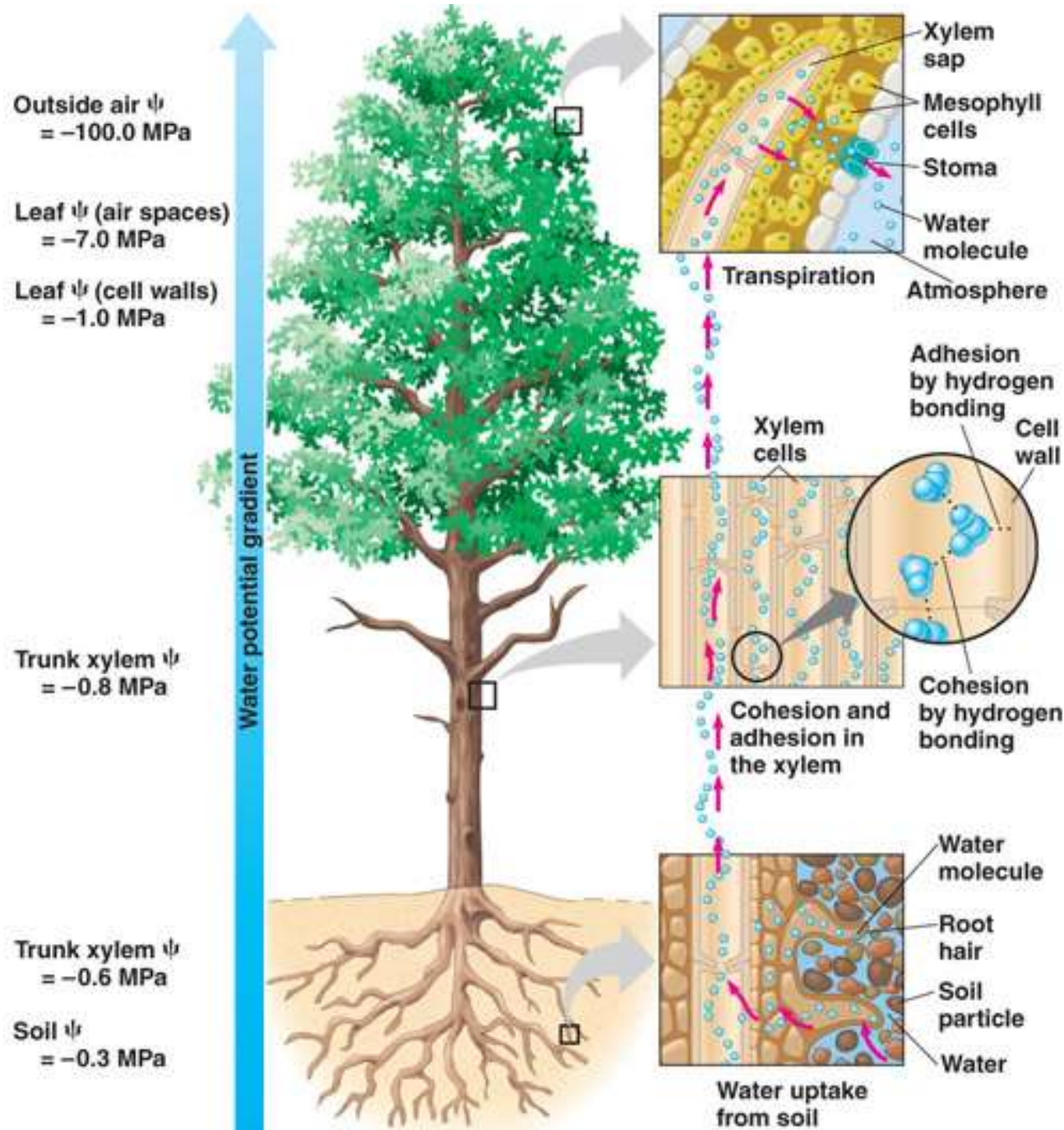


# Haustorium formation

- Sense and attach to host
  - Recognize chemicals also used to attract symbiotic fungi and bacteria to plant roots
- Penetrate host tissues
  - Fragment and dissolve cell walls rather than crushing them
- Avoid host immunity system
  - Mimic pollen tube growth to avoid immunity activation
- Develop vascular connection
  - Lower water potential than host plant

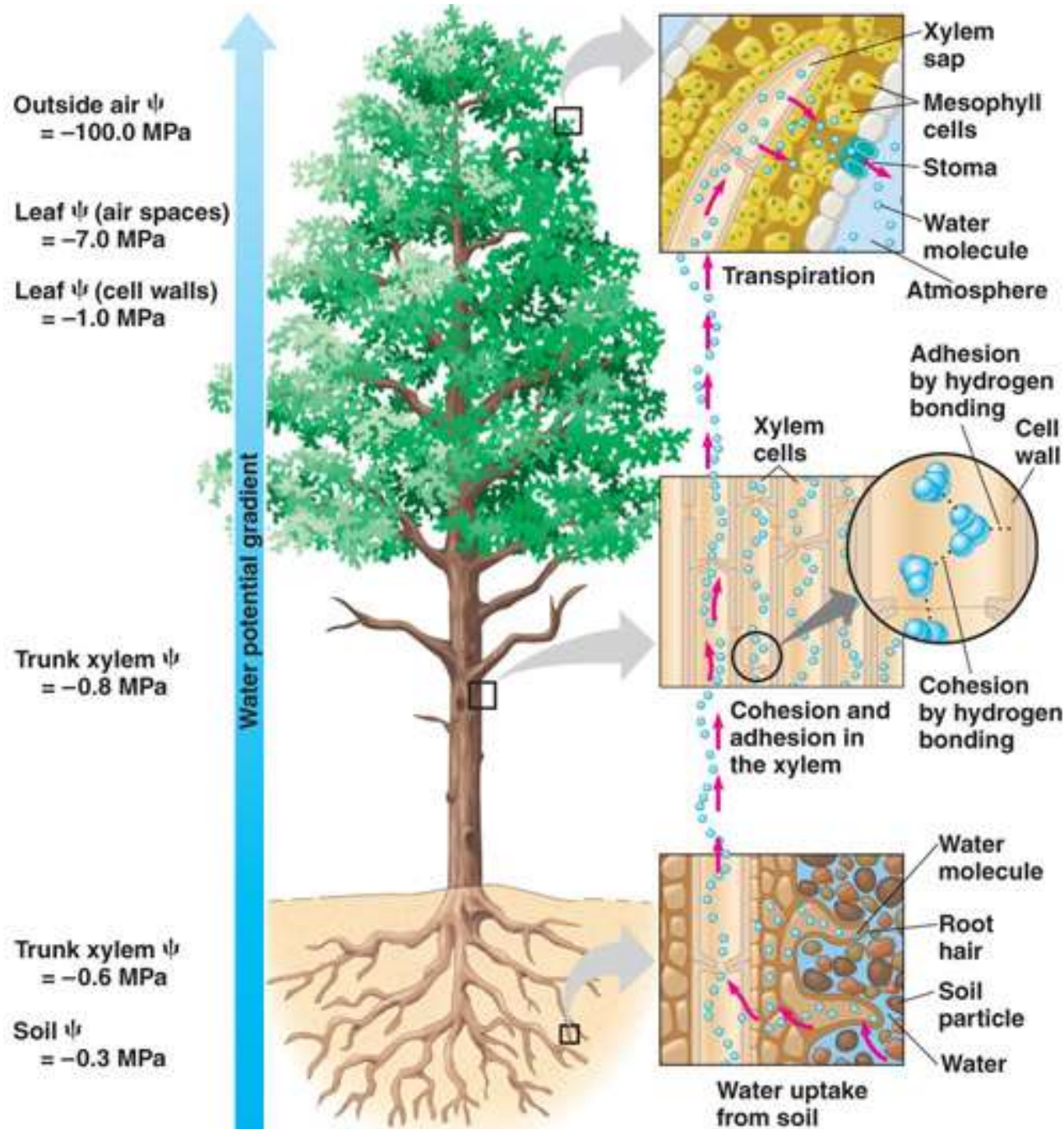






# Water potential

- Negative water potential causes water to evaporate from leaf
- Cohesive forces pull water up from roots to replace lost leaf water



# Water potential

- Water and mineral nutrients move from a host to a parasite through the xylem connection.
- A gradient of water potential between the host and parasite should drive the flow direction.
- Solute accumulation, open stomata, or a combination of these could allow a parasitic plant to maintain a lower water potential than the host.



# Life forms

Witchweed (*Striga bilabiata*)



<https://www.britannica.com/plant/parasitic-plant>

Dodder (*Cuscuta gronovii*)



<https://www.britannica.com/plant/parasitic-plant>

European mistletoe (*Viscum album*)



CC BY-SA 2.0, <https://commons.wikimedia.org/w/index.php?curid=34475>



# Life forms



O Roberts

*Nuytsia floribunda*  
Western Australian Christmas Tree

<http://anpsa.org.au/n-flo.html>



*Okoubaka aubrevillei*  
Death tree

© nidadfoto - Fotolia

<https://www.netdokter.de/homoeopathie/okoubaka/>

*Rafflesia* spp.  
Corpse flower



<https://www.sciencefocus.com/nature/top-5-parasitic-plants/>



# Types of parasitic plants

- Attachment point
  - Stem or root
- Nutritional dependence
  - Hemiparasite or holoparasite
- Life cycle requirements
  - Obligate or facultative



MBP: American Mistletoe in Harford Co., Maryland (12/16)



<https://www.prairiemoon.com/castilleja-coccinea-indian-paintbrush-prairie-moon-nursery.html>



[https://commons.wikimedia.org/wiki/File:Conopholis\\_america\\_-\\_Bear\\_Corn.jpg](https://commons.wikimedia.org/wiki/File:Conopholis_america_-_Bear_Corn.jpg)

# Attachment Point

- Stem parasites

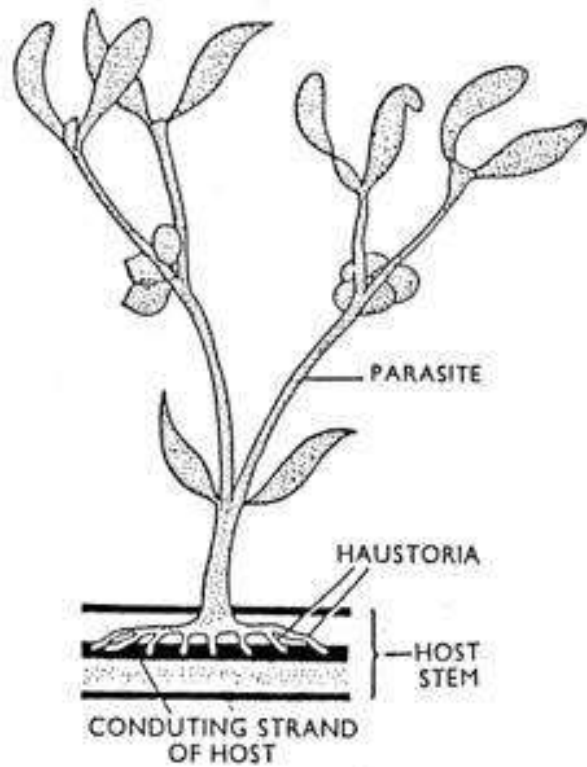


Fig. 12.2. *Viscum* (Mistletoe)

Mistletoe – *Phoradendron leucarpum*  
American/Eastern mistletoe



MBP: American Mistletoe in Harford Co., Maryland (12/16/2017). Photo by [Josh Emm](#).



MBP: American Mistletoe fruiting in Harford Co., Maryland (12/16/2017). Photo by [Josh Emm](#). ([MBP list](#))



# Attachment Point

- Stem parasites

Dodder (Witches' hair) – *Cuscuta* spp.

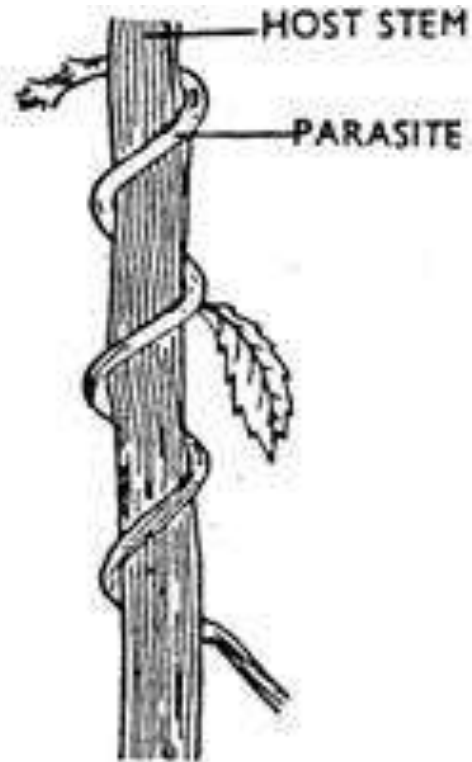


Fig. 12.1. *Cuscuta*.



<https://commons.wikimedia.org/w/index.php?curid=209875>

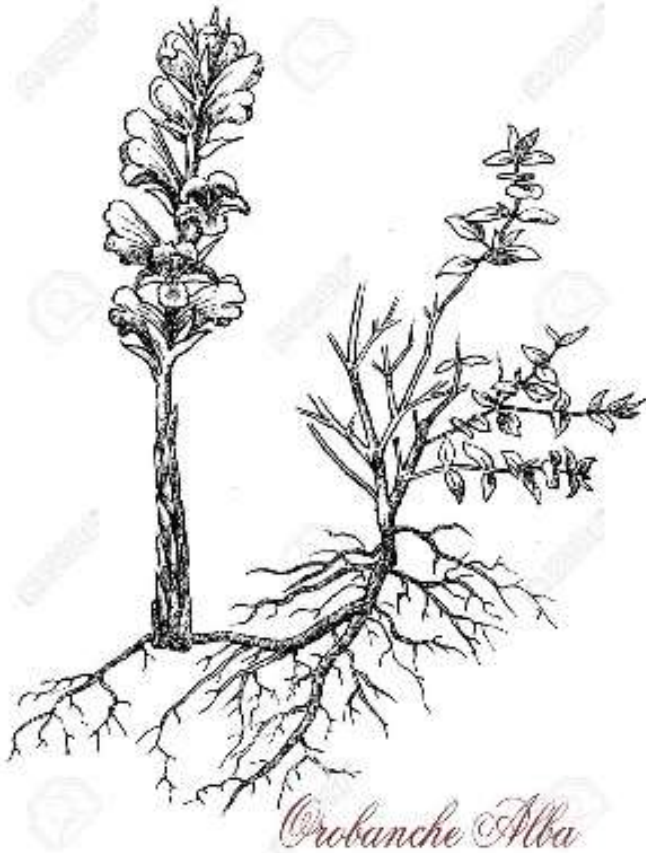


Plant genetics: Gene transfer from parasitic to host plants. November 2004. *Nature* 432(7014):165-6



# Attachment Point

- Root parasites



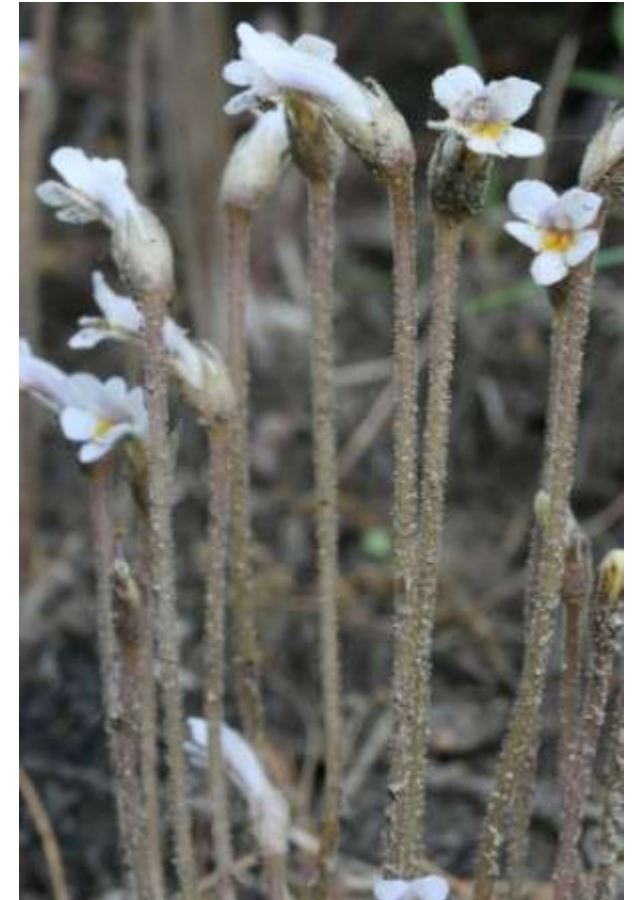
[https://www.123rf.com/photo\\_96361208\\_vintage-engraving-of-orobanche-alba-or-thyme-broomrape-parasitic-plant-with-stems-completely-lacking.html](https://www.123rf.com/photo_96361208_vintage-engraving-of-orobanche-alba-or-thyme-broomrape-parasitic-plant-with-stems-completely-lacking.html)



<http://www.farmalierganes.com/Flora/Angiospermae/Orobanchaceae/Orobancha/Orobanche/Grex/Glandulosae/Orobanche/alba/Orobanche/alba.htm>

*Orobanche* spp.  
(Broomrape)

*Orobanche uniflora*



By Arie Tal. Copyright © 2019 Arie Tal. botphoto.com  
<https://gobotany.newenglandwild.org/species/orobanche/uniflora/>



# Attachment Point

- Root parasites



<https://trekohio.com/2012/09/24/beechnuts-our-third-plant-without-chlorophyll/>

Beech drops  
*Epifagus virginiana*



[https://commons.wikimedia.org/wiki/File:Epifagus\\_virginiana.jpg](https://commons.wikimedia.org/wiki/File:Epifagus_virginiana.jpg)



# Attachment Point

- Root parasites



[https://commons.wikimedia.org/wiki/File:Conopholis\\_americana\\_-\\_Bear\\_Corn.jpg](https://commons.wikimedia.org/wiki/File:Conopholis_americana_-_Bear_Corn.jpg)

## *Conopholis americana* (Squawroot, Bearcorn)



<https://botanyphoto.botanicalgarden.ubc.ca/2005/05/conopholis-americana/>



# Attachment Point

- Root parasites



<https://www.prairiemoon.com/castilleja-coccinea-indian-paintbrush-prairie-moon-nursery.html>

*Castilleja coccinea*  
Eastern Indian  
Paintbrush



<https://shop.sussexconservation.org/products/castilleja-coccinea-indian-paintbrush>



# Nutritional Dependence

## Hemiparasite



MBP: American Mistletoe in Harford Co., Maryland (12/16/2017). Photo by [Josh Emm](#).



<https://shop.sussexconservation.org/products/castilleja-coccinea-indian-paintbrush>

## Holoparasite



<https://commons.wikimedia.org/w/index.php?curid=209875>



*Epifagus virginiana* ( Beechdrops ) Gene G. King Park, Bridgewater, 9/17/2012, Photo H. & M. Ling



[https://commons.wikimedia.org/wiki/File:Conopholis\\_america\\_-\\_Bear\\_Corn.jpg](https://commons.wikimedia.org/wiki/File:Conopholis_america_-_Bear_Corn.jpg)



By Arie Tal. Copyright © 2019 Arie Tal. botphoto.com <https://gobotany.newenglandwild.org/species/orobanche/uniflora/>



# Life cycle requirements

## Obligate

- All holoparasites
- All stem parasites (holoparasites and hemiparasites)
- Some root hemiparasites

## Facultative

- Some root hemiparasites



# Generalists vs. specialists

## *Cuscuta* spp. (dodder)

- Hundreds of hosts in diverse families



<https://commons.wikimedia.org/w/index.php?curid=209875>

## *Epifagus virginiana* (beech drops)

- One host *Fagus grandifolia*



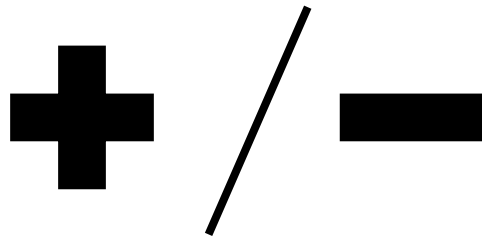
[https://commons.wikimedia.org/wiki/File:Epifagus\\_virginiana.jpg](https://commons.wikimedia.org/wiki/File:Epifagus_virginiana.jpg)



# Biting the hand that feeds you

**An organism that lives in or on an organism of another species (its host) and benefits by deriving nutrients at the other's expense.**

Symbiosis





# *Striga hermonthica* (witchweed)



[https://www.wur.nl/upload\\_mm/7/a/9/c3f2a783-b897-4464-b583-337e8d145594\\_Striga%20close-up%205\\_0c658f2c\\_490x330.jpg](https://www.wur.nl/upload_mm/7/a/9/c3f2a783-b897-4464-b583-337e8d145594_Striga%20close-up%205_0c658f2c_490x330.jpg)



Treated (back) vs. Un-treated (front)

<https://pesticideguy.org/2014/10/09/herbicide-technology-can-reduce-massive-crop-losses-caused-by-parasitic-weeds-in-africa/>



# *Arceuthobium*

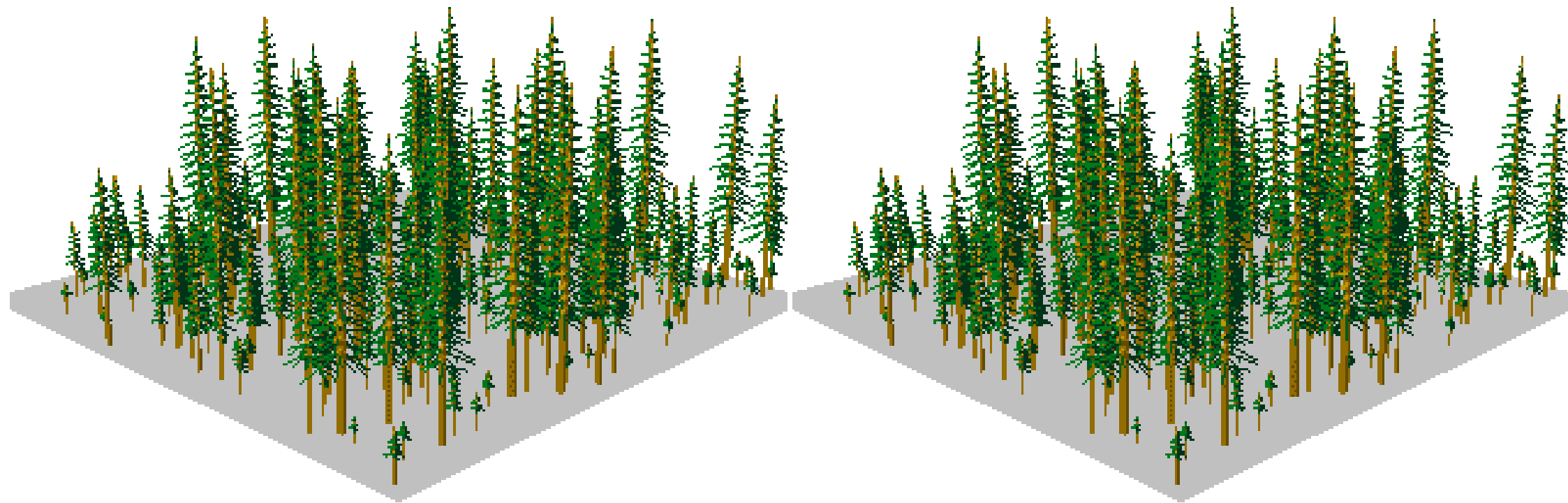


**With Mistletoe**

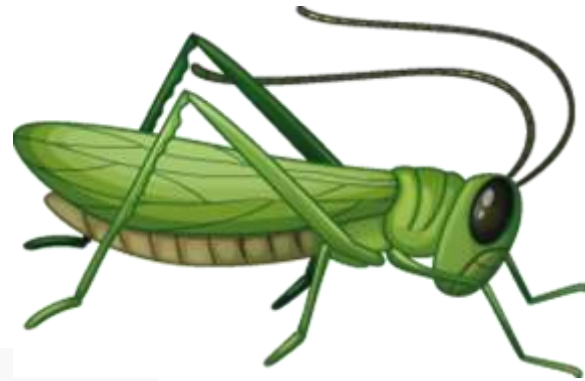
**Year**

**Without Mistletoe**

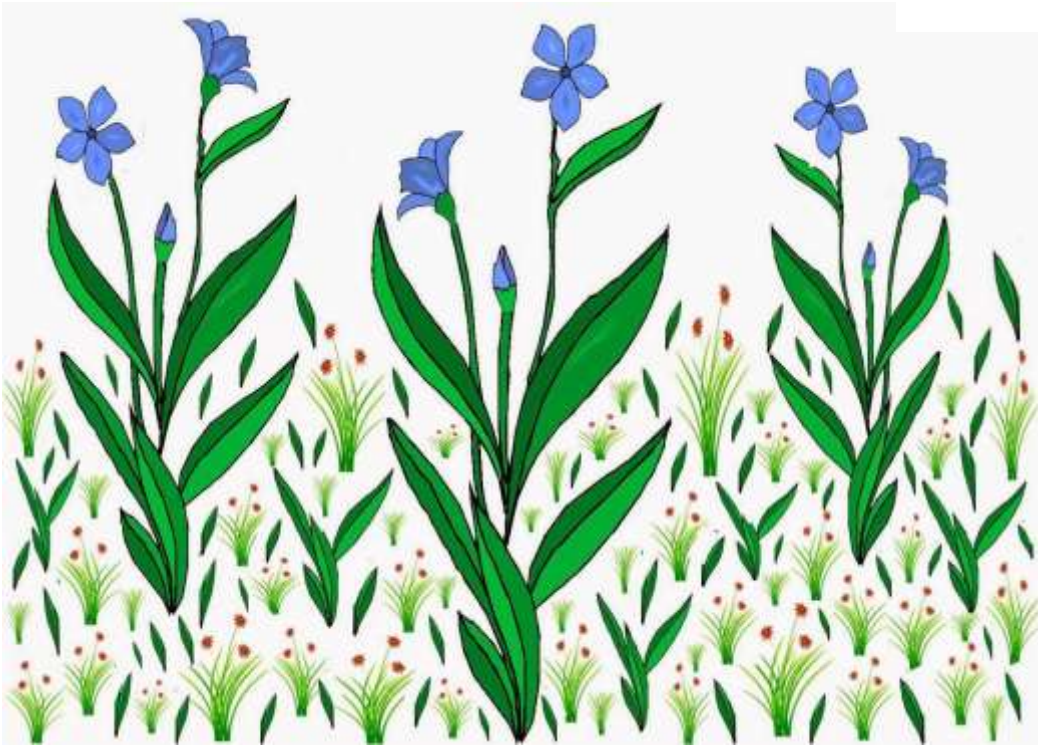
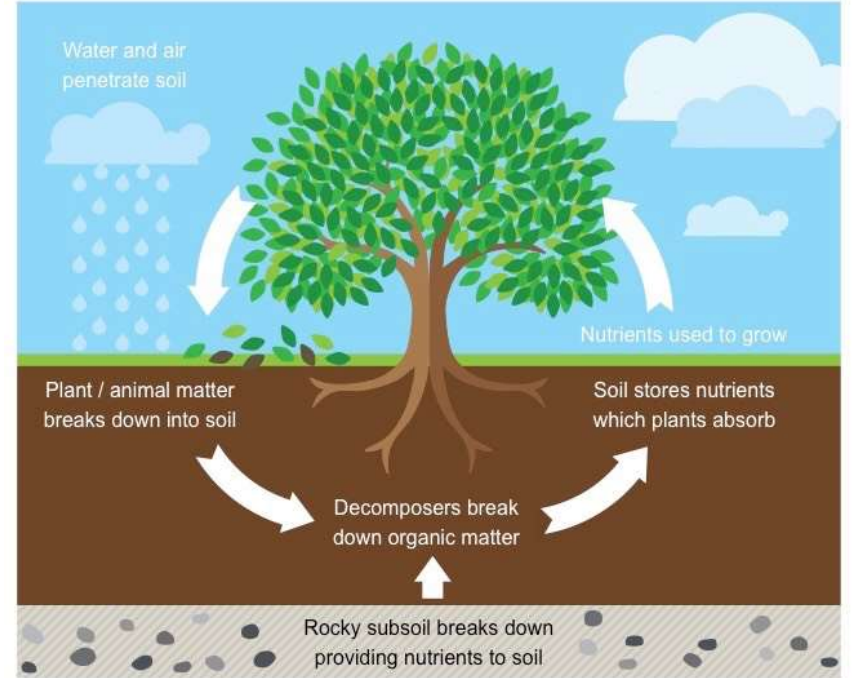
**0**



# Impacts



[http://ib.bioninja.com.au/\\_Media/nutrient-cycling\\_med.jpeg](http://ib.bioninja.com.au/_Media/nutrient-cycling_med.jpeg)



<http://www.musingsone.com/2015/02/the-size-advantage-hypothesis-for-plant.html>



<https://www.fs.fed.us/wildflowers/pollinators/>



# True parasites in Maryland

Bastard Toadflax *Comandra umbellata*



Bastard Toadflax blooming in Allegany Co., Maryland (5/19/2016). Photo by [Ed Boyd](#). ([MBP list](#))

American Mistletoe  
*Phoradendron leucarpum*



American Mistletoe growing on Red Maple in Somerset Co., Maryland (1/20/2013). Photo by [Bill Hubick](#). ([MBP list](#))

Five-angled Dodder  
*Cuscuta campestris*



Five-angled Dodder in Anne Arundel Co., Maryland (6/25/2011). Photo by [Bill Harms](#). ([MBP list](#))

# True parasites in Maryland

Downy Yellow False Foxglove  
*Aureolaria virginica*



Downy Yellow False Foxglove in Allegheny Co., Maryland  
(6/30/2015). Photo by [Kimberly Booth](#). ([MBP list](#))

Scarlet Indian Paintbrush  
*Castilleja coccinea*



Scarlet Indian Paintbrush in Garrett Co., Maryland  
(5/28/2007). Photo by [Gary Van Velsir](#). ([MBP list](#))

Purple Gerardia *Agalinis purpurea*



Purple Gerardia blooming on Assateague Island,  
Maryland (8/30/2013). Photo by [Bill Hubick](#). ([MBP list](#))



Canadian Lousewort *Pedicularis canadensis*



Canadian Lousewort blooming in Garrett Co., Maryland (5/28/2007). Photo by [Wayne Longbottom](#). ([MBP list](#))

# True parasites in Maryland

Narrow-leaved Cow-wheat *Melampyrum lineare*



Narrow-leaved Cow-wheat blooming in Frederick Co., Maryland (7/8/2013). Photo by [Bonnie Ott](#). ([MBP list](#))

By Keir Morse. Copyright © 2019 Keir Morse.  
[www.keiriosity.com](http://www.keiriosity.com)



# True parasites in Maryland

Squawroot *Conopholis americana*



Squawroot in Garrett Co., Maryland (5/22/2016). Photo by [Robert Ferraro](#). ([MBP list](#))

Beechdrops *Epifagus virginiana*



Beechdrops in bloom in Howard Co., Maryland (10/2/2014). Photo by [Nancy Magnusson](#). ([MBP list](#))

One-flowered Broomrape  
*Aphyllon (Orobanche) uniflorum*



One-flowered Broomrape blooming in Cecil Co., Maryland (4/29/2017). Photo by [Ashley Bradford](#). ([MBP list](#))



# Heterotrophs (“different feeding”)

- True parasites: obtain carbon compounds from host plants through haustoria.
- Myco-heterotrophs: obtain carbon compounds from host plants via mycorrhizal fungal connection.
- Carnivorous plants (not parasitic): obtain nutrients (phosphorus, nitrogen) from trapped insects.



Image Credit: Flickr User wackybadger, via CC

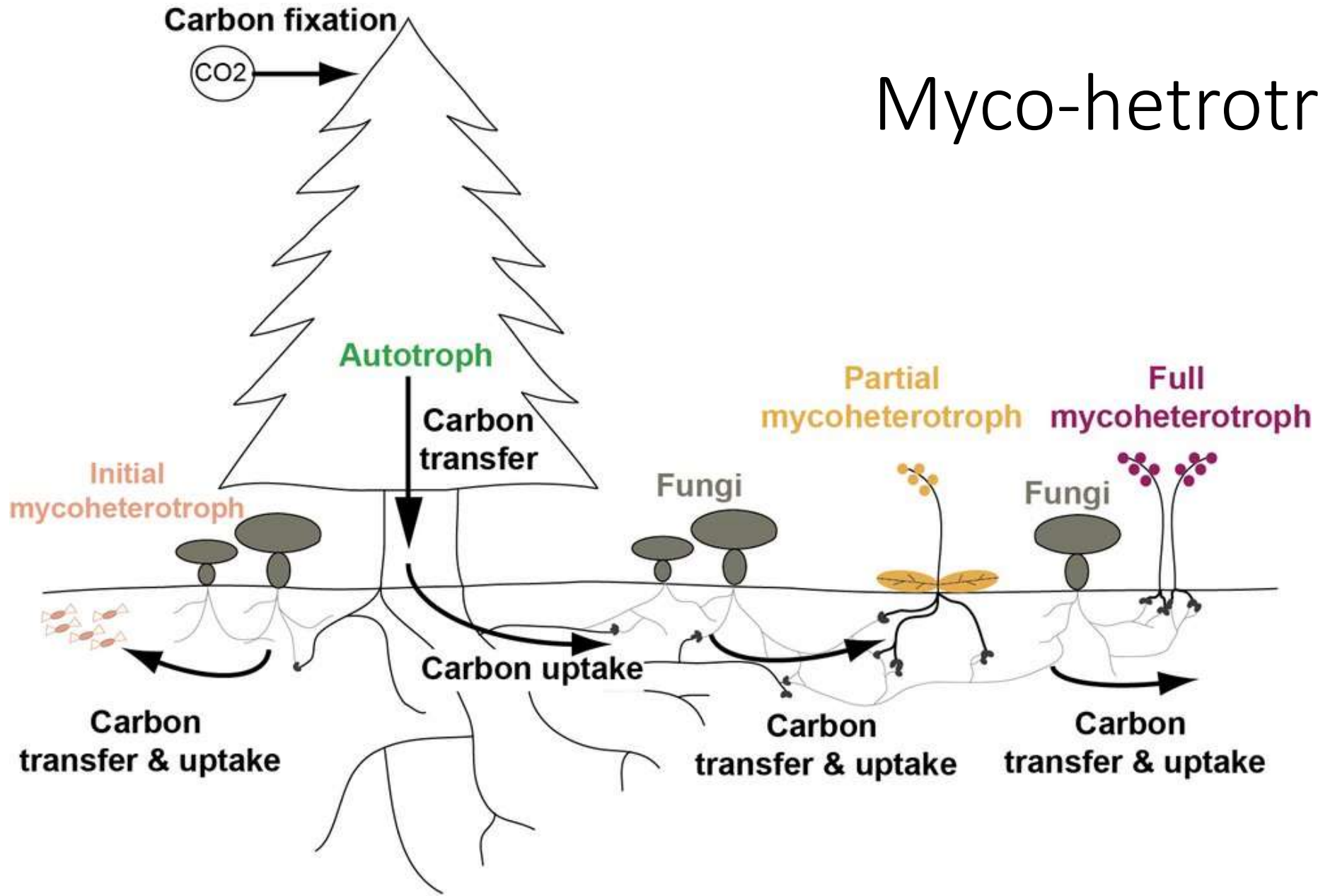


[https://commons.wikimedia.org/wiki/File:Pink\\_indian\\_pipes.jpg](https://commons.wikimedia.org/wiki/File:Pink_indian_pipes.jpg)



<http://www.welivealot.com/venus-flytrap-facts-for-kids/>

# Myco-heterotrophs





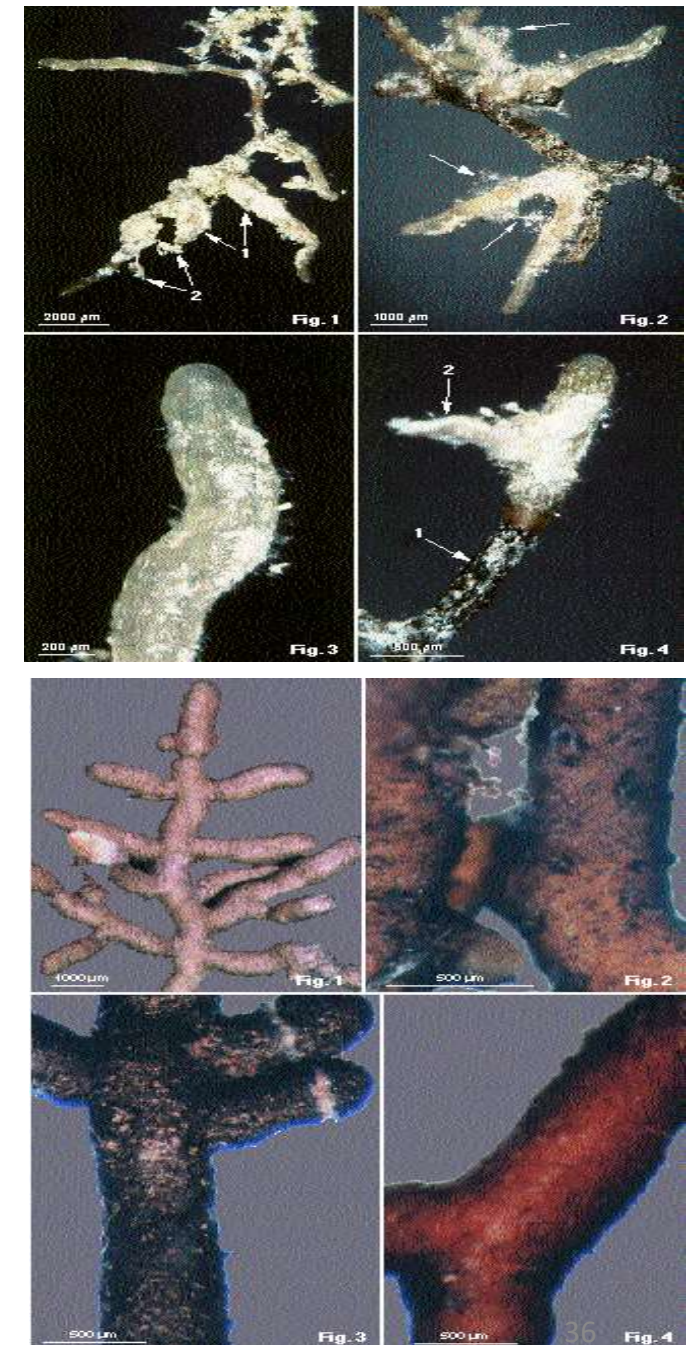
# Mycorrhizal Fungi

- Mycorrhiza means “fungus root” and was first used in 1885
- 95% of all plant species belong to a genera that characteristically form mycorrhizae.
- Thought to have evolved with the first land plants
- More prevalent in perennial plants than in annual plants



# Ectomycorrhizae

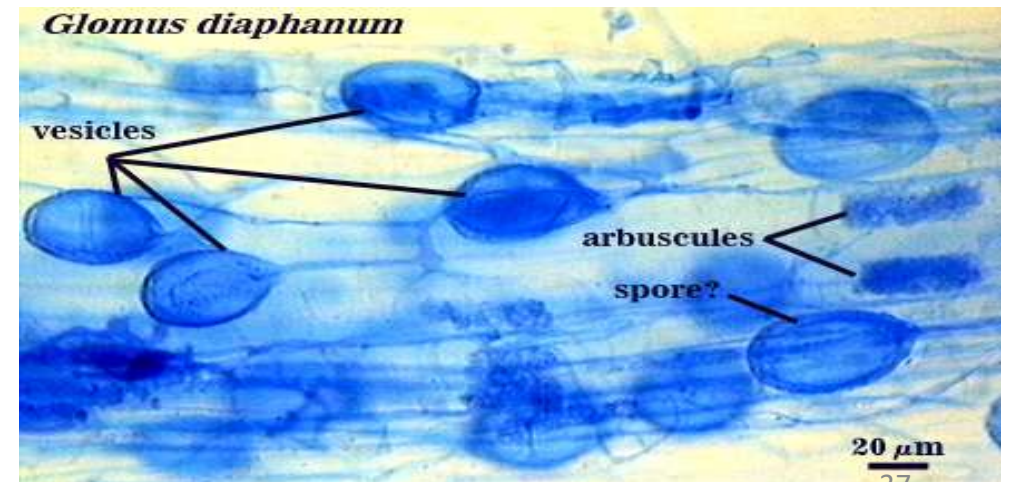
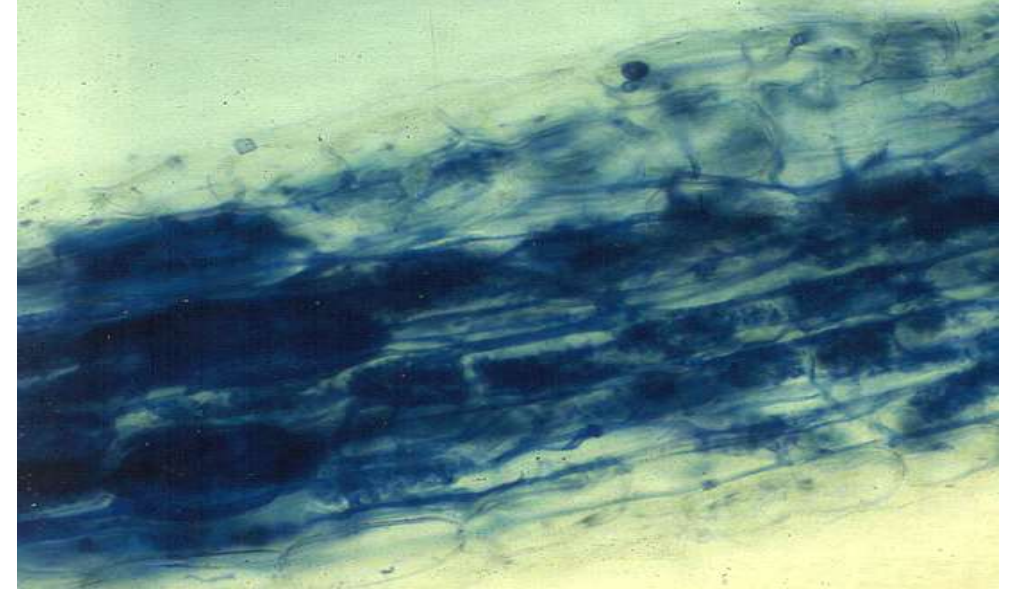
- Found in northern forests where decomposition is slow and nitrogen remains locked up in organic matter
- Forms structures on the outside of plant roots (ecto)
- Can often be seen with the naked eye
- Reproduce by mushrooms
- Oaks, Pines and Eucalyptus
- Little specificity (either way)
  - Douglas-fir reported to be associated with some 2,000 fungal species across its range

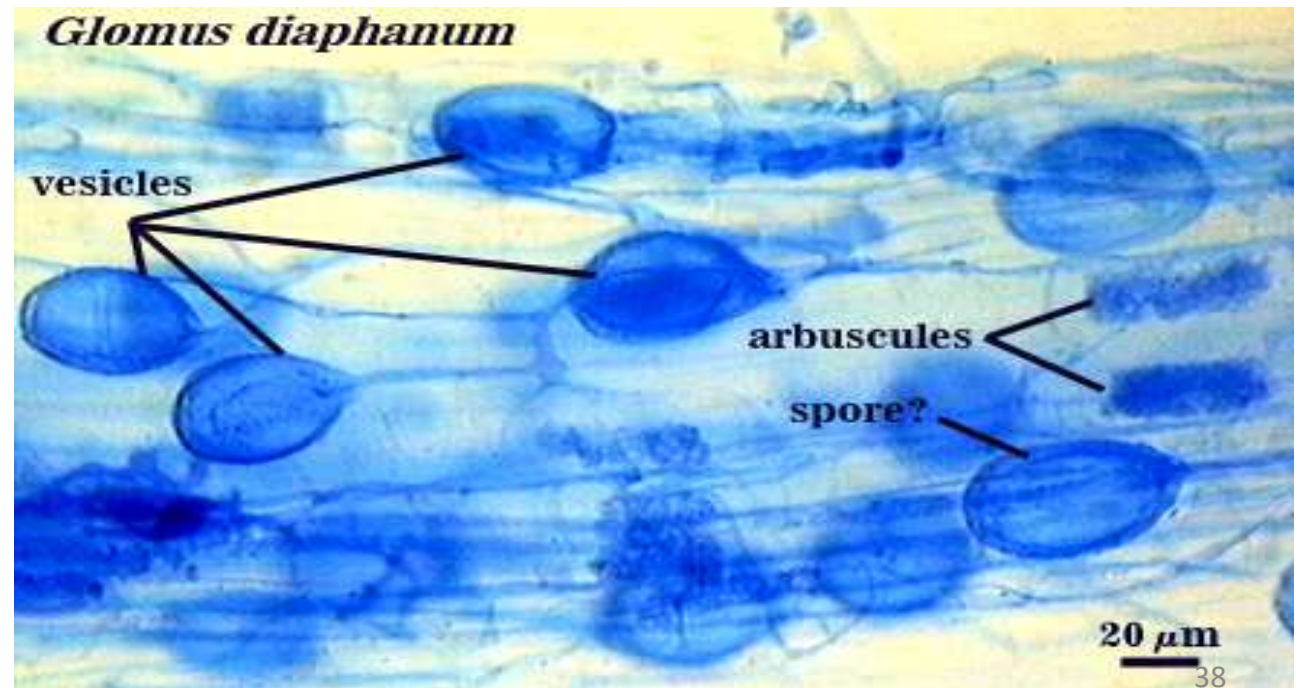
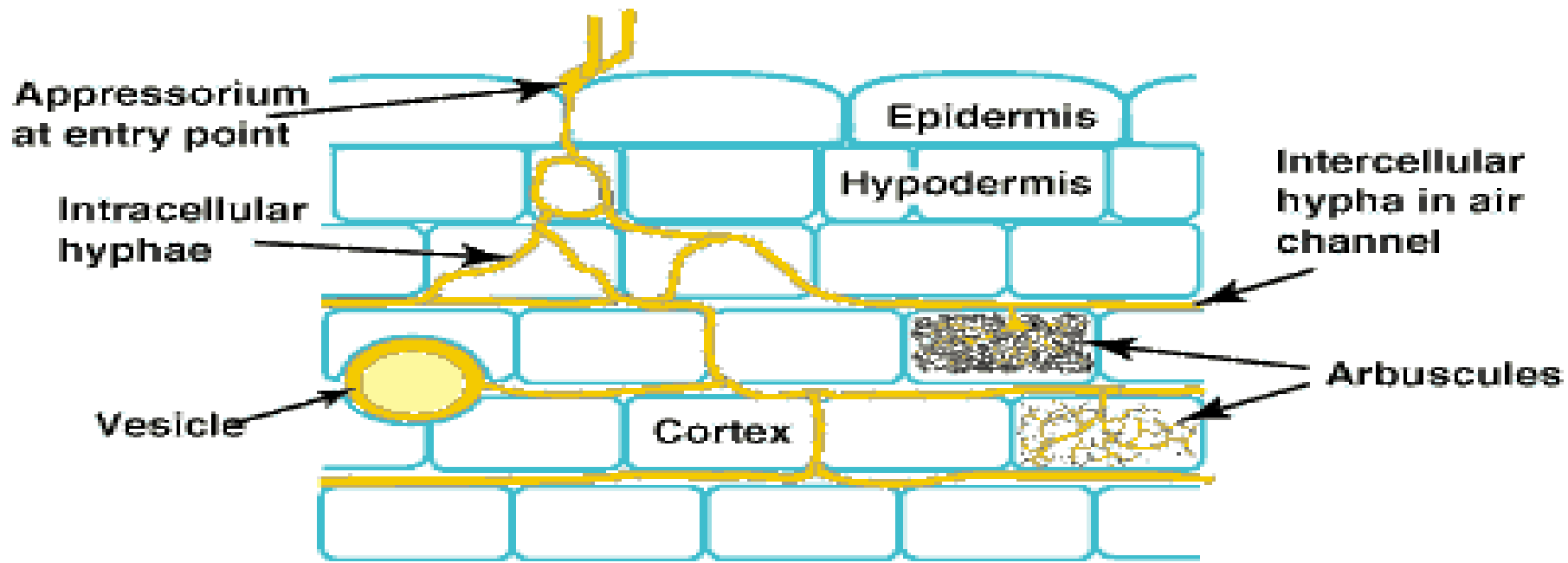




# Endomycorrhizae (Arbuscular mycorrhizae)

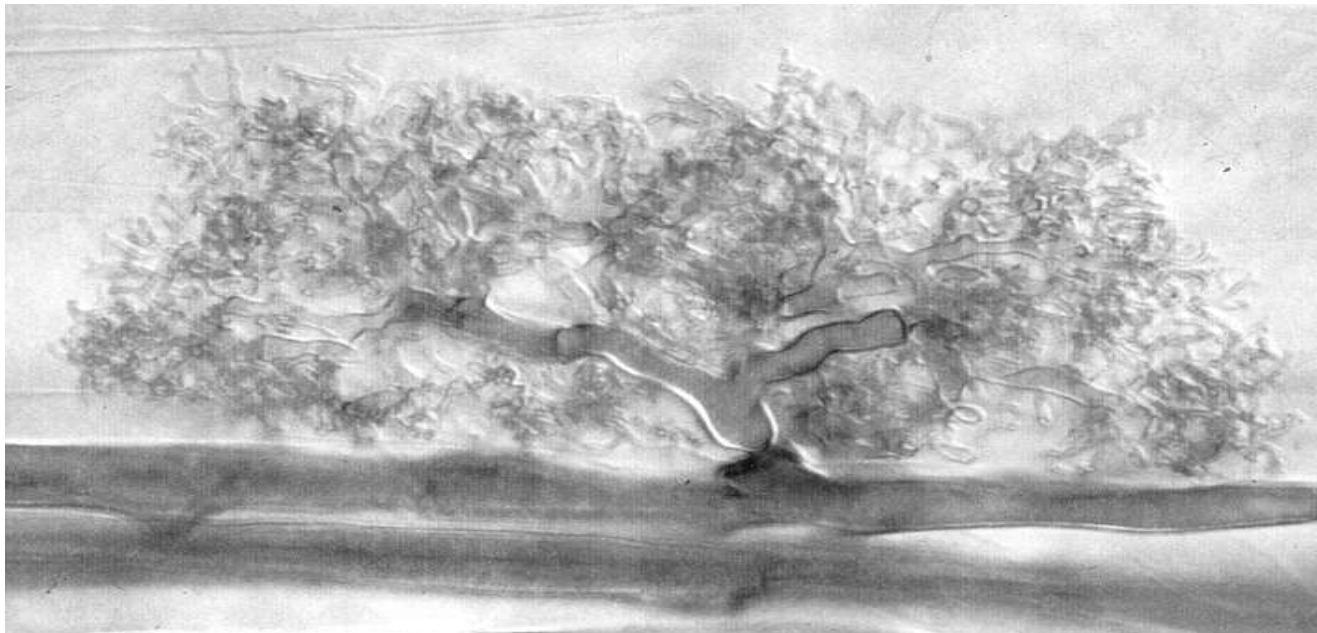
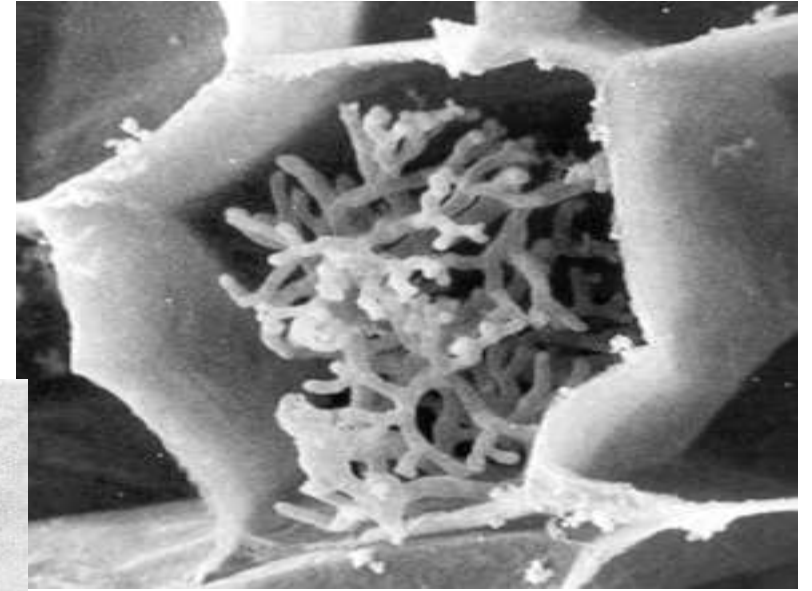
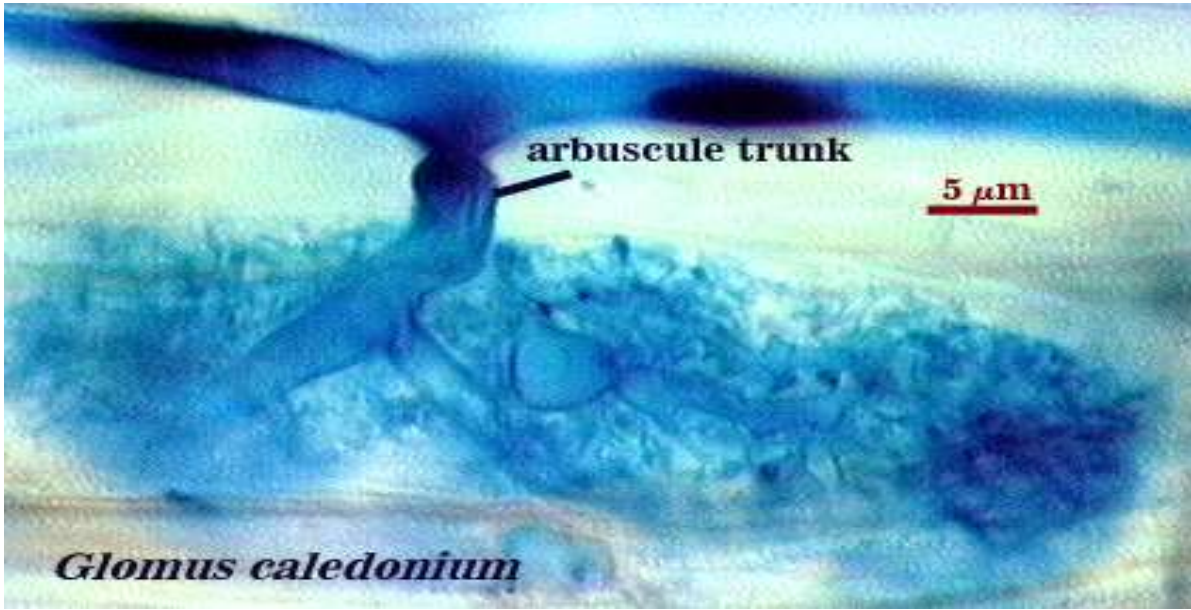
- Found in southern forests and grasslands where fast decomposition doesn't limit nitrogen
- Important for transferring phosphorus that binds to mineral soil particles
- Forms structures on the inside of plant roots (endo)
- Roots need to be stained to observe fungi
- Reproduce by forming spores in the soil
- Ancient association
- Little specificity (either way)







# Arbuscules



# Parasite vs. Myco-heterotroph

## Parasite

Symbiosis = Parasitism

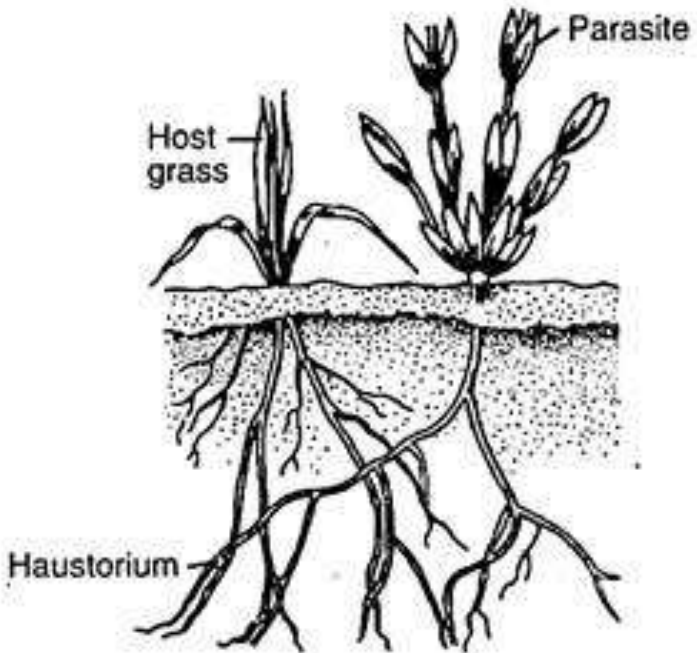
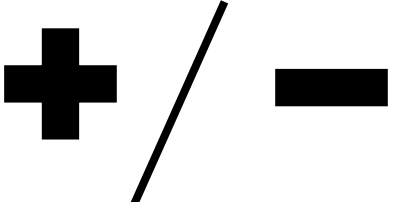
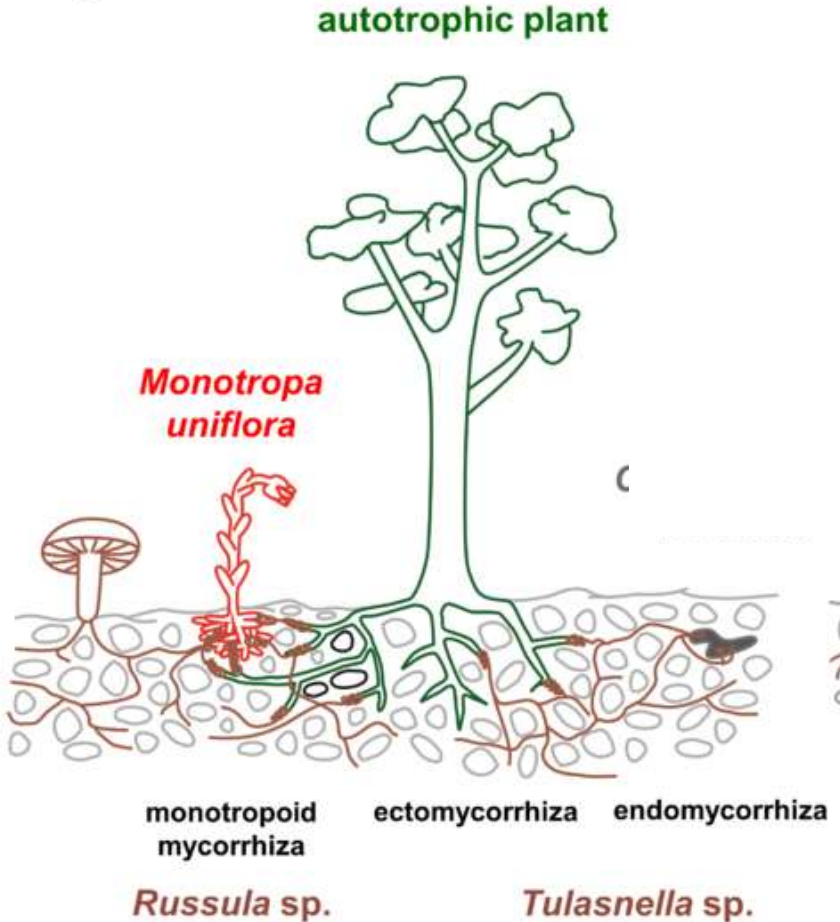
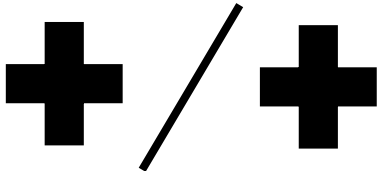


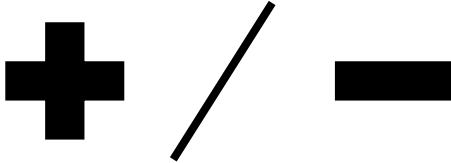
Fig. 1.13 : Partial root parasites : *Thesium alpinum* with haustorial suckers attached with grass roots

## Myco-heterotroph

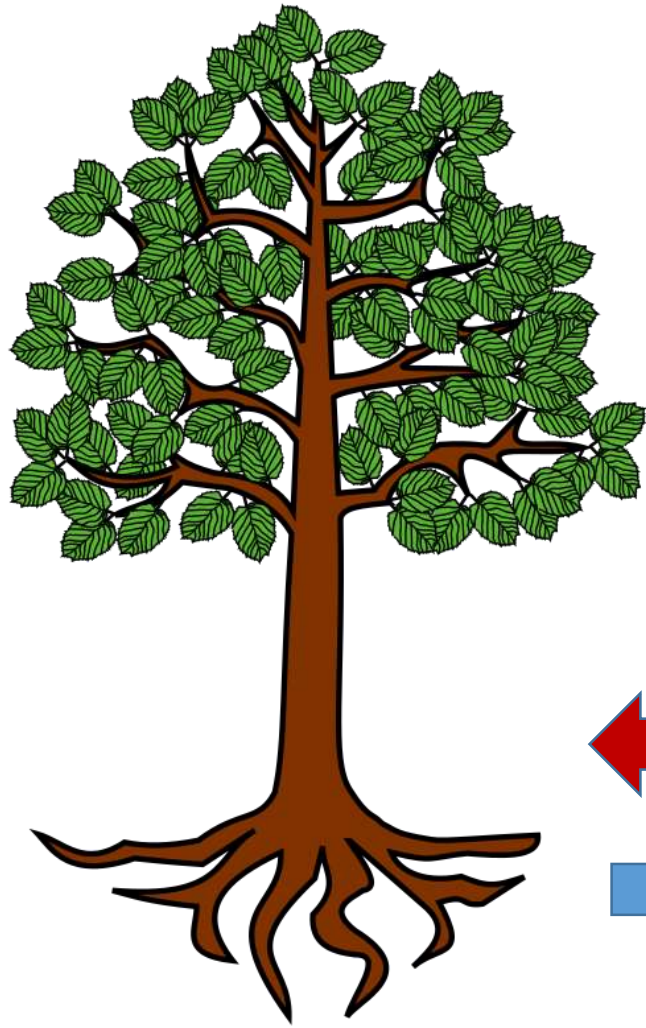
Symbiosis = Mutualism



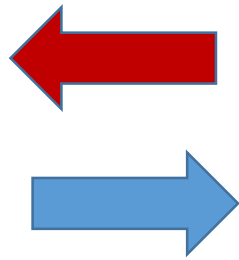
Symbiosis = Parasitism



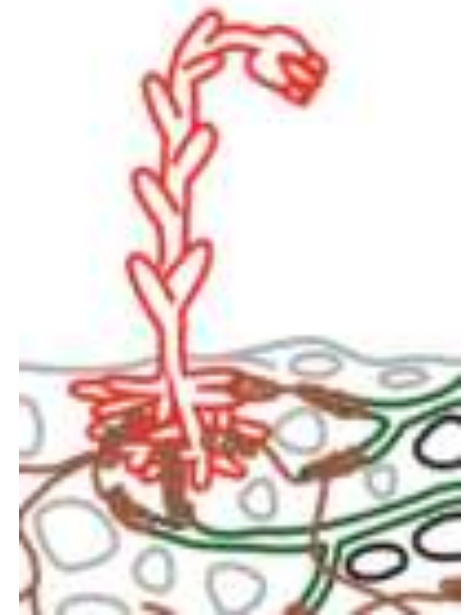




[https://en.wikipedia.org/wiki/File:Meuble\\_h%C3%A9raldique\\_aulne.svg](https://en.wikipedia.org/wiki/File:Meuble_h%C3%A9raldique_aulne.svg)



<https://pixabay.com/en/mushrooms-toadstools-fungi-fungus-576065/>

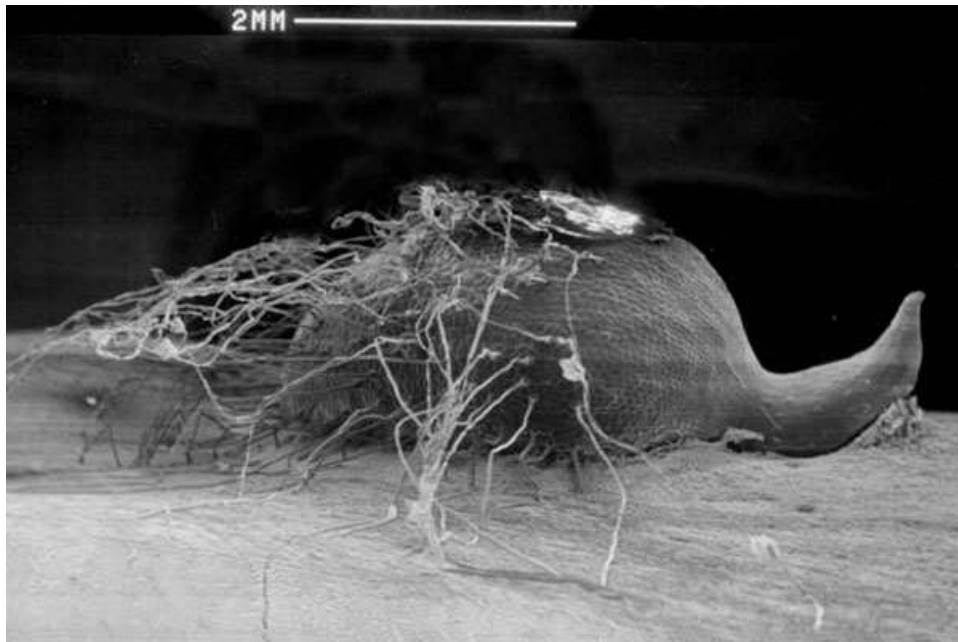


<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2778383/>

# Diversity of myco-heterotrophs

## Facultative myco-heterotrophs

- Only during establishment phase



<https://www.kings.co.nz/userfiles/Editorial/orchids/orchid-seed-germinating.jpg>

## Obligate myco-heterotrophs

- Dependent throughout lifetime



•Mycoheterotrophy: The Biology of Plants Living on Fungi



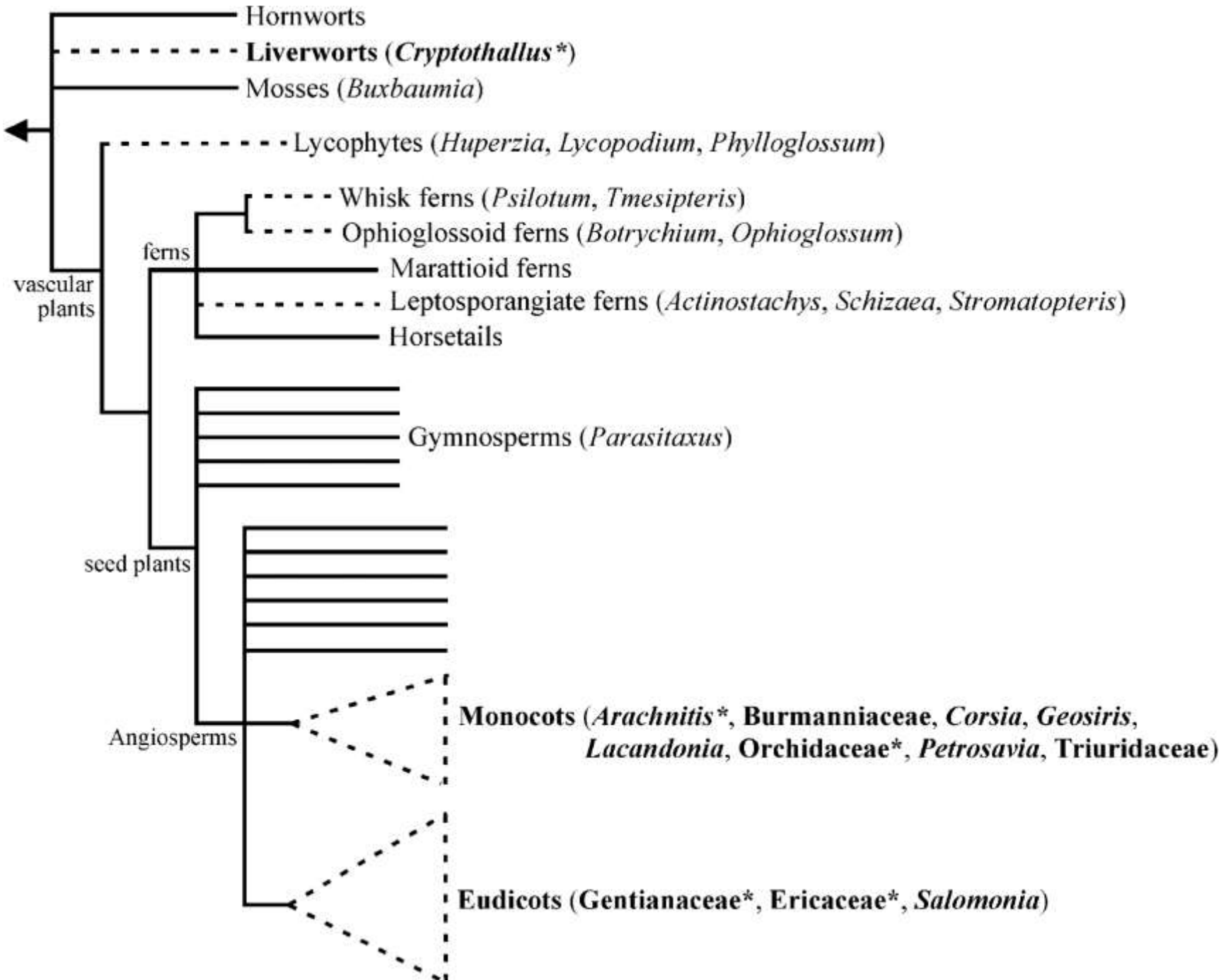
# Diversity

- Initial MHT

- 20,000 spp.
- Orchids, ferns, lycophytes

- Full MHT

- 500 spp.
- some Orchidaceae and Gentianaceae,
- all Monotropeoideae and Triuridaceae



# *Parasitaxus usta*



<https://www.flickr.com/photos/tim-waters/349306324/in/photolist-wShAQ-4esgmy/>



Edouard FARIA ©

*Parasitaxus ustus*

<http://stanhopea-passion.over-blog.com/>



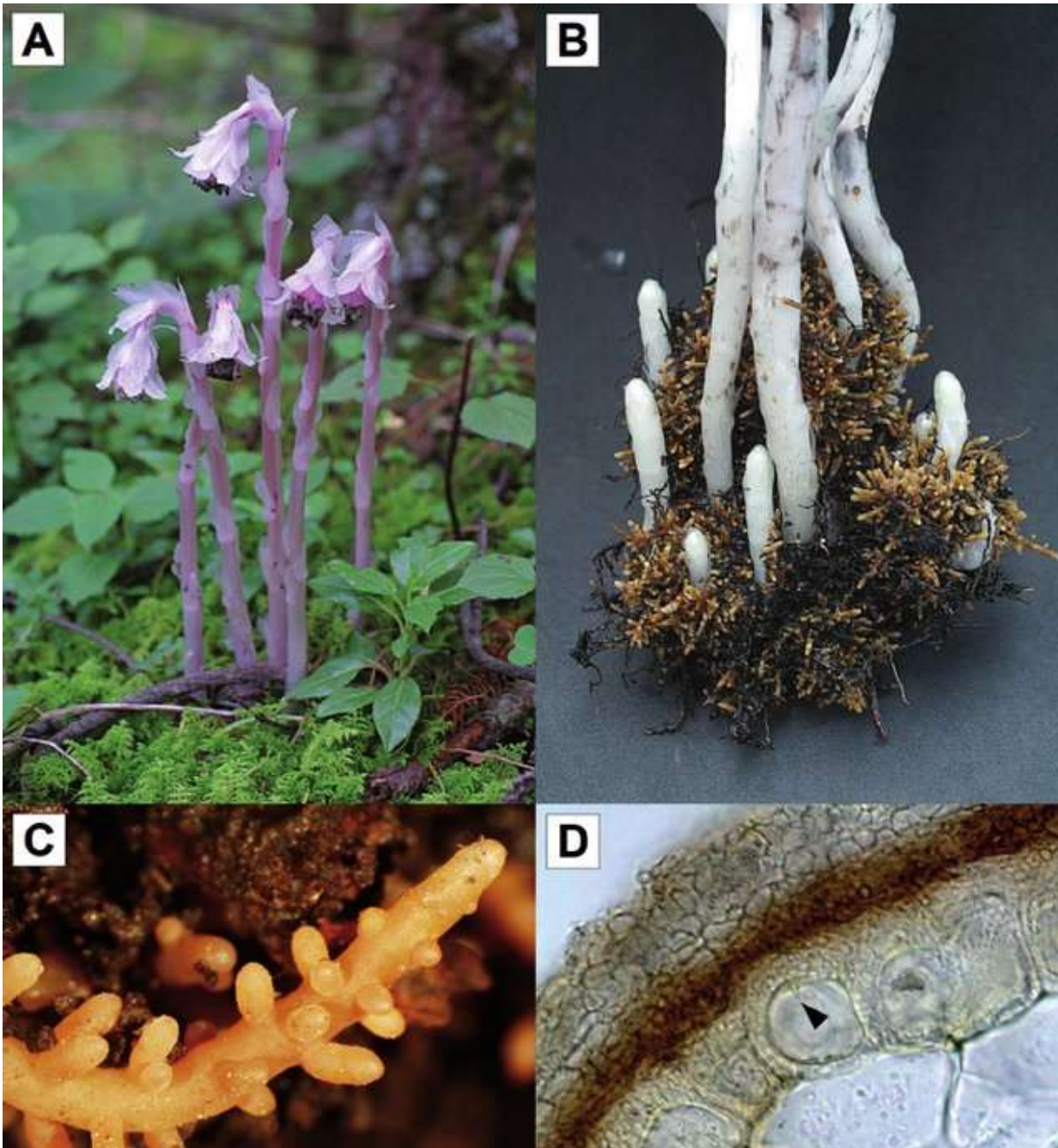


***Hypopitys monotropa***  
yellow pine-sap

1821

Is *M. hypopithys*  
‘parasitic on the  
roots of other  
plants?’





## *Monotropa uniflora*

(Ghost plant, Indian pipe)

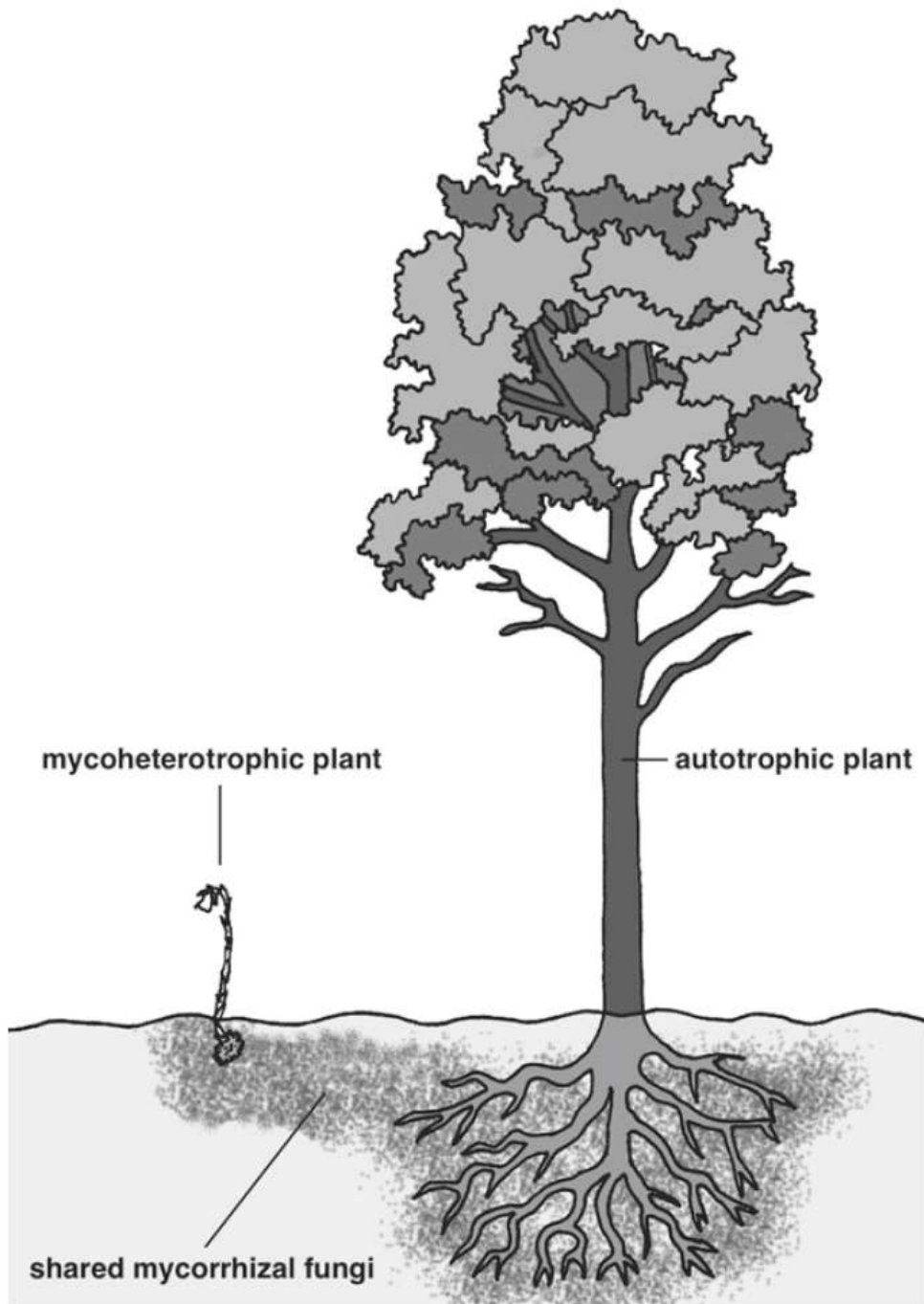
A. Mature plants in the field

B. Root system showing the typical cluster of mycorrhizas.

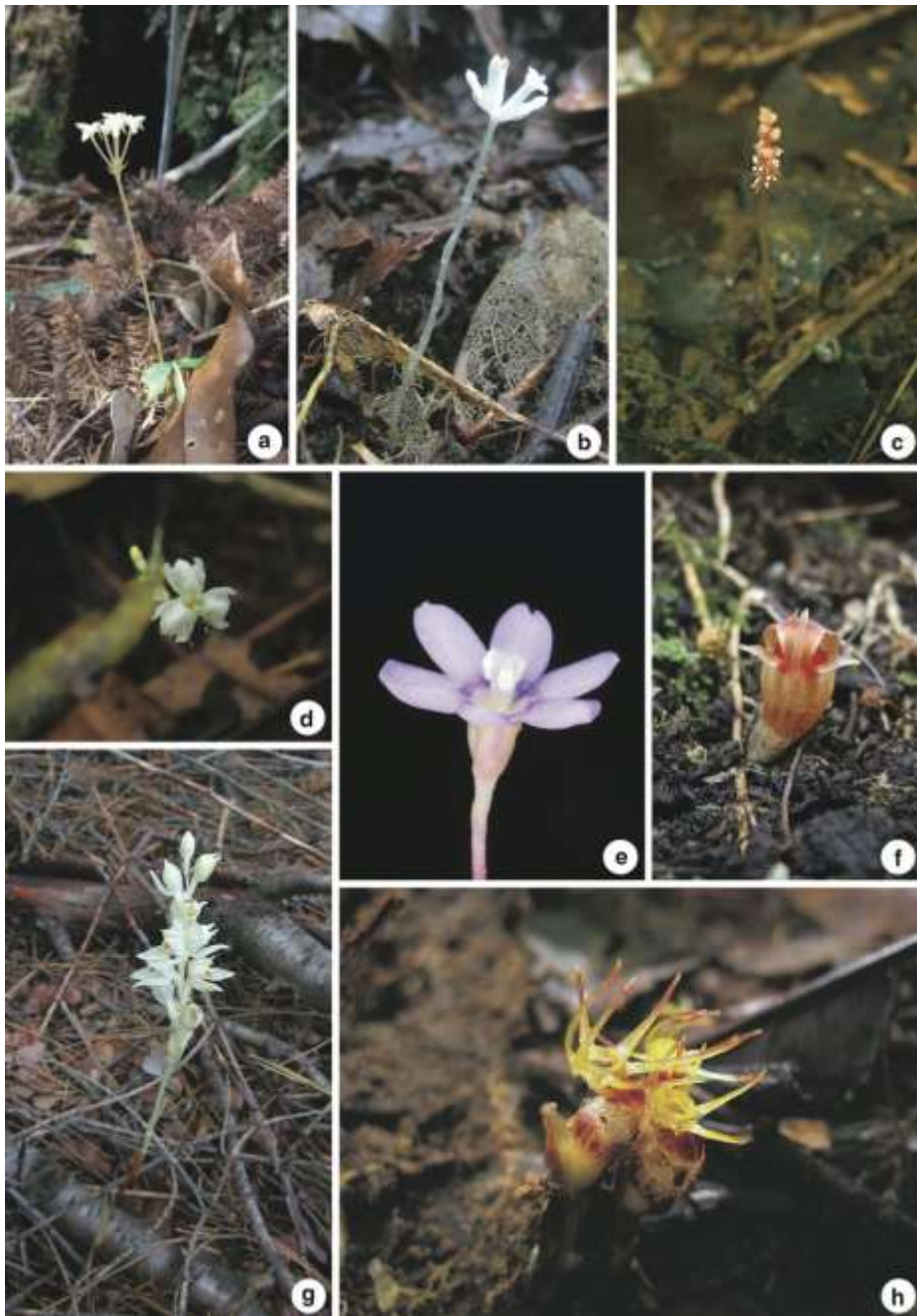
C. Individual mycorrhizal root tip.

D. Transversal section of a mycorrhiza showing a pseudoparenchymatous mantle, brown tannin layer, Hartig net surrounding epidermal cells, and the hyphal peg (arrow head) penetrating an epidermal cell.





- Successful exploiters of the ectomycorrhizal symbiosis ultimately evolved from mutualists via defection.
- Exceptionally high specificity of myco-heterotrophic plants towards narrow clades of ecto- and arbuscular mycorrhizal fungi relative to autotrophic plants.
- Are nonphotosynthetic mycorrhizal plants parasitic?
  - If they supply nutrients, then no.



Fully mycoheterotrophic species in monocots



Fully mycoheterotrophic species in eudicots



# Myco-heterotrophs in Maryland

Spotted Coralroot *Corallorhiza maculata*



Spotted Coralroot flowers in Iron Co., Wisconsin (8/1/2008). Photo by [Corey Raimond](#). ([MBP list](#))

Spotted Wintergreen  
*Chimaphila maculata*



Spotted Wintergreen in Frederick Co., Maryland (6/28/2015). Photo by [Bob Cammarata](#). ([MBP list](#))

American Wintergreen *Pyrola americana*



American Wintergreen blooming in Montgomery Co., Maryland (6/15/2016). Photo by [Robert Ferraro](#). ([MBP list](#))

# Myco-heterotrophs in Maryland

Pinesap *Monotropa hypopithys*



Pinesap in St. Mary's Co., Maryland (6/30/2018).  
Photo by [Bill Hubick](#). ([MBP list](#))

Indian Pipe *Monotropa uniflora*



Indian Pipe in Cecil Co., Maryland (9/21/2014). Photo by  
[Beth Johnson](#). ([MBP list](#))

Virginia Pennywort  
*Obolaria virginica*



Virginia Pennywort in Montgomery Co., Maryland  
(4/26/2015). Photo by [Mike Ostrowski](#). ([MBP list](#))



Pygmy Pipes  
*Monotropis odorata*



## On Going Unnoticed by Robert Frost

As vain to raise a voice as a sigh  
In the tumult of free leaves on high.  
What are you in the shadow of trees  
Engaged up there with the light and breeze?

Less than the coral-root you know  
That is content with the daylight low,  
And has no leaves at all of its own;  
Whose spotted flowers hang meanly down.

You grasp the bark by a rugged pleat,  
And look up small from the forest's feet.  
The only leaf it drops goes wide,  
Your name not written on either side.

You linger your little hour and are gone,  
And still the wood sweep leafily on,  
Not even missing the coral-root flower  
You took as a trophy of the hour.

Western Spotted Coralroot - *Corallorhiza maculata*

