BIOTIC DISEASES caused by:

Parasitic plants
Bacteria
Fungi
Oomycetes
Viruses

Nematodes

Biotic diseases can be grouped by:

- Agent causing disease (fungus, oomycete, virus, bacteria, plant)
- Host specificity of pathogen: generalist, specialist or “in between” (e.g. limited to a plant family or to conifers)

- Plant part affected (flower , fruit, leaves, branches, stems, roots, vessels, cambium)
- Scale of infection (from one tree to a whole forest)

- Age of host (juvenile vs. adult vs. mature)
- Whether plant tissue is dead or alive: biotroph, hemibiotroph, necrotroph,

- Type of hosts1: whether it affects primary (source) and secondary (sink) hosts
- Type of hosts 2: whether it has transmissive and dead-end hosts

- Type of hosts 3: whether it needs to alternate between different host
- Virulence: whether it is primary, secondary (opportunistic) or a latent pathogen that can change lifestyle

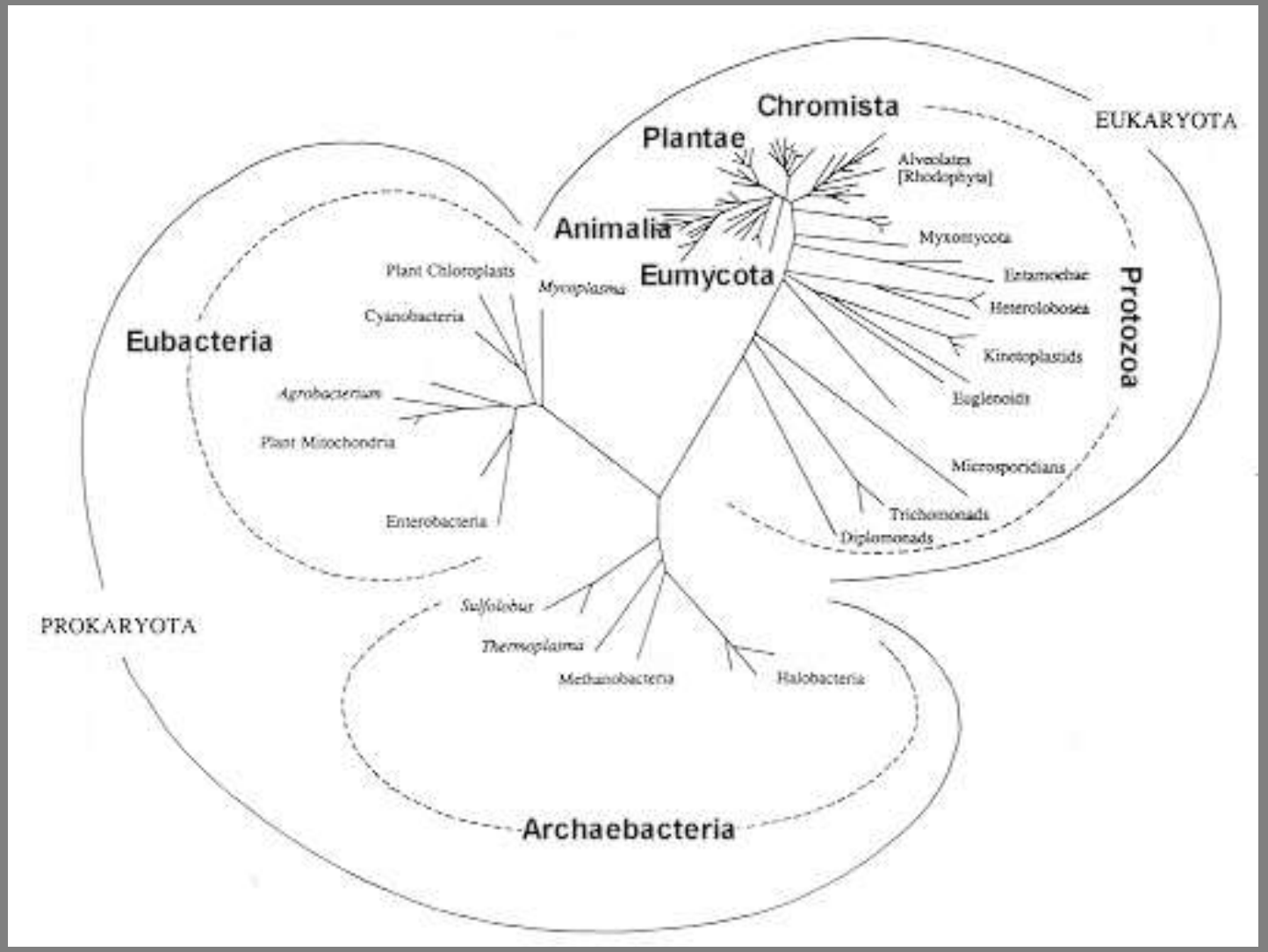
- Wound vs non-wound pathogen
- Airborne vs waterborne and/or soilborne

- Vectored by animals or not
- Pathogen’s reproductive mode: clonal, sexual , mixed

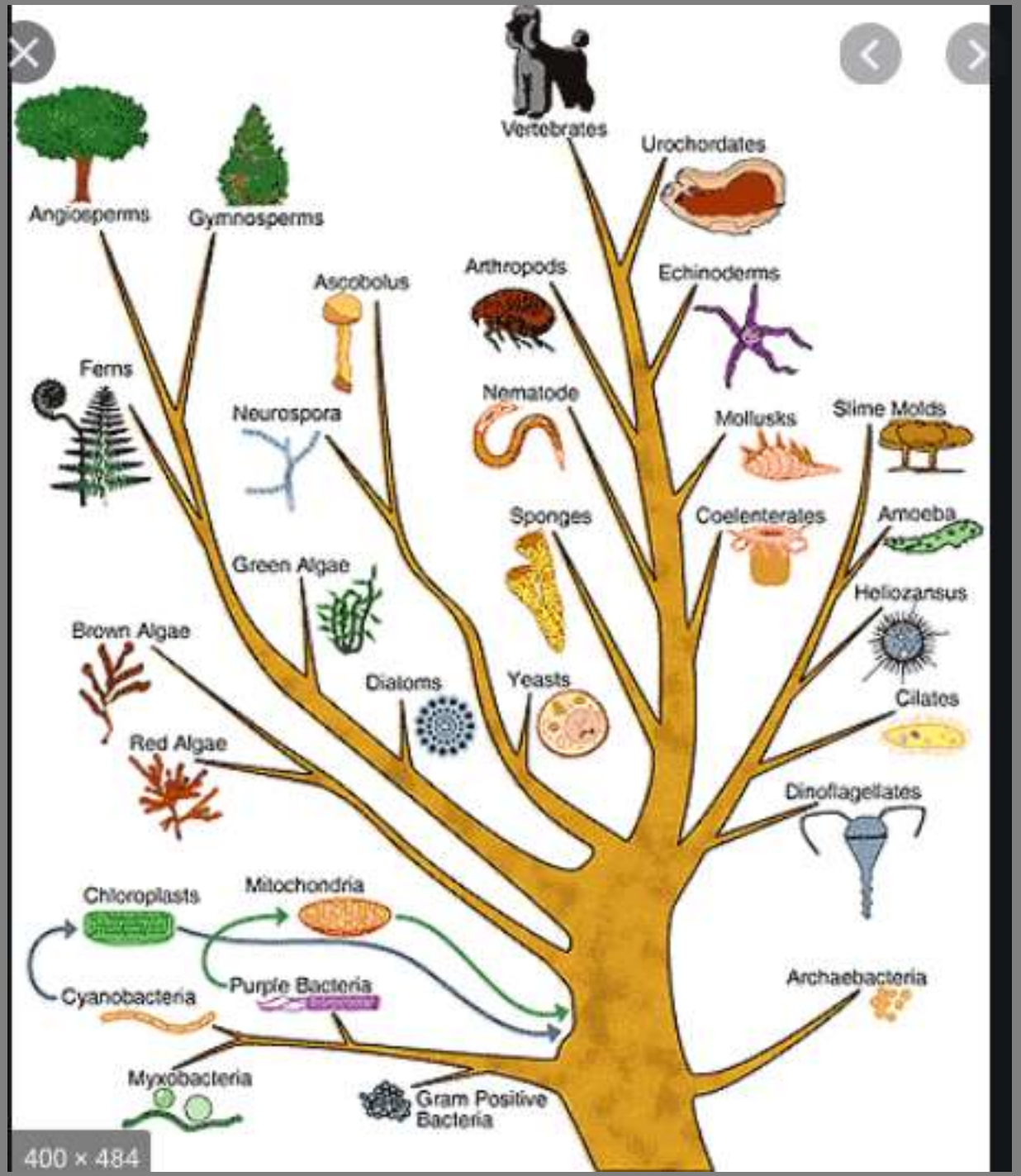
Definitions

- Biotroph: a plant pathogen which establishes a long term feeding relationship with the living cells of a host, without killing it as part of the infection process.
- Hemibiotroph:an organism that is parasitic in living tissue for some time and then continues to live in dead tissue
- Necrotroph:a parasitic organism that kills the living cells of its host and then feeds on the dead matter

Tree of Life, from Patterson & Sogin, 1992



CHROMISTA now referred to as STRAMINIPILA


Vertebrates
Urochordates
Angiosperms
Gymnosperms
Arthropods
Echinoderms
Ascobolus
Ferns
Nematode
Neurospora
Mollusks
Slime Molds
Sponges
Coelenterates
Amoeba
Green Algae
Heliozansus
Brown Algae
Diatoms
Yeasts
Ciliates
Red Algae
Dinoflagellates
Chloroplasts
Mitochondria
Archaebacteria
Purple Bacteria
Cyanobacteria
Myxobacteria
Gram Positive Bacteria

400 × 484

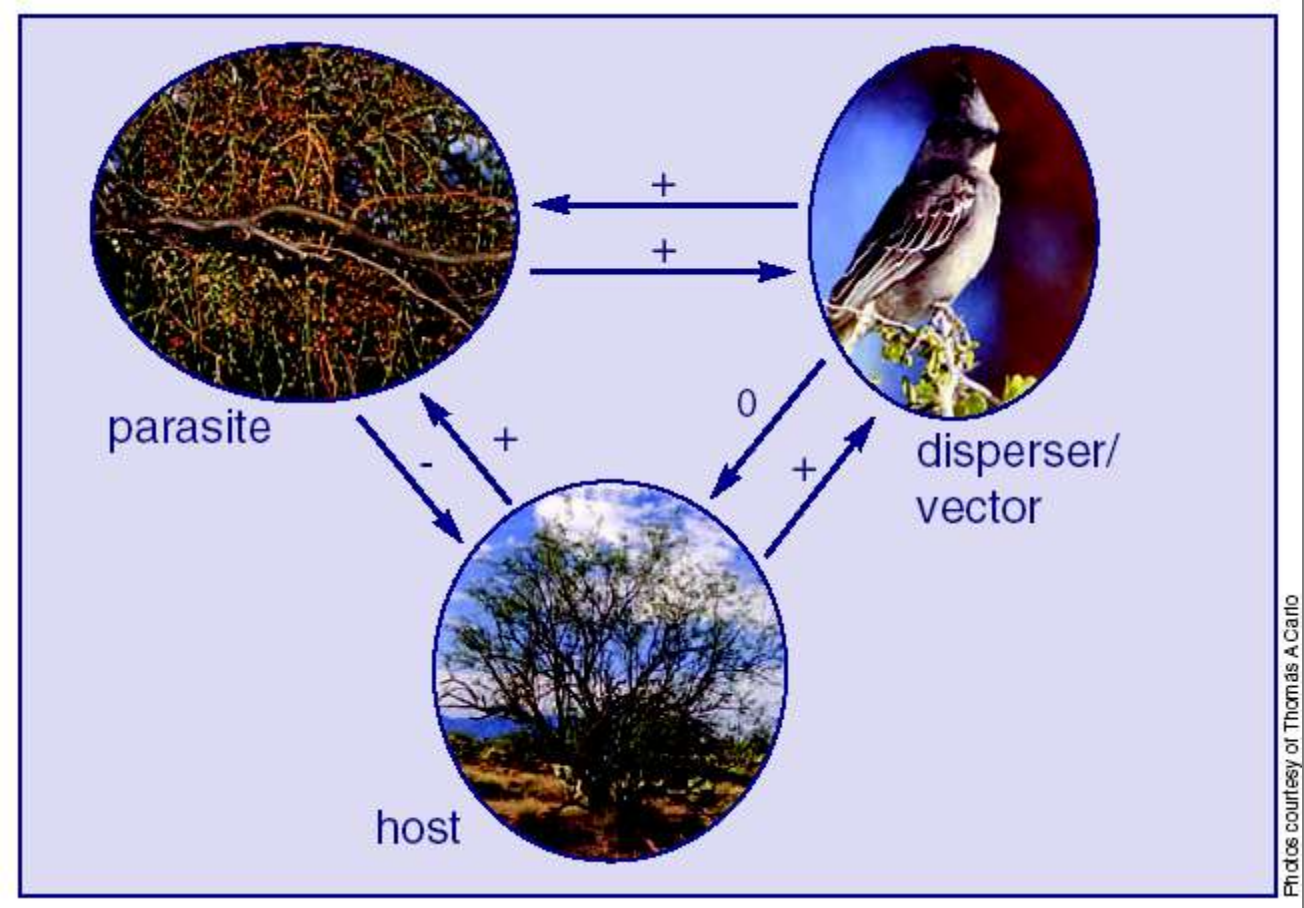
PARASITIC PLANTS:

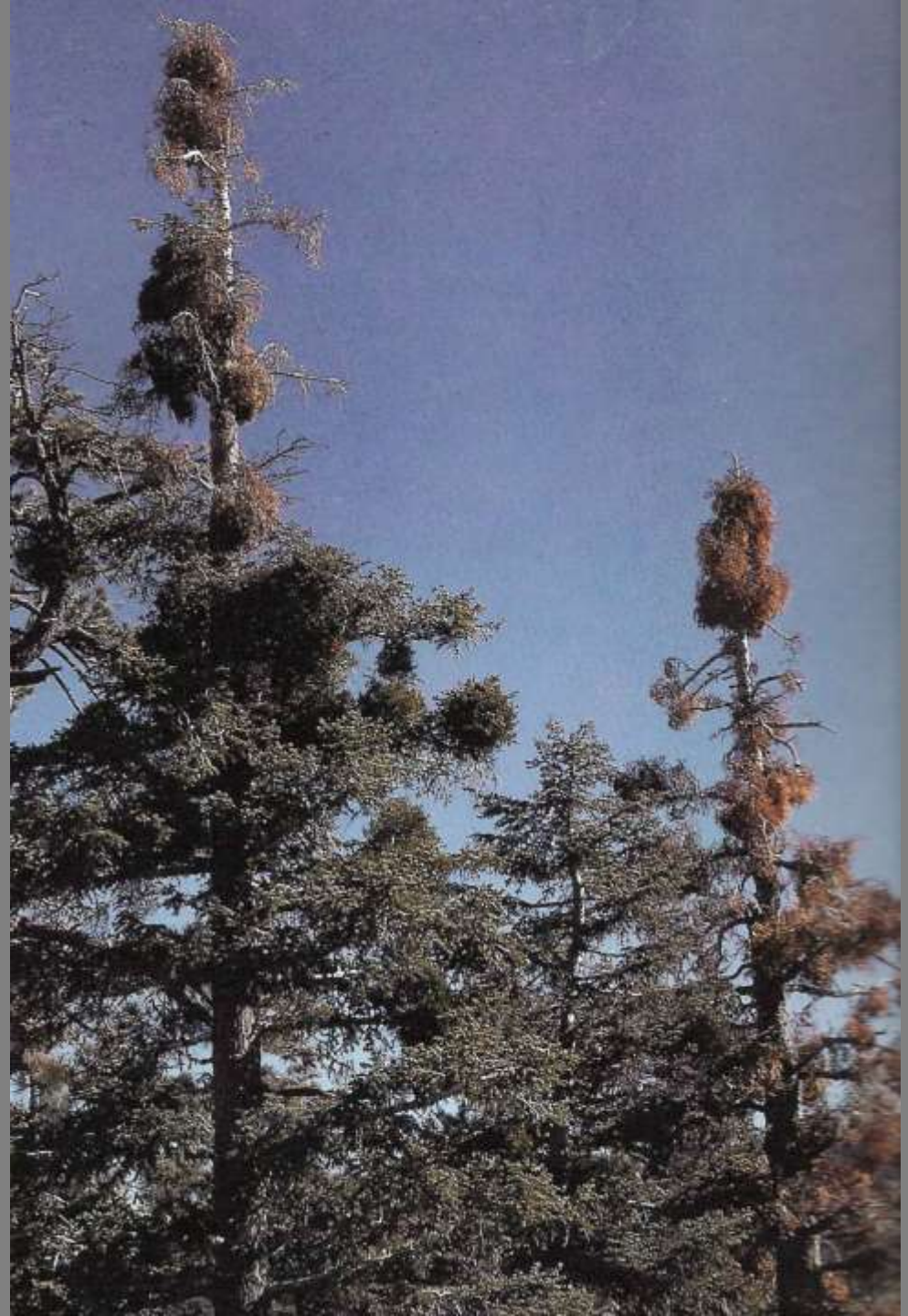
True Mistletoe
Dwarf Mistletoe
Dodder
Orchids
Ericaceous plants (Indian pipe)

***Phorodenron villosum* on oak**

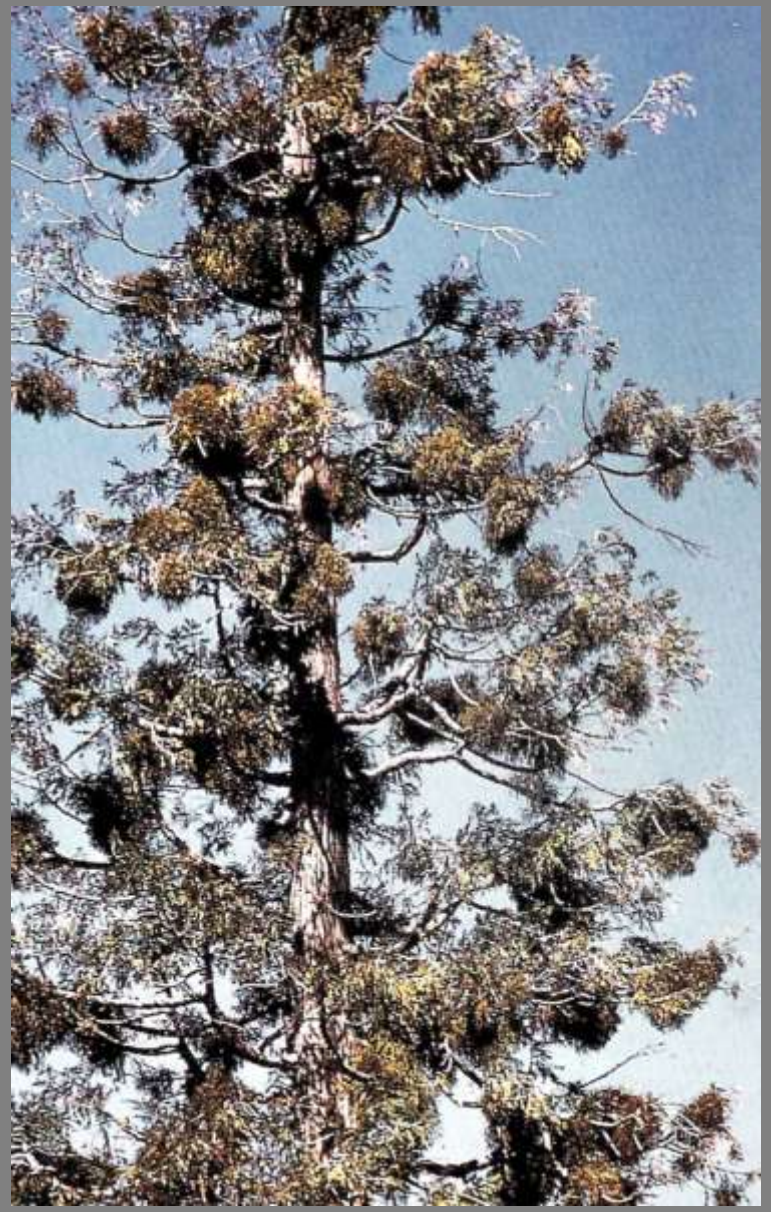
Leafy or true mistletoe

Sticky seed adhere to birds, they also can be ingested and spread in feces


+
+
parasite
+
-
0
+
disperser/
vector
host
Photos courtesy of Thomás A Carlo



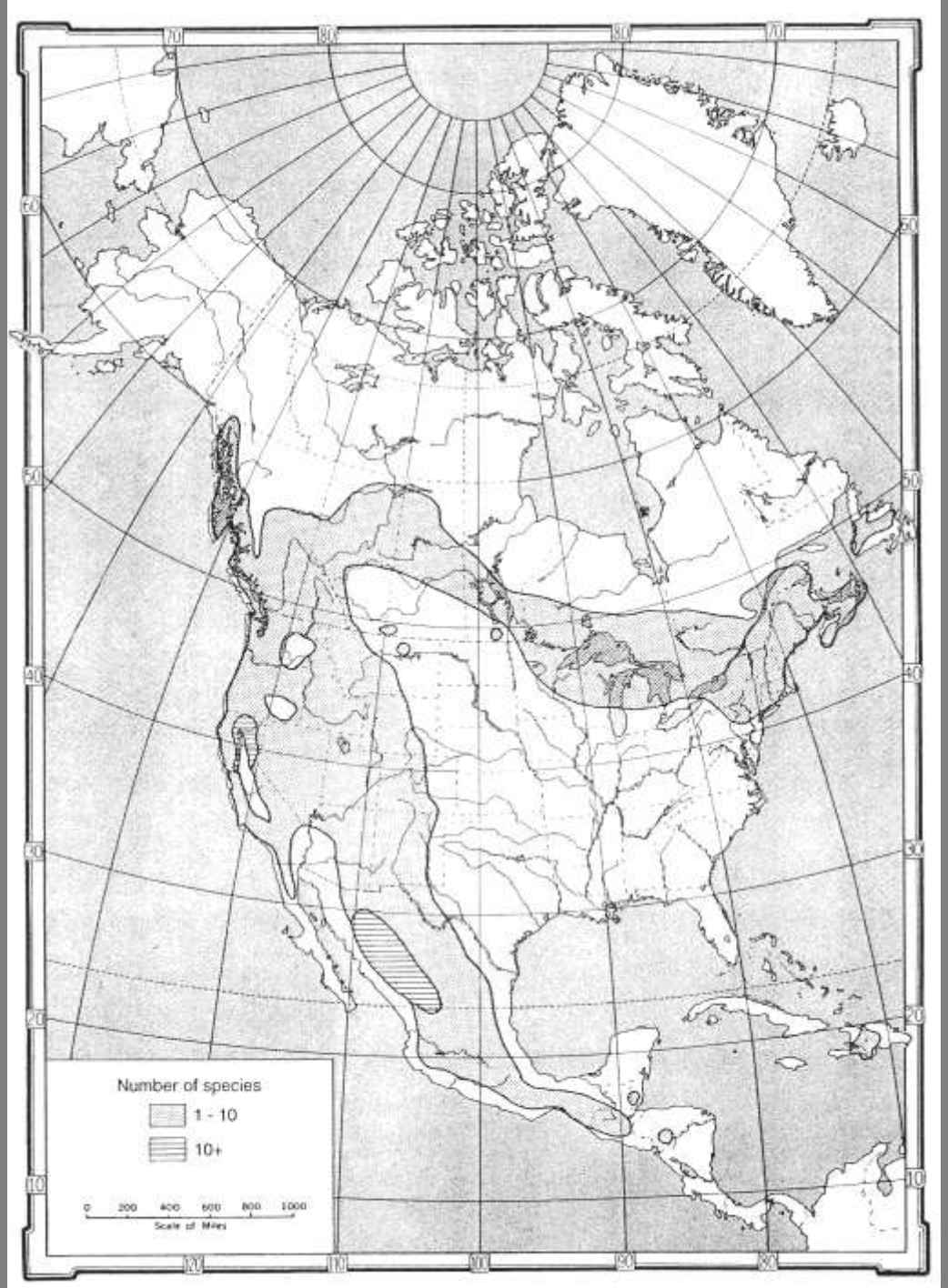
Phorodendron pauciflorum on white fir



Phorodendron libocedri on incence cedar

Figure 5.1 –World distribution of *Arceuthobium*. The distribution is primarily in the Northern Hemisphere, crossing the Equator only in Kenya.

Dwarf Mistletoe



Large number of species because of high host specificity and co-evolution between parasite and plant

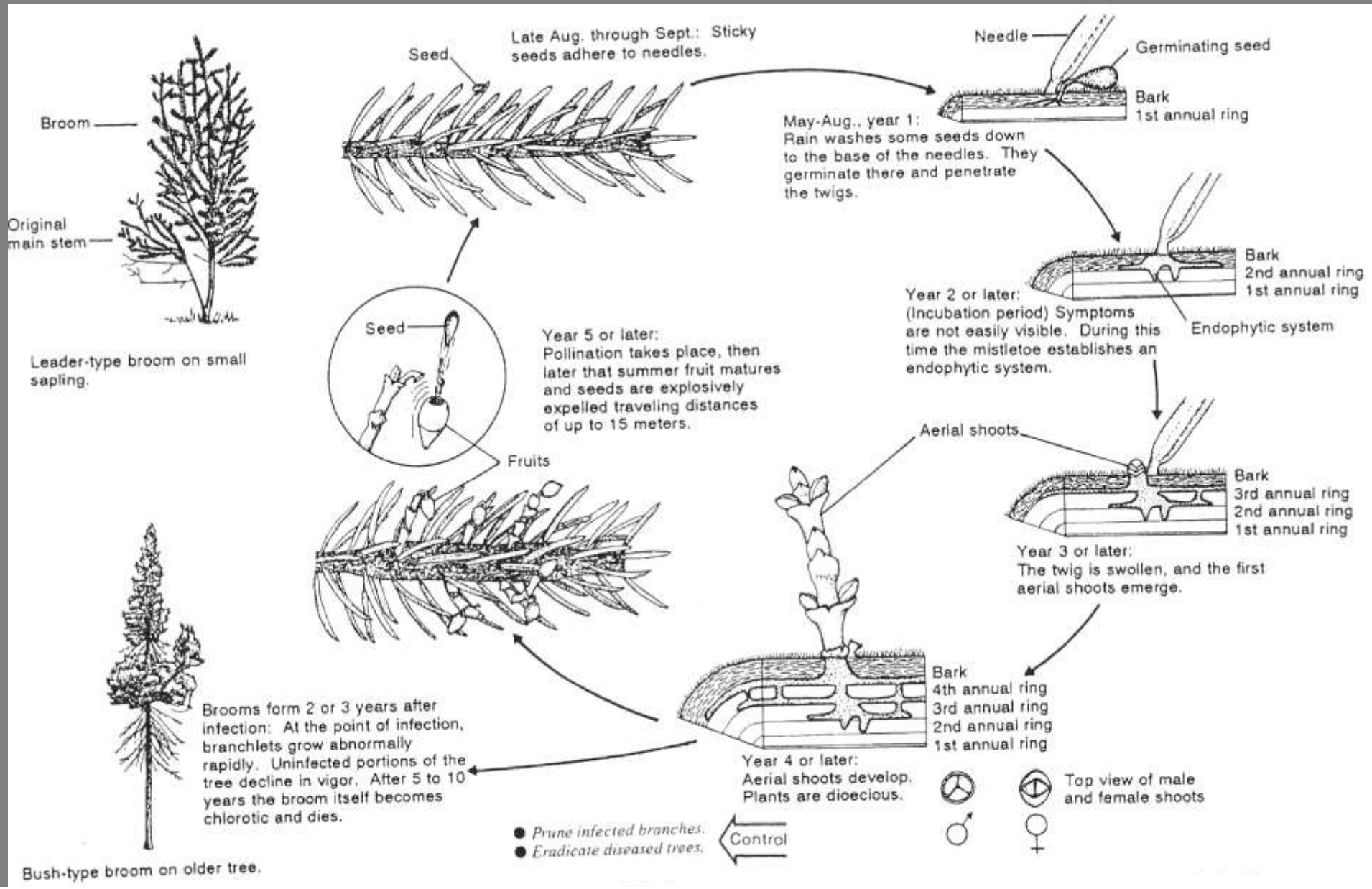
Arceuthobium campylopodum on Jeffrey pine

Arceuthobium douglasii
on Douglas-fir

Male flowers

Mature female shoots - seeds

Explosive seed dispersal of *Arceuthobium*

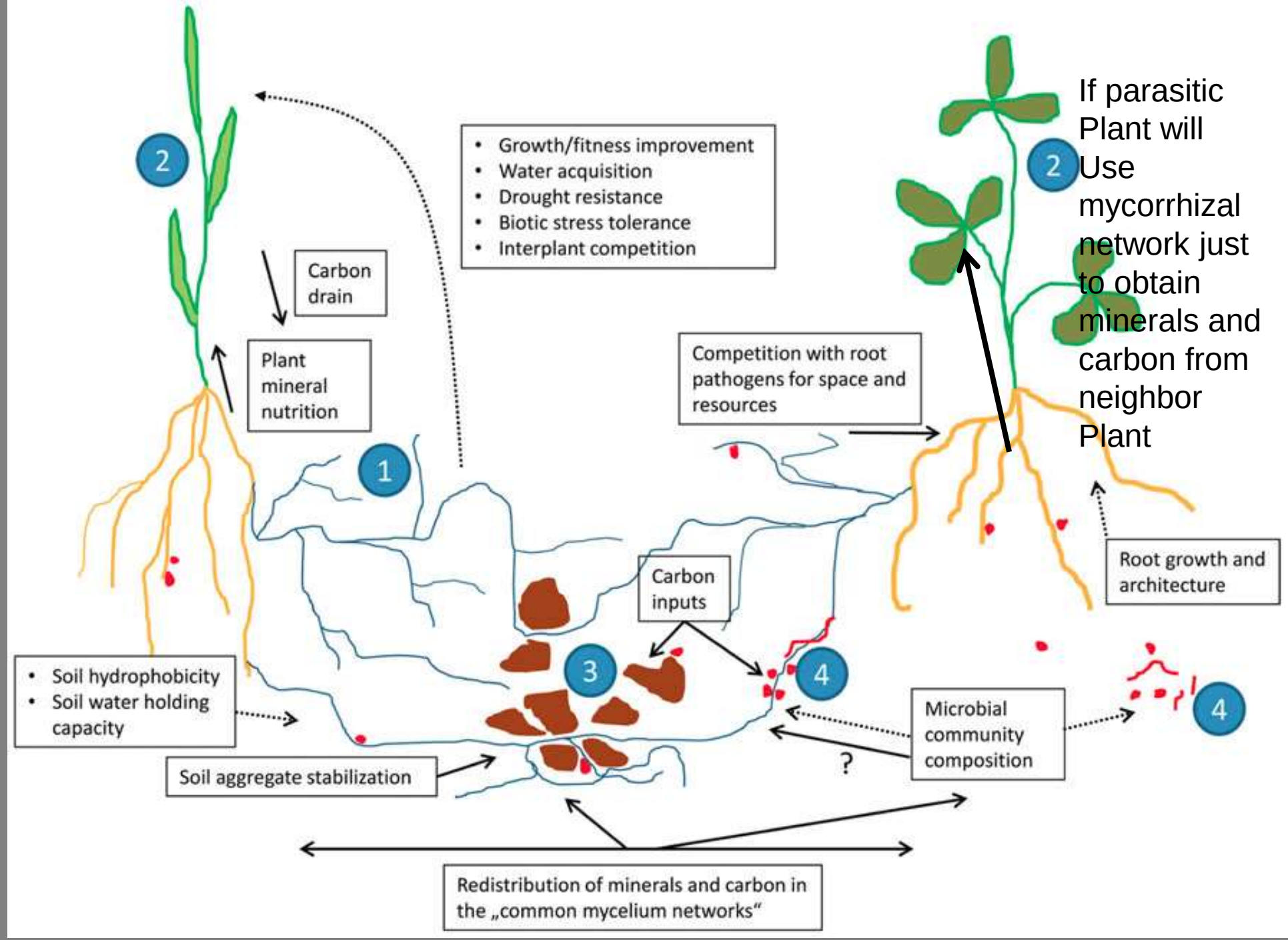

Broom
Original main stem
Leader-type broom on small sapling.
Seed
Late Aug. through Sept.: Sticky seeds adhere to needles.
Needle
Germinating seed
Bark
1st annual ring
May-Aug., year 1: Rain washes some seeds down to the base of the needles. They germinate there and penetrate the twigs.
Bark
2nd annual ring
1st annual ring
Endophytic system
Year 2 or later: (Incubation period) Symptoms are not easily visible. During this time the mistletoe establishes an endophytic system.
Seed
Year 5 or later: Pollination takes place, then later that summer fruit matures and seeds are explosively expelled traveling distances of up to 15 meters.
Fruits
Aerial shoots
Bark
3rd annual ring
2nd annual ring
1st annual ring
Year 3 or later: The twig is swollen, and the first aerial shoots emerge.
Bark
4th annual ring
3rd annual ring
2nd annual ring
1st annual ring
Year 4 or later: Aerial shoots develop. Plants are dioecious.
Top view of male and female shoots
Brooms form 2 or 3 years after infection: At the point of infection, branchlets grow abnormally rapidly. Uninfected portions of the tree decline in vigor. After 5 to 10 years the broom itself becomes chlorotic and dies.
Bush-type broom on older tree.
Prune infected branches.
Eradicate diseased trees.
Control

Management issues associated with dwarf mistletoe

- Multi layered forest increases infection
- Group selection also
- You can have up to 30% reduction in growth
- Larger clearcuts is the only way to mitigate problem

Parasitic orchid and ericaceous plants

Coralroot orchids



If parasitic Plant will Use mycorrhizal network just to obtain minerals and carbon from neighbor Plant

Proc. Natl. Acad. Sci. USA
Vol. 94, pp. 4510–4515, April 1997
Evolution

Independent, specialized invasions of ectomycorrhizal mutualism by two nonphotosynthetic orchids

(mycorrhiza/ecology/symbiosis/specificity/ribosomal DNA sequences)

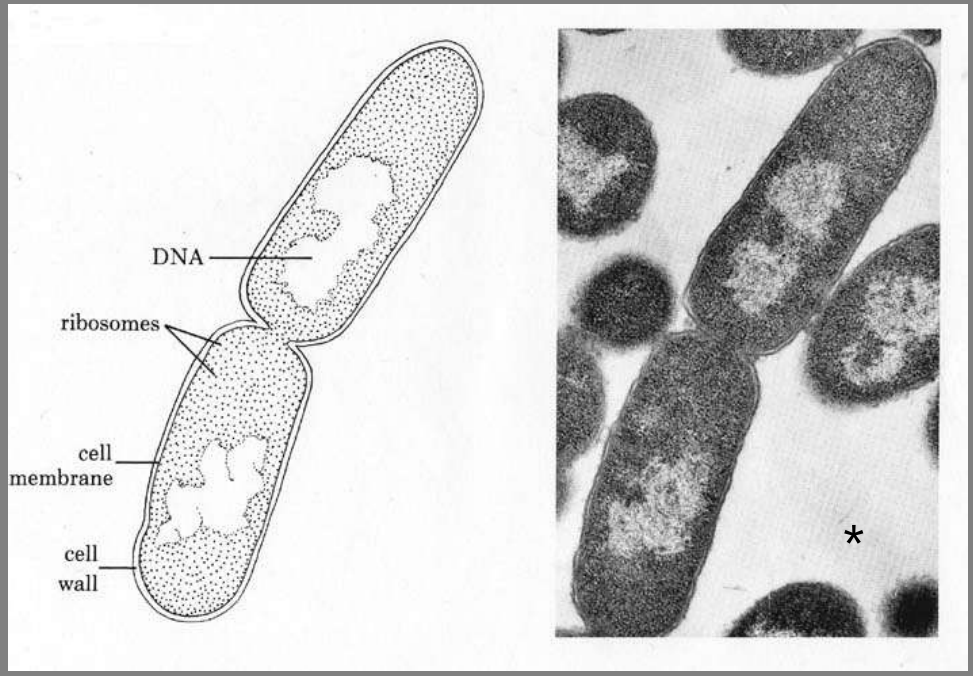
D. LEE TAYLOR* AND THOMAS D. BRUNS

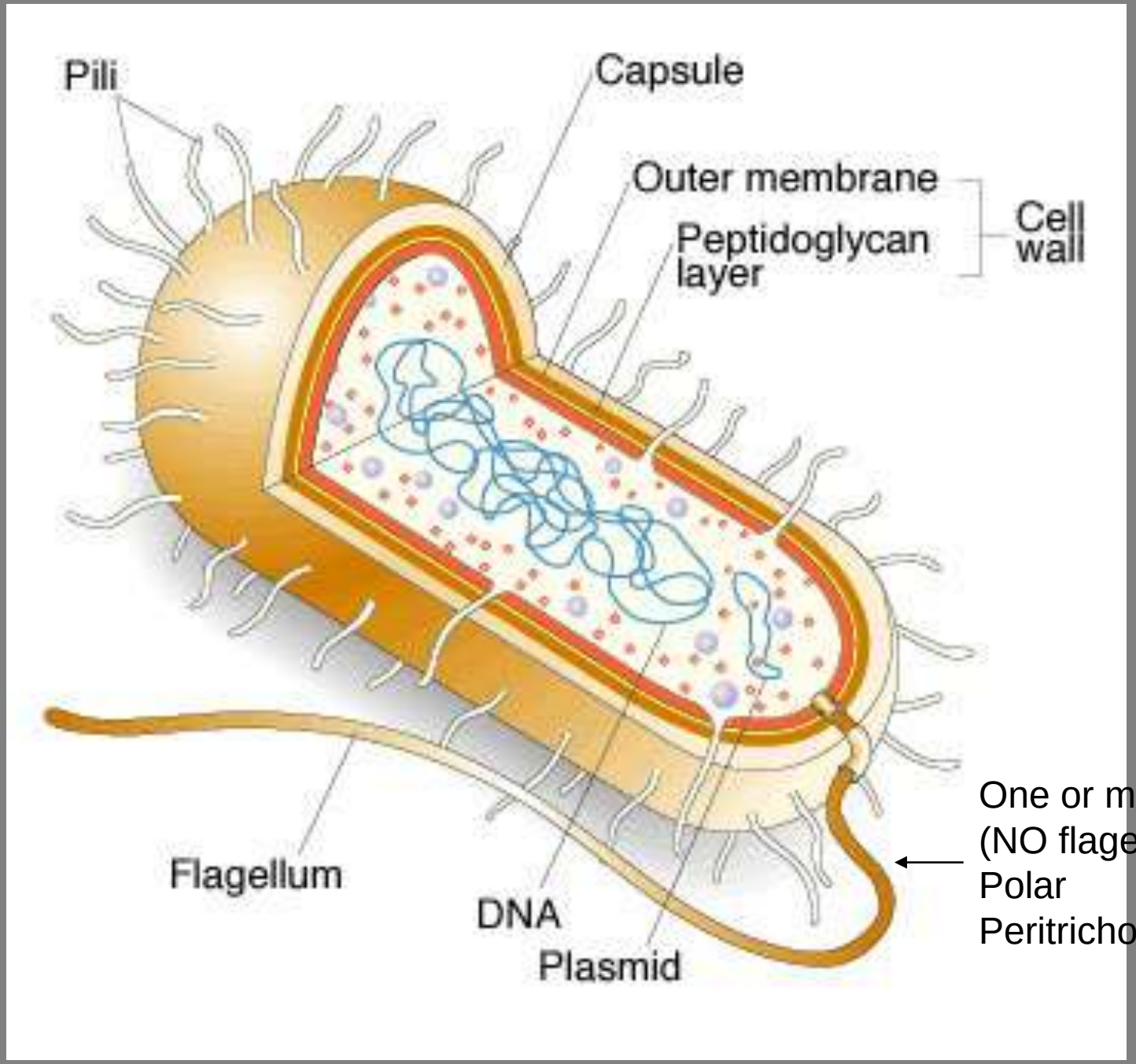
Epiparasitic plants specialized on arbuscular mycorrhizal fungi

Martin I. Bidartondo*†, Dirk Redecker†‡, Isabelle Hijri‡, Andres Wiemken‡, Thomas D. Bruns*, Laura Domínguez§, Alicia Sérsic§, Jonathan R. Leake‖ & David J. Read‖

BACTERIA

Prokaryotes
Unicellular
Variously shaped
Do not produce spores
Reproduce by binary fission




Pili
Capsule
Outer membrane
Peptidoglycan layer
Cell wall
Flagellum
DNA
Plasmid
One or more flagella
(NO flagella)
Polar
Peritrichous

Genetic elements

Chromosome (single and circular)

Plasmids

Primary mechanisms of variation

Mutations

Loss/acquisition of plasmids and transposons

Recombination through:
Transformation: incorporation in chromosome or as a plasmid of exogenous DNA
Conjugation: incorporation of DNA from another bacterium
Transduction: incorporation through bacterial viruses called bacteriophages

Bacterial Leaf Scorch
Xylella fastidiosa

Xylella fastidiosa: The early years

Anaheim vine disease

-1882

-30,000 - 40,000 acres lost

-50 wineries closed

Pierce investigated viticulture, climate, epidemiology

Vector and pathogen not known

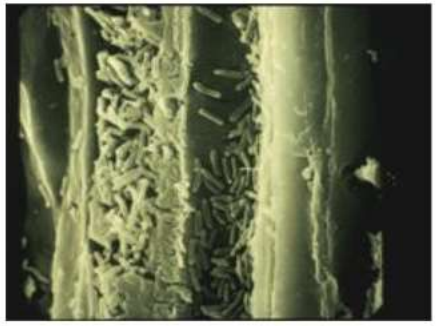
-thought to be a virus

Isolated, identified as bacterium in 1978

Xylella fastidiosa biology

Download

Xylem-limited bacterium



Wide host range
- -crops, native, ornamental, weedy plants
- -disease severity differs among hosts

Substantial genetic variation
- -host-specific strains
- -pathogenicity varies among strains

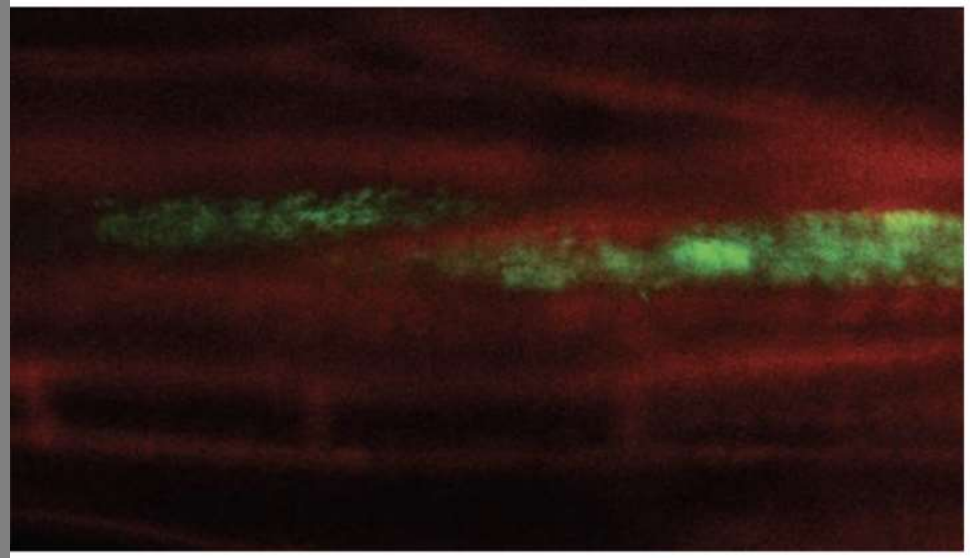
Transmitted by xylem-sap feeders
- -sharpshooters are most important vectors
- -many sources of variation

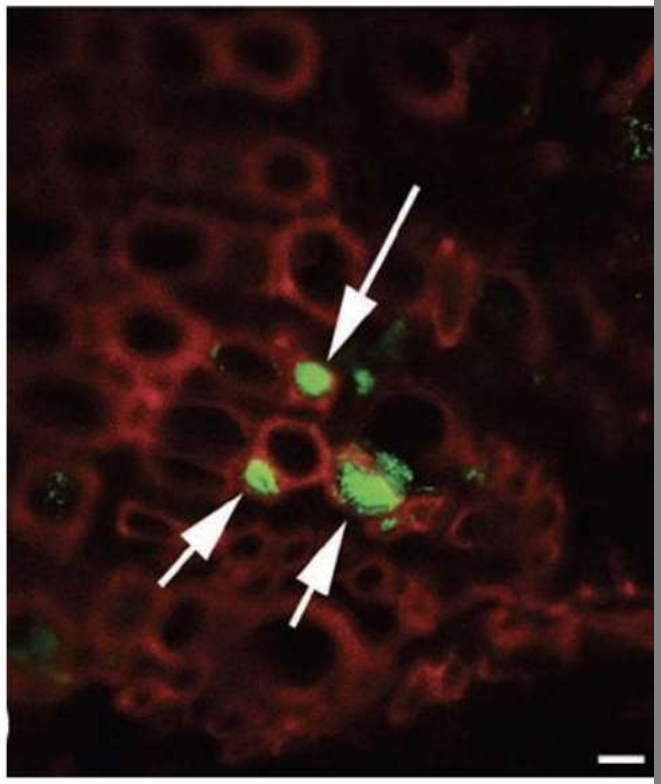
No cure

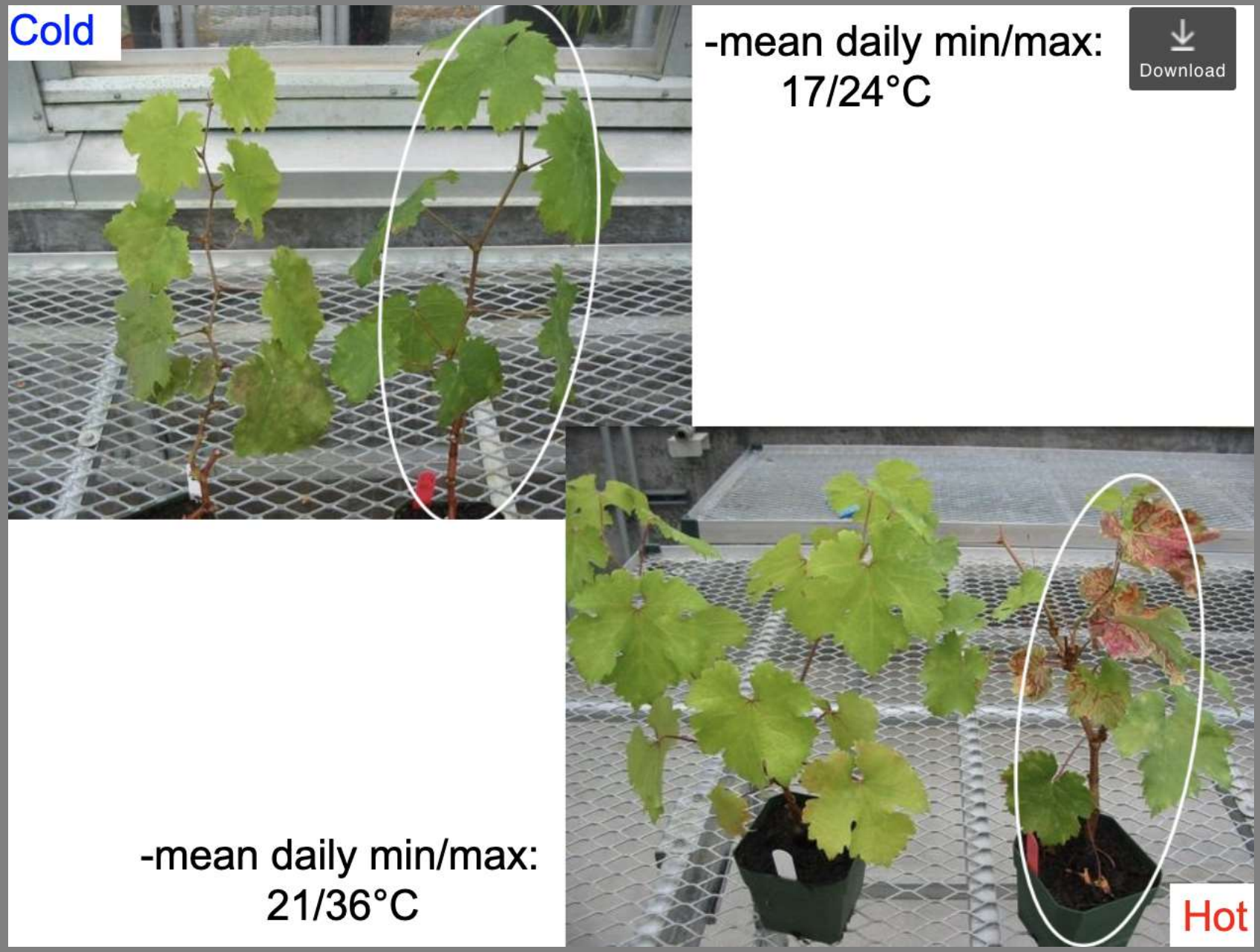
Mechanism of pathogenicity

1. Vessel occlusion
   -bacterial aggregates
   -restricted water flow
   -water stress symptoms

2. “Phytotoxin”
   -toxin not known






Cold
-mean daily min/max:
17/24°C
Download
-mean daily min/max:
21/36°C
Hot

Hosts

Scientific	Common
Acer sp.	
A. Rubrum	Red maple
A. negundo	Boxelder
A. saccharum	Sugar maple
C. florida	Flowering dogwood
C. occidentalis	Hackberry
L. stryraciflua	Sweet gum
Morus alba	Whitemulberry
Platanus sp.	
P. occidentalis	American sycamore
P. x acerifolia	London plane
Ulmus americana	American elm

Scientific	Common
Quercus sp.	
Q. velutina	Black oak
Q. incana	Bluejack oak
Q. macrocarpa	Bur oak
Q. prinus	Chestnut oak
Q. laurifolia	Laurel oak
Q. virginiana	Live oak
Q. rubra	Northern red oak
Q. palustris	Pin oak
Q. stellata	Post oak
Q. coccinea	Scarlet oak
Q. imbricaria	Shingle oak
Q. shumardii	Shumard oak
Q. falcata	Southern red oak
Q. bicolor	Swamp white oak
Q. laevis	Turkey oak
Q. nigra	Water oak
Q. alba	White oak
Q. phellos	Willow oak

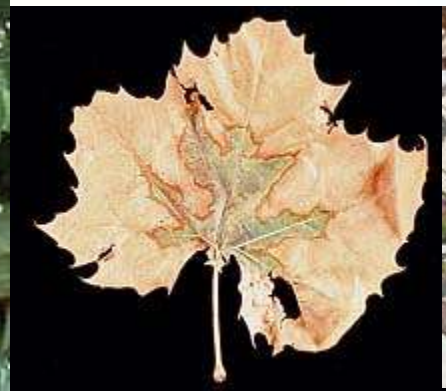
TABLE 1 | Partial list of the main plant hosts of *Xilella fastidiosa* and their *X. fastidiosa* subspecies.

Host scientific name	Type of infection	EPPOCode	Subspecies
Acacia saligna	Incidental	ACASA	*pauca*
Acer rubrum	Incidental	ACRRB	*multiplex*
Carya illinoinensis	Minor	CYAIL	*multiplex*
Citrofortunella microcarpa	Minor	CJFMI	nd
Citroncirus	Minor	1CJCG	nd
Citrus	Minor	1CIDG	*pauca, fastidiosa*
Citrus sinensis	**Major**	CIDSI	*pauca*
Coffea sp.	**Major**	COFSS	*pauca* (BRA)
Coffea sp.	**Major**	COFSS	*fastidiosa (C.Rica)*
Cyperaceae	Wild/Weed	1CYPF	nd
Fortunella	Minor	1FOLG	nd
Liquidambar styraciflua	Incidental	LIQST	*multiplex*
Medicago sativa	Minor	MEDSA	*fastidiosa*
Morus alba	Incidental	MORAL	*morus, (former multiplex, sandyi)*
Morus rubra	Incidental	MORRU	*fastidiosa*
Nerium oleander	**Major**	NEROL	*sandyi*
Olea europaea	**Major**	OLVEU	*pauca* (ITA, ARG, BRA)
Olea europaea	**Major**	OLVEU	*multiplex* (USA, FRA)
Persea americana	Incidental	PEBAM	nd
Platanus occidentalis	Minor	PLTOC	*multiplex*
Poaceae	Wild/Weed	1GRAF	nd
Polygala myrtifolia	**Major**	POGMY	*pauca* (ITA)
Polygala myrtifolia	**Major**	POGMY	*multiplex* FRA)
Poncirus trifoliata	Minor	PMITR	nd
Prunus angustifolia	Incidental	PRNAN	nd
Prunus armeniaca	Minor	PRNAR	*multiplex*
Prunus avium	Minor	PRNAV	*pauca* (ITA)
Prunus avium	Minor	PRNAV	*fastidiosa* (USA)
Prunus caroliniana	Incidental	PRNCF	*multiplex*
Prunus domestica	Minor	PRNDO	*multiplex*
Prunus dulcis	Minor	PRNDU	*multiplex-fastidiosa* (USA)
Prunus dulcis	Minor	PRNDU	*pauca* (ITA)
Prunus persica	**Major**	PRNPS	*multiplex, fastidiosa*
Prunus salicina	Minor	PRNSC	*multiplex*
Quercus palustris	Minor	QUEPA	*multiplex*
Quercus rubra	Minor	QUERU	*multiplex*
Sorghum halepense	Wild/Weed	SORHA	nd
Spartium junceum	Incidental	SPJUJ	*fastidiosa* (USA)
Spartium junceum	Incidental	SPJUJ	*multiplex* (FRA), *pauca* (ITA)
Ulmus americana	Minor	ULMAM	*multiplex*
Vaccinium corymbosum	Minor	VACCO	*multiplex*
Vaccinium virgatum	Minor	VACVG	nd
Vinca minor	Incidental	VINMI	*pauca* (ITA)
Vitis	Minor	1VITG	*fastidiosa*
Vitis labrusca	Minor	VITLA	*fastidiosa*
Vitis vinifera	**Major**	VITVI	*fastidiosa*
Westringia fruticosa	Incidental	WESRO	*pauca* (ITA)
woody plants	Wild/Weed	2WOOP	*multiplex*

Source: EPPO Global Database (https://gd.eppo.int/taxon/XYLEFA/hosts), and EFSA Journal database (EFSA, 2015). Major infections are indicated in bold.

Symptoms

- First appear in late summer /early fall
- Leaf scorching
- Limb death



Vector

- Not determined for each tree species yet
- Most likely Graphocephala, Oncometopia and Homalodisca species.

Graphocephala atropunctata

Oncometopia orbona

Homalodisca vitripennis

Distribution Maps of Plant Diseases

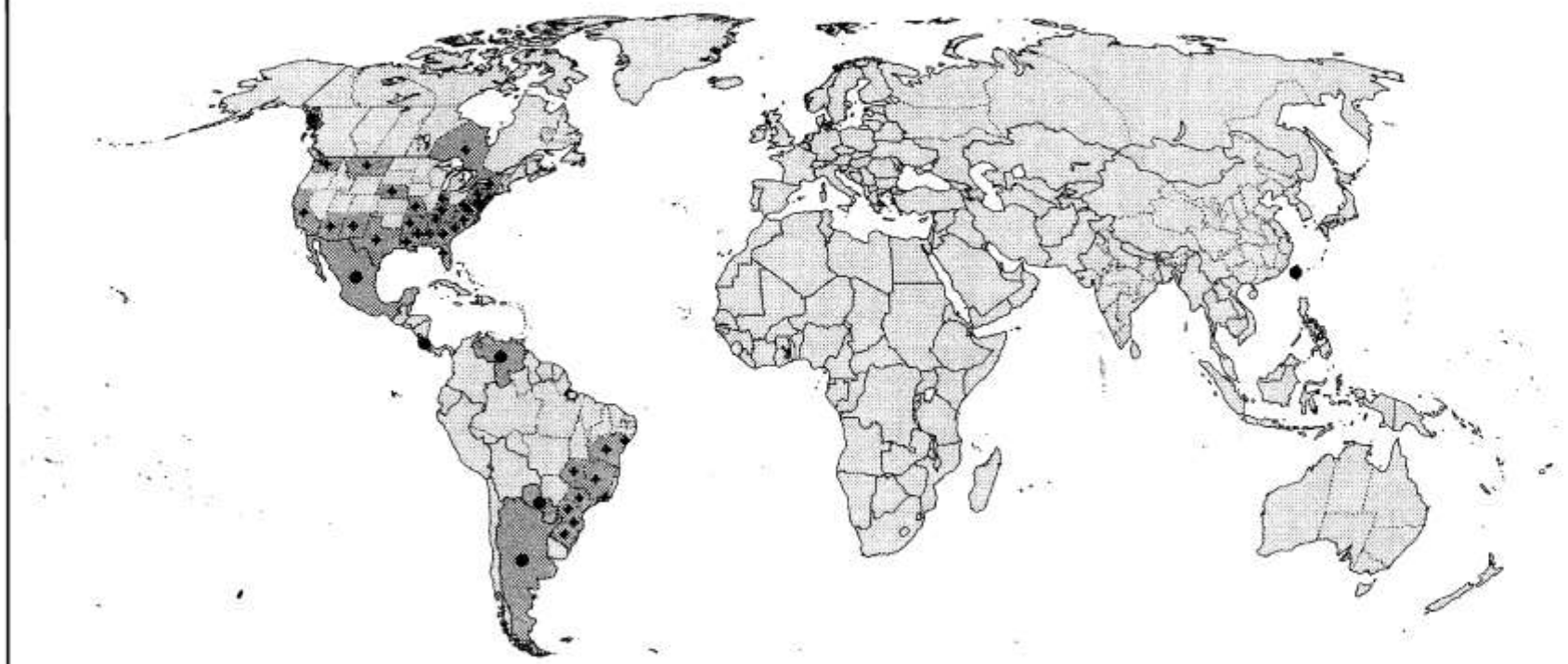
Compiled by CABI in association with EPPO

Map No. 262 **Edition 5** **Issued April 2006**

Xylella fastidiosa Wells et al.

Bacteria

Hosts: Grapevine (Vitis vinifera and others), peach (Prunus persica), Citrus, almond (Prunus dulcis), lucerne (Medicago sativa), some wild trees (incl. Acer rubrum, Platanus occidentalis, Quercus rubra, Ulmus americana), other wild plants and weeds.



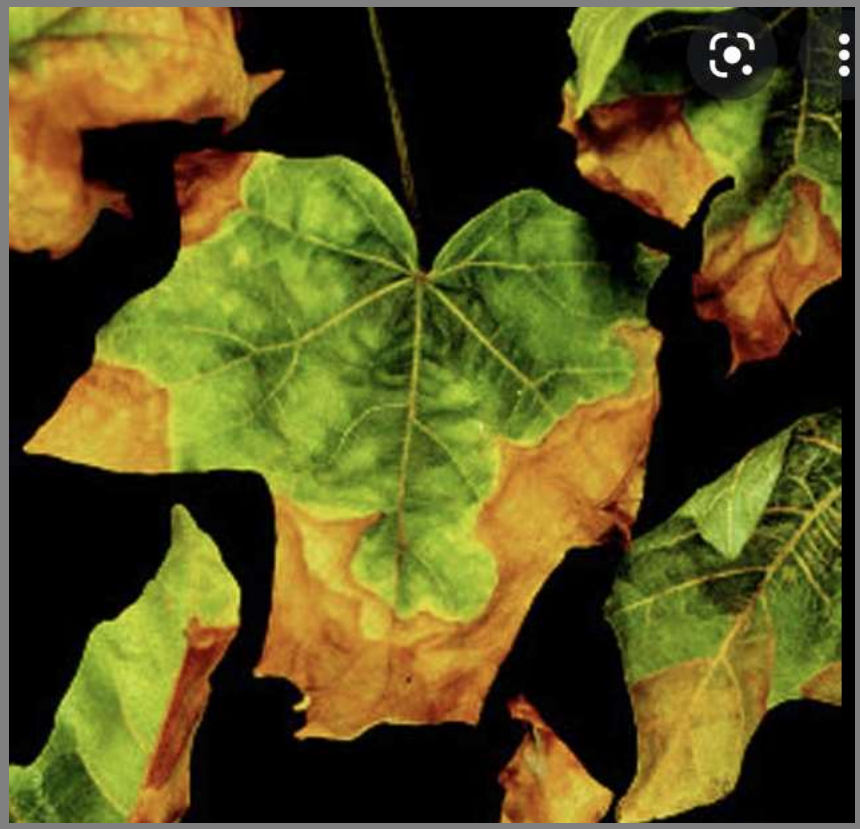
● Present: national record

+ Present: subnational record

CABI/EPPO (2006) Xylella fastidiosa. Distribution Maps of Plant Diseases No. 262.
CABI Head Office, Wallingford, UK.

ISSN 0012-396X

Major problem on maples in Pacific Northwest including Northern California



Phytoplasmas

Prokaryotes lacking a cell wall (MLOs - *Mollicutes*)

Usually vascular pathogens

Generally vectored by piercing insects

VIRUSES and VIROIDS

Submicroscopic parricles always intracellular when in the host, infectious and pathogenic

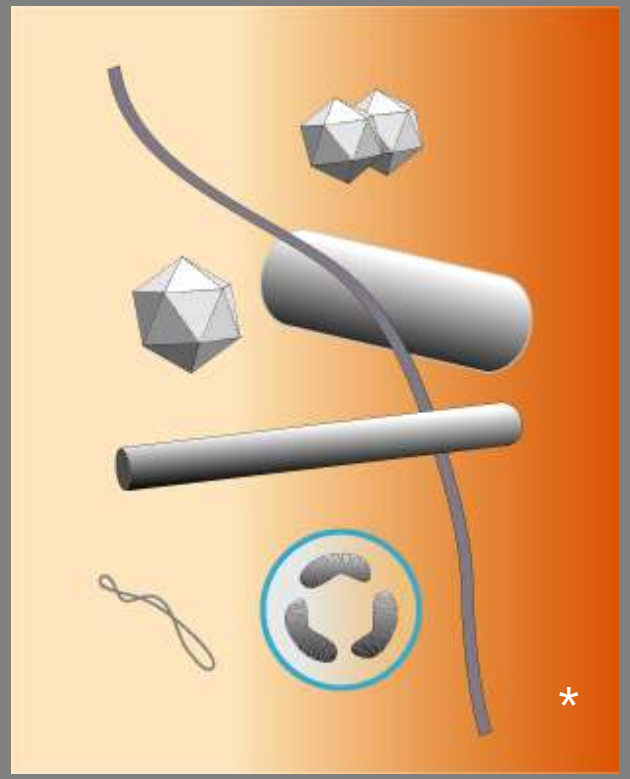
They comprise

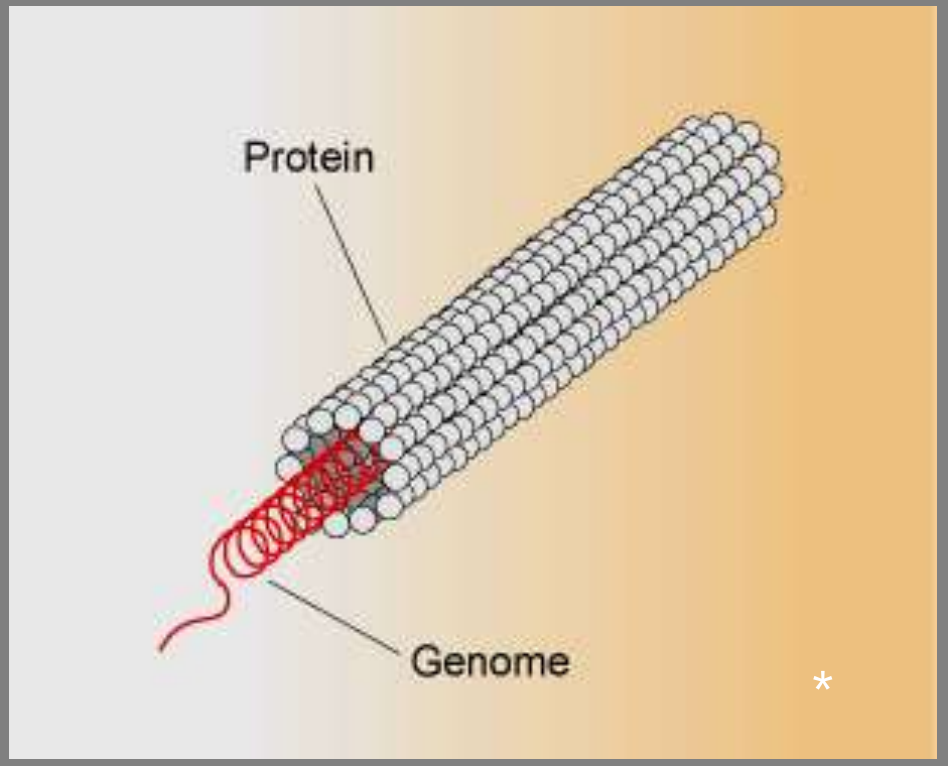
Nucleic Acids (RNA or DNA) and a capsid protein

Viroids instead are simply constituted by a single RNA molecule, they do not code for or possess proteins

Nucleic acid: ssRNA, dsRNA, ssDNA, dsDNA

Protein capsid: protects virus during transport





VIRAL REPLICATION

The genome of the virus codes for:

1- capsid protein;

2- polymerase;

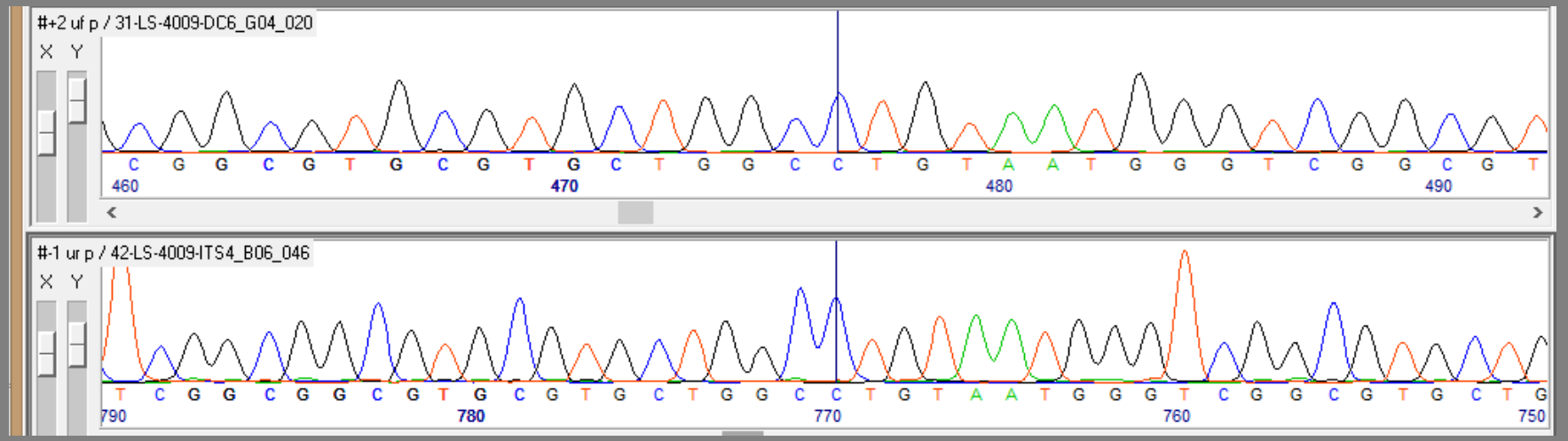
3- protein for intracellular movement;

4- proteins involved in transmission and relationship with vectors

How does a virus code for all of the necessary proteins in such a small structure?

1- One virus may require multiple particles to successfully infect a host. Each particle codes for different genes

2- Same DNA or RNA strand, but coding is staggered, i.e. transcription starts at differnt points, thus one strand can code for multiple genes



Gene a

Gene b

Some examples of bacteria, phytoplasmas and viruses present in forests

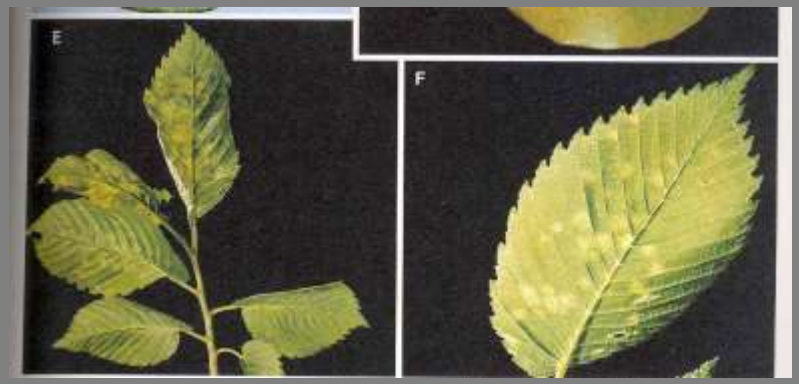
- Bacterial leaf scorch: *Xylella fastidiosa*
- Crown Gall: *Agrobacterium tumefaciens*
- Ash and elm yellows: Ca. *Phytoplasma alni* and *P. ulmi*
- Bacterial wetwood *(Enterobacter, Klebsiella, Erwinia and Pseudomonas)*
- *Poplar mosaic virus, poplar potyvirus*
- *Cherry leaf roll virus* (elms, dogwood)
- *Tobacco Mosaic Virus (tanoak, oaks alders)*

A. tumefaciens

Elm yellows

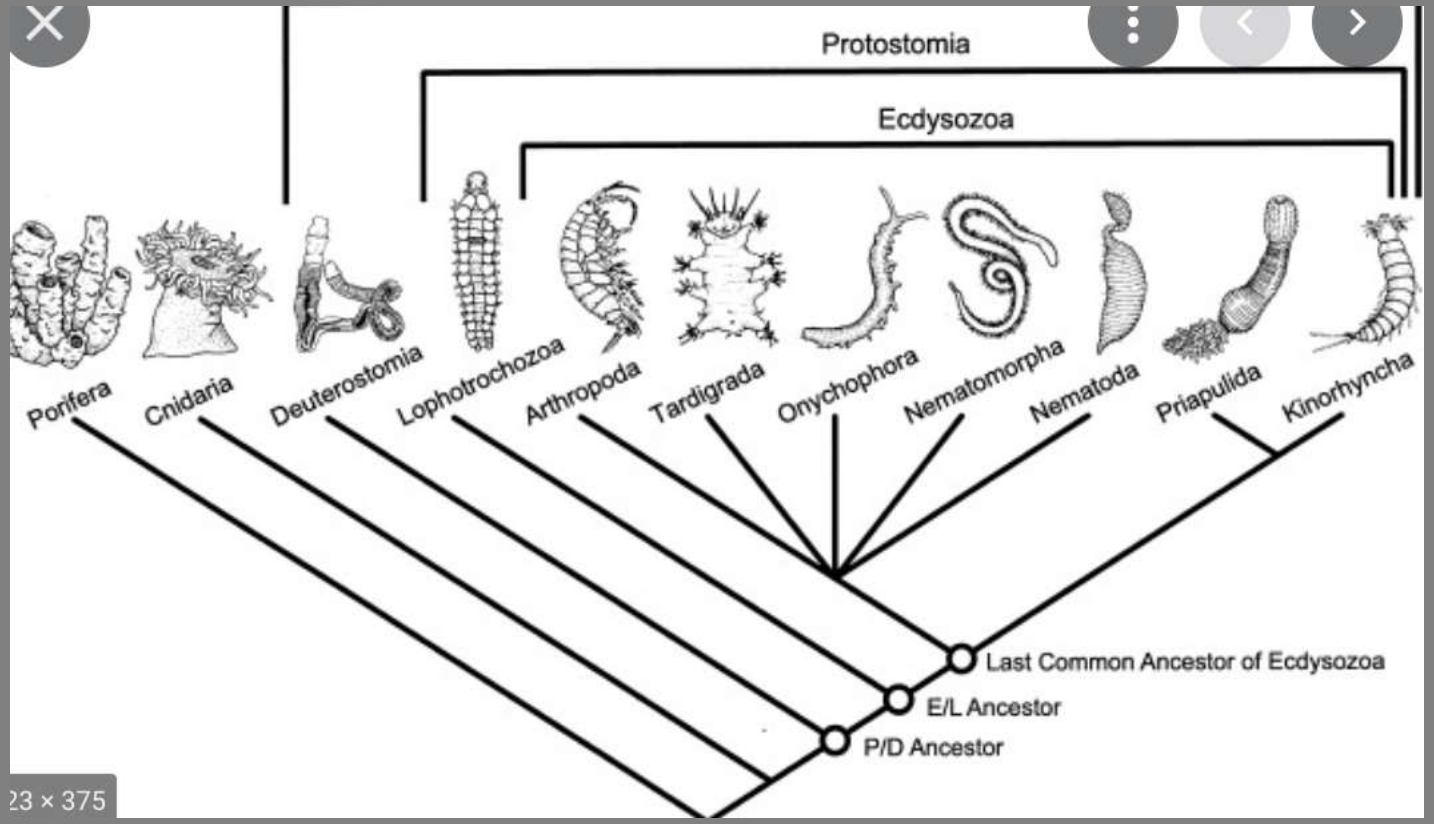
Ash yellows

Bacterial wetwood



Cherry Leaf Roll virus

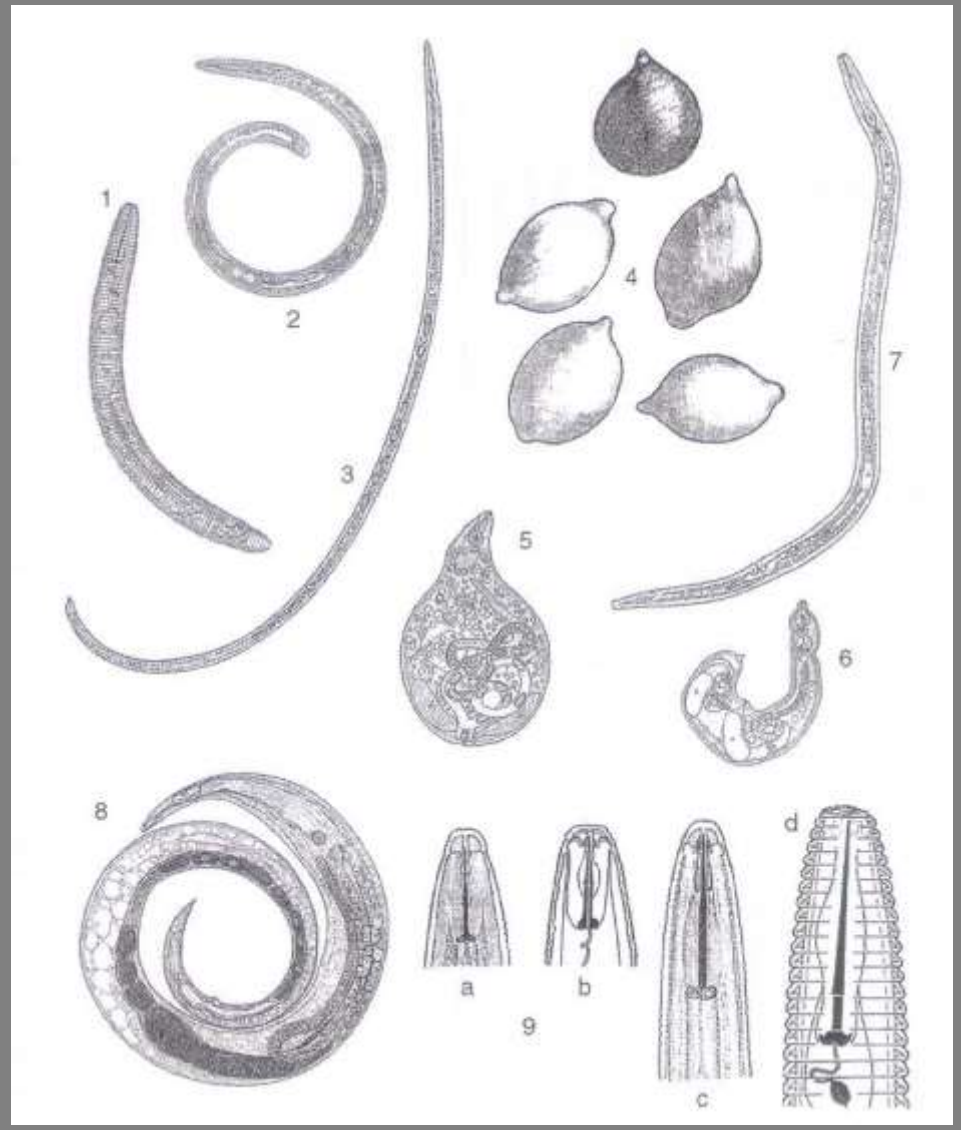
NEMATODES



Very common soil and root pathogens

Can also colonize xylem vessels: Pine Wood Nematode

NEMATODES



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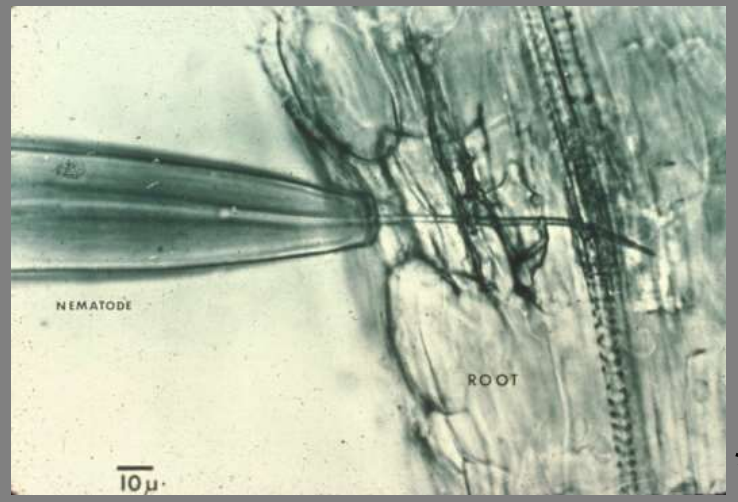

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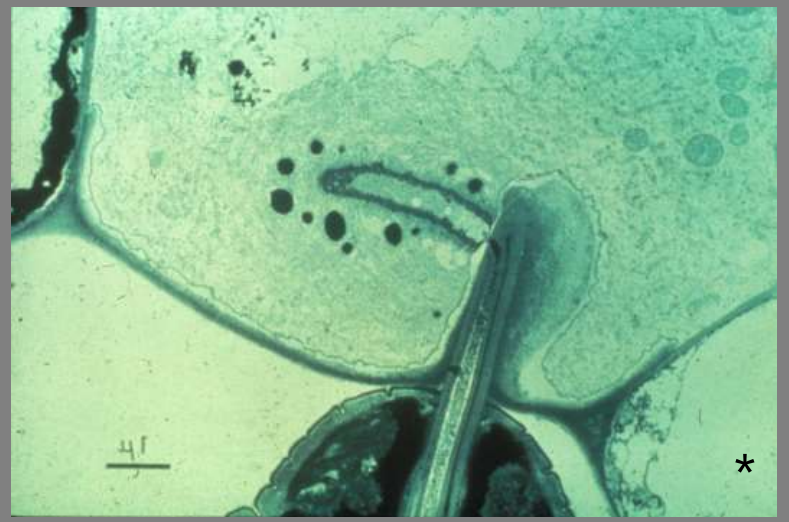

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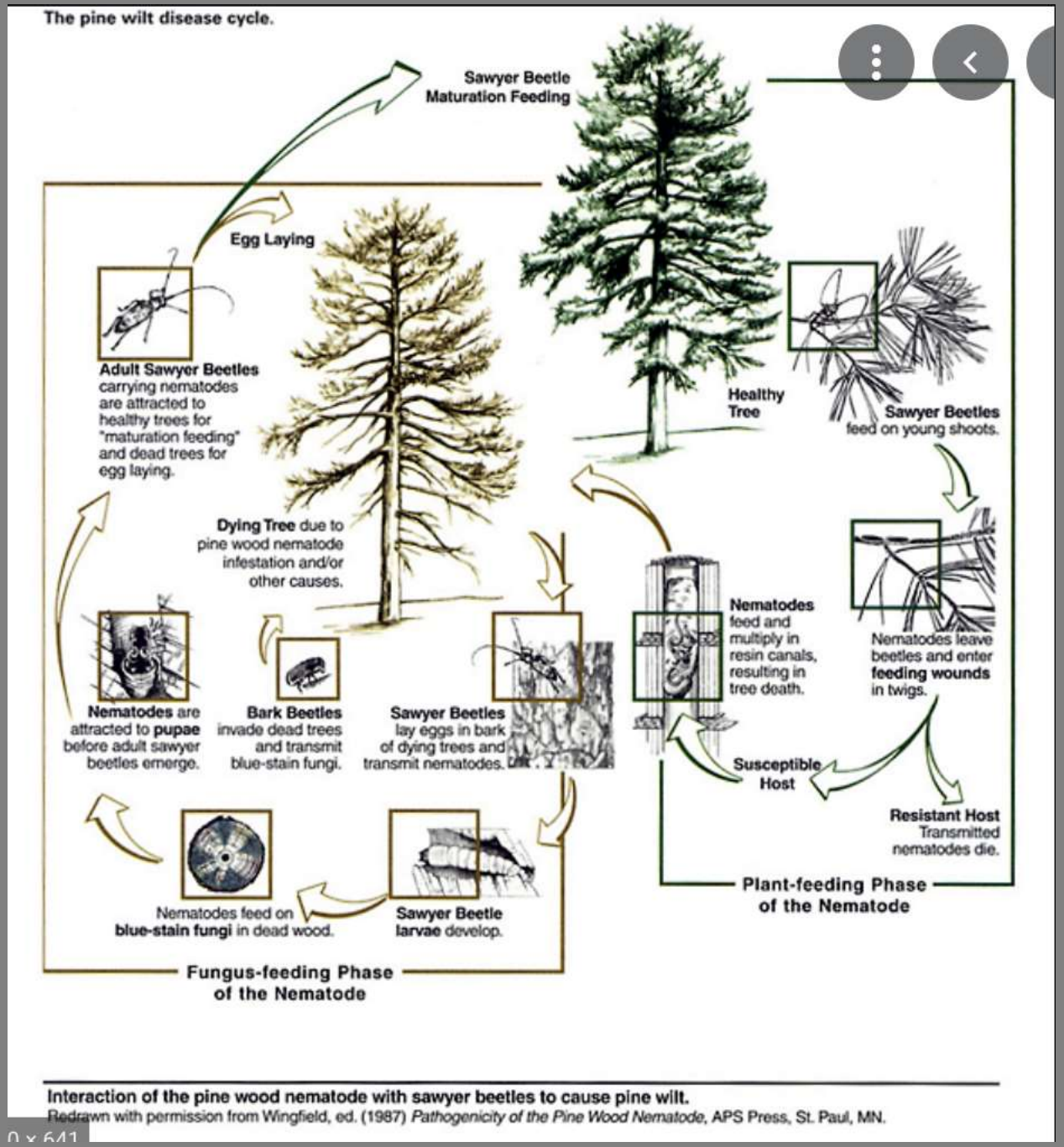

Interaction of the pine wood nematode with sawyer beetles to cause pine wilt.
Redrawn with permission from Wingfield, ed. (1987) *Pathogenicity of the Pine Wood Nematode*, APS Press, St. Paul, MN.

0 x 641

Nematode
Bursaphelenchus xylophylus

Longhorn beetles
Genus *Monochamus*

Bark beetles (Ips, Dendroctonus)
Fungi: Blue Stain Fungi Ceratocystis

Native to North America
Introduced in East Asia and Iberian Peninsula


UGA1442032

Fungi

- Eukaryotic organisms, heterotrophs, characterized by chitin and B-glucans in the cell wall, feeding through absorption, reproducing by spores and producing a vegetative structure made up of tubular structures, branched, irregular, and indefinite in growth (modified from B. Kendric 1992)