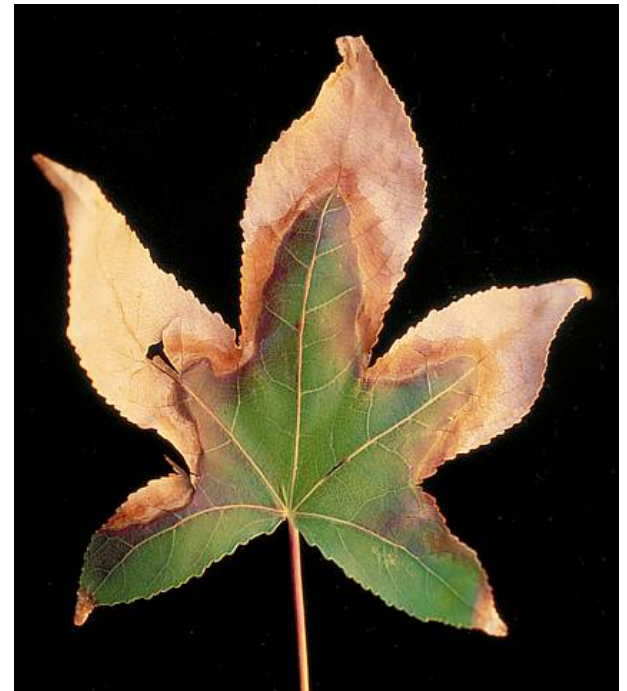


ABCs of Plant Pathology



UC Nursery and Floriculture Alliance



**Presented
by**

**Jim Downer
Maria de la Fuente**



**Prepared
by**

**Steve Tjosvold
Maria de la Fuente
Deborah Mathews
Jim Downer**



Overview

- Introduction to the principles of plant pathology
- Pathogen types and major diseases
- Emerging diseases
- Management strategies



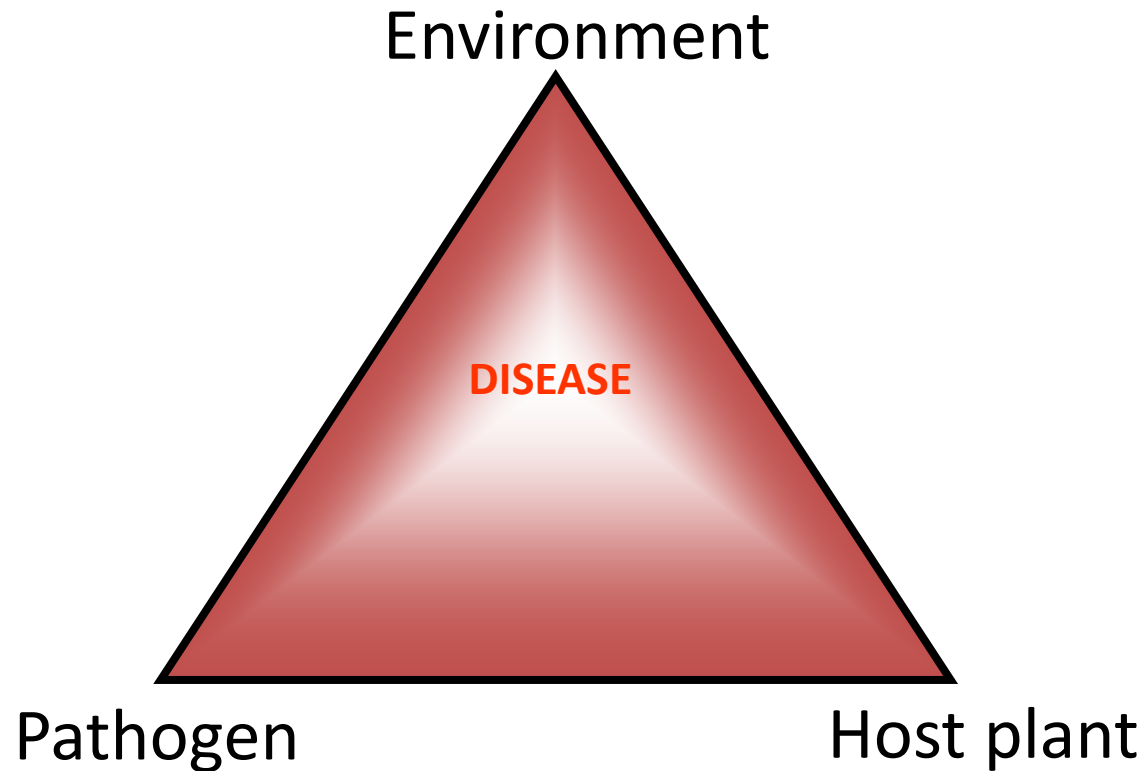
Plant Pathology

- Pathology = study of disease
- Disease = Progressive malfunction
- Can be caused by biotic or abiotic factors



Foundation of Plant Pathology

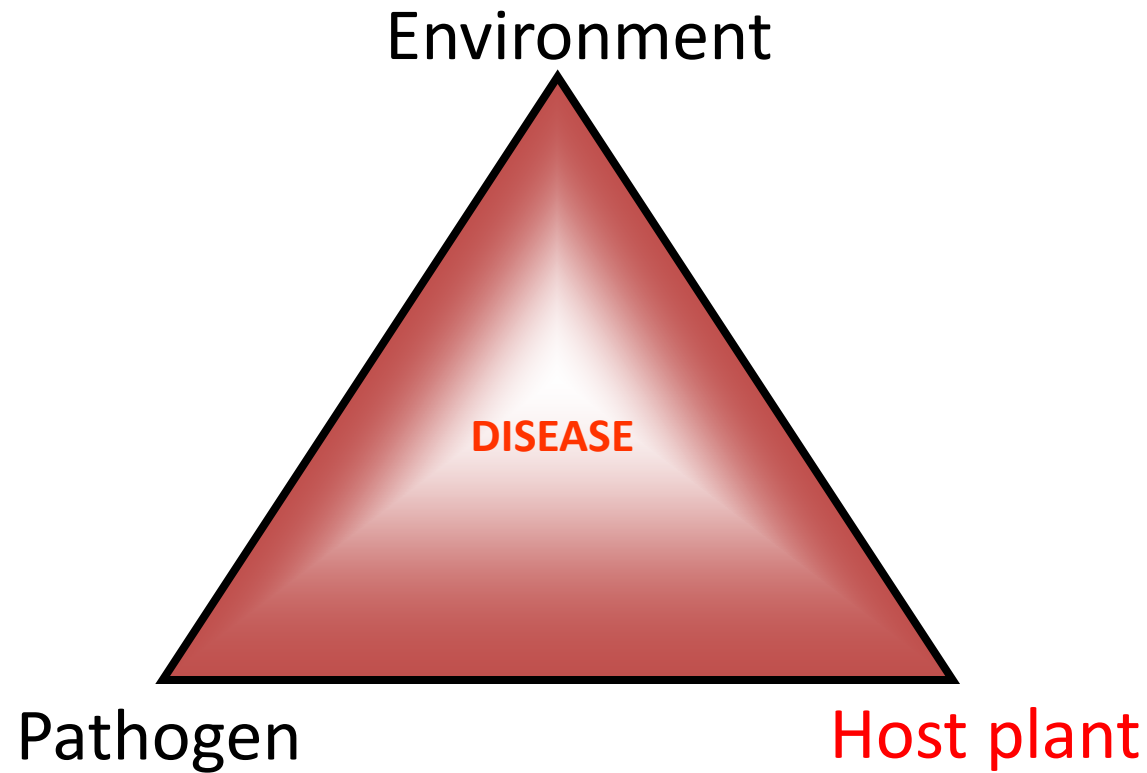
The Disease Triangle



Plant diseases- their occurrence and severity- result from the interactions among the host plant, pathogen, and environment



Disease Triangle





The Disease Triangle: Host Plants

- Anatomy (plant tissues and organs)
- Life cycles (seed, seedling, vegetative, flowering, fruiting)
- Physiology (physical and chemical defenses)
- Genetics
 - Resistant
 - Tolerant
 - Susceptible



Host Plant Symptoms

- How a host plant reacts to the pathogen.
- Will be useful for identification of disease.
- Symptoms fall into 4 categories:



Host Plant Symptoms

- Change of Color: **Chlorosis**
- Cell or Tissue Death: **Necrosis**
- Water Imbalance: **Wilt**
- **Abnormal Growth:**
 - Hypertrophy or hyperplasia: Galls
 - Hypotrophy or hypoplasia: Stunting

Host Plant Symptoms

Change of Color: Chlorosis



Erwinia crown rot
on Primula



Host Plant Symptoms

Cell or Tissue Death: Necrosis



Foliar nematode
on Anemone



Host Plant Symptoms

Cell or Tissue Death: Necrosis



Damping-off disease
of Alfalfa seedlings



Host Plant Symptoms

Cell or Tissue Death: Necrosis



Cytospora Canker on
Corkscrew Willow,
Salix matsudana

Host Plant Symptoms

Water Imbalance: Wilt



Eustoma infected with
Verticillium sp.



Host Plant Symptoms

Abnormal Growth: Galls



Crown Gall on rose caused by
Agrobacterium tumefaciens



Host Plant Symptoms

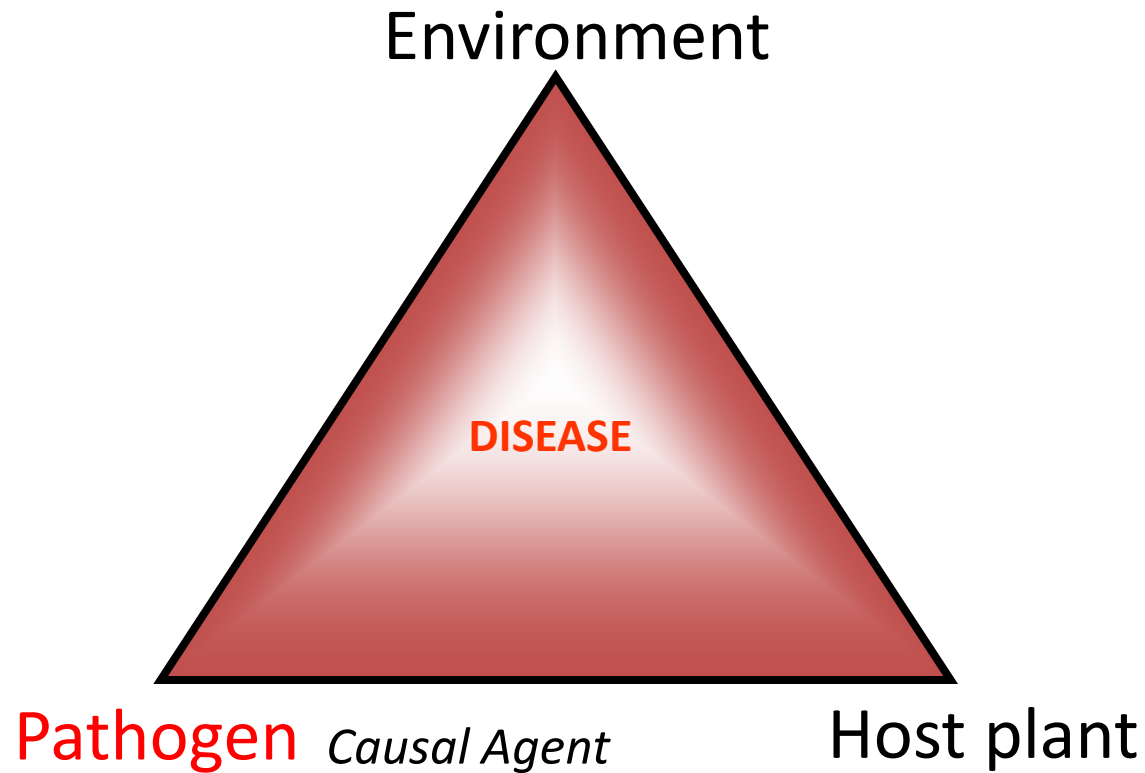
Abnormal Growth: Stunting



Chrysanthemum infected
by *Fusarium oxysporum*



Disease Triangle





The Disease Triangle

- **Pathogens**
 - Living parasites such as fungi, bacteria, virus, and nematodes.
 - Infectious and spread
- **Abiotic factors** (cause “Disorders”)
 - Nonliving factors causing physiological malfunctions or damage such as from drought, frost, nutrient deficiency, excessive salts, herbicides, air pollution.
 - Non-infectious and do not spread

Abiotic Factors

Nutrient Deficiencies



Abiotic Factors

Air Pollutants



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Chlorosis on this mother fern (*Asplenium bulbiferum*) was caused by chronic ozone exposure.

Necrosis on orchid (right) caused by ozone exposure.

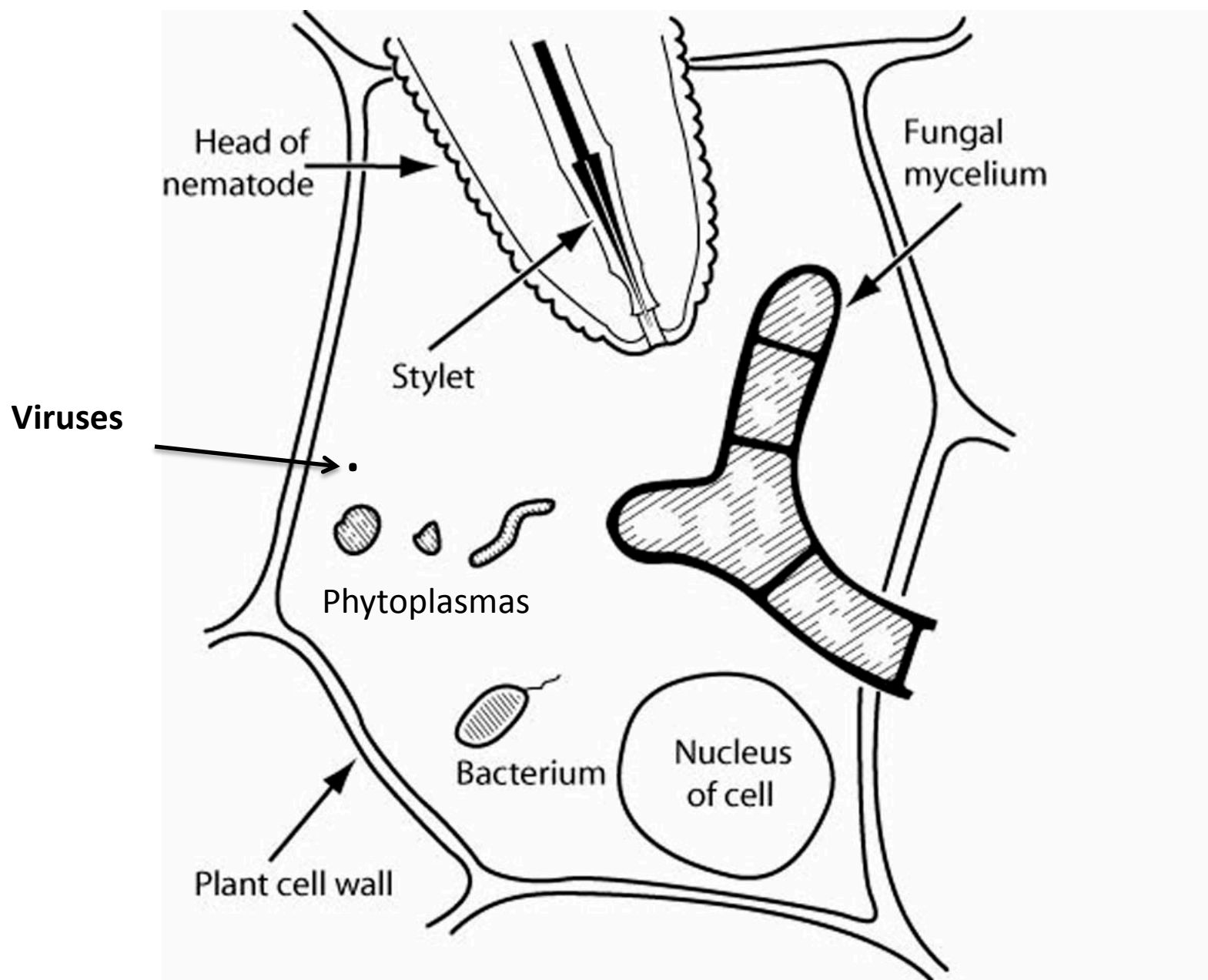


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Pathogens

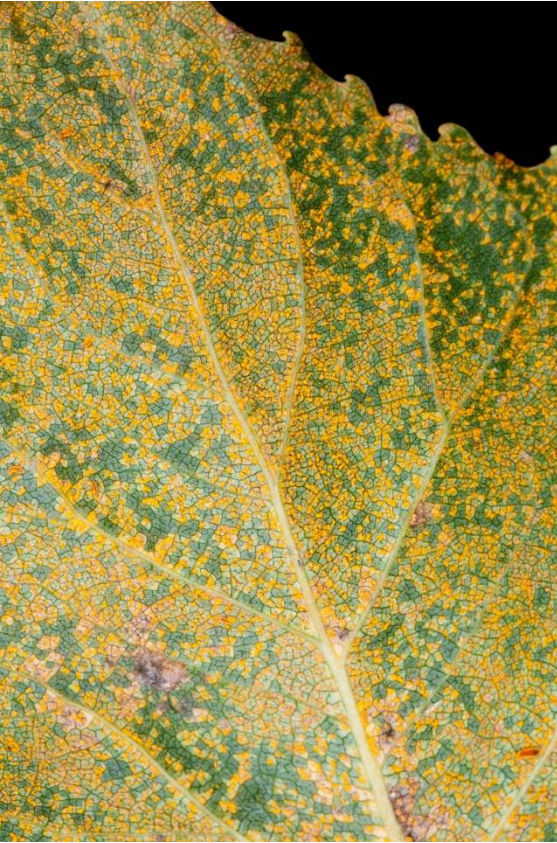
- Fungi
- Bacteria
- Viruses
- Nematodes



Shapes and sizes of pathogens relative to a plant cell.



Pathogen: Obligate parasites Saprophytes



Poplar rust



Penstemon rust



Euphorbia rust

Pathogen: Facultative Parasites/Saprophytes



Botrytis on larkspur

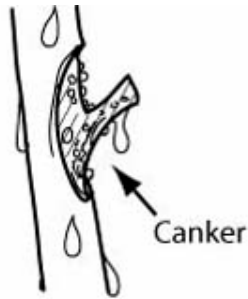


Botrytis on statice

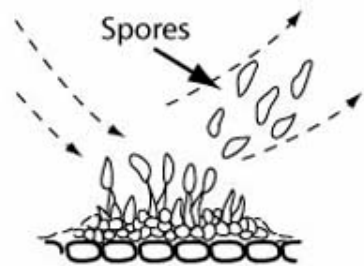


Botrytis on poinsettia

Pathogen movement



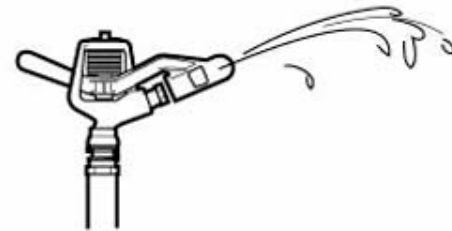
Water splashing



Wind and
wind-blown rain



Insects



Irrigation runoff



Contaminated
seeds



Infected
transplants



Soil and debris
on boots/shoes

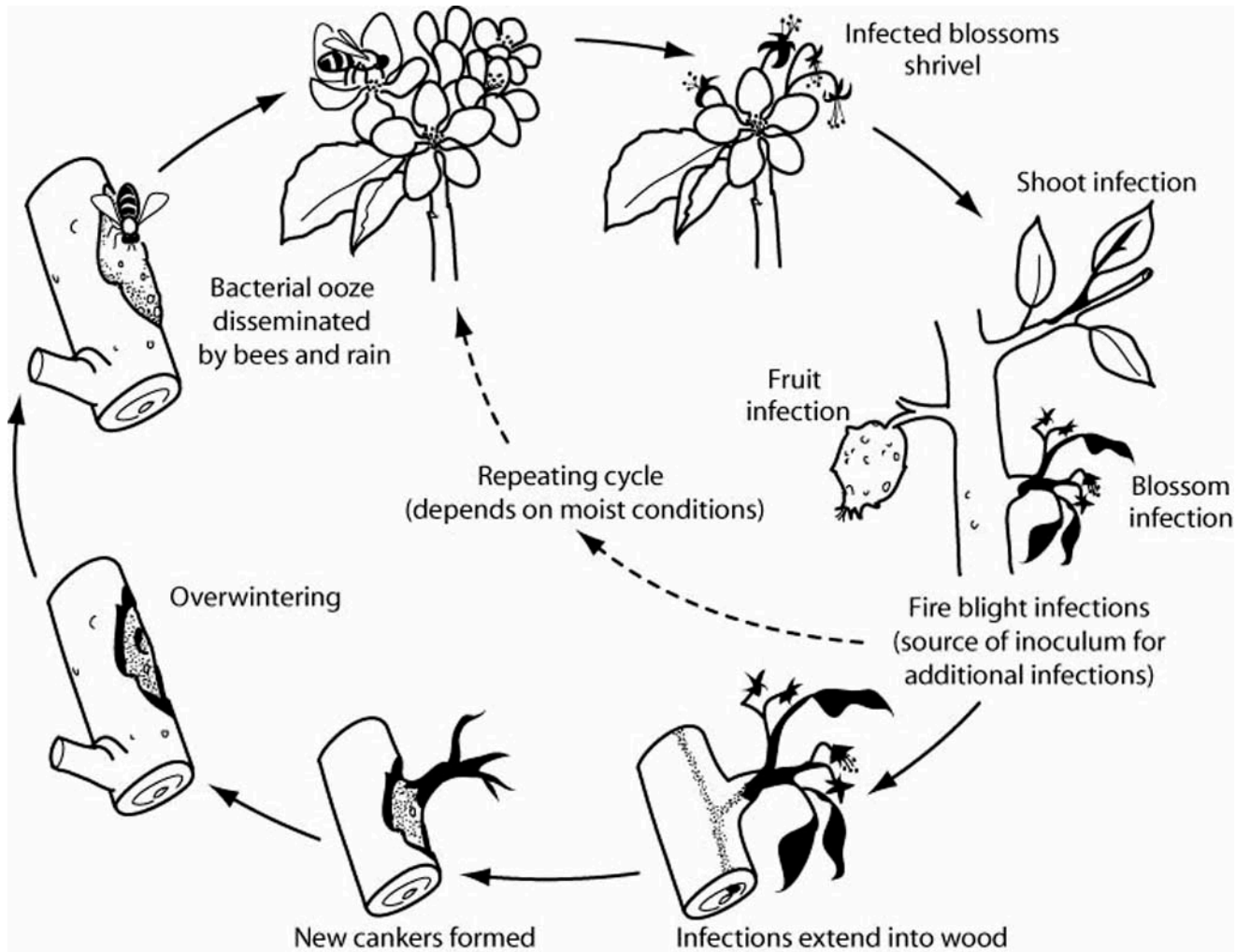


Tools and
equipment



Infected plant debris
left in garden

Disease Cycle



Fireblight on pear and apple caused by the bacterium *Erwinia amylovora*



Pathogen: Signs

- Signs: structures or products of a pathogen in or on the diseased plant.
- The signs can help diagnose the cause of the disease.



Pathogen: Signs

Fungal mycelium
and spores



Rose powdery mildew



Pathogen: Signs

Fungal
sclerotia
and
mycelia

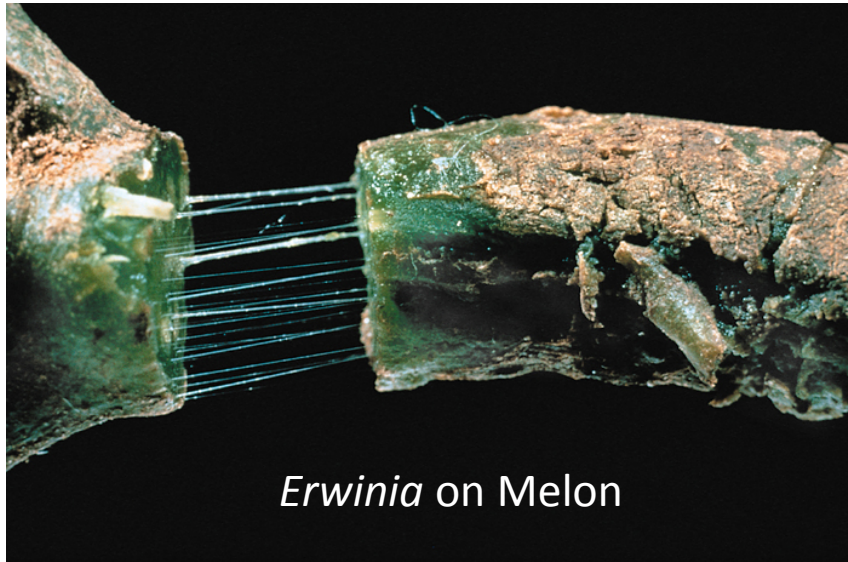


Dahlia Stem Rot, *Sclerotinia sclerotiorum*



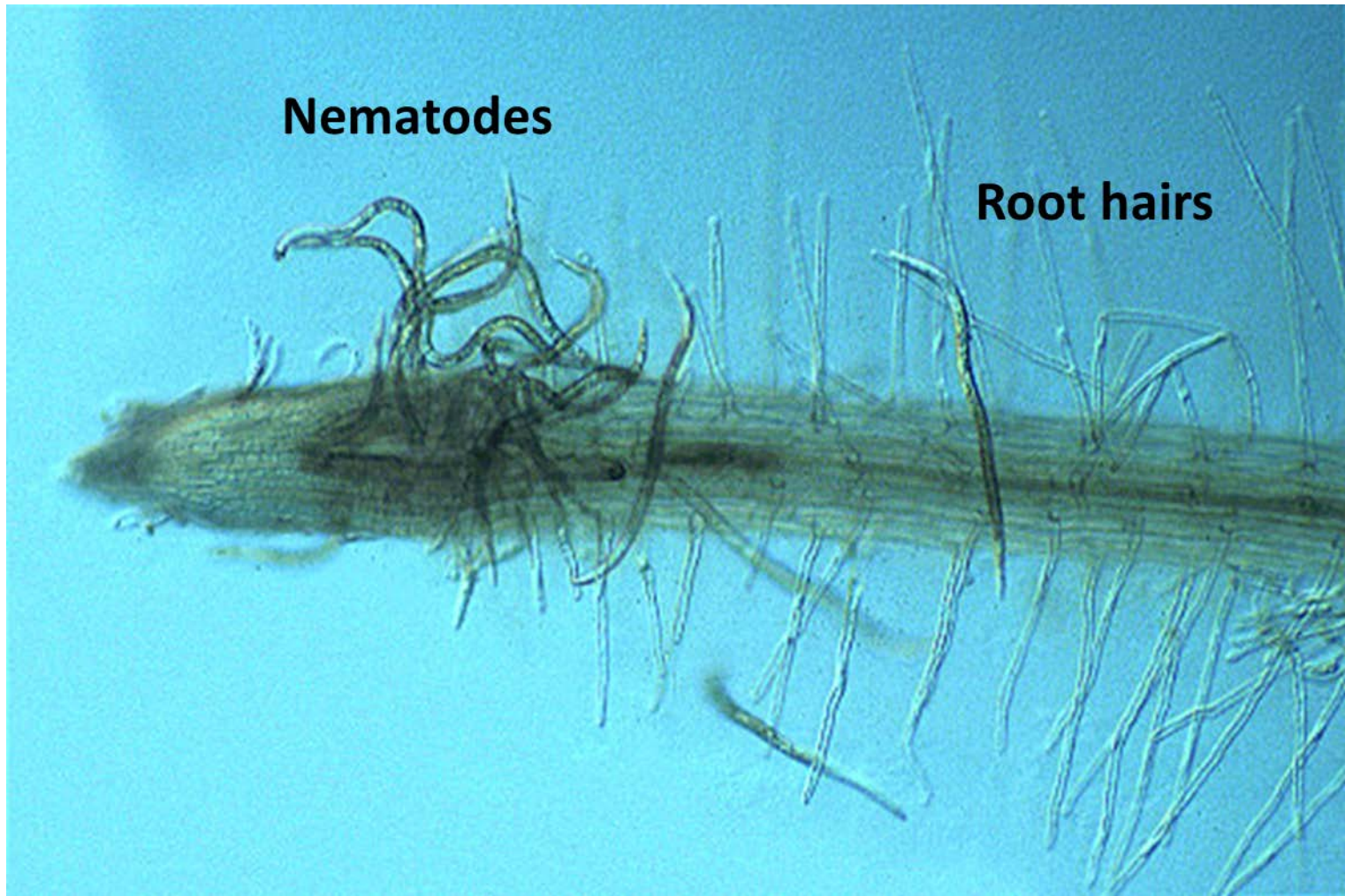
Pathogen: Signs

Bacterial exudates



Bacterial Ooze

Pathogen: Signs



Fungi

- Composed of hyphae as basic structure, masses are called mycelium.
- 300,000 species of fungi known
- 78,000 unique fungus-host combinations in US alone



Armillaria mellea



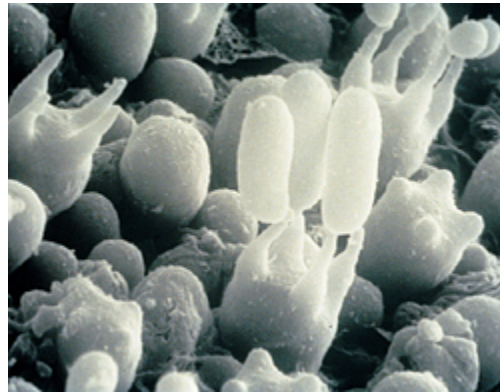
Sclerotinia sclerotiorum on Petunia

Fungi

- Many types of spores, asexual, sexual, and for survival/resistance



**Conidia masses on fruit
(asexual spore)**



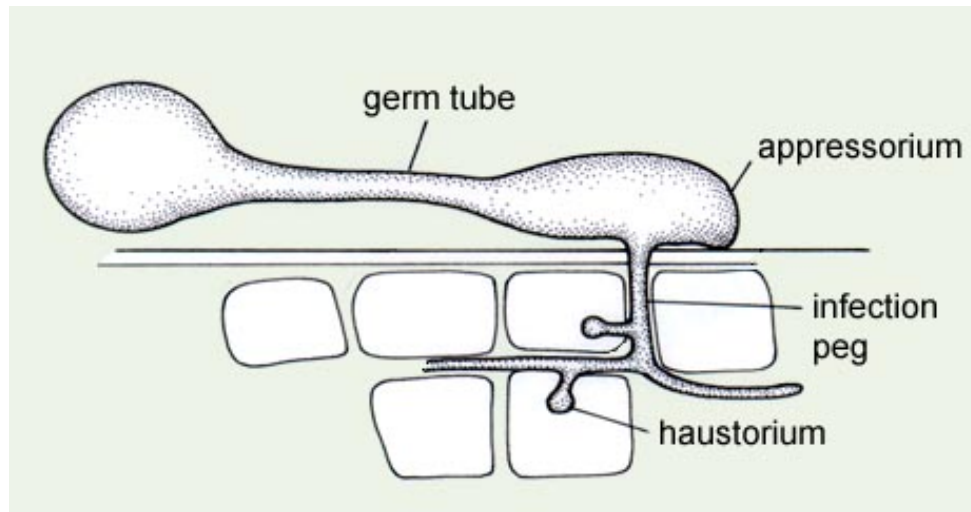
**Basidiospores
(sexual spore of
mushrooms)**

**Conidia on conidiophore
(asexual spore)**



Fungi

- Enter plant through direct penetration using specialized structures, or through stomates, hydathodes, and wounds.



Vascular Wilts

Caused by Fungi



Fusarium oxysporum f. sp. cyclaminis

Verticillium Wilt
on *Eustoma*



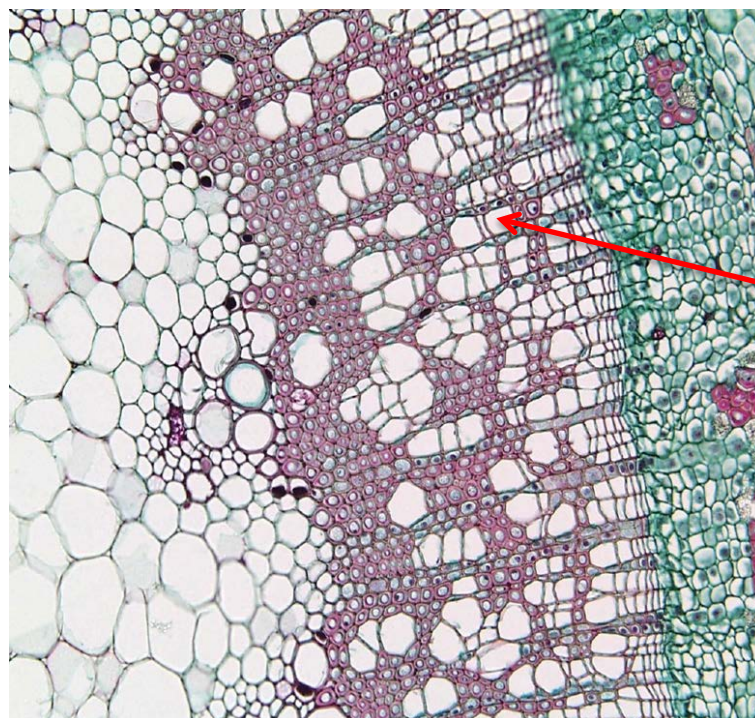
Vascular wilts caused by fungi

- Very common diseases, many hosts, and specific.
- Some can be good saprophytes.



Fusarium oxysporum f. sp. cyclaminis

Verticillium wilt on Stock



**Vessels that
conduct water**

Vascular wilts caused by fungi

- Prefer warm air and soil (75-86 °F)
- Move mainly by water, tools, infected soil, propagation of cuttings
- Resting spores can survive for years in soil



Fusarium oxysporum
in Freesia

Root Rots



***Fusarium* Root Rot of Bean**



***Pythium* on Asiatic lily (right),
healthy plant (left)**

Root Rots



Pythium Root Rot

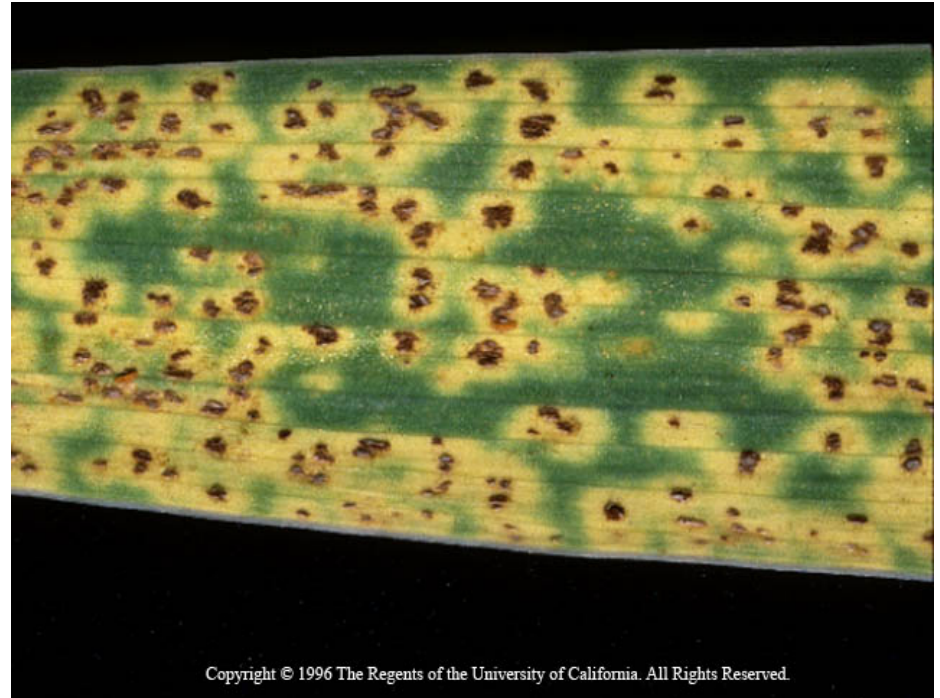
Damping off



Leaf spots caused by fungi



***Entomosporium* leaf spot on evergreen Pear**



***Didymellina* leaf spot on bearded Iris**



Leaf Spots

***Entomosporium* leaf Spot
on *Raphiolepis***



***Phyllosticta* leaf spot
on Calla Lily**

Cankers caused by fungi

***Botryosphaeria* Canker in Ficus**



***Thousand
Cankers
disease in
Walnut***

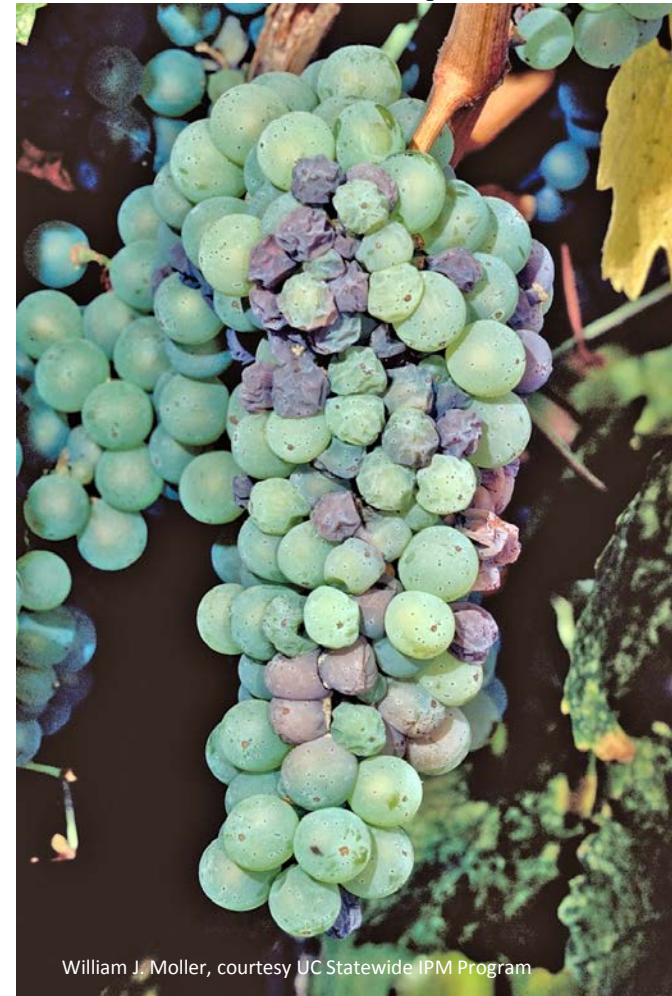
**Basal *Phytophthora*
canker in Kentia Palm**

Fruit Decay caused by fungi

Fruit rot on Orange



Botrytis Bunch Rot
on Grapes



Fungus : *Botrytis cinerea*

Often called gray mold



Pomegranate

Strawberry



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Fungus : *Botrytis cinerea*

Gray mold is one of the most Important diseases of greenhouse crops



**Crown Rot of
Calceolaria**



Fungus : *Botrytis cinerea*

Gray Mold



Botrytis on flowers





Fungus : *Botrytis cinerea*

- Weak as pathogen, very opportunistic
- Requires cool moist conditions to thrive
- Can germinate and infect within 6 hours
- Can survive from 28-90°F, prefers 70-77 °F



Botrytis spores on stalks



Botrytis on larkspur cutflowers



Powdery Mildews caused by fungi



Erysiphe euphorbiae on Poinsettia



Euonymous

Characterized by white mycelium
mainly on upper surface of leaves

Fungi : Powdery Mildews

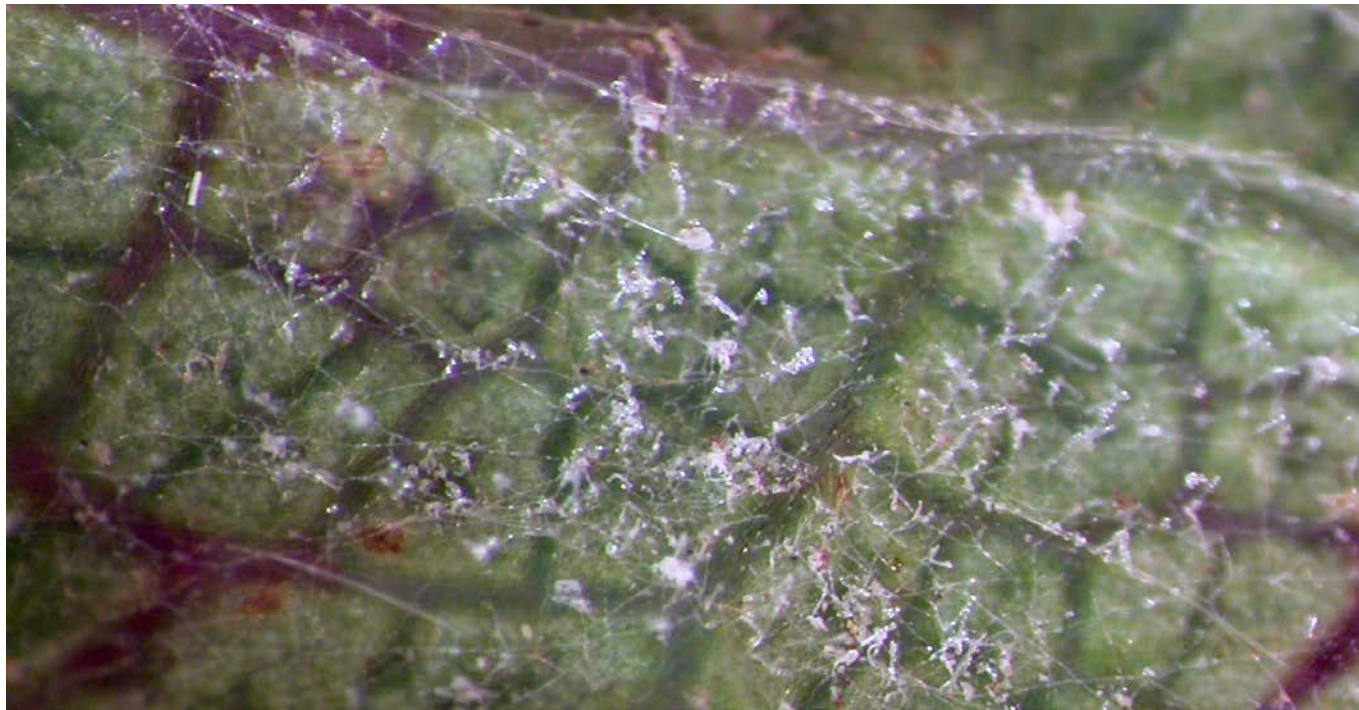
Obligate biotrophic parasites. Many with wide host ranges.

Erysiphe lagerstroemiae
on Crape Myrtle



Fungi : Powdery Mildews

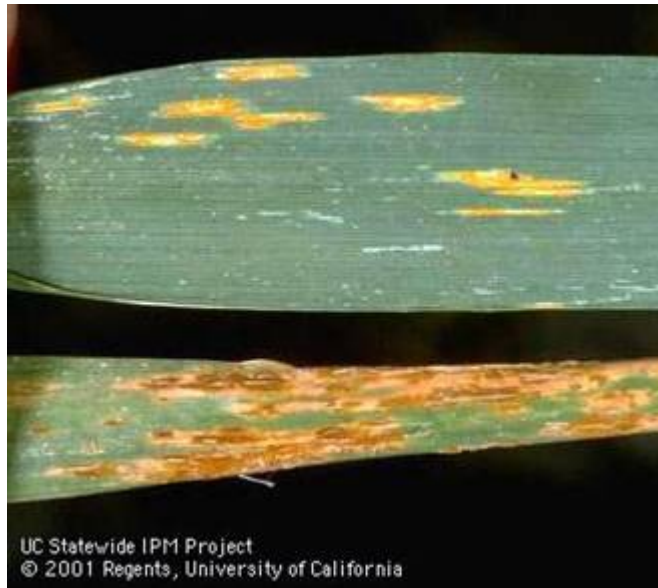
- Prefer warm days and cool nights (68-86 °F)
- Water not required for spore germination
- Some need high RH (98%), others do not
- Thrives in Greenhouses and California



Podosphaeria aphanis
on strawberry leaf

Rusts caused by fungi

- Form pustules with orange spores on leaves, stems
- Generally host specific; may have alternate host



***Puccinia* spp. on grasses**



Rust on rose leaf

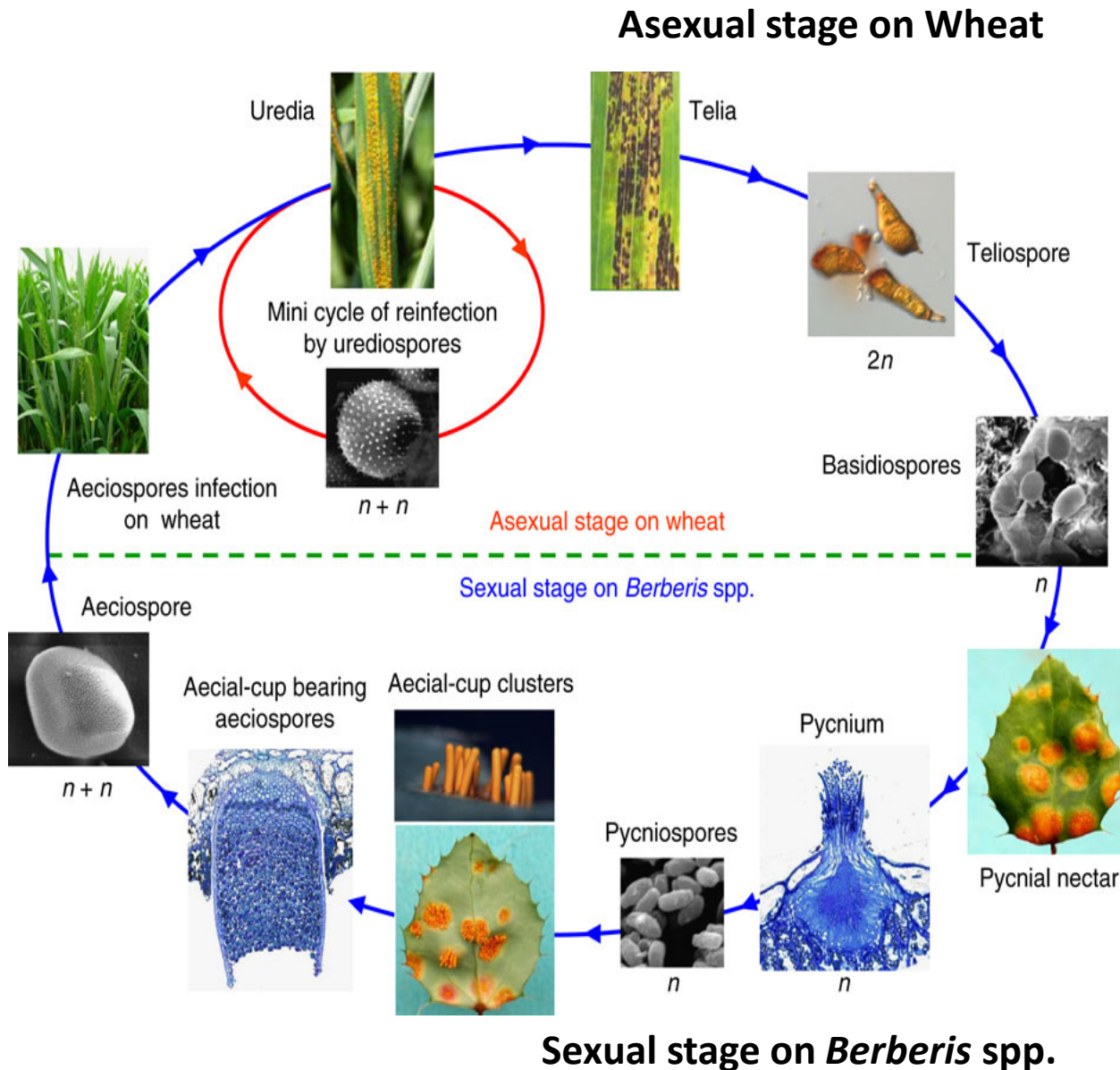


***Puccinia* on Chrysanthemum**



Close-up of pustules and spores

Fungi : Wheat Rust with alternate host



Fungi : *Armillaria mellea*

- Mainly affects hardwood trees and conifers
- Roots decay and tree gradually declines; may eventually topple over.



Mycelium under bark of citrus tree

Fungi : *Armillaria mellea*

- Rhizomorphs can grow and infect nearby roots
- Can form mushrooms at base of trunk



Mushrooms at base of almond tree



Rhizomorphs on large root



Oomycetes: the water molds

- The Oomycetes are fungus-like and often still referred to as fungi.
- Water is key to their life cycle and spread often with swimming infectious zoospores
- Oomycete “Fungicides” that are most active usually utilize different modes of action than fungicides.

Root and Root Crown Rot *Phytophthora*



Damping off or Root Rot Pythium



Root rot on Asiatic lily bulbs



Cotton seedling damping-off



Downy Mildews

- Fairly host specific
- Prefer 40-60°F for growth and RH 90% for spores



Lettuce

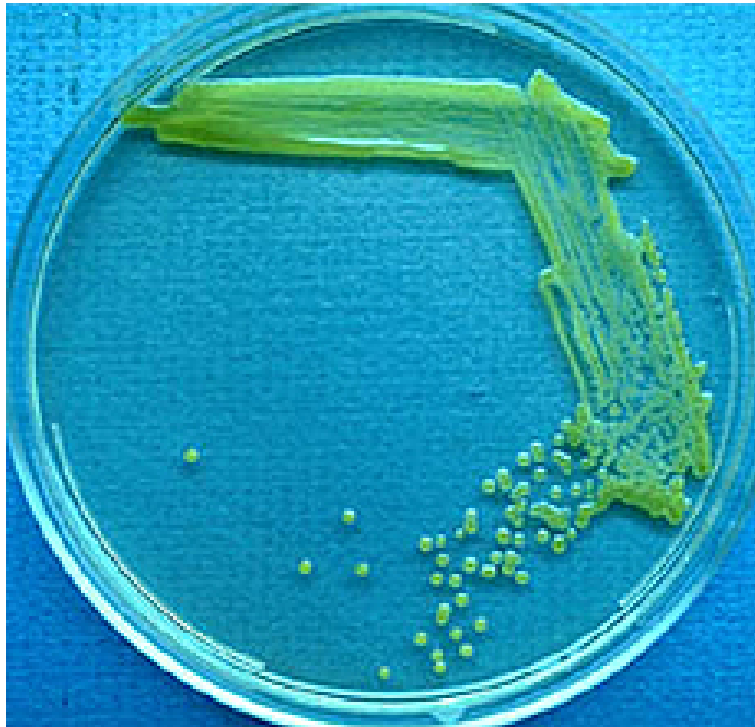
Downy Mildews

- Spores usually found on underside of leaves
- White, lavender, or purple spore masses

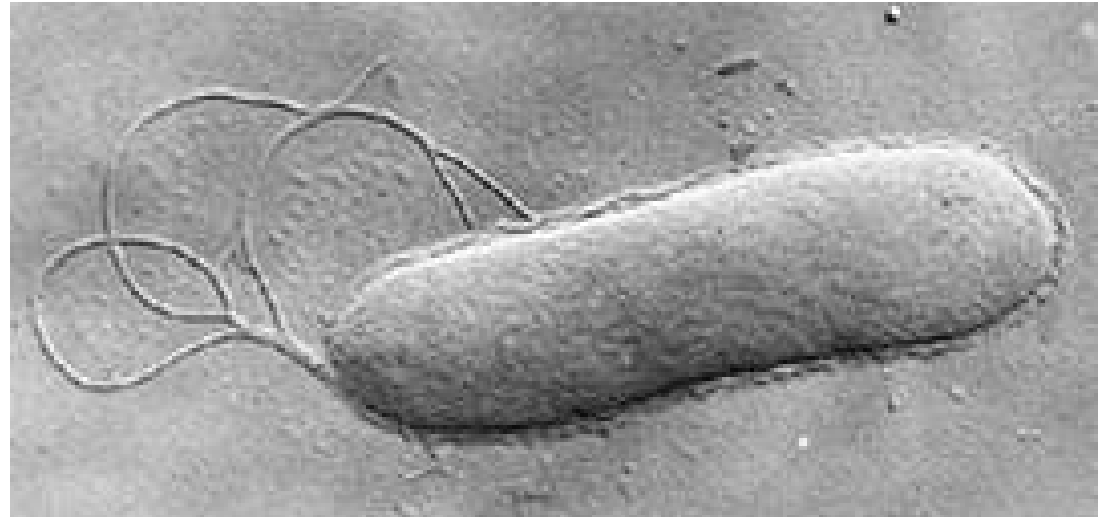


Bacteria

- Tiny single-celled organisms, 1-3 μm
- Have several shapes and some have flagella for motility



**Bacterial colonies of *Xanthomonas*
on nutrient agar**



**Bacilliform bacterium with polar
flagella**

Bacteria

- First recognized bacterial pathogen, *Erwinia amylovora* on pears and apples.
- Bacteria enter plants through wounds, stomates, hydathodes and other natural openings.



Shepard's crook symptom on Toyon



Fire blight on Ornamental Pear

Bacteria: Spots on Leaves and Fruits



Xanthomonas spp. on Pelargonium leaf
and tomato fruit

Bacteria: Vascular Wilts



***Erwinia* on tomato**



Bacteria: Galls



**Crown gall on Peach (left) and Euonymous (right) caused by
*Agrobacterium tumefaciens***



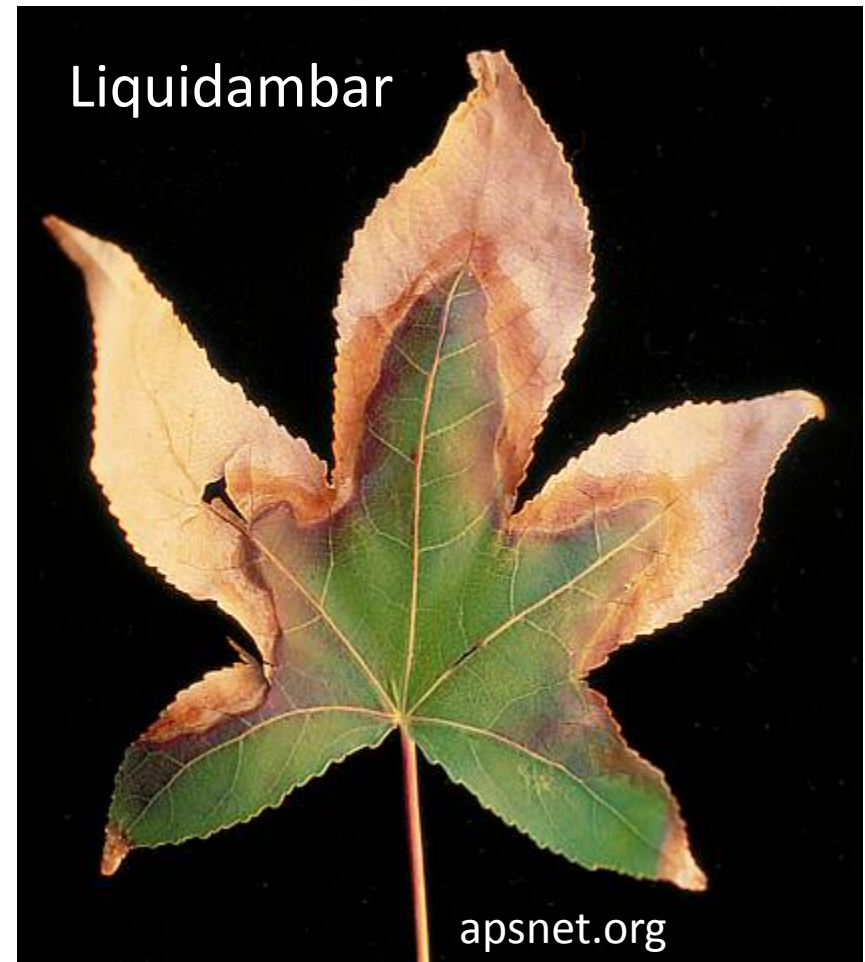
Bacteria: Soft Rots



Bell Pepper

Fastidious Bacteria: Bacterial Scorch

- Caused by *Xylella fastidiosa*



Insect Vectors of *Xylella fastidiosa*

Leafhoppers such as the Glassy-winged sharpshooter
(GWSS),
Homalodisca vitripennis (= *H. coagulata*)

GWSS vs blue-green sharpshooter

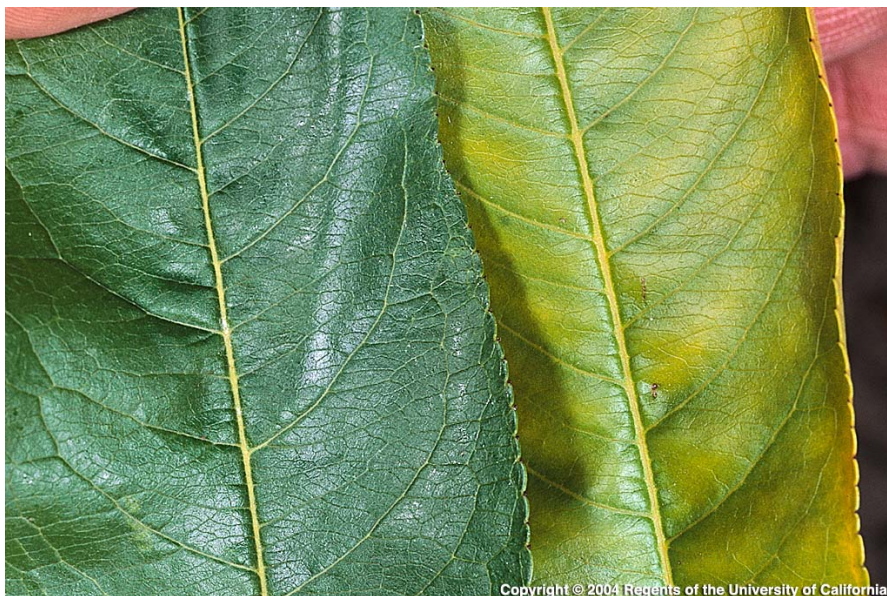


Symptomatic landscape plant species in CA from which
Xylella fastidiosa was detected

Plant Name	Common Name	Strain Group
<i>Ginkgo biloba</i>	Maidenhair Tree	ALS
<i>Lagerstroemia indica</i>	Crape Myrtle	ALS
<i>Liquidambar styraciflua</i>	Liquidambar	ALS
<i>Olea europaea</i>	Olive	ALS
<i>Prunus cerasifera</i>	Ornamental Plum	ALS
<i>Morus alba</i>	White Mulberry	MLS
<i>Nandina domestica</i>	Heavenly Bamboo	MLS
<i>Hermerocallis</i>	Day Lily	OLS
<i>Jacaranda mimosifolia</i>	Jacaranda	OLS
<i>Nerium oleander</i>	Oleander	OLS
<i>Cercis occidentalis</i>	Western Redbud	PD
<i>Prunus avium</i>	Cherry	PD
<i>Prunus dulcis</i>	Almond	PD, ALS
<i>Magnolia grandiflora</i>	Southern Magnolia	PD, OLS

Phytoplasmas

- Bacteria that lack cell wall and flagella
- Vectored by mostly leafhoppers and some psyllids



Peach yellow leafroll

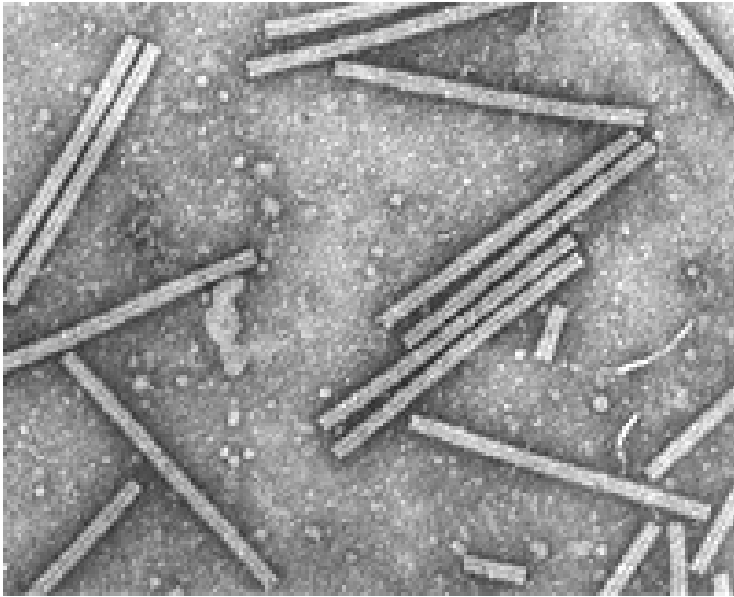


Aster yellows, Delphinium

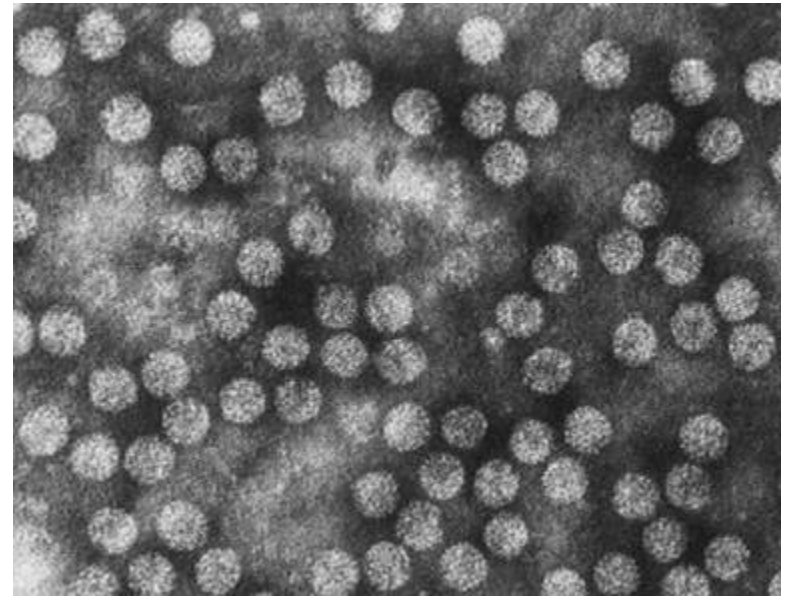


Viruses

- Composed of nucleic acid, DNA or RNA
- Surrounded by a self-made protective coat protein



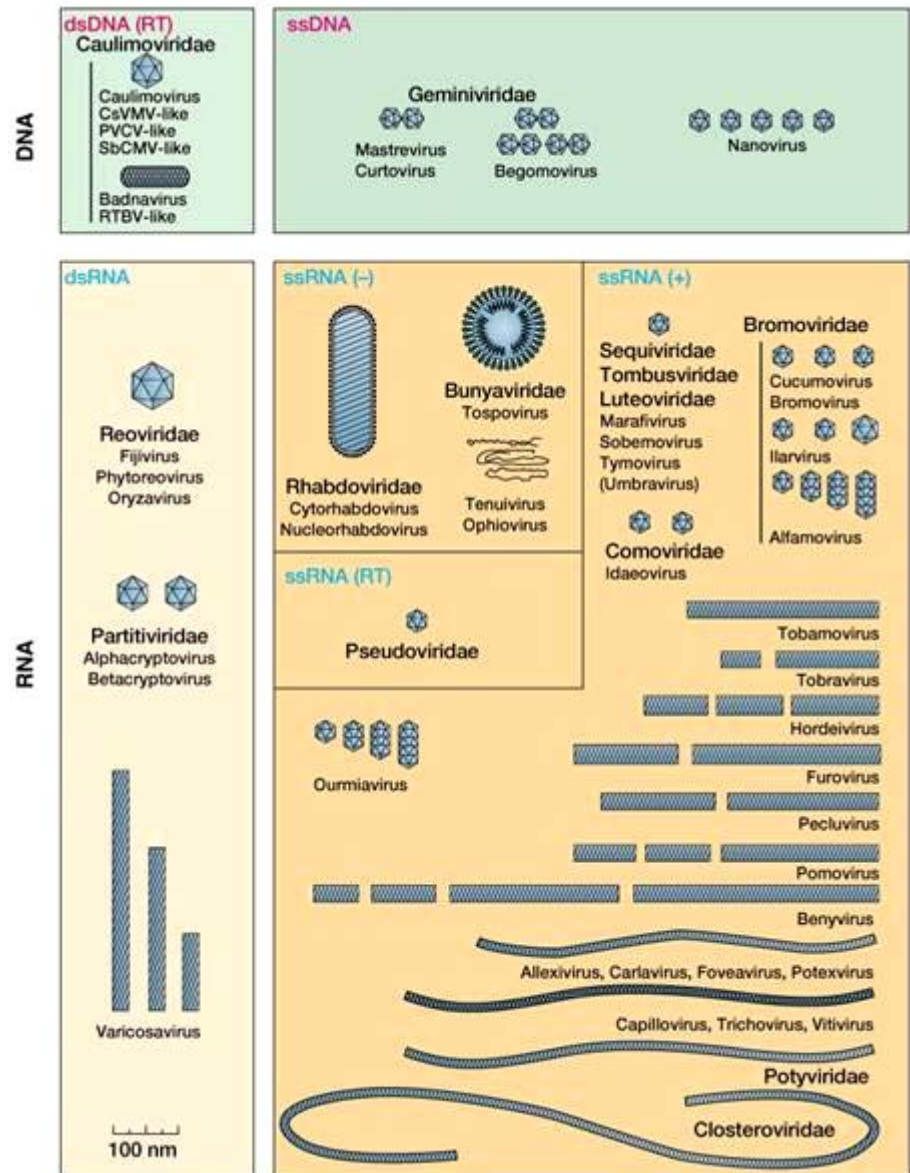
*Tobacco mosaic virus
(Tobamoviruses)*



Cucumber mosaic virus

Viruses

- Over 1000 species of plant viruses
 - Each species may have many strains
 - Named for *first* host and symptoms
- Tobacco Mosaic Virus



Virus transmission

Vegetative propagation and grafting

Insects

Pruning tools, touching, and other wounding

Irrigation water

Fungi, nematodes, seedborne, and pollen





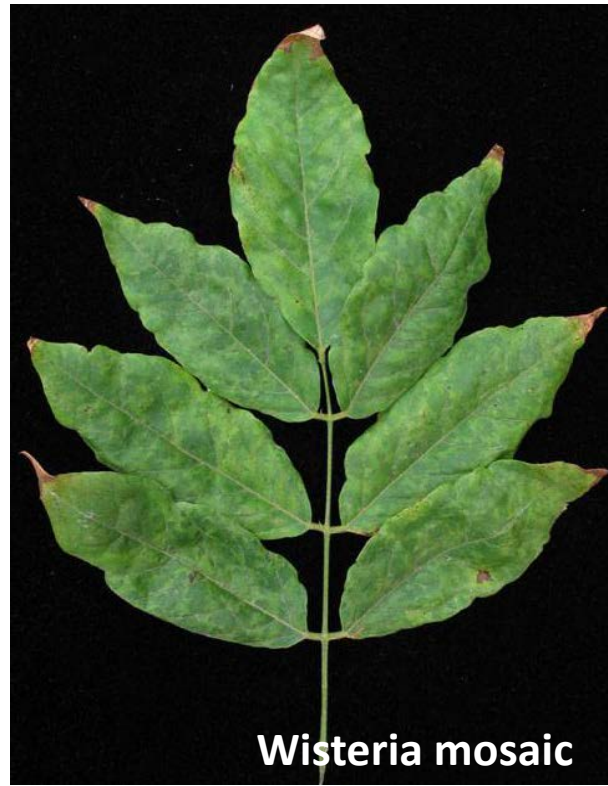
Viruses: Mosaic

Cucumber mosaic virus



Mandevilla

Wisteria mosaic



Wisteria

Hosta virus X



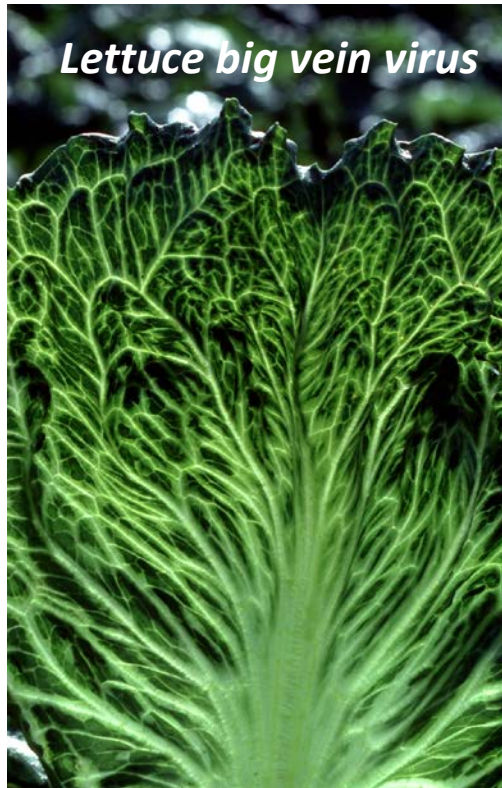
Hosta



Viruses: leaf malformations and stunting



Bean



Lettuce



Monocots

Viruses: Ringspots / Line Patterns



Photo: Ann Chase

Nemesia ring necrosis virus



Unknown virus on Impatiens



Hydrangea ringspot virus

Viruses: Flower Break



No virus



Angelonia flower
break virus

Viruses: Fruit Deformation



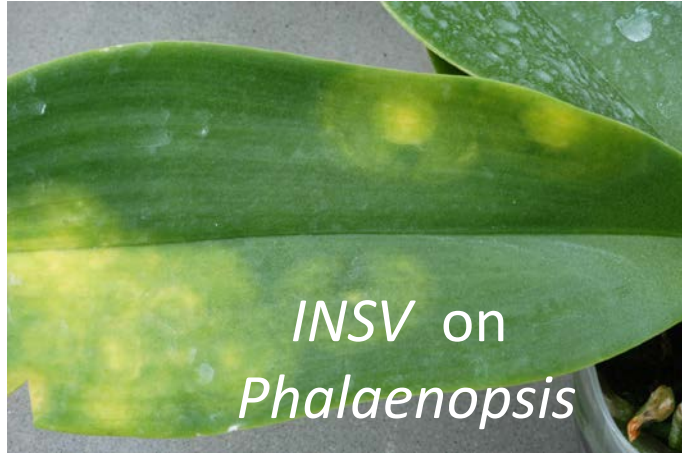
Potyvirus on yellow squash
(lower healthy, upper infected)



Cucumber mosaic virus
Pepper

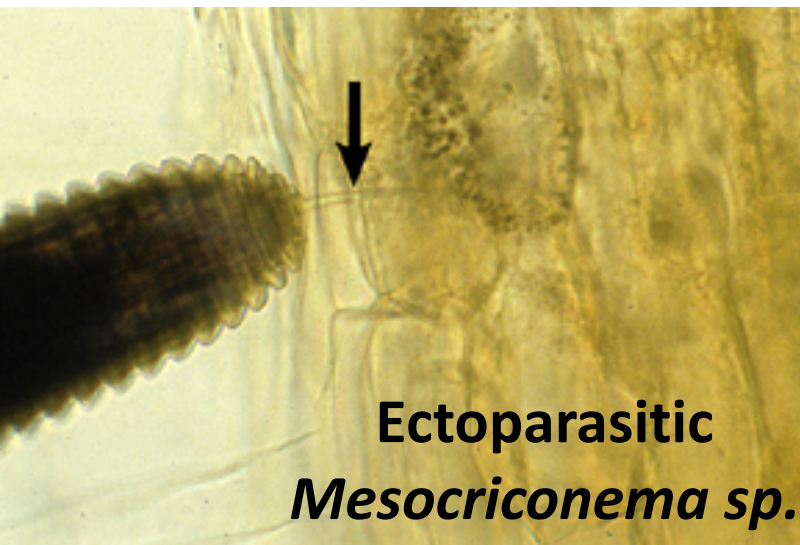
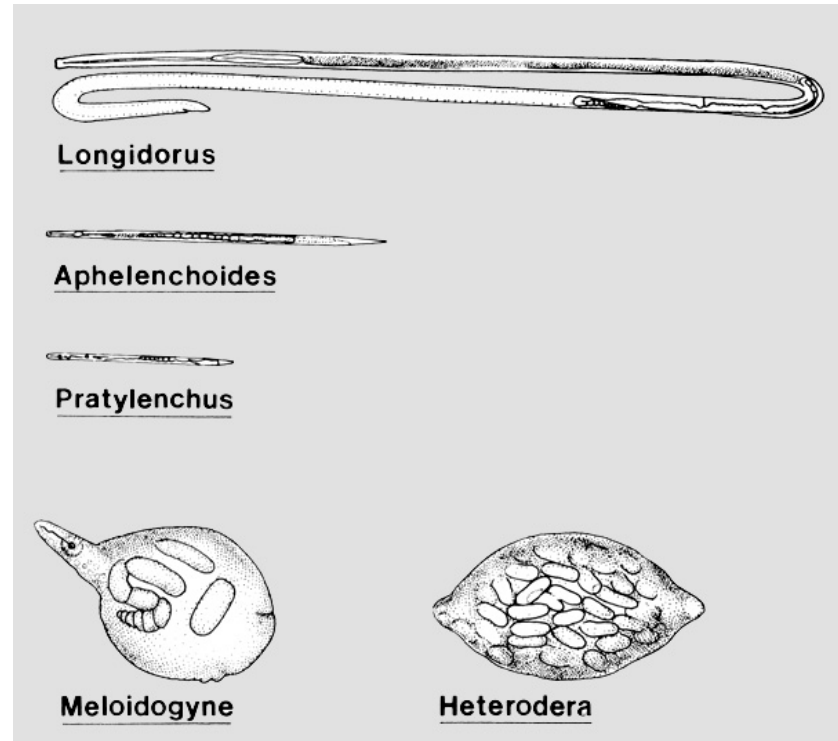


Tomato Spotted Wilt Virus (TSWV) Impatiens Necrotic Spot Virus (INSV)

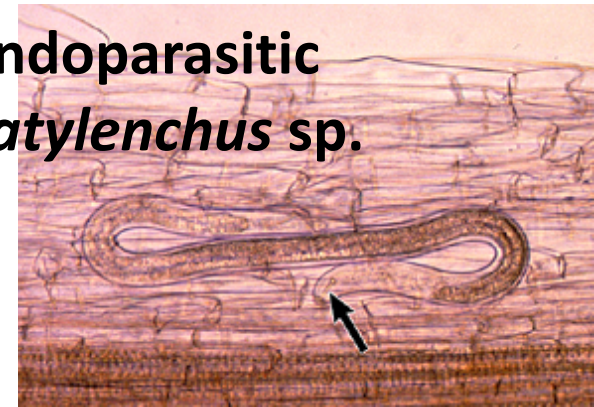


Nematodes

- Non-segmented round worms, 250 μ m-12mm
- Some feed externally, others internally



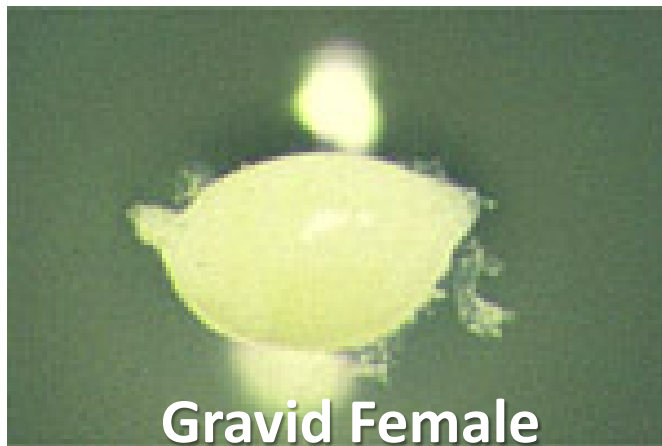
Endoparasitic
Pratylenchus sp.



Nematodes: Root Knot



Max Clover, courtesy UC Statewide IPM Program



Meloidogyne spp on several hosts

Nematodes: Root and Foliar Lesions

Red-brown lesions around the
root cortex on Potato

Pratylenchus spp.



Aphelenchoides spp.
on chrysanthemum





Emerging Diseases

- *Plasmopara obducens*, Impatiens Downy Mildew
- *Plasmopara halstedii*, Sunflower and Rudbeckia Downy Mildew
- *Phytophthora ramorum*
- *Phytophthora tentaculata*
- *Liberibacter asiaticus*, Citrus greening or Huanglongbing Disease
- *Ralstonia solanaceum*, Ralstonia Southern Bacterial Wilt
- Polyphagous shot hole vectored *Fusarium* diseases.
- *Botryosphaeria* canker diseases



Plasmopara obducens
Impatiens Downy Mildew

Plasmopara halstedii
Sunflower Downy Mildew



Plasmopara halstedii
Rudbeckia Downy Mildew





Sudden Oak Dead (SOD) and Diseases caused by *Phytophthora ramorum*



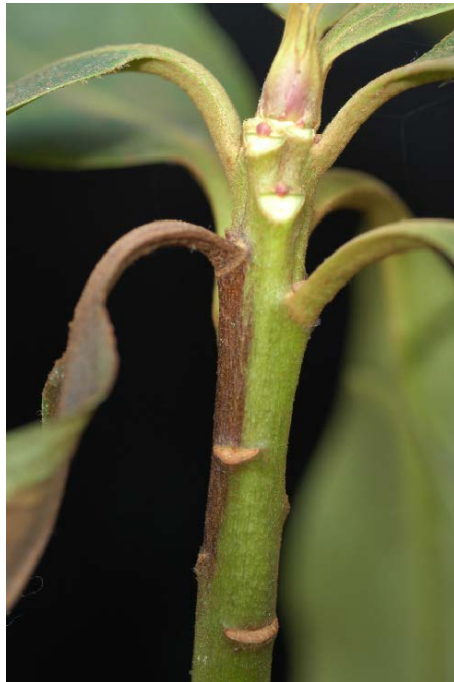
Rhododendron



Camellia



Pieris



Viburnum

Phytophthora tentaculata



Huanglongbing or Citrus Greening Disease

Candidatus *Liberibacter asiaticus*



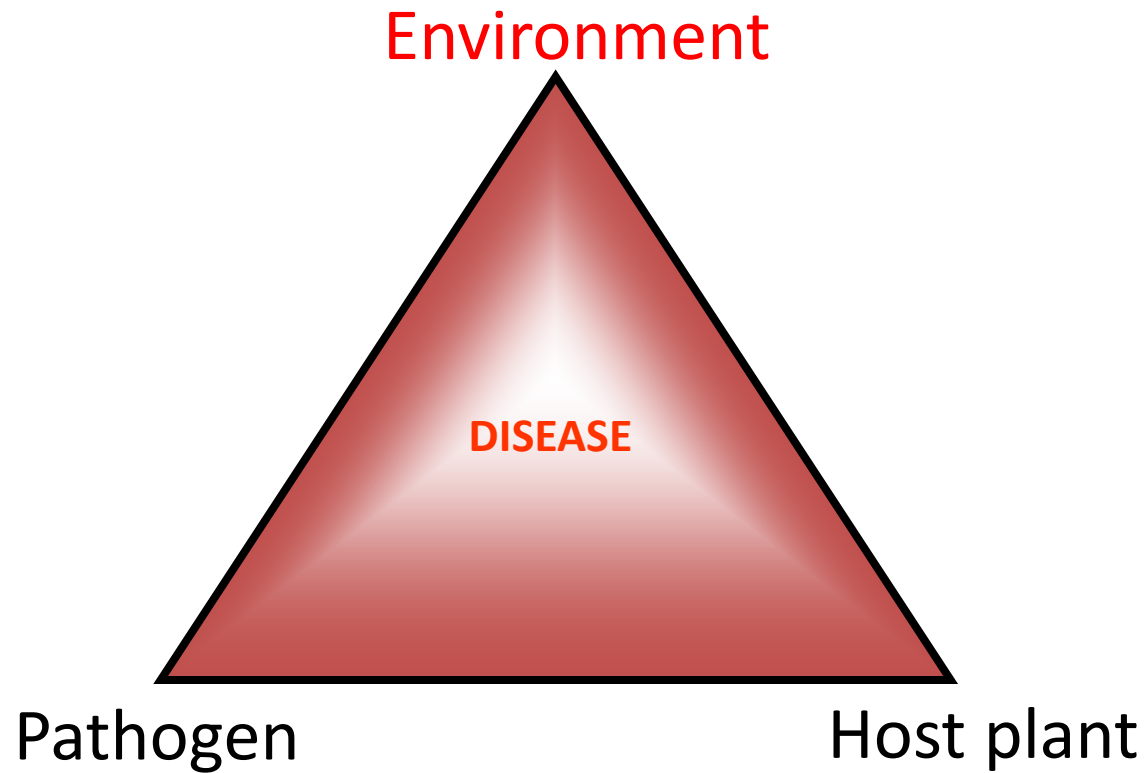
**Asian Citrus Psyllid,
vector of HLB**

Ralstonia Southern Bacterial Wilt, *Ralstonia solanacearum*





Disease Triangle





The Disease Triangle: Environment

Includes multiple factors and their interactions

- Temperature Humidity Light
- Water Soil Wind
- Human Activity Fertilizer Chemicals



The Disease Triangle:

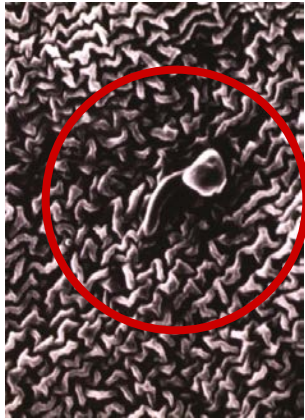
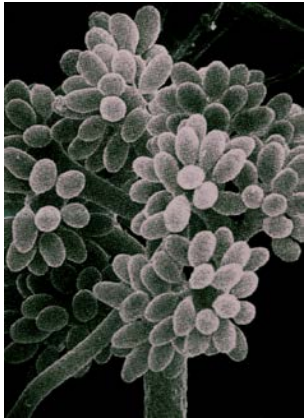
Environment: Importance of free water



**Free Water: dew, rain water,
irrigation water, pesticide sprays**

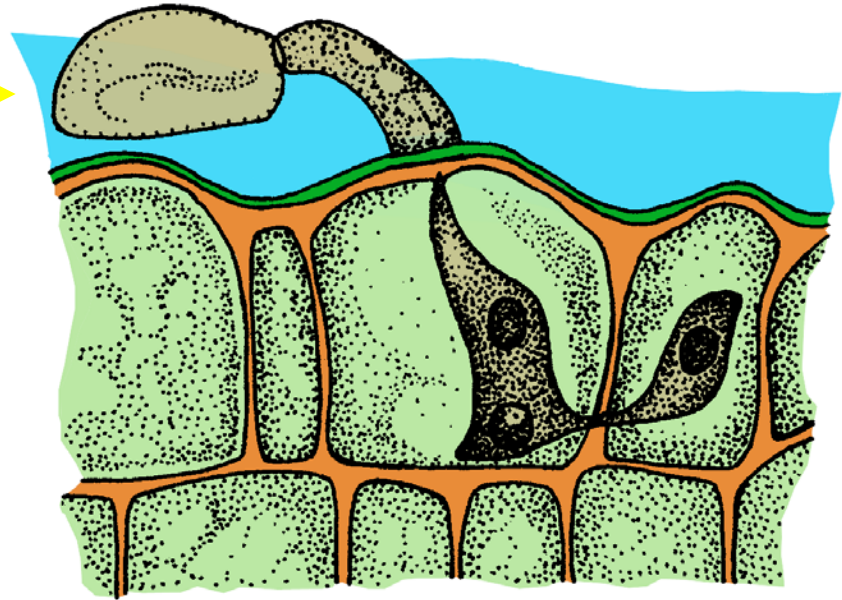
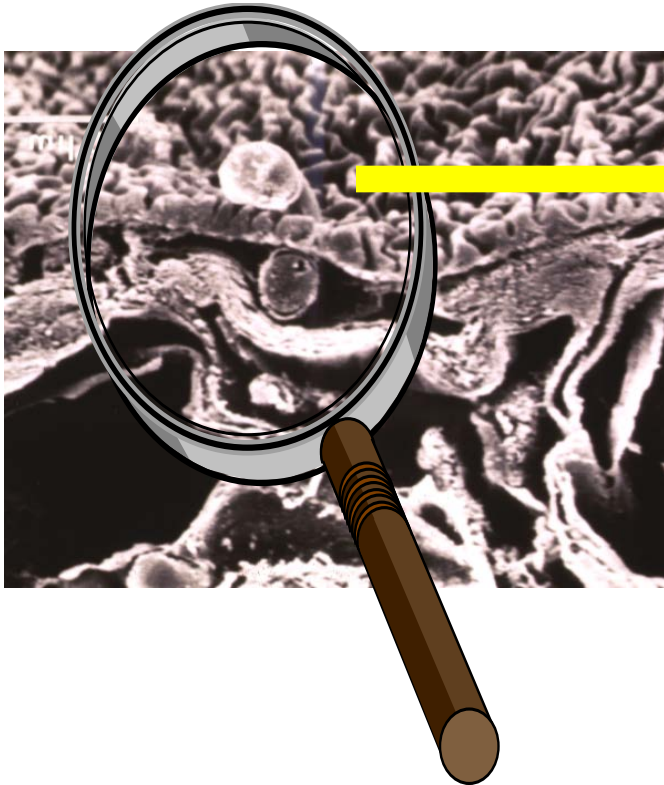
Botrytis (Gray mold)






Germination, Penetration, Infection
Botrytis cinerea

Free Water” Needed





Leaf Wetness Duration (LWD) Requirements for Infection of Some Plant Pathogens

Fungus	Disease	Host	Range of LWD Hours
<i>Botrytis cinerea</i>	Gray mold	Strawberry flowers	6 - 32
<i>Colletotrichum coccodes</i>	Anthrachnose	Tomato fruit	10 - 50
<i>Phytophthora cactorum</i>	Leather fruit rot	Strawberry fruit	0.5 - 5
<i>Puccinia recondita</i>	Leaf rust	Wheat	9 -15
<i>Pyricularia grisea</i>	Gray leaf spot	Ryegrass	6 - 48
<i>Diasporthe phaseolorum</i>	Stem rot	Soybean	2- 140

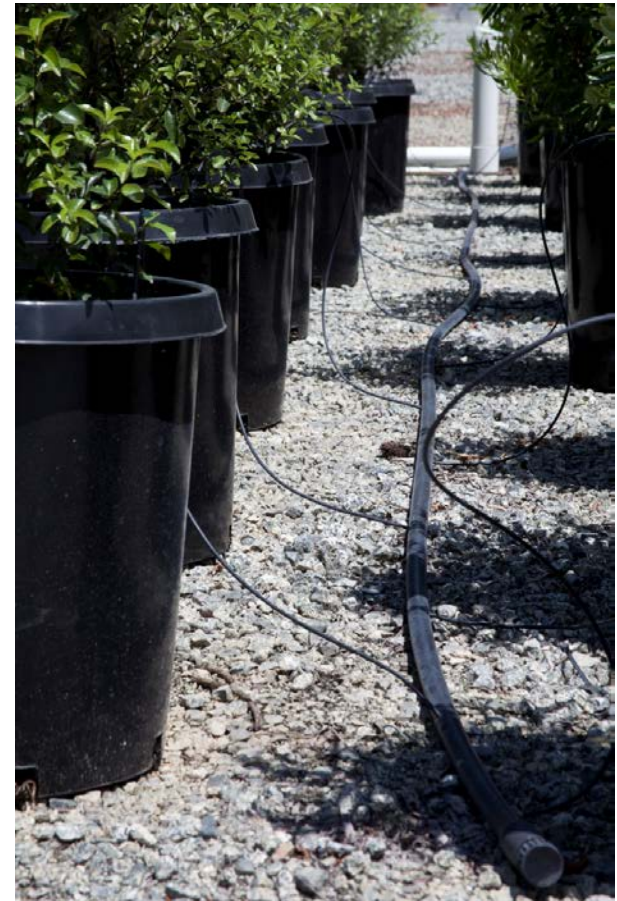
Adapted from L. Huber and T. Gillespie (1992)



- Avoid water on leaf or flower surfaces.
- Avoid increasing water vapor late **afternoon** or **evening**.



Management of Leaf and Flower Wetness



A photograph of a greenhouse interior. In the foreground, there are rows of green plants. A large black industrial fan is visible in the upper right. The greenhouse structure with its white frame and translucent panels is visible in the background.

AIR CIRCULATION

- Evaporate water and dry plant surfaces.
- Keep temperatures of plants and greenhouse uniform.
- Plant spacing.



**“Holding in the
heat”holds
moisture in too !!**

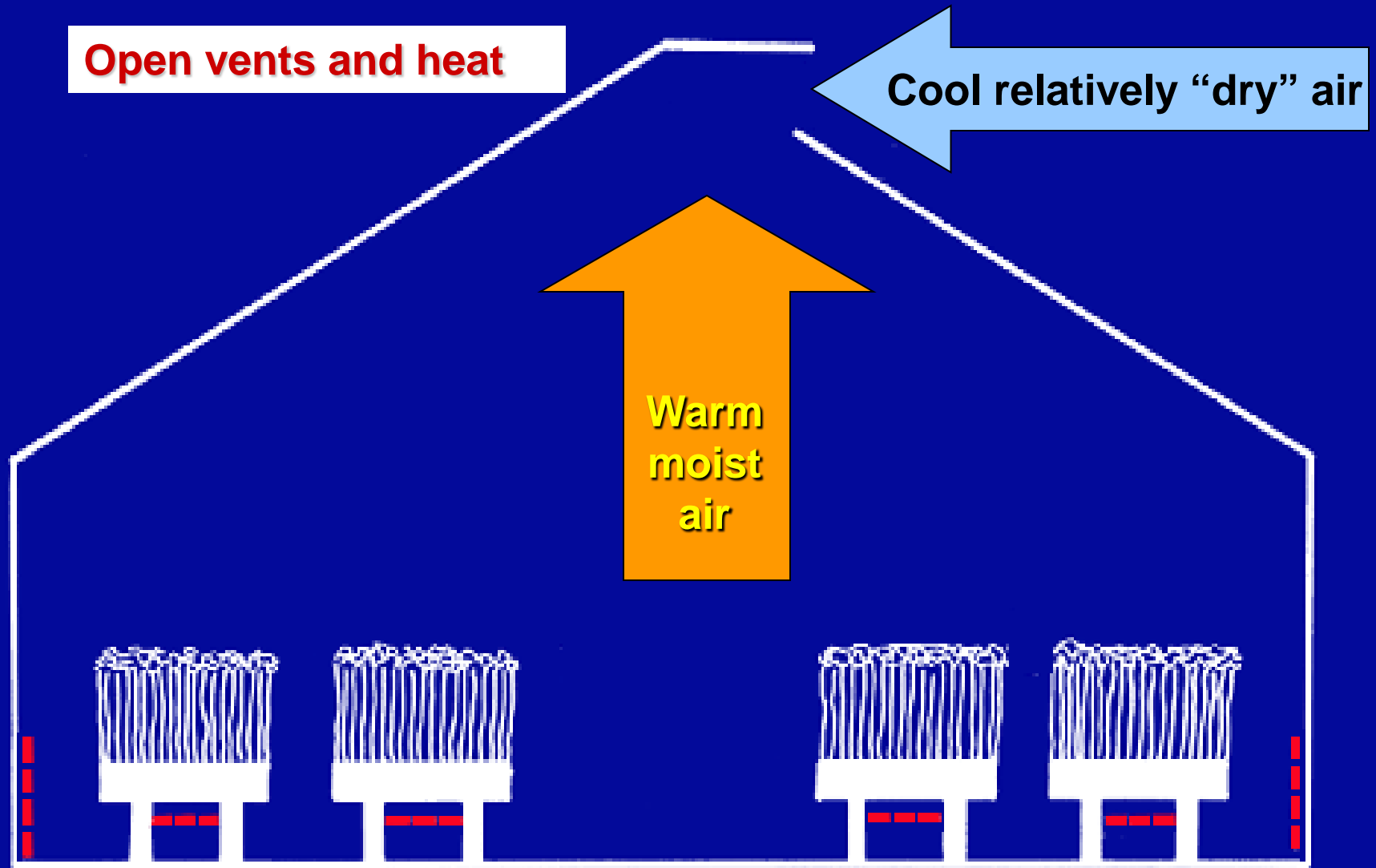
Vent Closed

Warm moist air

**At sundown, air cools
and relative humidity
rises**



Purge Cycles: Control RH at night



Repeat to avoid prolonged 100% leaf wetness



Disease Management Strategies

- Use disease-free hosts
- Use non-hosts: resistant varieties and crop rotation.
- Site selection and environmental manipulation
- Cultural practices favorable to the plant, not the pathogen.



Disease Management Strategies

- Vector control (weeds, insects, and people!)
- Plant protection with chemical or biological treatments
- Sanitation

Sanitation: Remove diseased plants



Downy mildew, snapdragons



Sanitation



Shoes



Tools



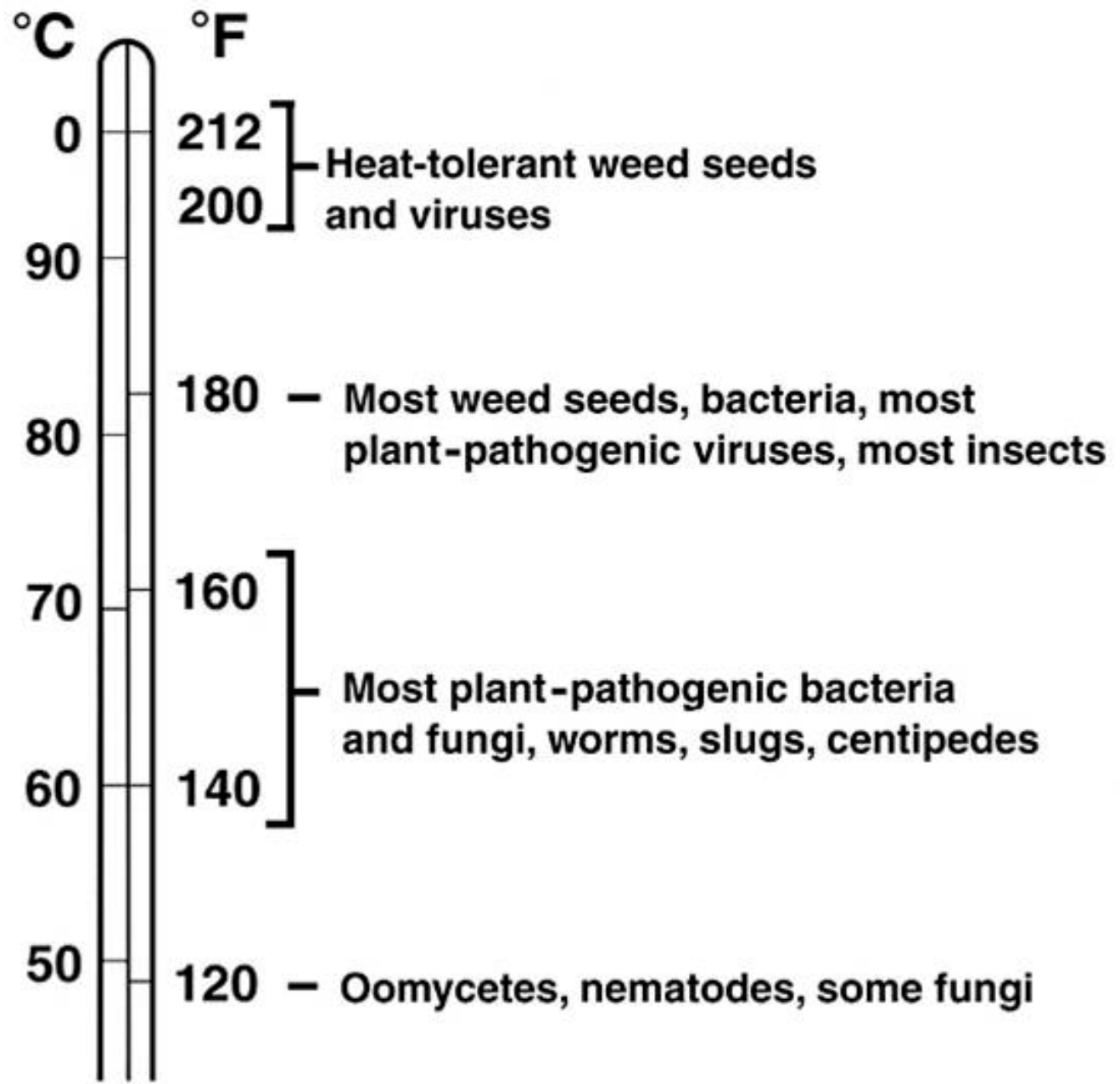
Plants

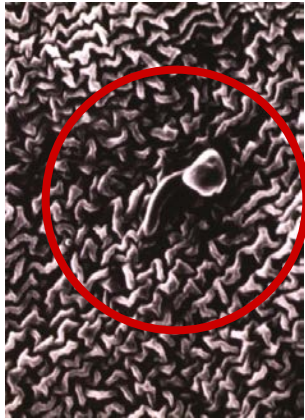
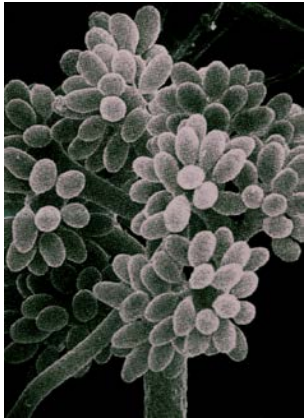
Sanitizing Soil Before Planting





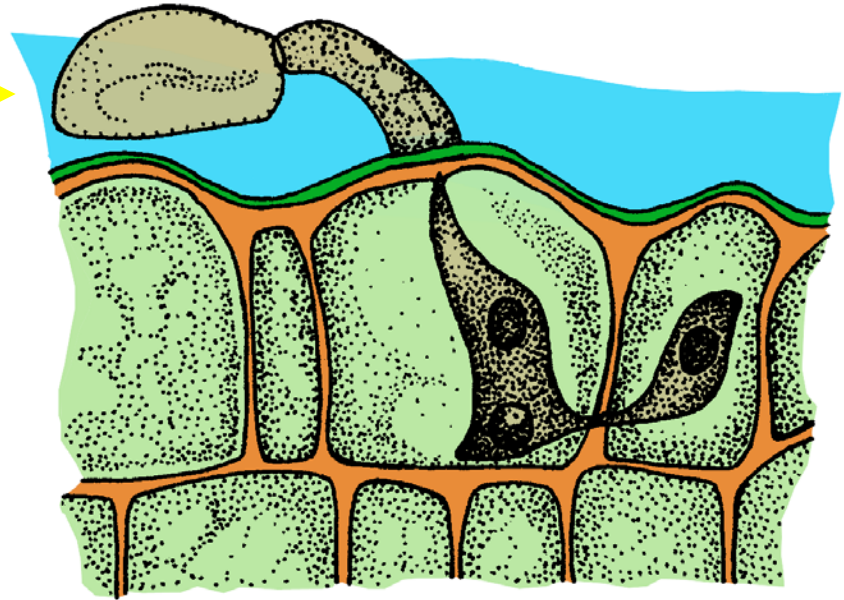
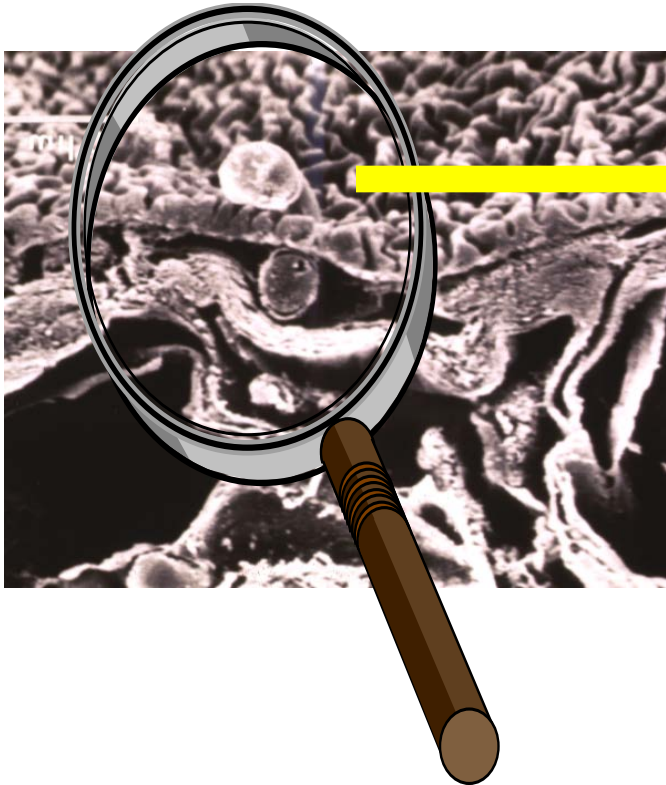
Temperatures Required to Kill Various Pathogens



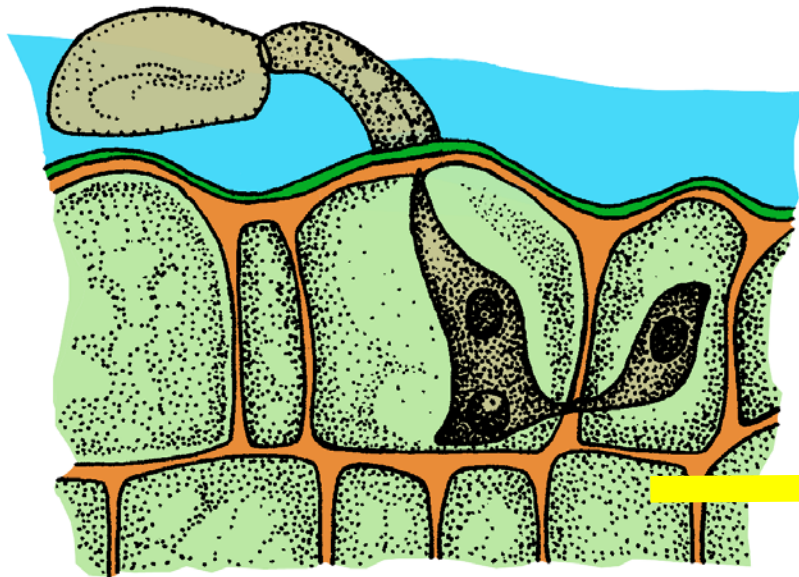


Germination, Penetration, Infection

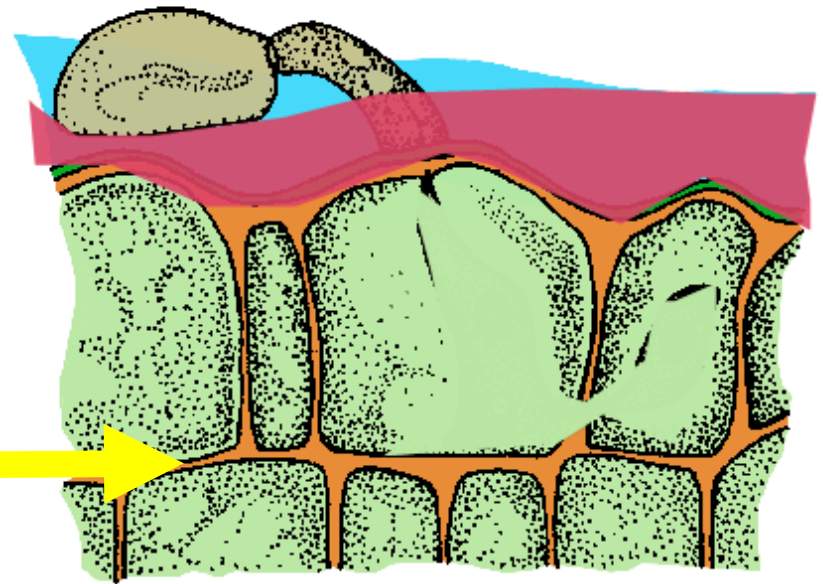
Botrytis cinerea



Protectant Fungicides

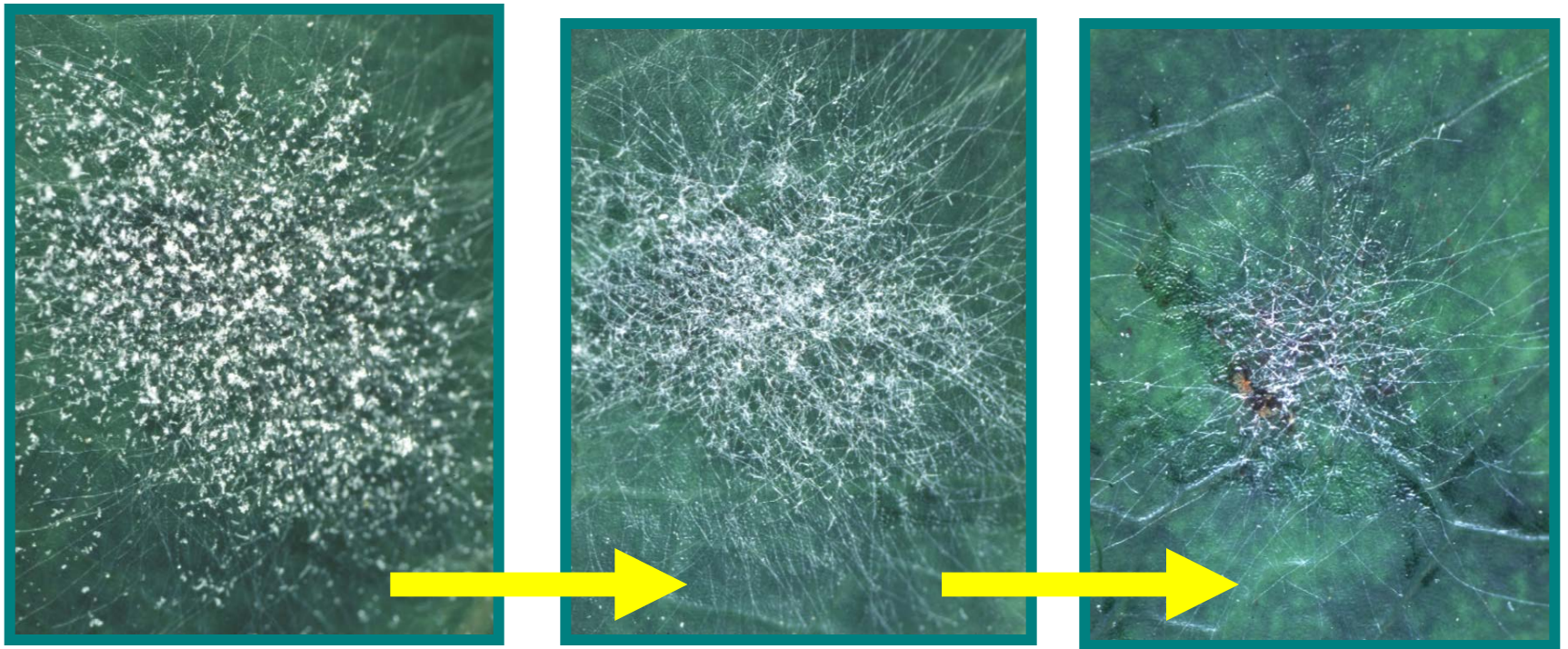


Germination, penetration and infection



Fungicide applied

Eradicant Fungicides



2 Days

5 Days

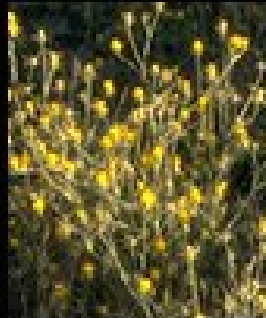
Control of rose powdery mildew with piperalin



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UNIVERSITY OF CALIFORNIA STATEWIDE INTEGRATED PEST MANAGEMENT PROJECT



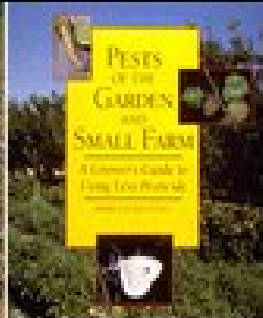
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UC IPM**



**HOW TO
MANAGE
PESTS**



**PESTICIDES:
EDUCATION &
DATABASES**



**OTHER
RESOURCES**



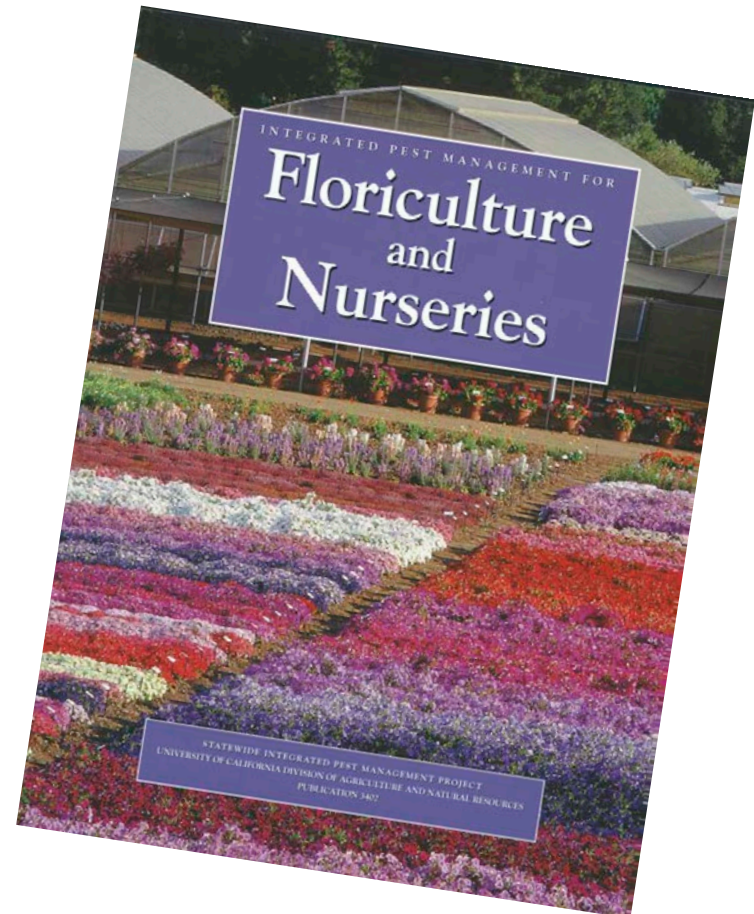
**UC IPM
FUNDED
PROJECTS**



**WHAT'S
NEW?**

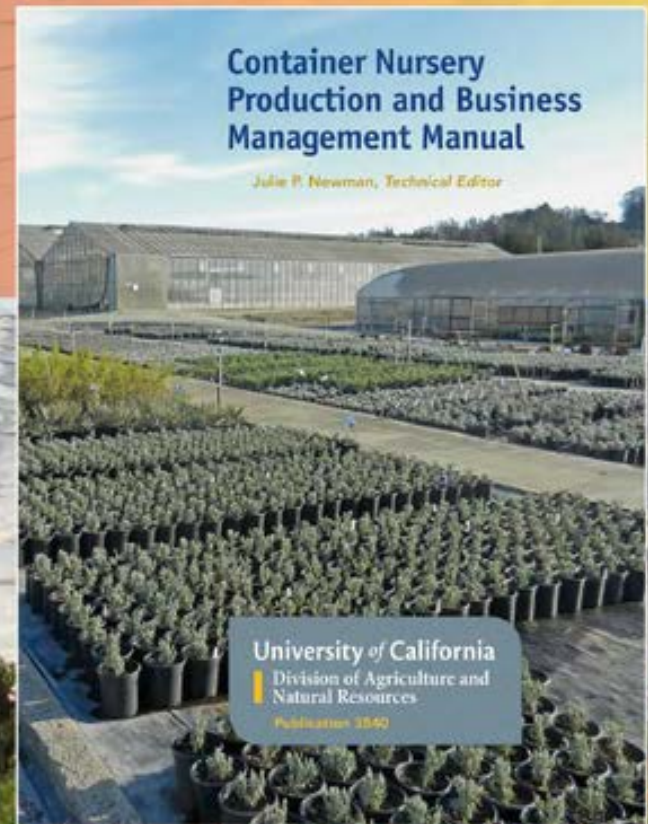
[http:// ipm.ucdavis.edu](http://ipm.ucdavis.edu)

References



<http://anrcatalog.ucdavis.edu/>

New! Container Nursery Production and Business Management Manual



<http://anrcatalog.ucdavis.edu>



Thank you



Jim Downer
ajdowner@ucanr.edu



María de la Fuente
medelafuente@ucanr.edu