Basic Plant Pathology

Master Gardener Training

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Plant Disease Diagnostic Clinic

Why is my plant sick?

- Evaluate each situation.
- Diagnose some diseases.
- Understand why certain disease management situations are appropriate and others are not.
- Overall understanding of plant pathogens.

Causal Agents of Disease.

Living vs. Non-living factors

- Fungi
- Bacteria
- Nematodes
- Viruses
- Phytoplamas

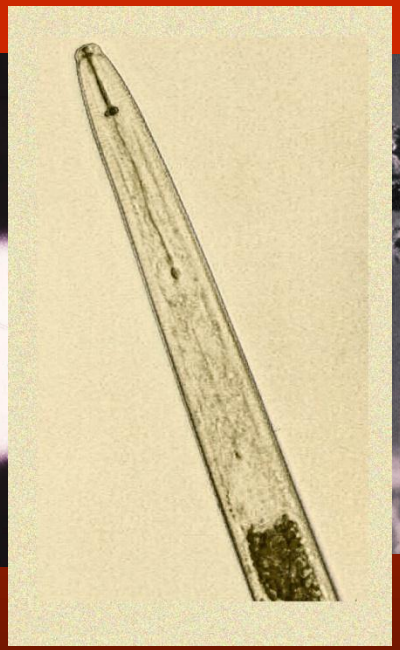
- Nutrient deficiencies
- Mineral toxicities
- Lack/excess of…
  soil moisture & light
- Too low/high temperatures
- Air pollution
- Soil pH

Definitions

PLANT DISEASE -- Any alteration in the physiological processes of a plant, caused by living organisms or nonliving agents, which negatively affects the plant.

PATHOGEN -- a pathogen is an organism that is capable of changing the physiological processes of a plant, thus causing disease.

PATHOGENIC means "disease causing"



History of Plant Pathology

- 700 B.C.- The Romans sacrificed red dogs and cattle to the Gods to rid their crops of rust.
- 470B.C.-Pliny reported that crushed olives sprinkled on plants prevented blight.
- 1844-1845-The Irish Potato Famine prompts the birth of modern plant pathology.

Late Blight

Late Blight

Late Blight

Late Blight

Late Blight

Late Blight

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2009
•Macetas 100% biodegradables
•Se plantan y crecen más rápido
•Mejore el sabor de las recetas
•Agregue vegetales y hierbas frescos y saludables a su dieta
•Muchas variedades para usar en patios o recipientes
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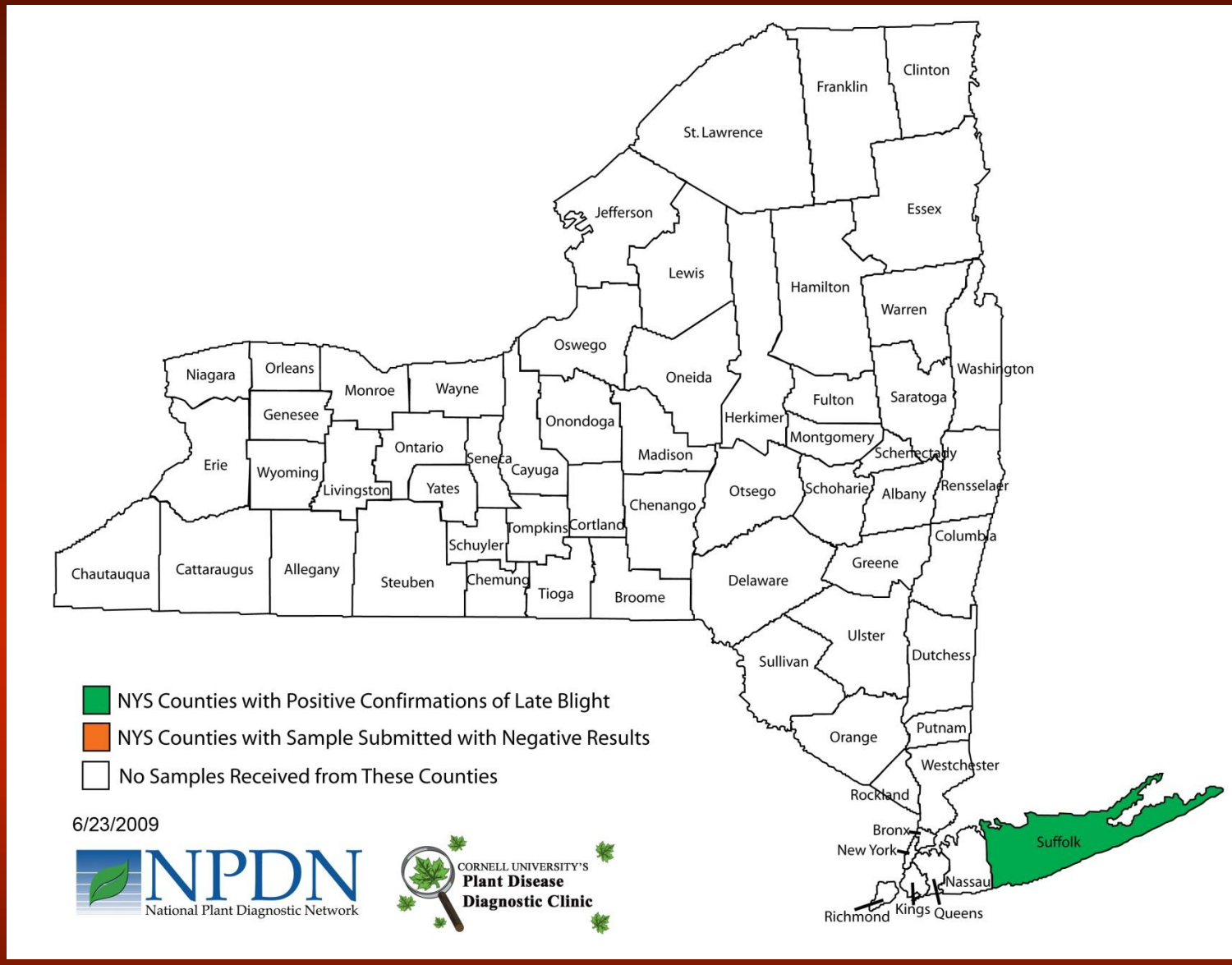
MACETA BIODEGRADABLE
Molded Fiber Container
Recycled Content
Minimum 88%
Be sure your plants are Bonnie's!
$5.98



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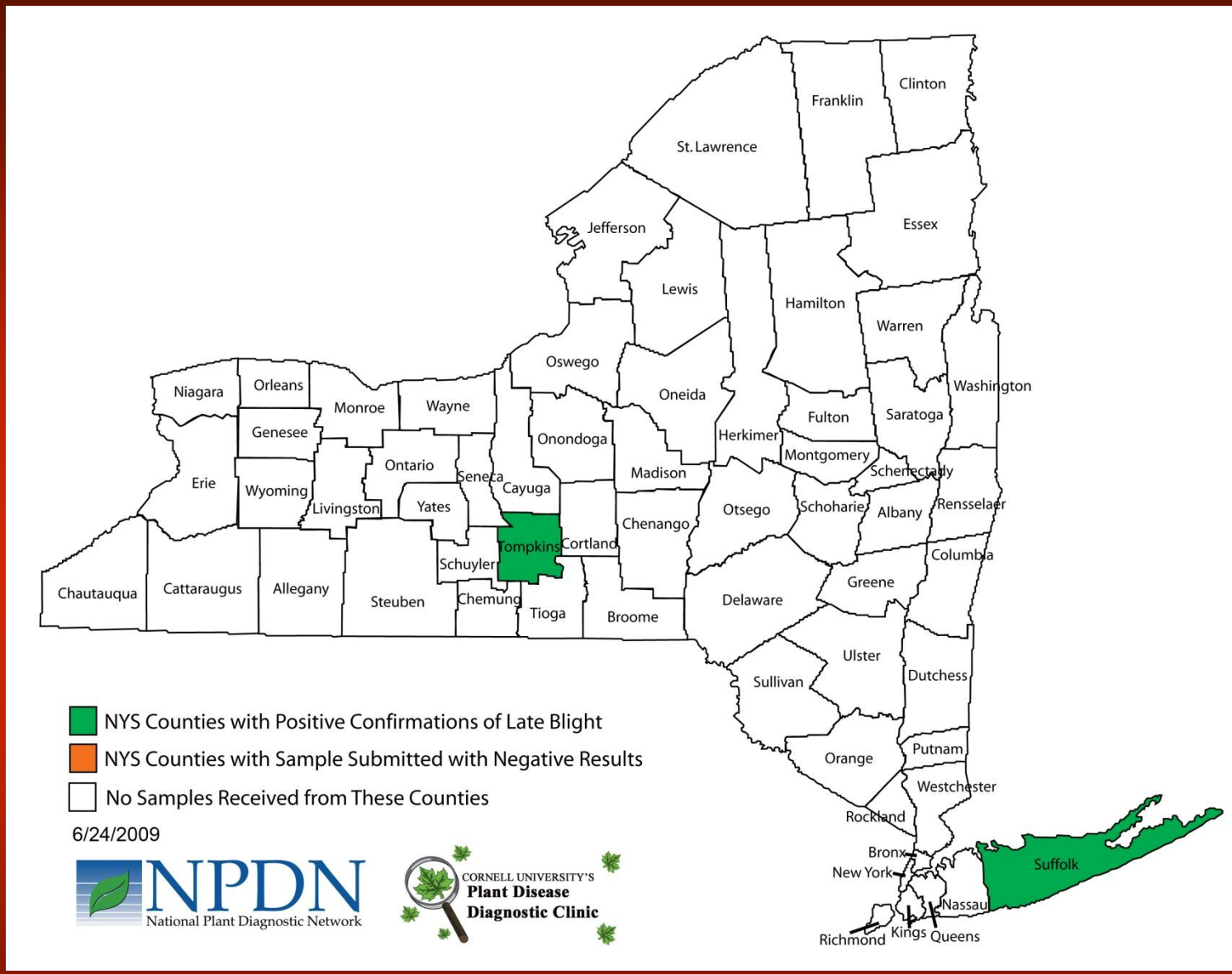

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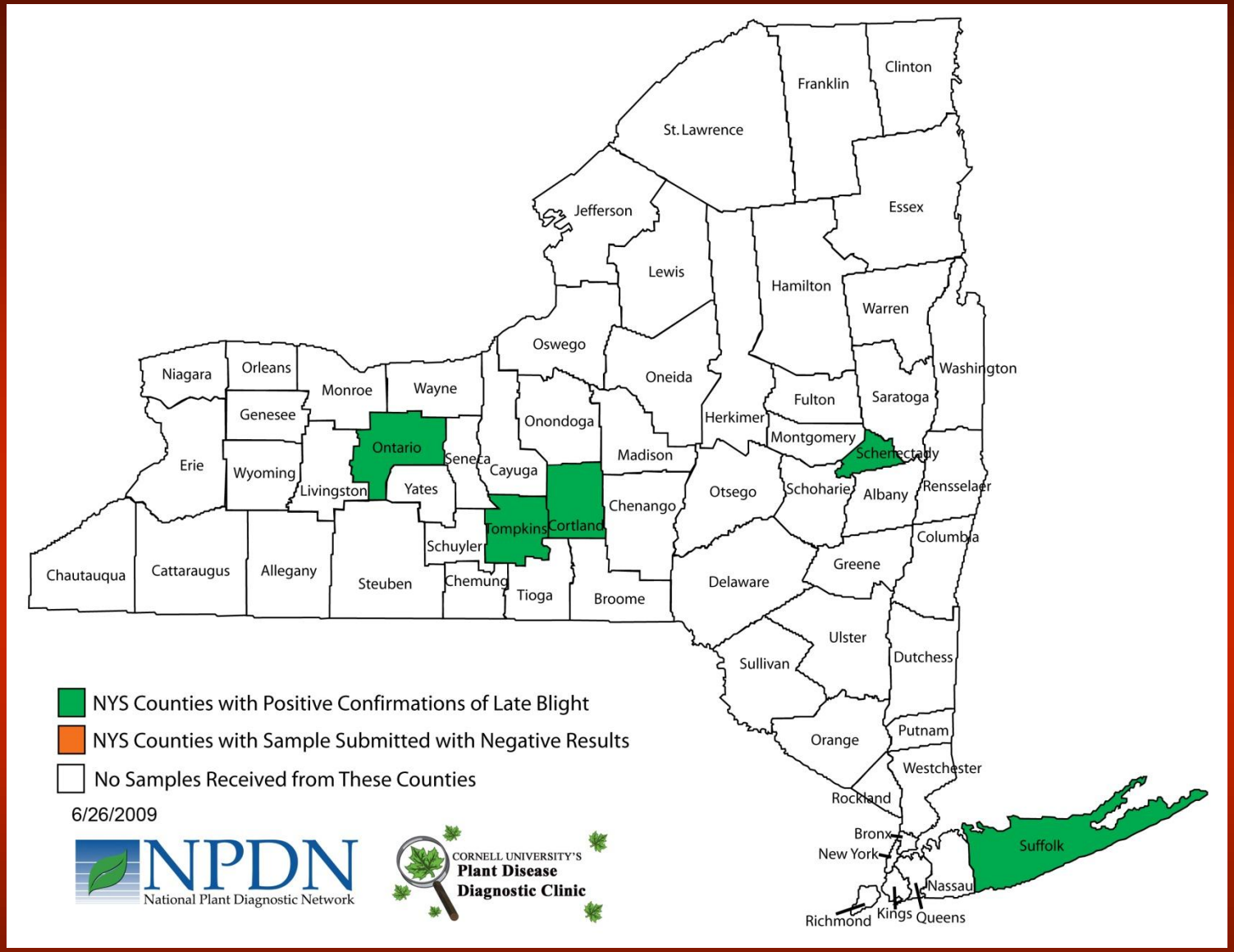

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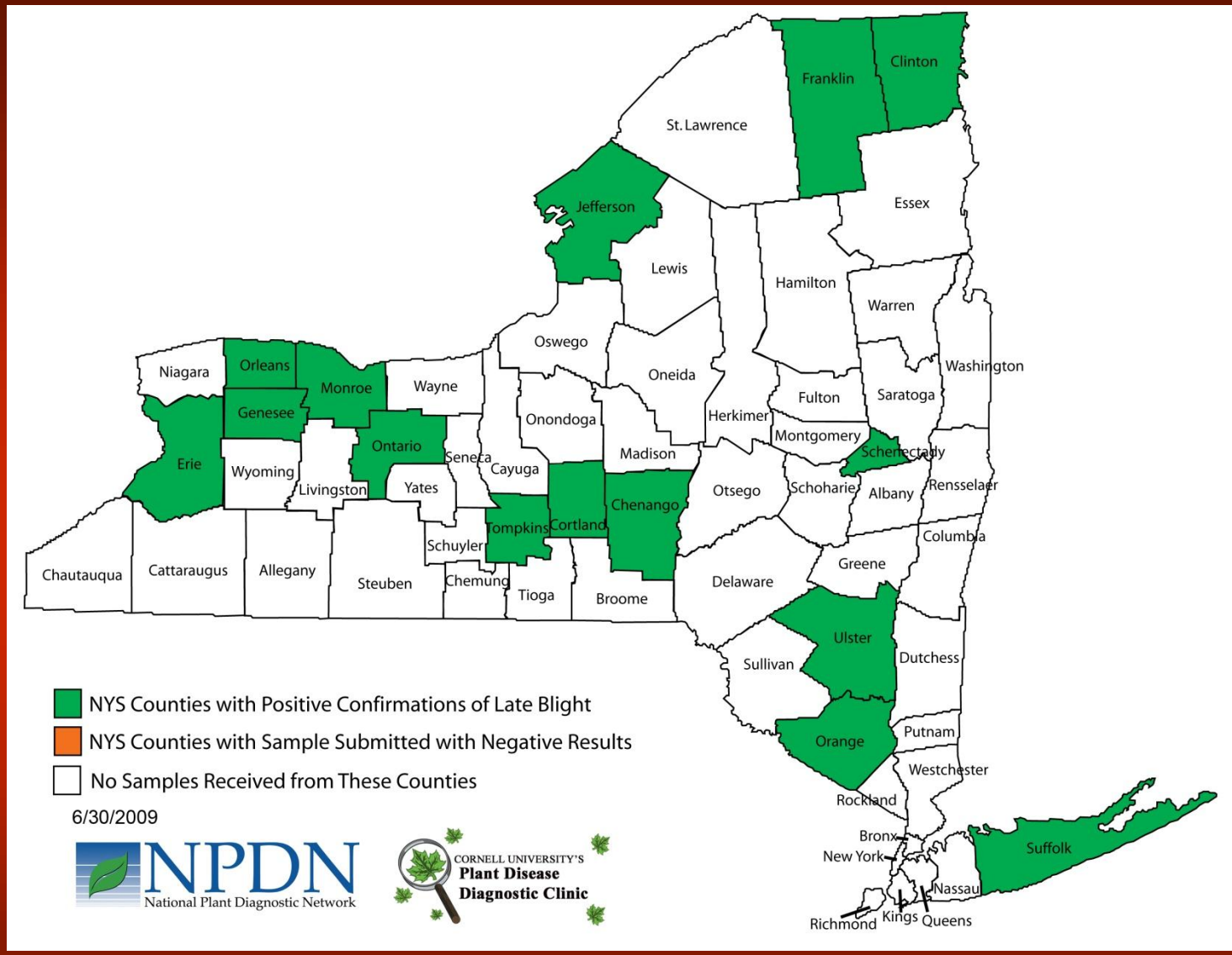

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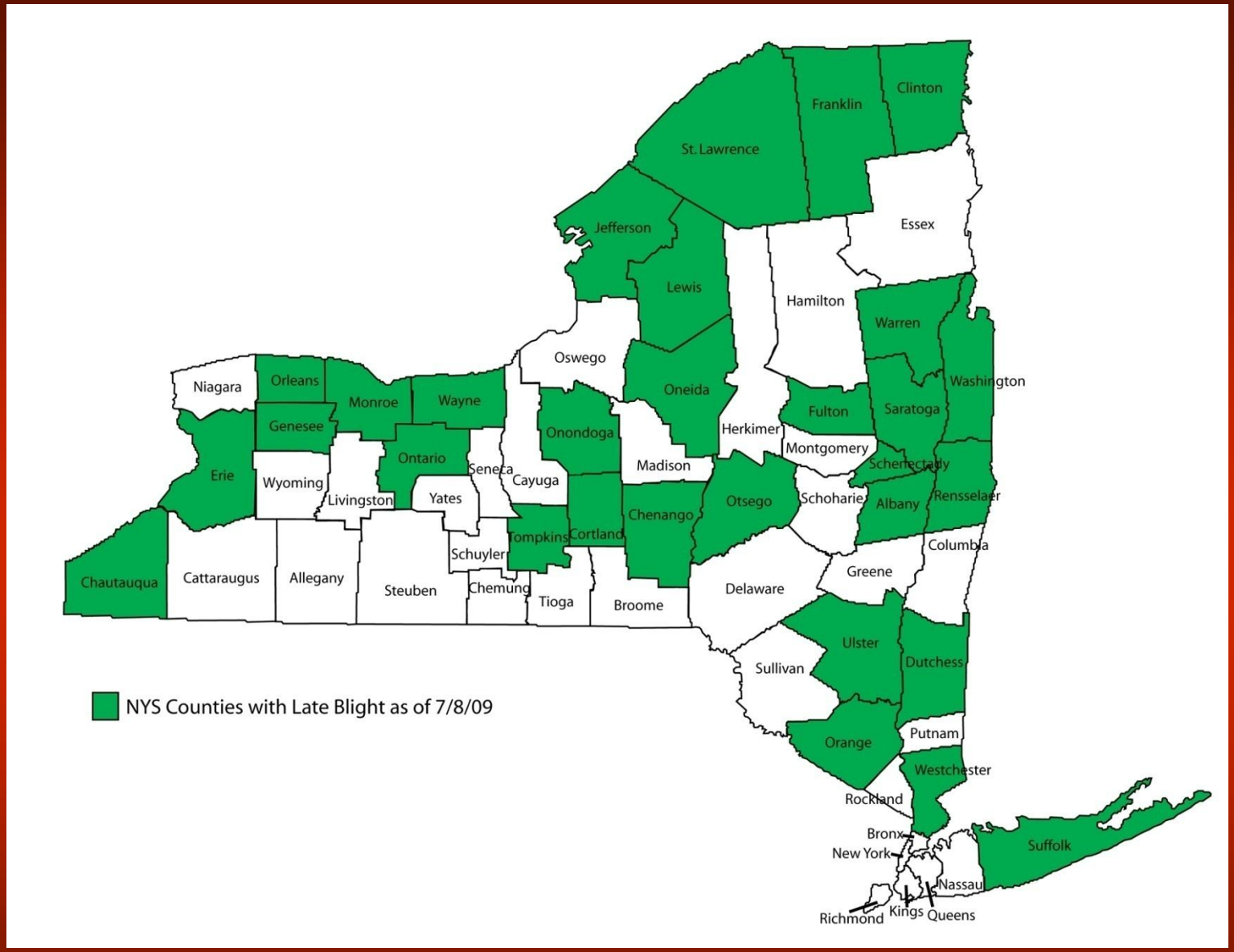

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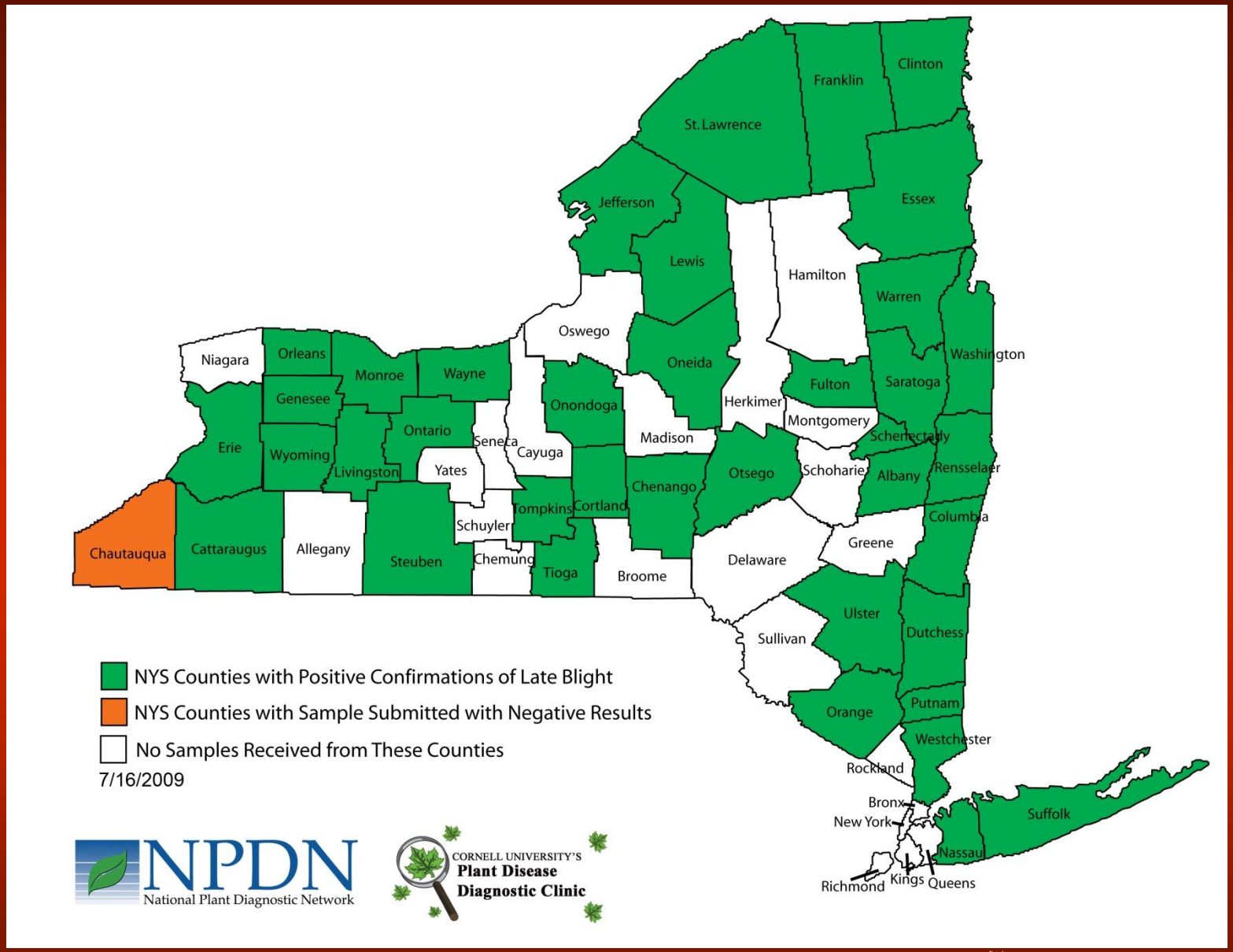

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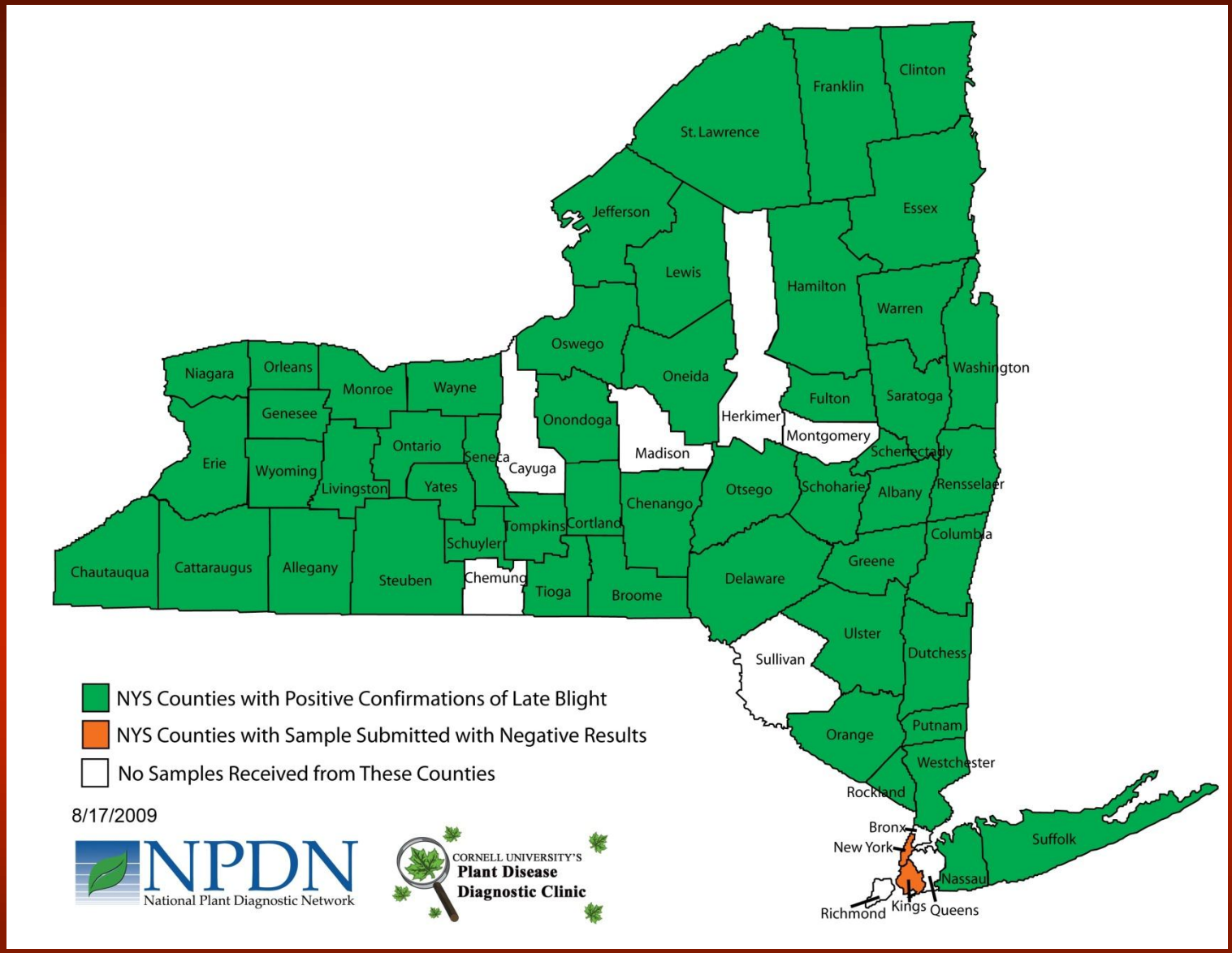

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The Washington Post

www.washingt

Late Bli

By Adrian Higgins, Wa

A roma tomato plant e
late blight that scientis
Of Cornell University
Biology)

The Boston Globe

Late bligh
bitter harv

By Bina Venkataraman
Globe Correspondent

Organic farms, including Lindentree Farm in Lincoln, have been hit especially hard by the outbreak of the contagious fungus. (Photos By Michele Mcdonald for The Boston Globe)

Newsday

http://www.newsday.com

Late blight
plants in L

The New York Times

www.nytimes.com August 8, 2009 ONE DOLLAR

You Say Tomato, I Say Agricultural Disaster

By DAN BARBER

Tarrytown, N.Y.

IF the hardship of growing vegetables and fruits in the Northeast has made anything clear, it's that the list of what can go wrong in the field is a very long one.

We wait all year for warmer weather and longer days. Once we get them, it seems new problems for farmers rise to the surface every week: overnight temperatures plunging close to freezing, early disease, aphid attacks. Another day, another problem.

The latest trouble is the explosion of late blight, a plant disease that attacks potatoes and tomatoes. Late blight appears innocent enough at first — a few brown spots here, some lesions there — but it spreads fast. Although the fungus isn't harmful to humans, it has devastating effects on tomatoes and potatoes grown outdoors. Plants that appear relatively healthy one day, with abundant fruit and vibrant stems, can turn toxic within a few days. (See the Irish potato famine, caused by a strain of the fungus.)

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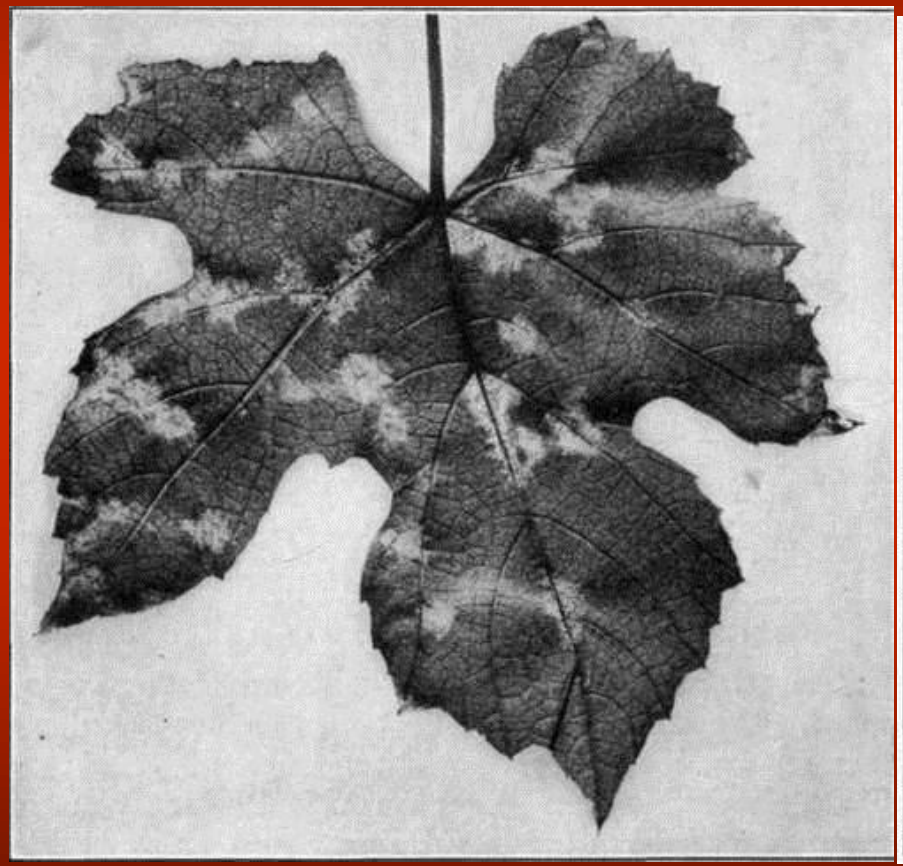
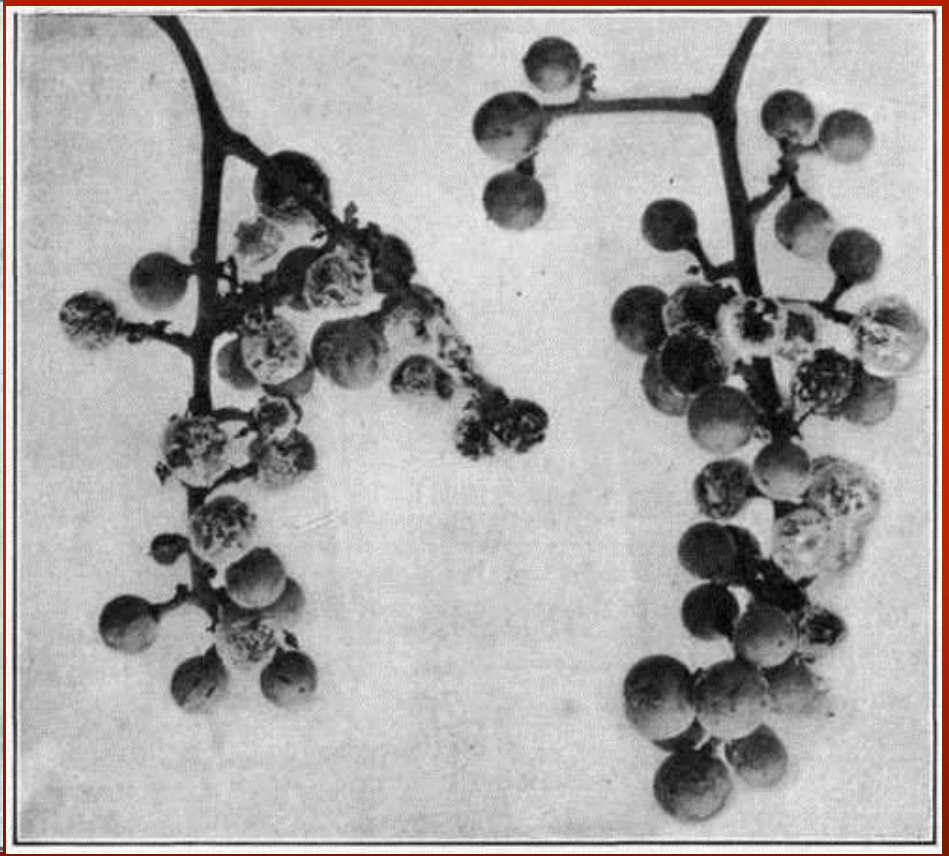
History of Plant Pathology II

- 1885-Bordeaux Mixture
  - Copper Sulphate/Lime and Downy Mildew.





History of Plant Pathology III

- 1900- White Pine Blister Rust (WPBR), caused by *Cronartium ribicola*, was introduced on seedlings from European nurseries.
- White pines, especially young trees, and plants belonging to the genus *Ribes* (currants and gooseberries) are susceptible to the disease.
- Although WPBR is occasionally a severe foliar disease on *Ribes* plants, on white pines it is LETHAL if allowed to spread from an infected branch into the trunk.

White Pine Blister Rust

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White Pine Blister Rust

This disease caused the first US quarantine in 1912. The following wording was part of an update to the act (Act 313 of 1929), “The cultivated black currant is hereby declared a public nuisance. Planting, possessing, growing, propagating, selling or offering for sale plants, roots, or cuttings of cultivated black currants within the state is hereby prohibited. Such roots, cuttings or plants now planted or growing may be destroyed by the commissioner or his agents”.

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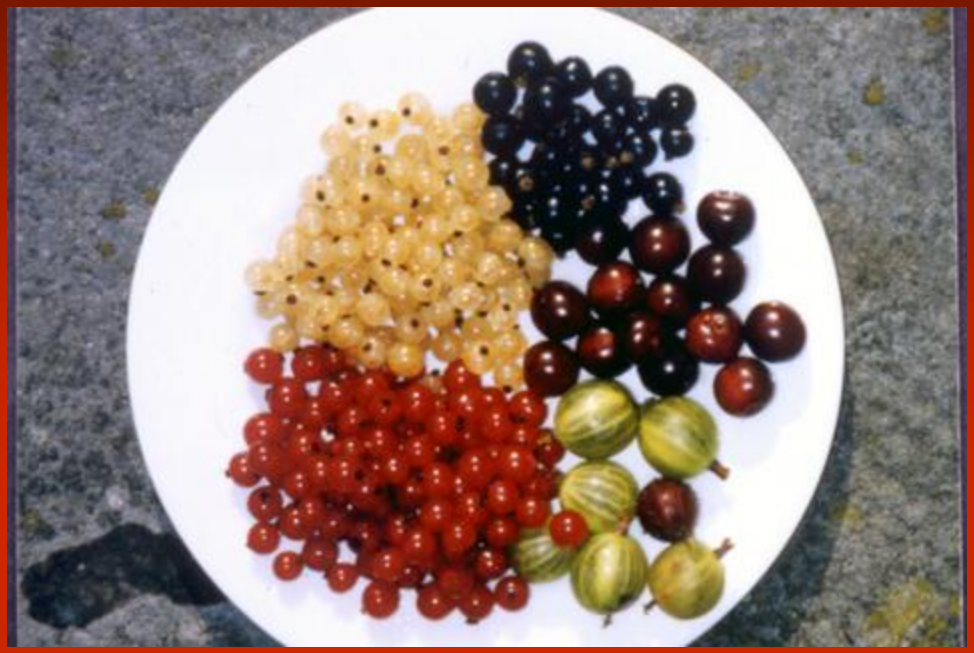
White Pine Blister Rust



"Current" information: Within the blister rust hazard areas, all susceptible *Ribes* should be removed from the vicinity of valuable white pines. *Ribes* are not allowed to be planted in nine northern counties of New York and parts of 6 others (see http://www.dec.state.ny.gov/regs/4079.html for more information). If you wish to plant *Ribes* in New York State, contact the NYS Dept of Agriculture & Markets Phone at 518-457-2087 *before purchasing or planting* to determine **if** you can plant in your area.

History of Plant Pathology III

- 1904-1940- Chestnut Blight- The disease wiped out all the mature American Chestnuts in the eastern North American states.
- The pathogen, *Cryphonectria parasitica*, was brought in from the Orient on infected trees and was first discovered at a zoo in NYC.

Chestnut Blight

A DEADLY FUNGUS ON THE AMERICAN CHESTNUT.

By HERMANN W. MERKEL,

CHIEF FORESTER AND CONSTRUCTOR.

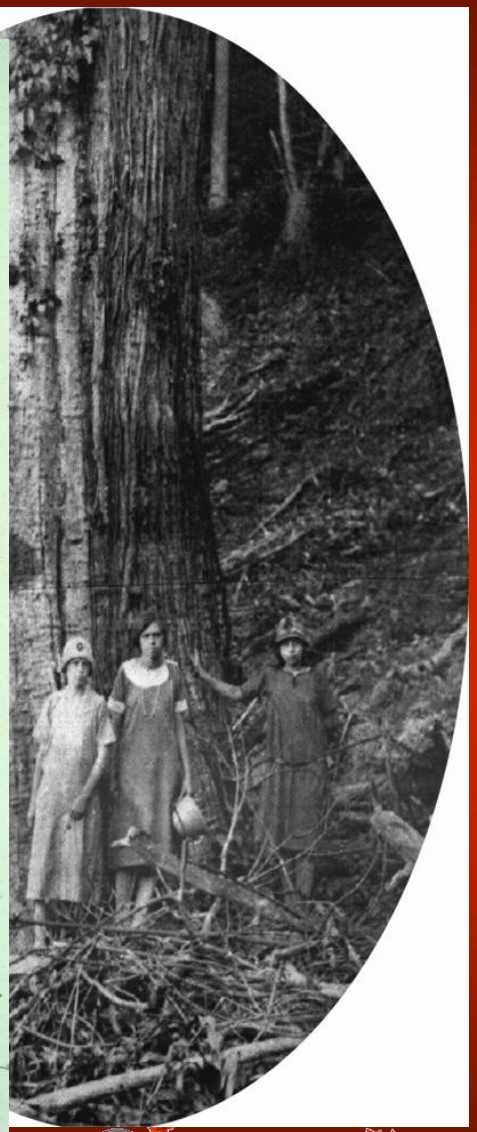
DURING the past year an epidemic of a fungus disease has occurred throughout the parks of this Borough, which, but for the fact that it was confined to a single species of tree, might have overshadowed in deadliness and rapid spread all the other enemies of tree life.

This disease was first noticed in the New York Zoological Park, in a few scattered cases which occurred during the summer of 1904. Since that time, however, it has spread to such an extent that to-day it is no exaggeration to say that 98 per cent of all the chestnut trees in the parks of this Borough are infected. The spread of this disease is so sudden that unless some radical measures are taken, or a natural enemy of this fungus develops, it is safe to predict that not a live specimen of the American Chestnut (*Castanea dentata*) will be found two years hence in the neighborhood of the Zoological Park.

This fungus attacks the live and apparently sound bark of twigs, branches, and limbs. The age and thickness of the bark present no obstacle, nor does the fungus seem to have any preference for susceptible points, such as crotches and eyes.

To the casual observer the first visible sign that the disease has fastened itself upon the tree is the wilting of a portion of foliage for no apparent reason. This may occur at any time during the growing season. Upon closer examination there will be found a ring of dry bark completely encircling the base of the wilted member, and in a short time the spore bearers of the fungus will be scattered thickly over the entire surface of the dry bark. These spore bearers are about the size of a pinhead, and at first are of the color of raw sienna, turning a dark umber with age. The width of this wilted ring on the bark may be anywhere from 1 inch on a small branch to 3 or 4 feet on a larger limb.

As far as may be inferred from the many cases under obser-



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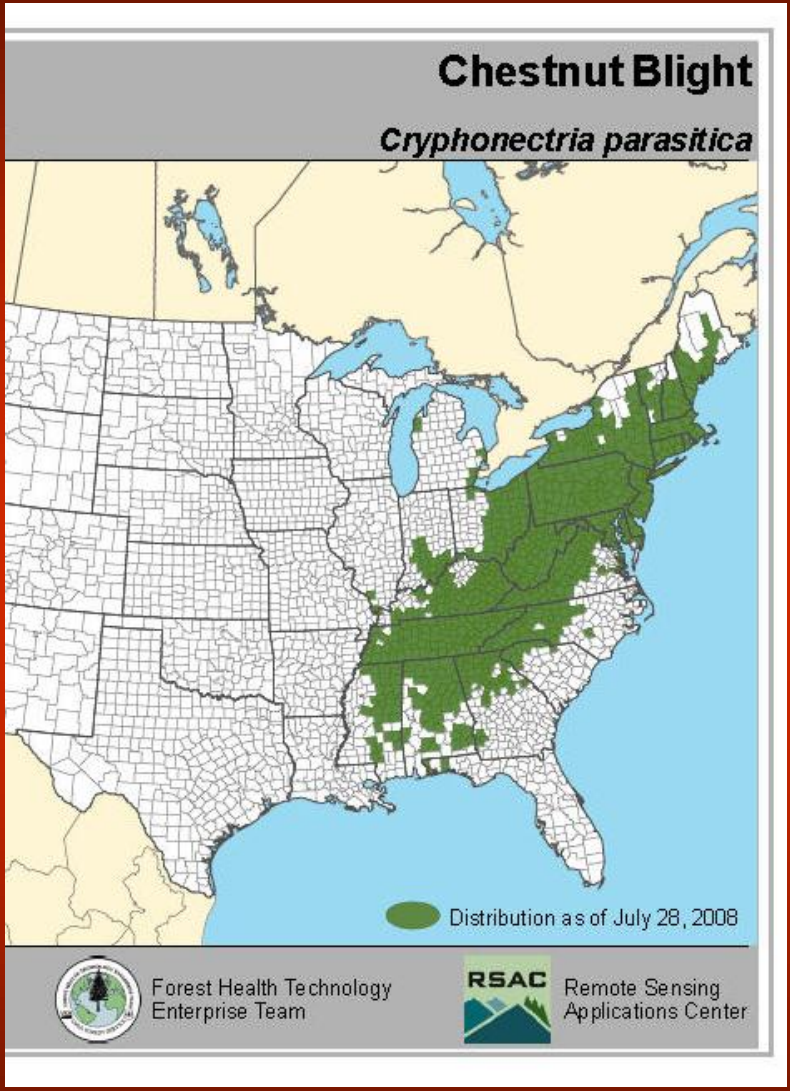
Chestnut Blight



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Chestnut Blight

Diffuse canker

Target canker

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History of Plant Pathology IV

- 1930-present-Dutch Elm Disease. This disease devastated the street tree plantings across the country.
- The disease was named Dutch Elm Disease because it was first described in Holland in 1921.
- The pathogen, *Ophiostoma novo-ulmi*, was first discovered in the US in Ohio.

Dutch Elm Disease

Dutch Elm Disease

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Dutch Elm Disease

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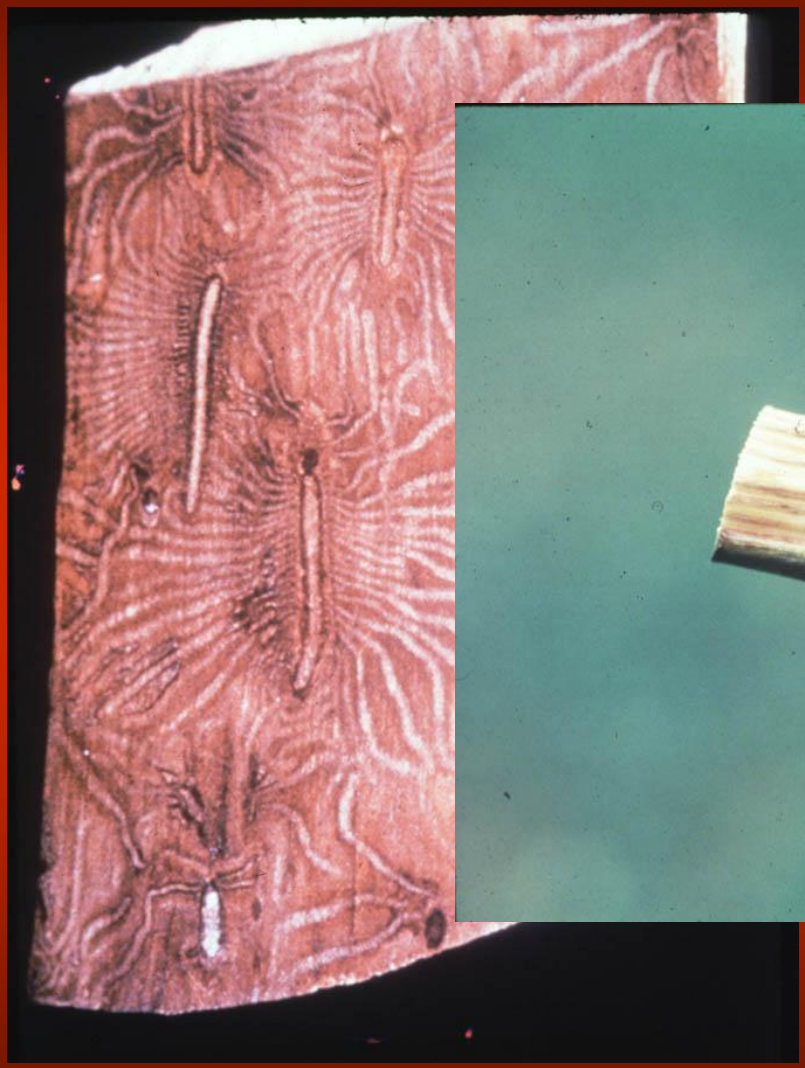
Dutch Elm Disease

Dutch Elm Disease



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History of Plant Pathology V

- Golden Nematode, *Globodera rostochiensis*, was discovered in 1941. It entered the country on the tracks of WWI equipment returning from Europe.
- It caused a slow decline in potato plants that eventually lead to death.
- As of 1955, the distribution was believed to be located only in Nassau and Suffolk counties in NYS.

Golden Nematode

Golden Nematode

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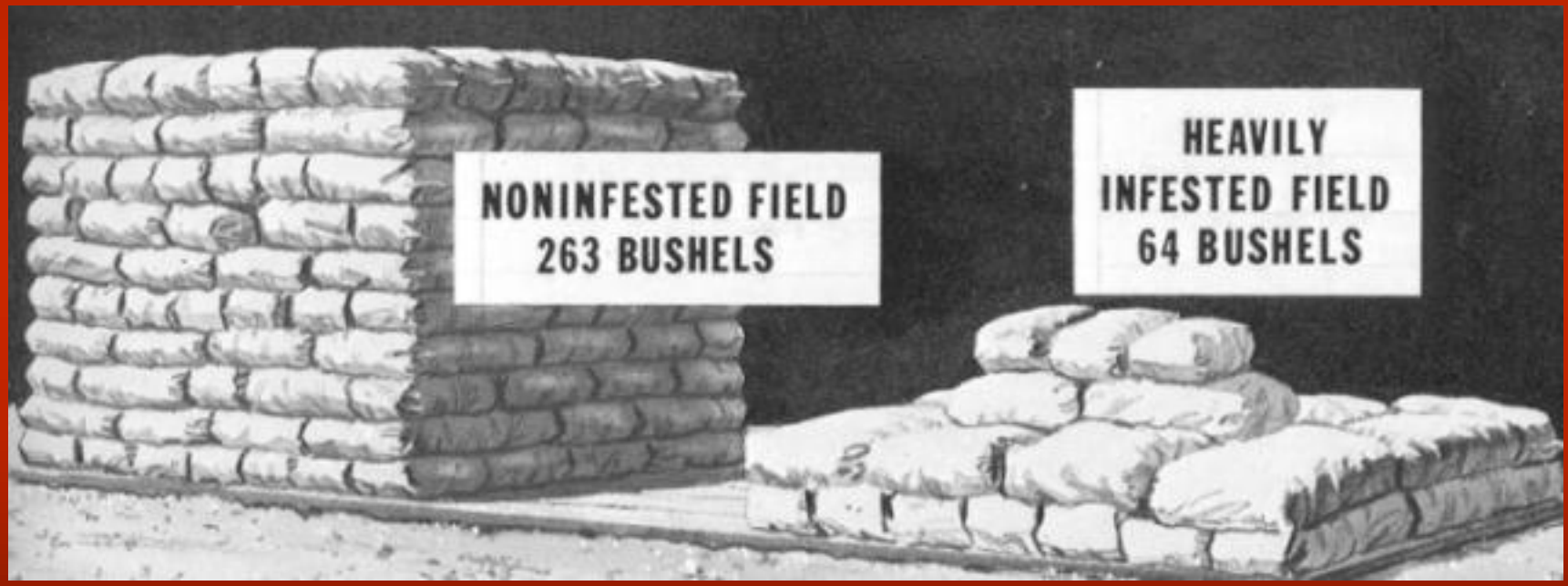
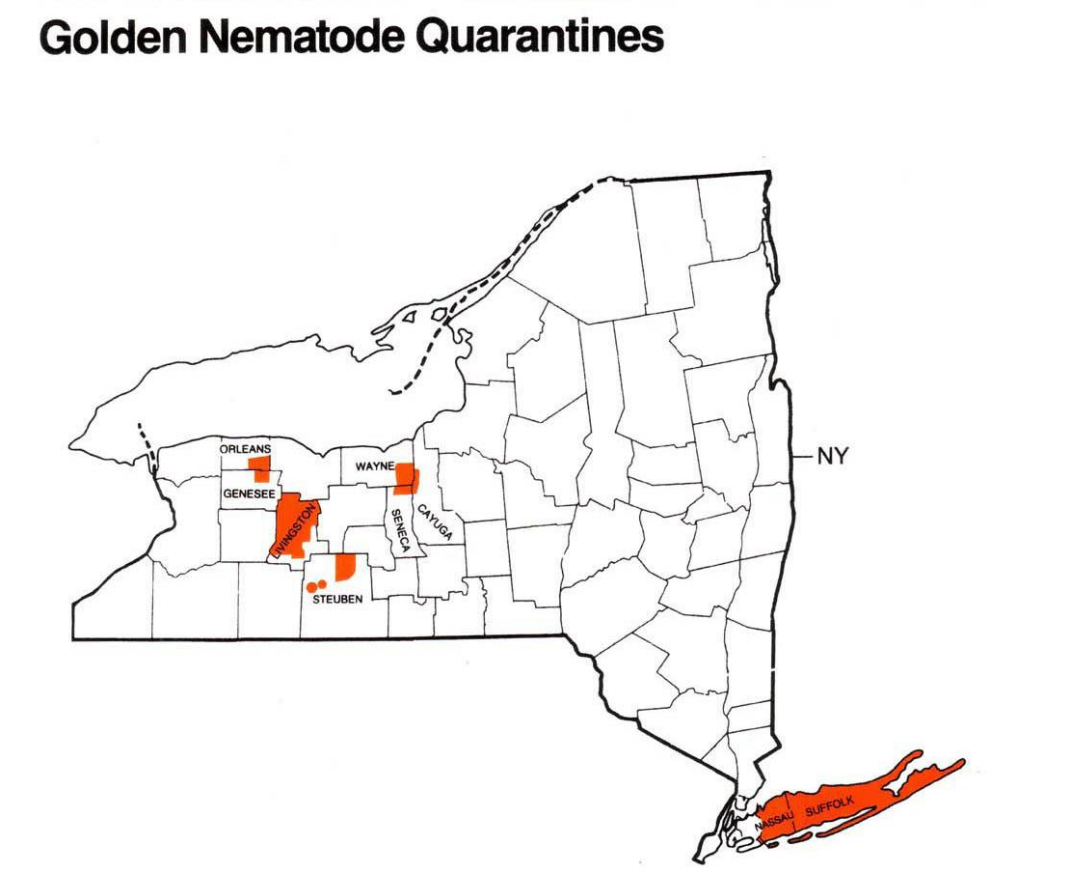
Golden Nematode

After decades of building their population levels, the GN was capable of reducing the potato yield up to 70%.



Golden Nematode

For over 60 years, an effective Federal and State quarantine program has confined the pest to nine counties in New York.



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History of Plant Pathology VI

- 1970-Southern Corn Leaf Blight, caused by *Helminthosporium maydis*. Originally considered a minor disease, a change in the genetics of seed corn caused an epidemic.
- In 1970, the disease was reported in every state east of the Mississippi River, also in several states west of the Mississippi River.
- The epidemic received enormous press coverage with over 37 articles printed in the Chicago Tribune alone.
- Losses due to the epidemic were officially estimated at nearly $1 billion nationally. Reduction in yield was greater in the South versus the min-west corn belt states. In some areas damage caused losses of 50-100%. Nationally losses averaged 20-30%.

Southern Corn Leaf Blight

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Southern Corn Leaf Blight

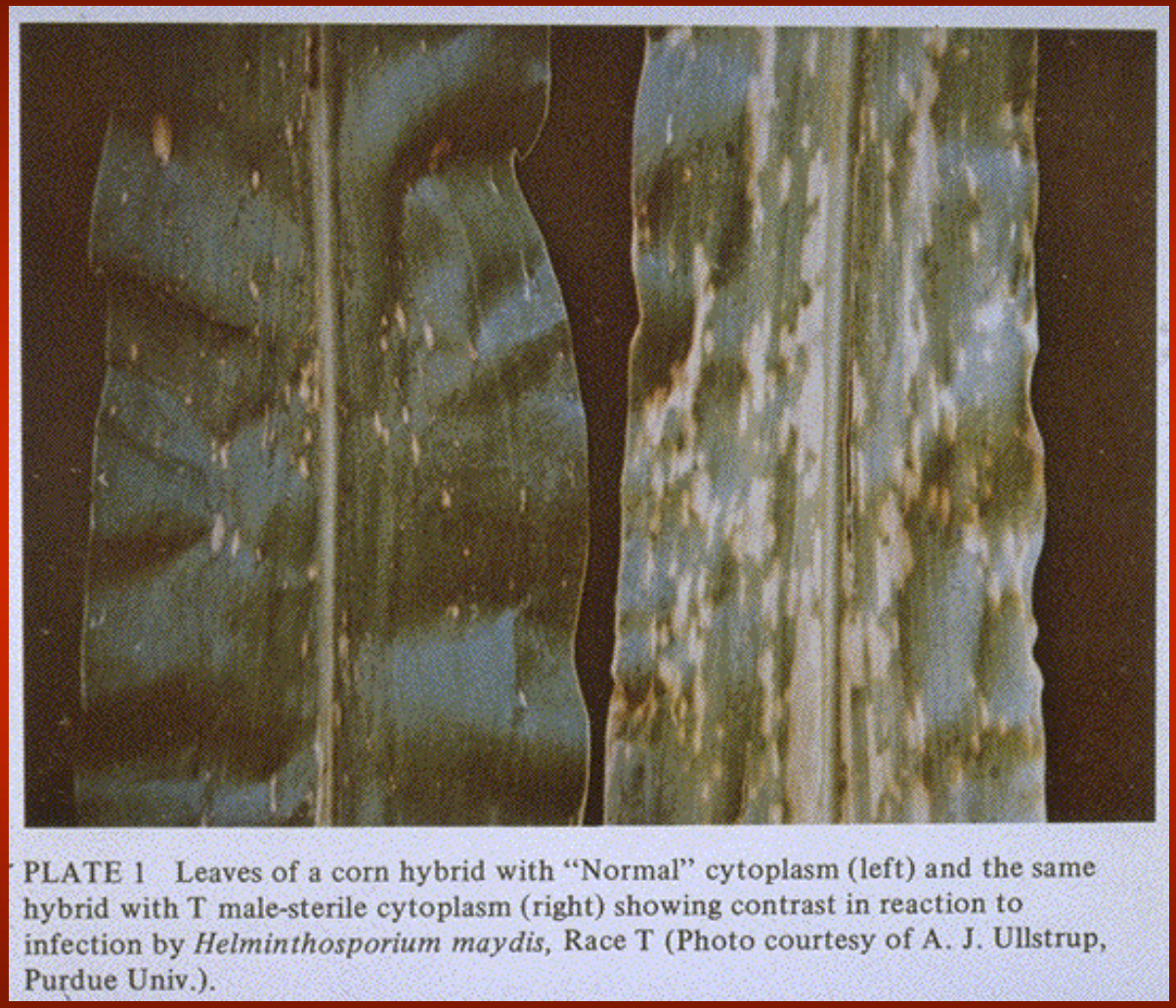
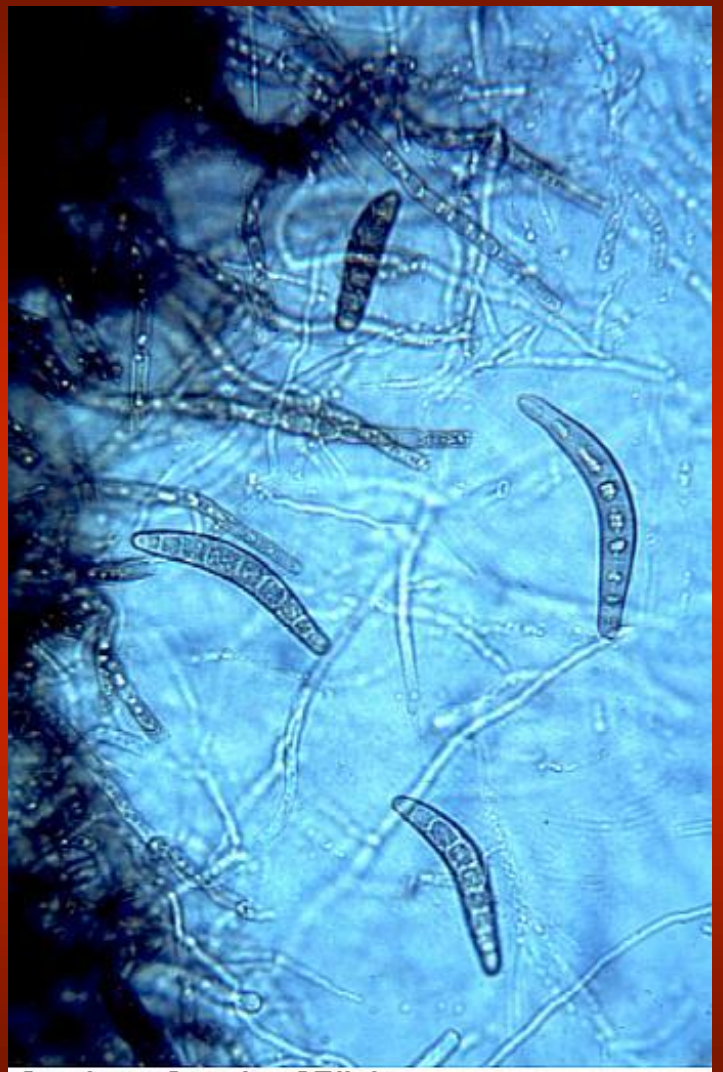


PLATE 1 Leaves of a corn hybrid with "Normal" cytoplasm (left) and the same hybrid with T male-sterile cytoplasm (right) showing contrast in reaction to infection by *Helminthosporium maydis*, Race T (Photo courtesy of A. J. Ullstrup, Purdue Univ.).

Southern Corn Leaf Blight

In an effort to reduce labor costs associated with detasseling to control pollination, breeders incorporated cytoplasmic male sterility, known as “Texas Male Sterile Cytoplasm”, in the seed corn. This inadvertently included a high susceptibility to the T race of the pathogen. This seed was widely planted in 1970, resulting in devastating outbreaks.



Southern Corn Leaf Blight (Bipolaris maydis) organism. Courtesy Harold Kaufman. TAEX. 1996.

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History of Plant Pathology VII

- Sudden Oak Death, caused by *Phytophthora ramorum*, was discovered in California.
- A large number of tanoaks were found to be declining with no known cause. It took 5 years to identify the pathogen that was causing the devastating damage.
- Also called ramorum blight and ramorum dieback.
- Although the disease was first observed in the United States in tanoaks, it is also found to infect **many, many** other plant species.

Sudden Oak Death

- *P. ramorum* identified in Germany and the Netherlands in 1993

- Sudden Oak Death named an a disease in the US in 1995, the pathogen identified as *P. ramorum* 5 years later by a UC Berkeley researcher.

- In 2002, the isolates from the US and UK are determined to be different.

- P. ramorum found in HUGE nursery in Los Angeles Co, CA.

(Govt of British Columbia, Ministry of Ag, Food, & Fisheries)

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Sudden Oak Death

- Nursery find sparked large national survey, *P.ramorum* found all over the country but only in containerized plants.

- We learned that the understory plants were the source of the inoculum for infection

- Federal Order in place so that any nurseries from CA, OR, and WA wishing to ship outside of their states must be inspected annually.

Common Regulated Hosts

Common Name	Scientific Name
Japanese camellia	*Camellia japonica*
Sasanqua camellia	*Camellia sasanqua*
Witch Hazel	*Hamamelis virginiana*
Himalaya pieris	*Pieris formosa*
Pieris 'Forest Flame'	*Pieris formosa* x *japonica*
Pieris 'Brouwer's Beauty'	*Pieris floribunda* x *japonica*
Japanese pieris	*Pieris japonica*
Douglas-fir	*Pseudotsuga menziesii* var. *menziesii*
Coast Live Oak	*Quercus agrifolia*
Rhododendron (including azalea)	*Rhododendron spp*
Bodnant Viburnum	*Viburnum* x *bodnantense*
Doublefile Viburnum	*Viburnum plicatum* var. *tomentosum*

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Common Plants associated with *P. ramorum*

Common Name	Scientific Name
Grand fir	*Abies grandis*
Horse-chestnut	*Aesculus hippocastanum*
Camellia	*Camellia reticulata*
Camellia	*Camellia* x *williamsii*
European beech	*Fagus sylvatica*
Mountain laurel	*Kalmia latifolia*
Drooping leucothoe	*Leucothoe fontanesiana*
Chinese pieris	*Pieris formosa* var. *forrestii*
Pieris	*Pieris formosa* var. *forrestii* x *Pieris japonica*
Formosa firethorn	*Pyracantha koidzumii*
Southern red oak	*Quercus falcata*
Northern red oak	*Quercus rubra*
Salmonberry	*Rubus spectabilis*
Lilac	*Syringa vulgaris*
David Viburnum	*Viburnum davidii*
Fragrant Viburnum	*Viburnum farreri*
Wayfaringtree Viburnum	*Viburnum lantana*
Burkwood Viburnum	*Viburnum x burkwoodii*
Prague Viburnum	*Viburnum x pragense*

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Symptoms

Bleeding Bark Canker

(Photos Joseph O'Brien, USDA Forest Service, www.forestryimages.org)

History of Plant Pathology VIII

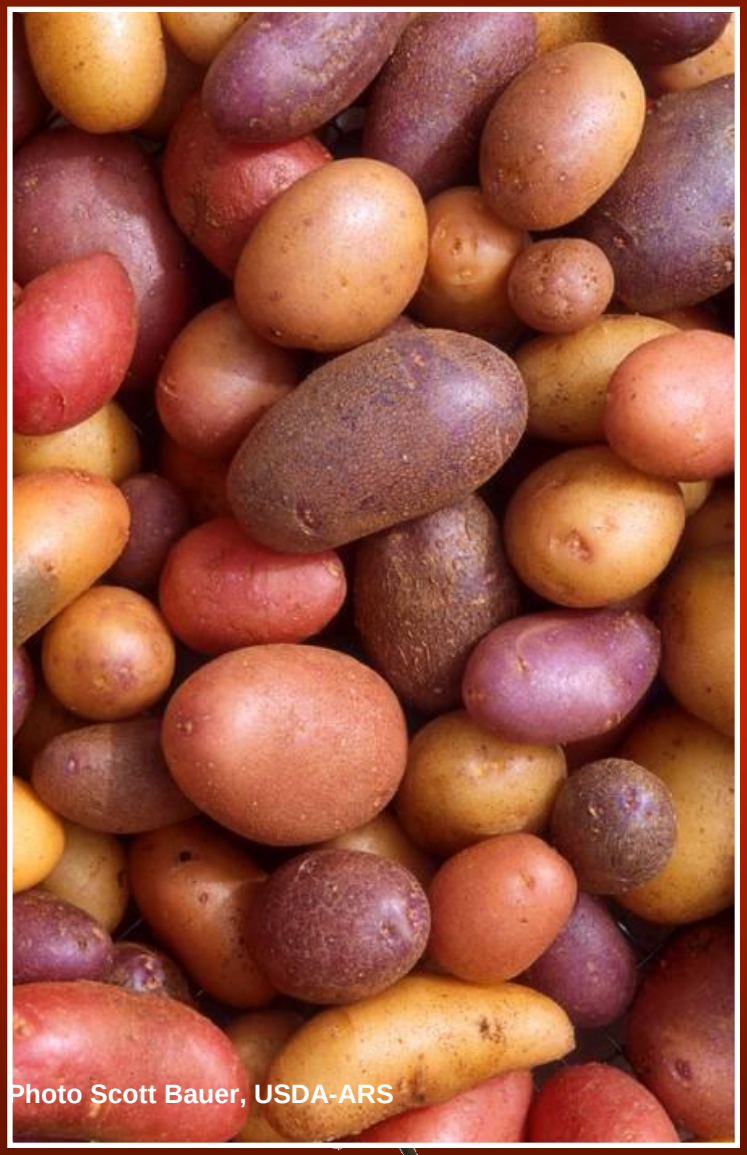
- 1999- Southern Wilt/Brown Rot, caused by *Ralstonia solancearum* R3 B2
- Southern Wilt is a disease of Geranium and Brown Rot is a disease of Potato
- *Ralstonia solanacearum* Race 3 Biovar 2 has appeared on Geranium a few times in recent years but it appears to be confined to greenhouse crops and there is no evidence of spread to potato, tomato, or eggplant

Southern Wilt / Brown Rot

• There are a number of races and biotypes of this pathogen that affect different plants.

•We are concerned with Race 3 Biovar 2 because it infects solanaceous plants.

•It is also able to survive in temperate climates and may be able to overwinter in cull piles and in plant debris or tubers left in fields.



Southern Wilt / Brown Rot

• The pathogen may be introduced on infected geranium cuttings.

•Cuttings are produced overseas and shipped here.

•They may be asymptomatic until placed in warmer greenhouses for rooting and then symptoms will become present.

•In 2003, 127 greenhouse in 27 states received infected cutting from a producer in Kenya.

•In 2004 , another introduction occurred from a producer in Guatamala.

(Wisconsin Department of Agriculture)

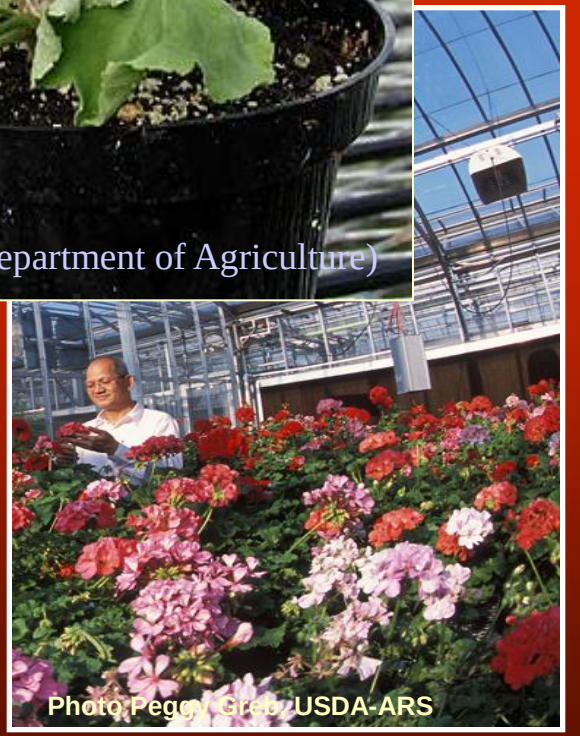


Photo Peggy Greb, USDA-ARS

Symptoms

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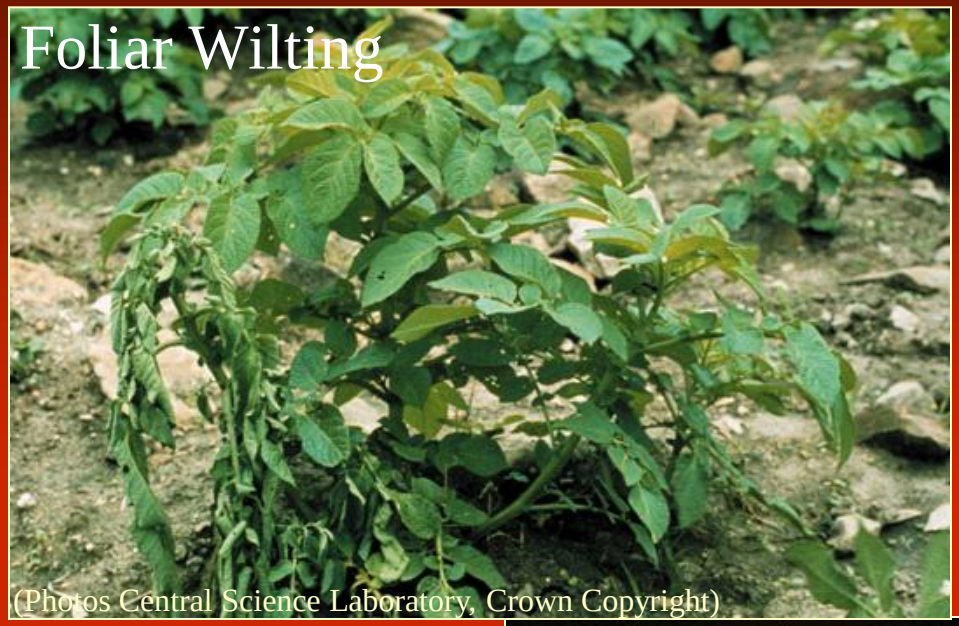
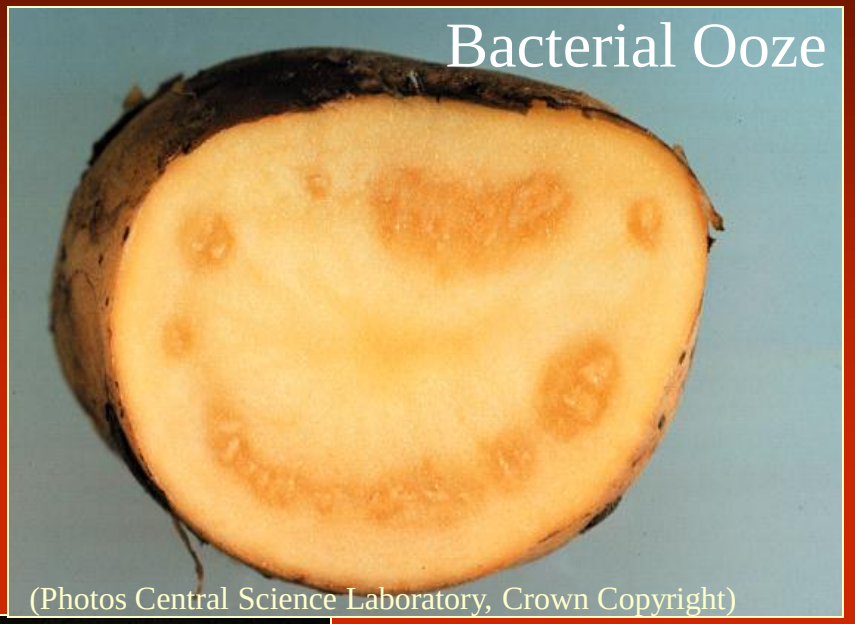
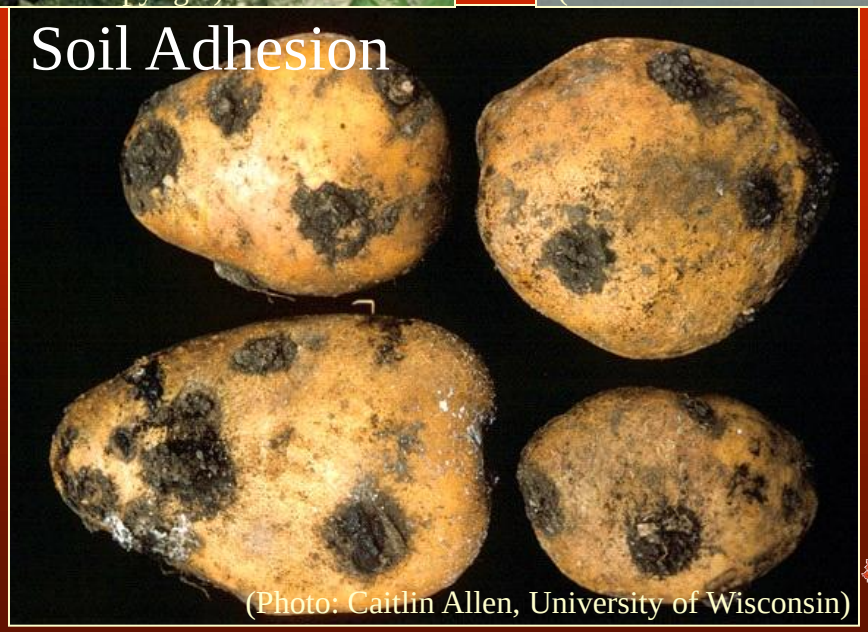
Symptoms







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History of Plant Pathology X

- 1999- Plum Pox, caused by *Plum Pox Virus*, is a disease of stone fruits caused by a viral pathogen called the Plum Pox Virus
- Also known as “Sharka”
- First discovered in an Adams County, Pennsylvania Orchard in 1999
- A member of the Agricultural Bioterrorism Select Agent Listing of 2002. It was removed from the listing in April 2005 due to its limited ability to spread easily.

Plum Pox

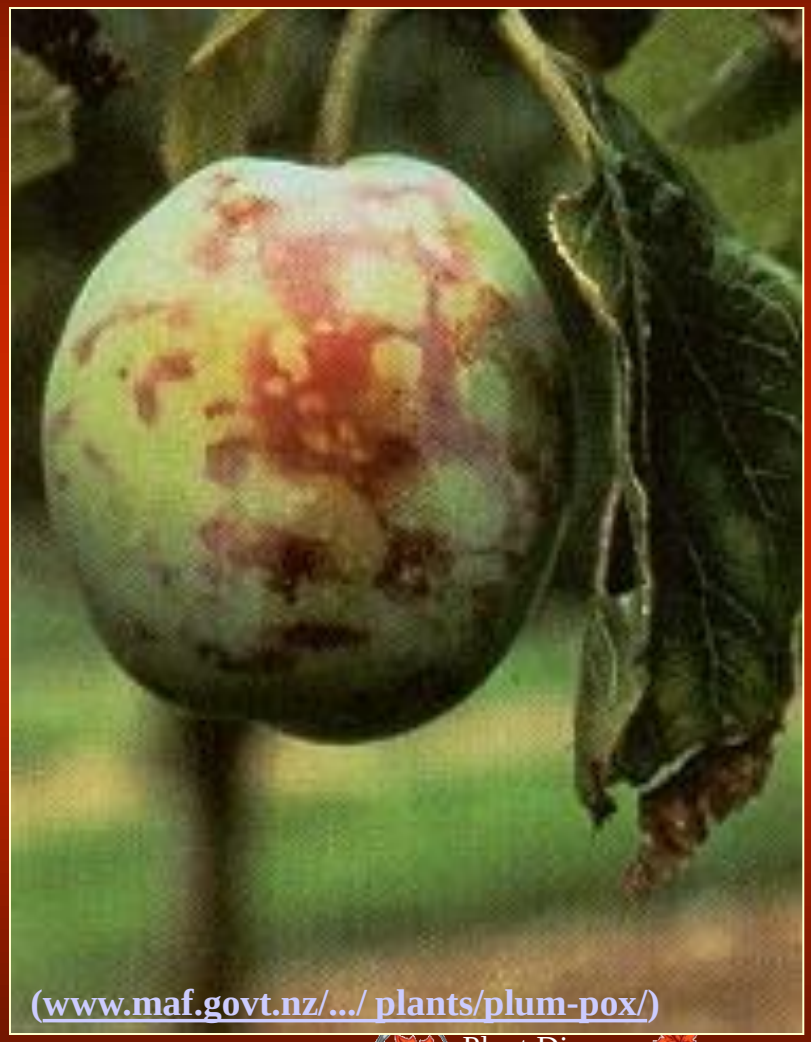
• Plum Pox has been in Europe since the early part of the century.

•First found in the US in Adams Co, Pennsylvania in 1999 and in two locations in Canada, Ontario and Nova Scotia, in 2000.

•Surveys have been conducted in NYS since 1999.

•Found in New York in 2006 and in Michigan in 2006.

•Pennsylvania declared free of Plum Pox in 2009.



(www.maf.govt.nz/.../ plants/plum-pox/)

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Symptoms

Foliar Mottling

Fruit Spotting

Pit Symptoms

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History of Plant Pathology XI

- 2004-Soybean Rust, is caused by two fungi named *Phakopsora pachyrhizi* and *Phakopsora meibomiae*
- A member of the Agricultural Bioterrorism Select Agent Listing of 2002. It was removed from the listing in April 2005 due to its established presence in the US.
- *P. pachyrhizi* appeared in the US in November 2004, apparently entering on winds of Hurricane Ivan. It was found in 9 States shortly thereafter. Detected by a NPDN exercise participant.
- It was found in Florida early in 2005 on Kudzu and volunteer Soybean and new detections for this season remained in the South.

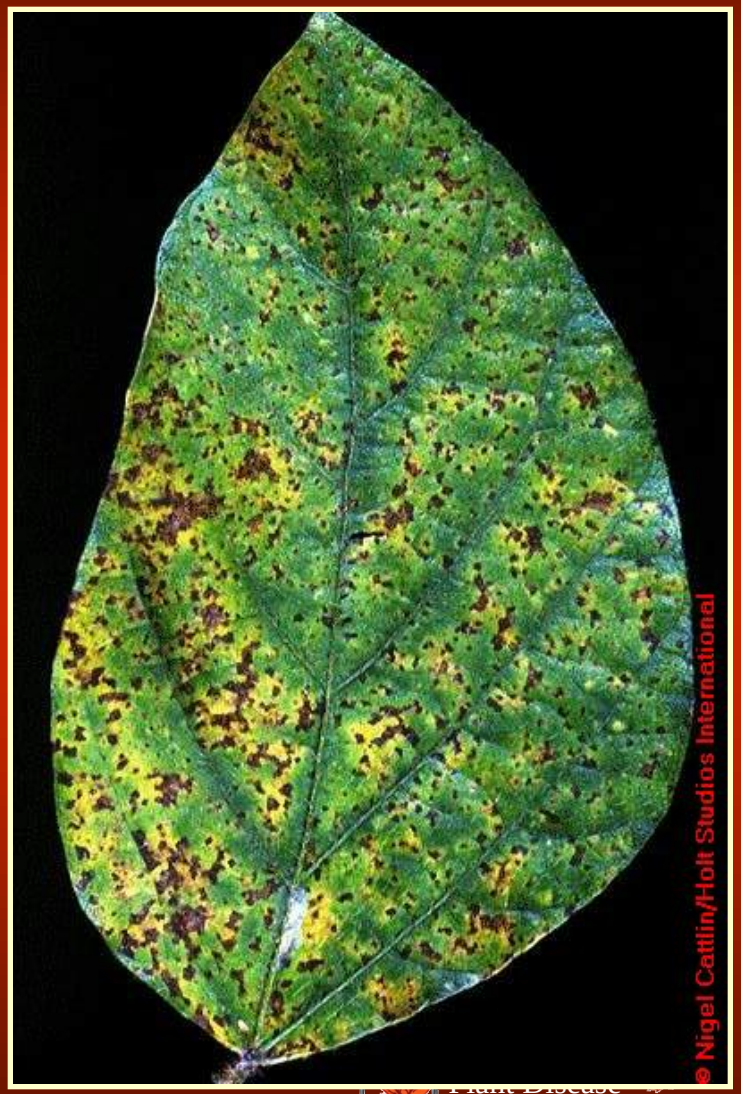
Soybean Rust

• The pathogens that cause Soybean Rust were originally found only in tropical and sub-tropical areas of Asia and Australia.

•In the 70's and 80's the pathogen was found in Africa and South America.

•Concern began when the pathogen was discovered 5 degrees north of the equator in Cali, Colombia in August of 2004.

•Discovered in Louisiana by an NPDN first detector in November 2004.



Diagnostic Clinic

Symptoms

Leaf Surface

Spores on Leaf

Urediniospores

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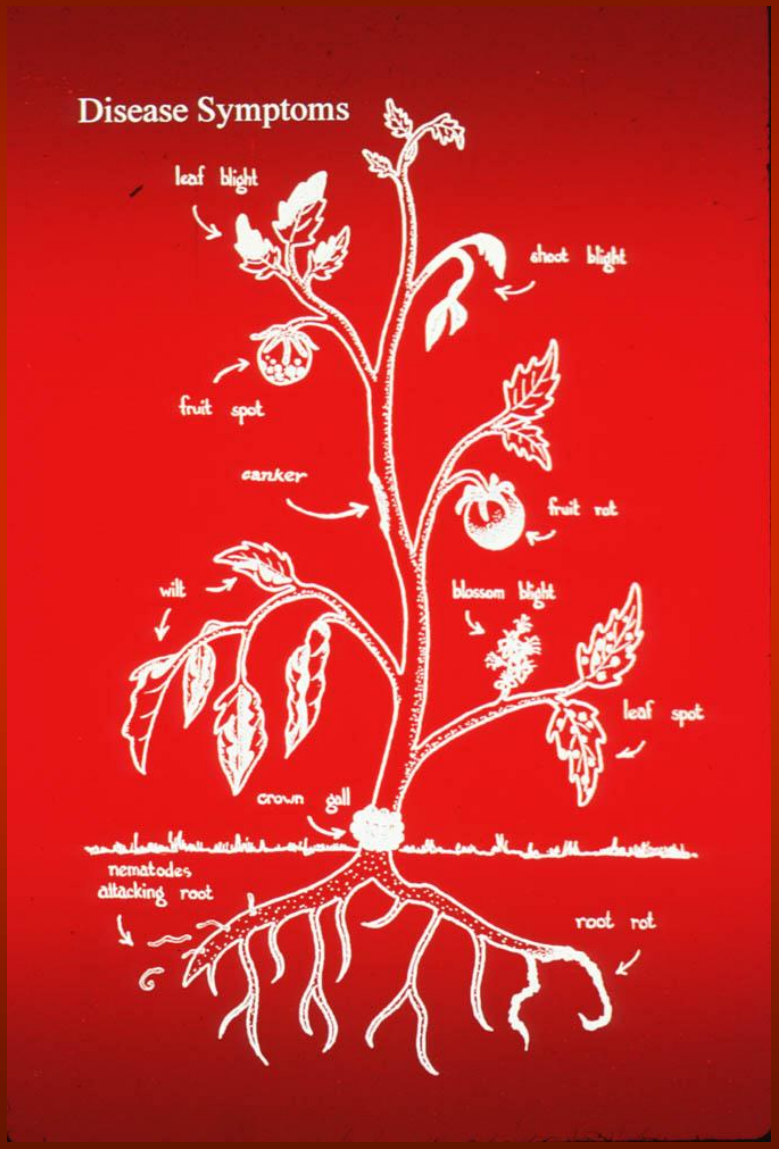
Basic Plant Pathology



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Symptoms and their Causal Agents

	Bacteria	Fungi	Viruses	Nematodes	Phytoplasmas
Wilts	√	√		√	√
Leaf Spots & Blights	√	√	√		
Fruit Rots	√	√			
Root Rots	√	√		√	
Damping Off		√			
Distorted Growth	√	√	√	√	√

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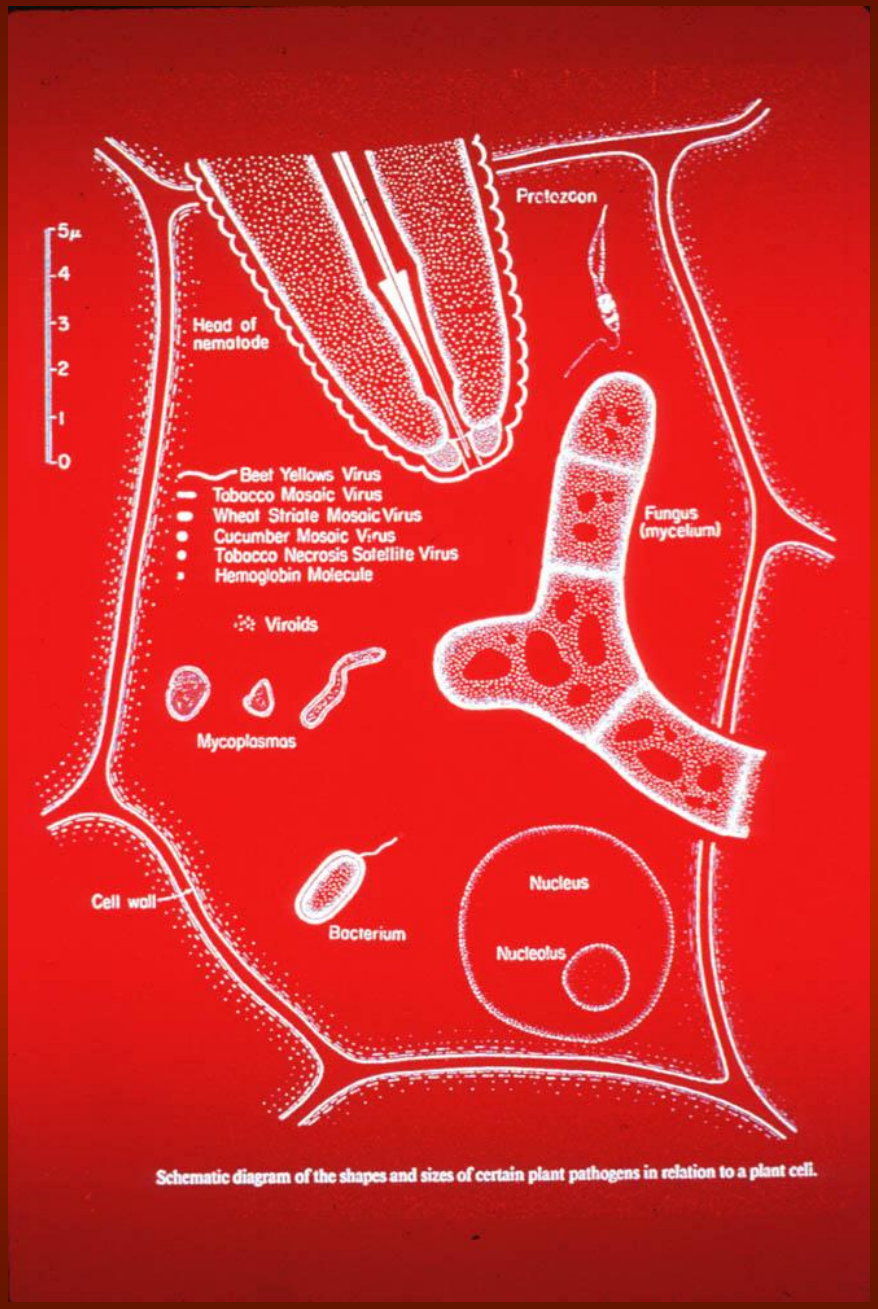

Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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Parasites vs. Saprophyte

- Parasite- an organism that derives nourishment from another living organism.

- Saprophyte- an organism that derives nourishment from dead organic matter.

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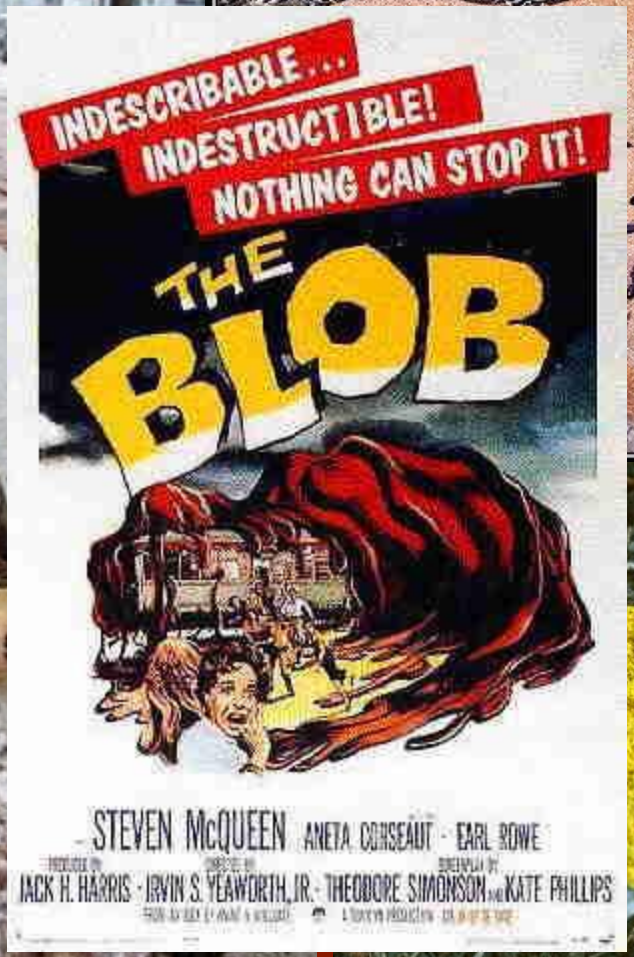
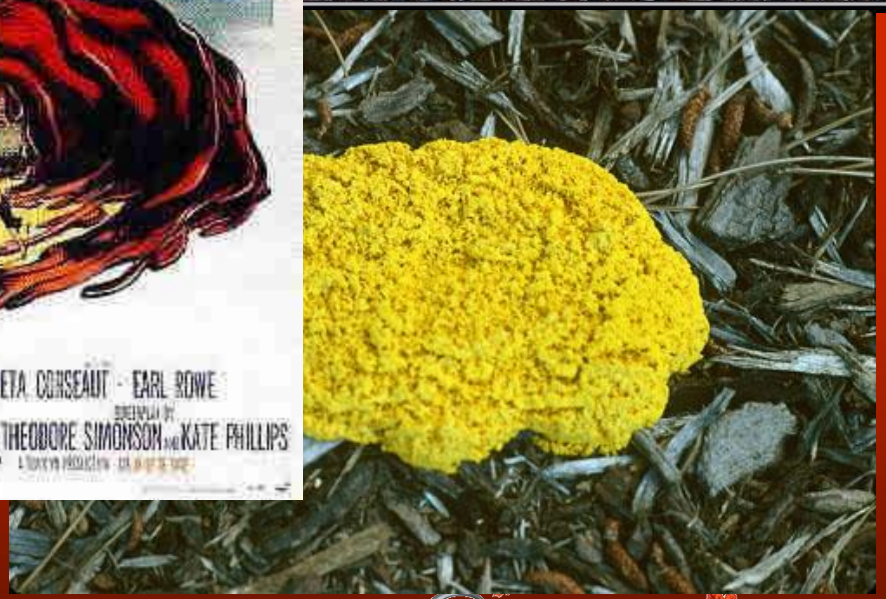
Photo by cottonmanifesto





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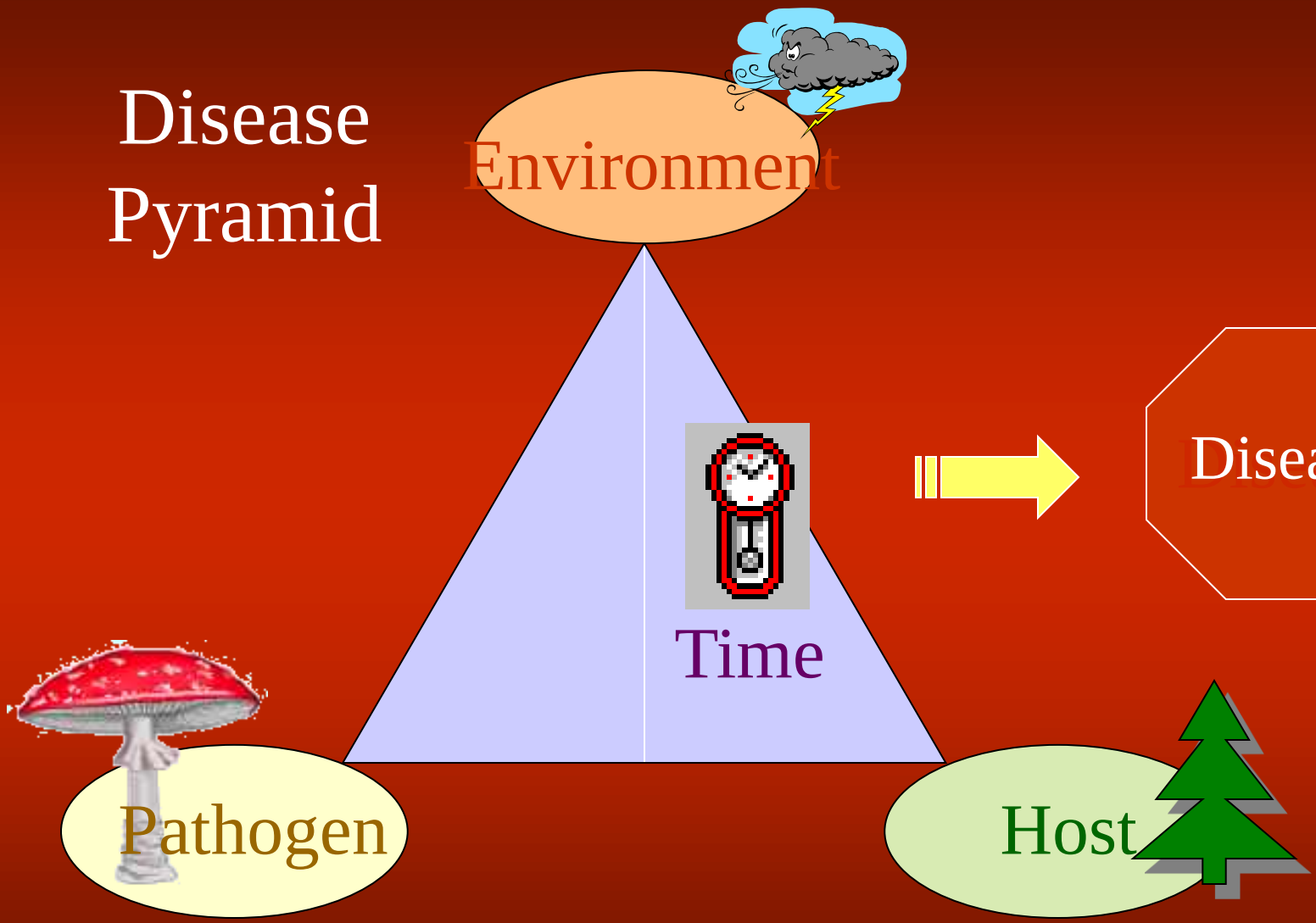
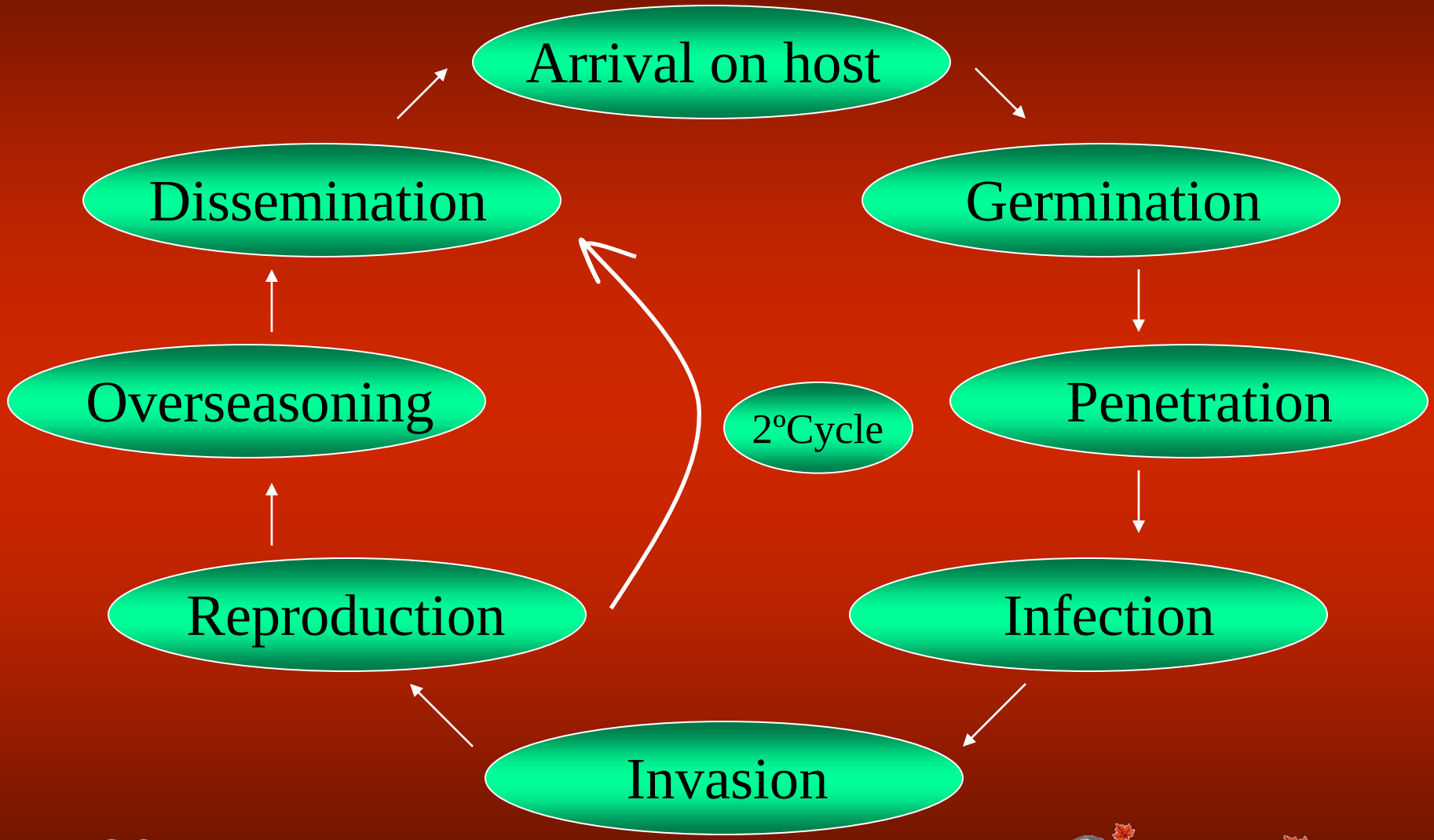
Disease Pyramid



Generalized Pathogen Lifecycle



Spread


Survival strategy…
…survive within the host.

Survival strategy…

…survive as sclerotia.

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Survival strategy…

…survive on perennial weeds.

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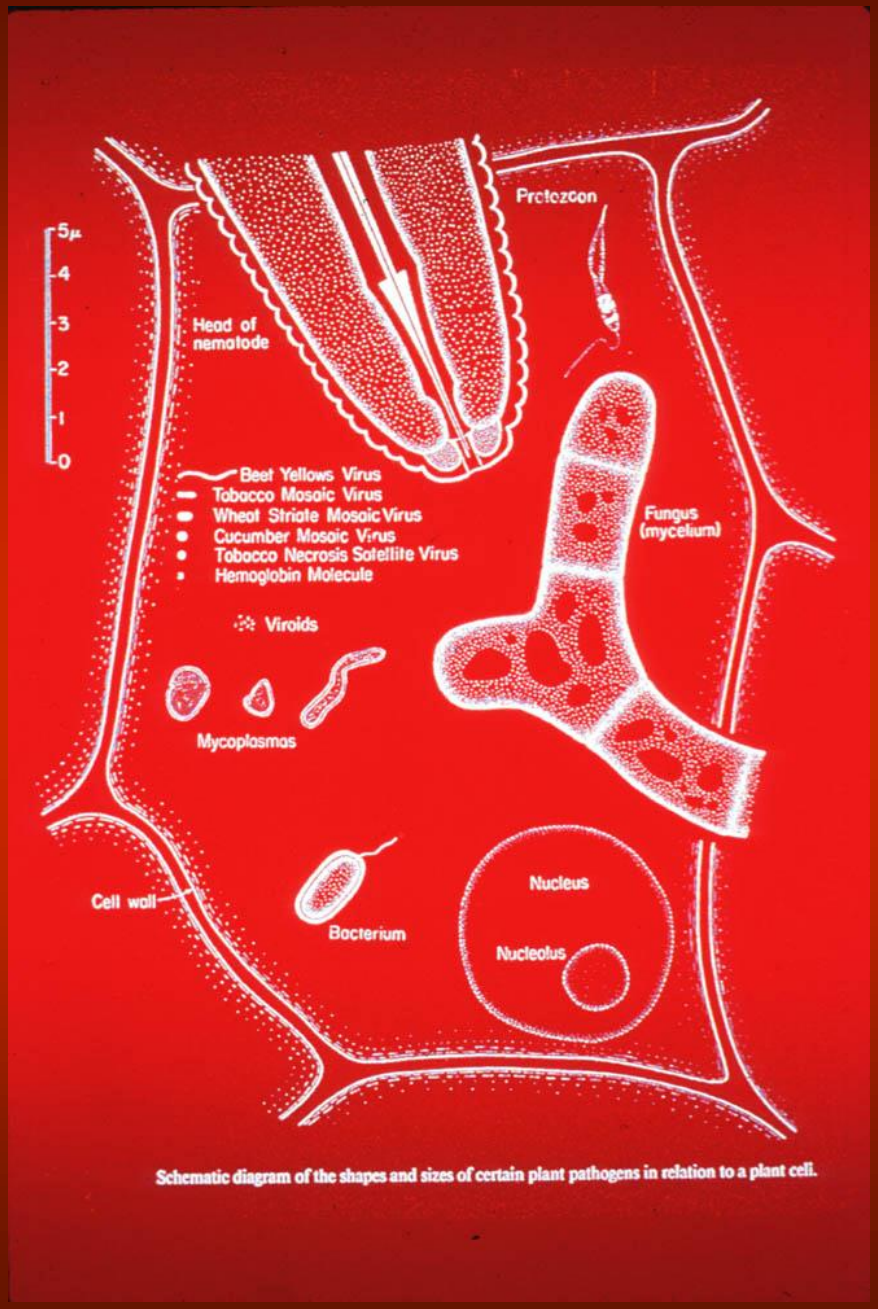
Survival strategy…
…introduced from other areas.

Fungi

A fungus is a non-photosynthesizing eukaryote that produces enzymes and absorbs its food; usually producing and living inside a network of apically extending, branching tubes called hyphae. It produces reproductive structures called spores.



Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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Fruit Bod

diophores.

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Fruit Bodies…

…pycnidia.

Fruit Bodies…

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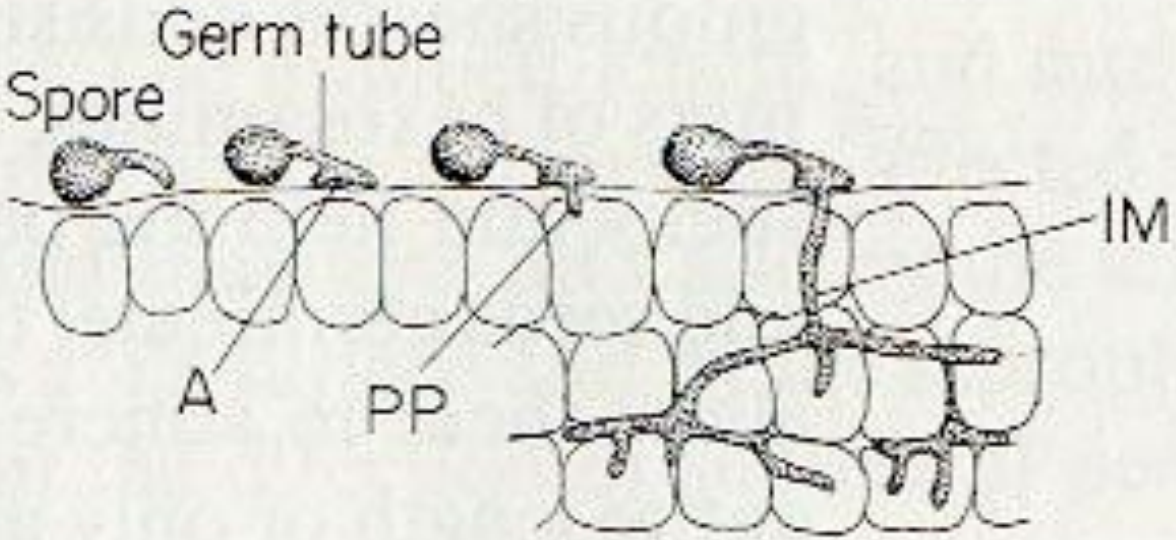
Fungal Invasion…

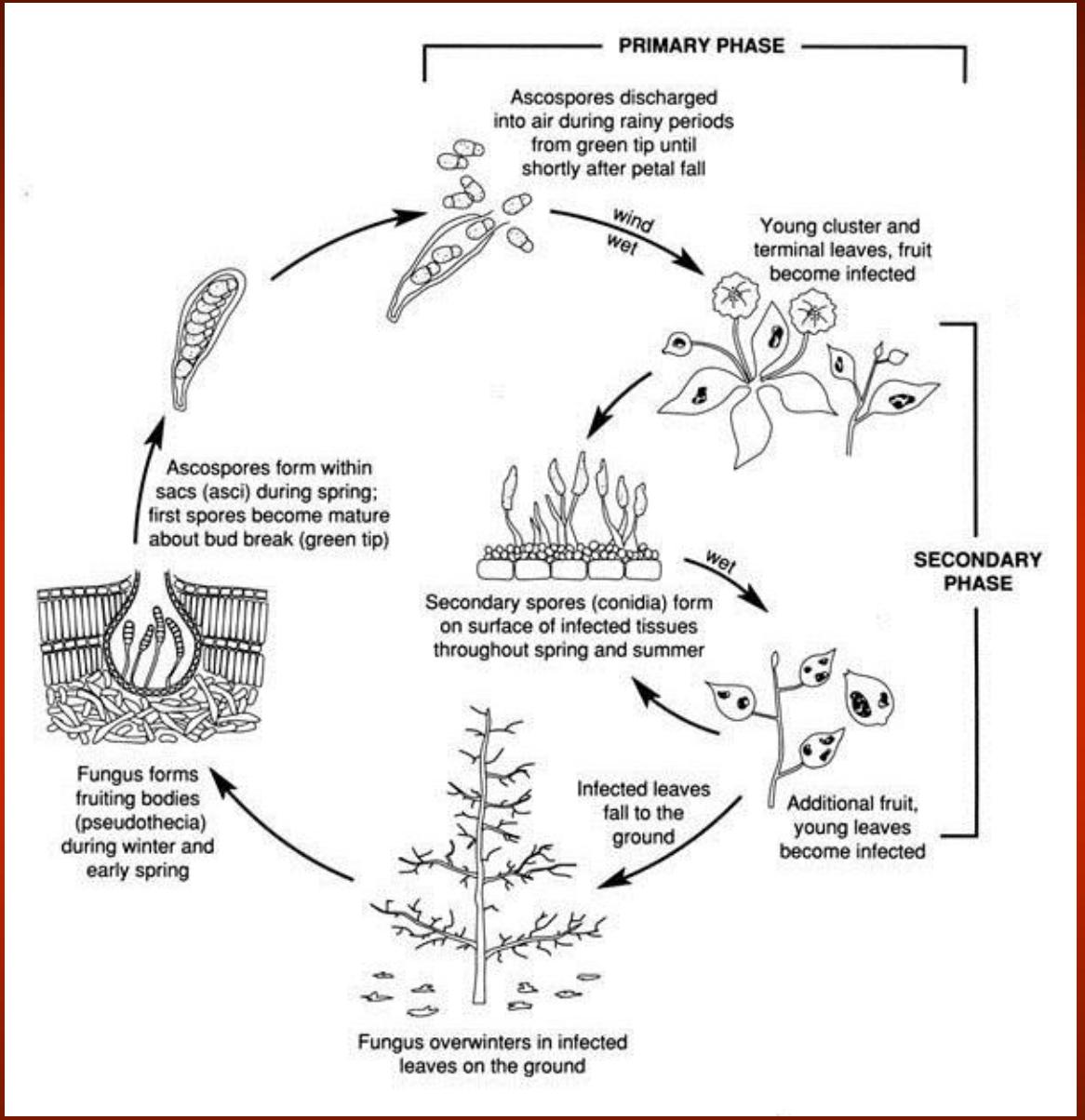


Direct with appressorium (A), penetration peg (PP), and intracellular mycelium (IM)

Moisture Favors…

- Fungus Growth
  - Spore Production
    - Spore Germination
      - Spore Dispersal

Apple Scab Disease Cycle



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Apple Scab

Apple Scab

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Apple Scab Pseudothecia

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Fungi Spread

- Environmental Conditions
  - Slight Air Movement to Wind, Splashing Rain
- Vectors
  - People, Animals, Insects
- Planting Material
  - Vegetative parts
- Mechanical Means
  - Tools, Equipment, Plant Contact

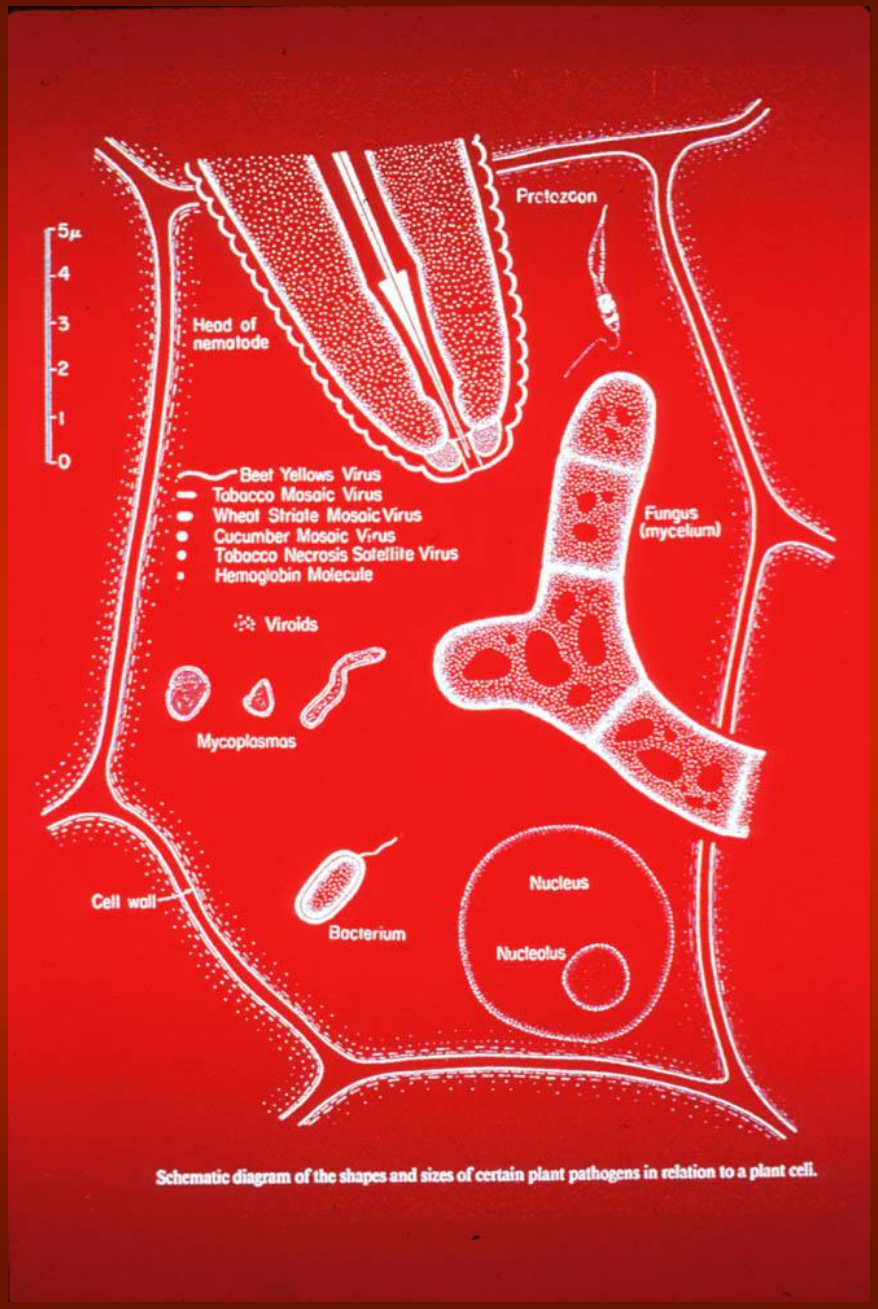
Fungi Management Techniques

- Fungicides
- Exclusion
- Eradication
- Resistant Varieties
- Clean Tools and Materials
- Avoid Wounds, Stress

Eradication of Barberry, an alternate host of the dreaded Wheat Rust.

Bacteria

A bacterium (bacteria=plural) is a prokaryotic single celled microscopic organism that multiples by division.



Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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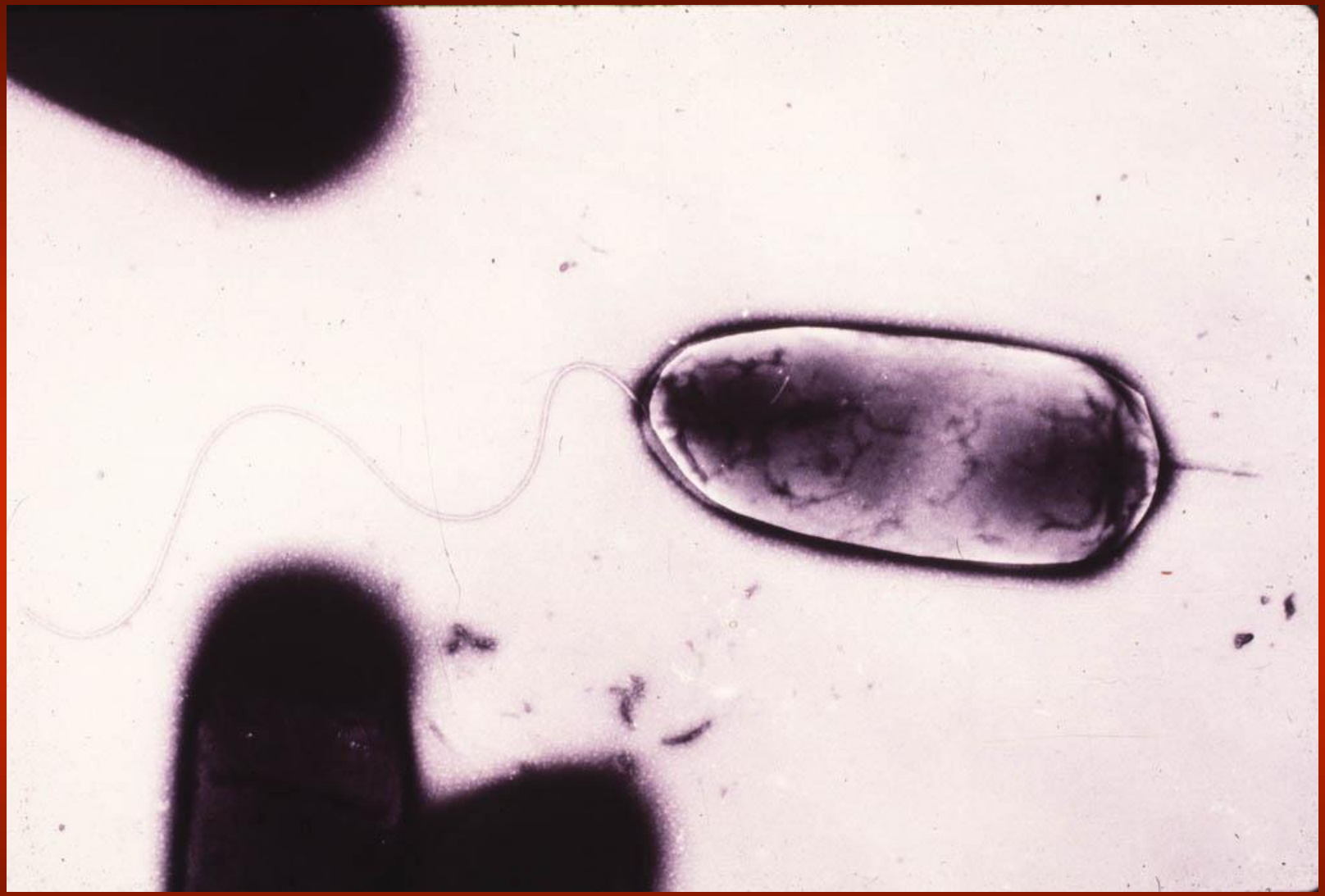


multiplication of bacteria

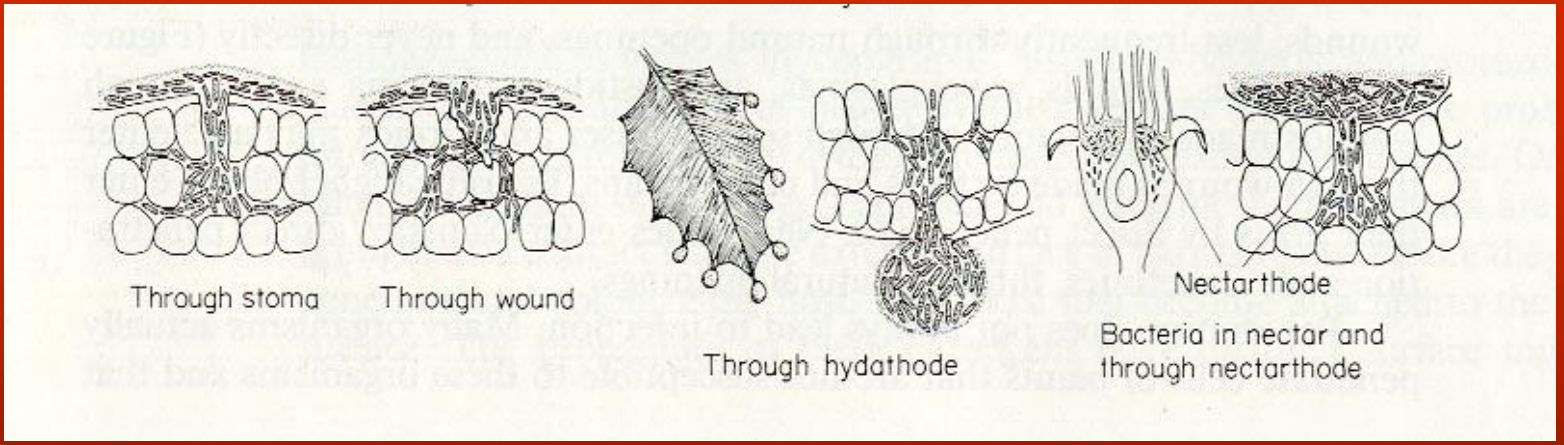
1 cell ⟶ 24 hrs. ⟶ 17 million cells

Each colony contains thousands…

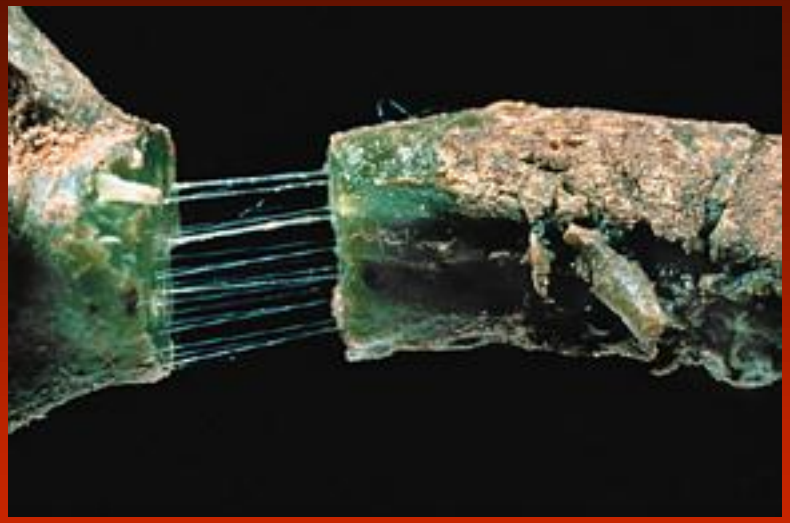
…perhaps millions of cells.

Bacterial Infection Routes

•Bacteria can infect plants through natural openings and wounds.



Diagnostic techniques



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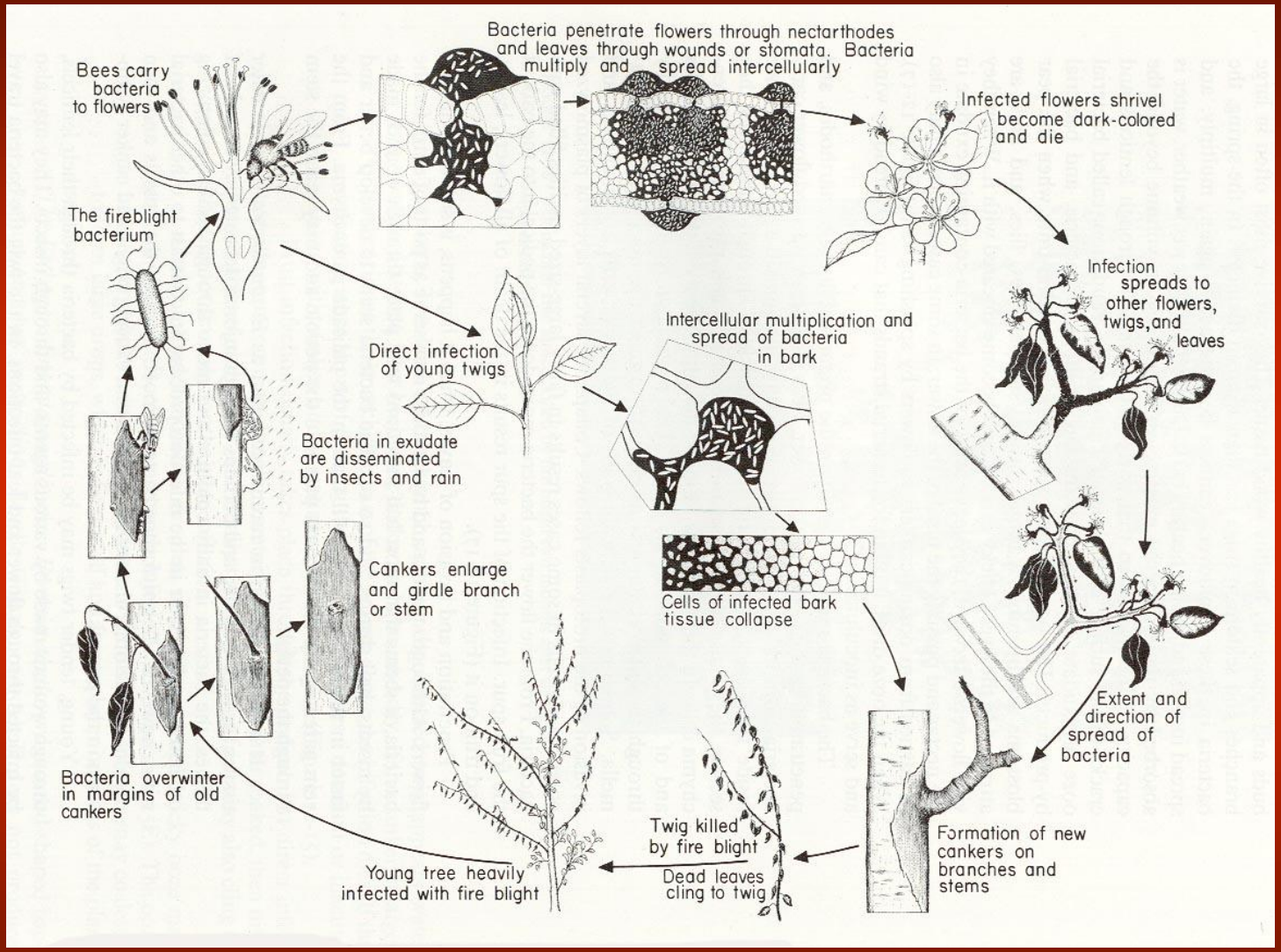
Fire Blight Life Cycle



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Washington Agricultural Experiment Station, Pullman, Wash., February, 1915. Popular Bulletin No. 80
Ira D. Cardiff, Director and Botanist.

FIRE BLIGHT

IS THE GREATEST DANGER TO THE FRUIT INDUSTRY

Blight is a PREVENTABLE Disease

Pear Blight, commonly called "Fire Blight," is caused by microscopic, invisible plants (bacteria), growing inside the bark of the tree. No chemical has yet been found which will kill these bacteria without killing the tree.

Blight is the "GREAT WHITE PLAGUE" of the Fruit Industry

It causes losses of $25,000,000 annually to the country. If a foreign foe should invade the country and demand a tenth of this amount, millions would be expended on our army to defeat it. If a fleet of pirates should prey upon our commerce at the rate of $1,000,000 per year, a hundred million would be expended on battleships to combat the foe.

ROUT THE ENEMY—BLIGHT—AT ALL COSTS!

Canker on Living Branch

THE DISEASE CAN BE CONTROLLED

Inspection is Necessary

Give the Inspectors Your Support.

Consult County Agriculturist, State Inspector, or Experiment Station for methods.

Write Experiment Station for Bulletin on Blight.

Canker near tree trunk. Trees affected thus should be pulled out and burned

Cleaning Up "HOLD-OVER" BLIGHT is the Best Means of Prevention

THE ONLY KNOWN WAY TO CONTROL BLIGHT IS BY SURGERY

In cutting it out, cut 6 to 24 inches below the canker. DISINFECT TOOLS AND CUTS WITH CORROSIVE SUBLIMATE.

Aphis, flies, ants, and other insects are important carriers of blight. Combat these insects. Birds are the natural enemies of insects. Protect the birds.

Inspect Nursery Stock carefully for blight. Avoid excessive watering of trees.

THERE IS NO PATENT CURE

BEWARE OF THE FAKIR WITH THE "BLIGHT CURES." Do not attempt to cure blight by sprays, tree paints, inoculations, or soil "doctoring."

Blight fighting is a community matter. Organize and go after it. Winter is the best time to fight the disease. NOW is the accepted time. Encourage your neighbors to clean up their orchards.

Eternal Vigilance is the Price of Clean Orchards

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Fireblight

Bacteria Spread

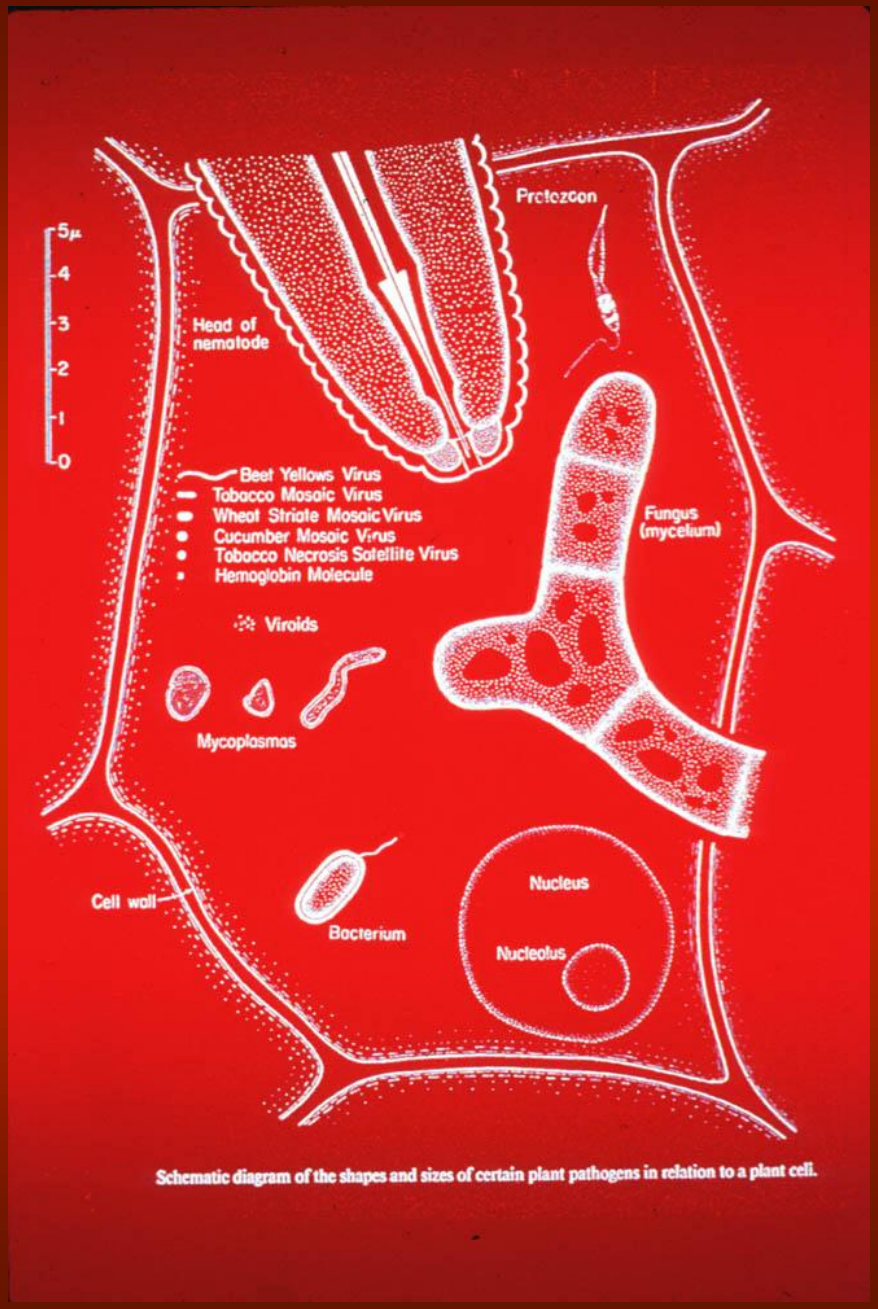
- Environmental Conditions
  - Splashing Rain
- Vectors
  - People, Animals, Insects
- Mechanical Means
  - Wounds by Tools and Equipment, Wounds by Insect feeding

Bacteria Management Techniques

- Bactericides used for protection
- Antibiotics
- Exclusion
- Eradication
- Resistant Varieties
- Clean Tools and Materials
- Avoid Wounds, Stress

Viruses

A virus (viruses=plural) is made up of small particles of genetic material encased in a protein coat. They can only reproduce in a living cell.



Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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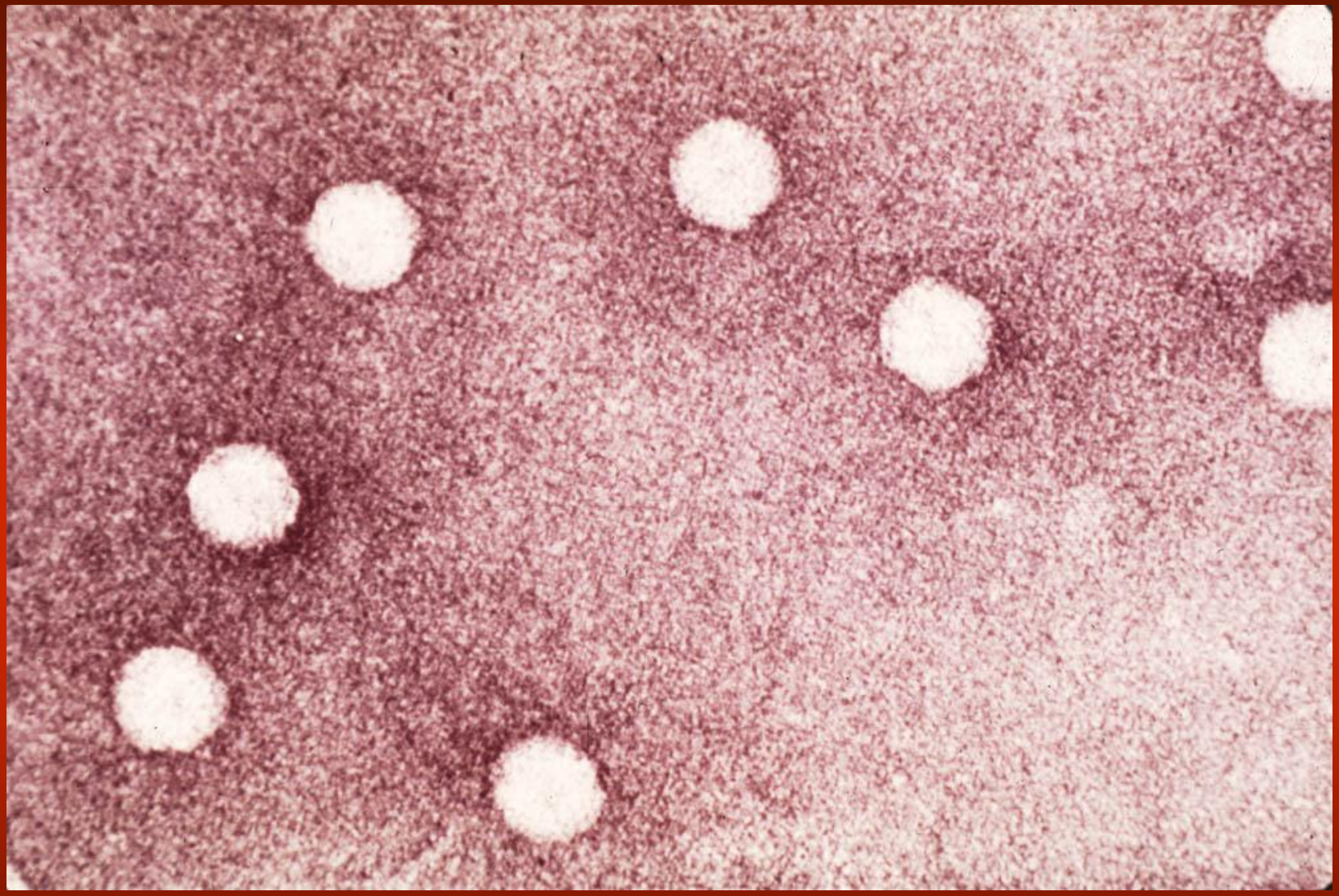

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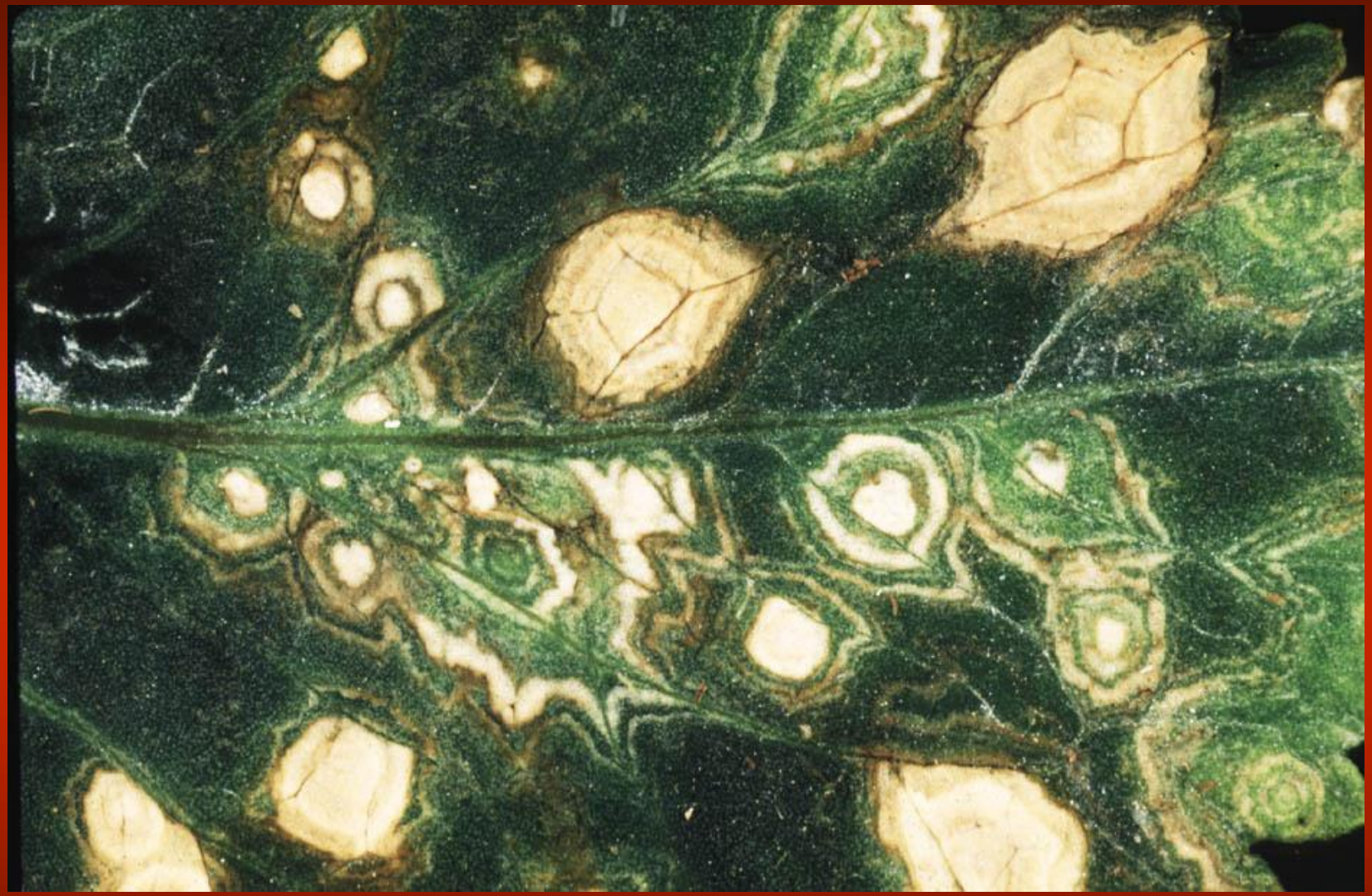

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Border Rows

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Weeds

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Virus Spread

- Insects
  - Aphids
  - Leafhoppers
- Planting Material
  - Vegetative parts
- Mechanical Means
  - Tools
  - Plant Contact

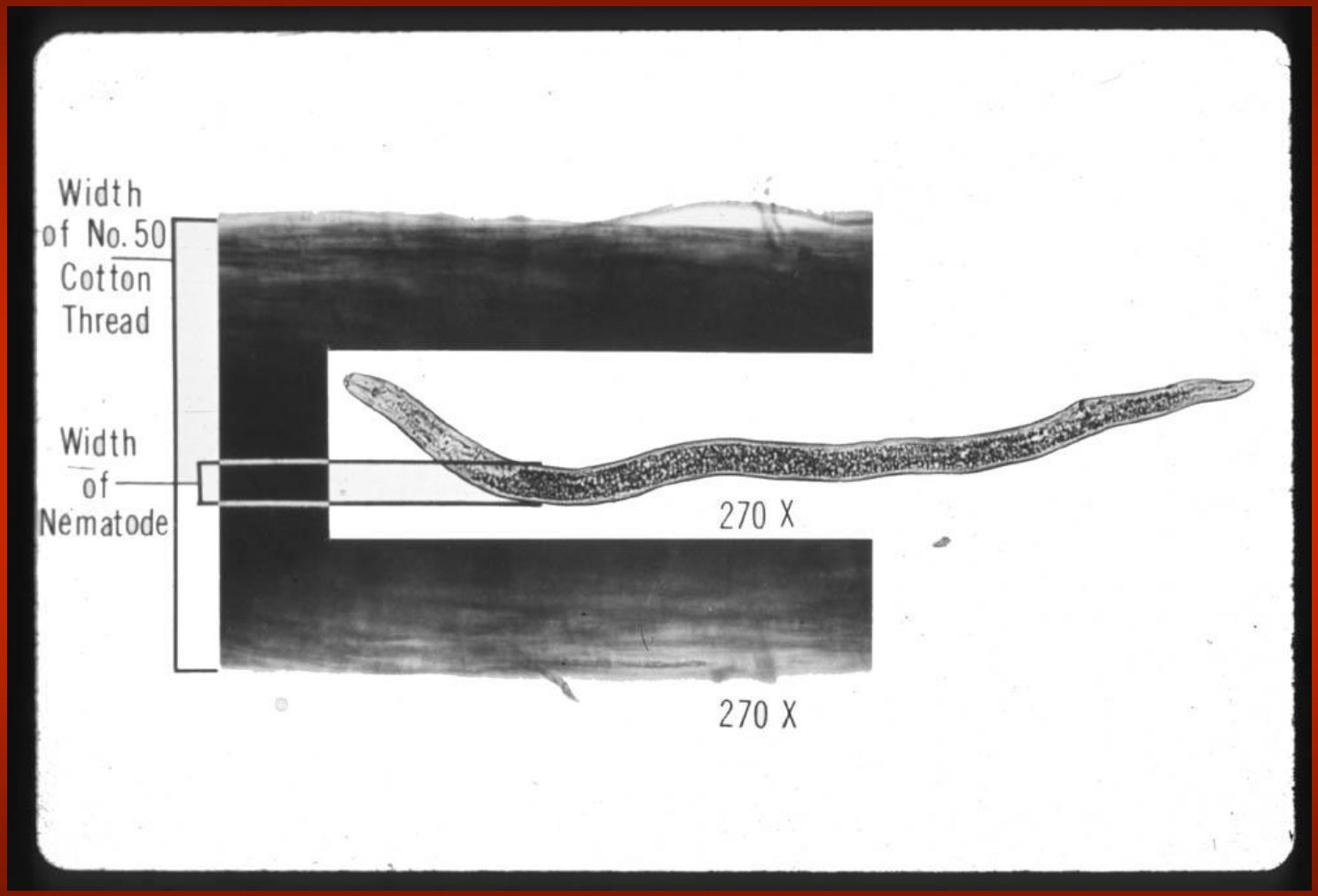
Virus Management Techniques

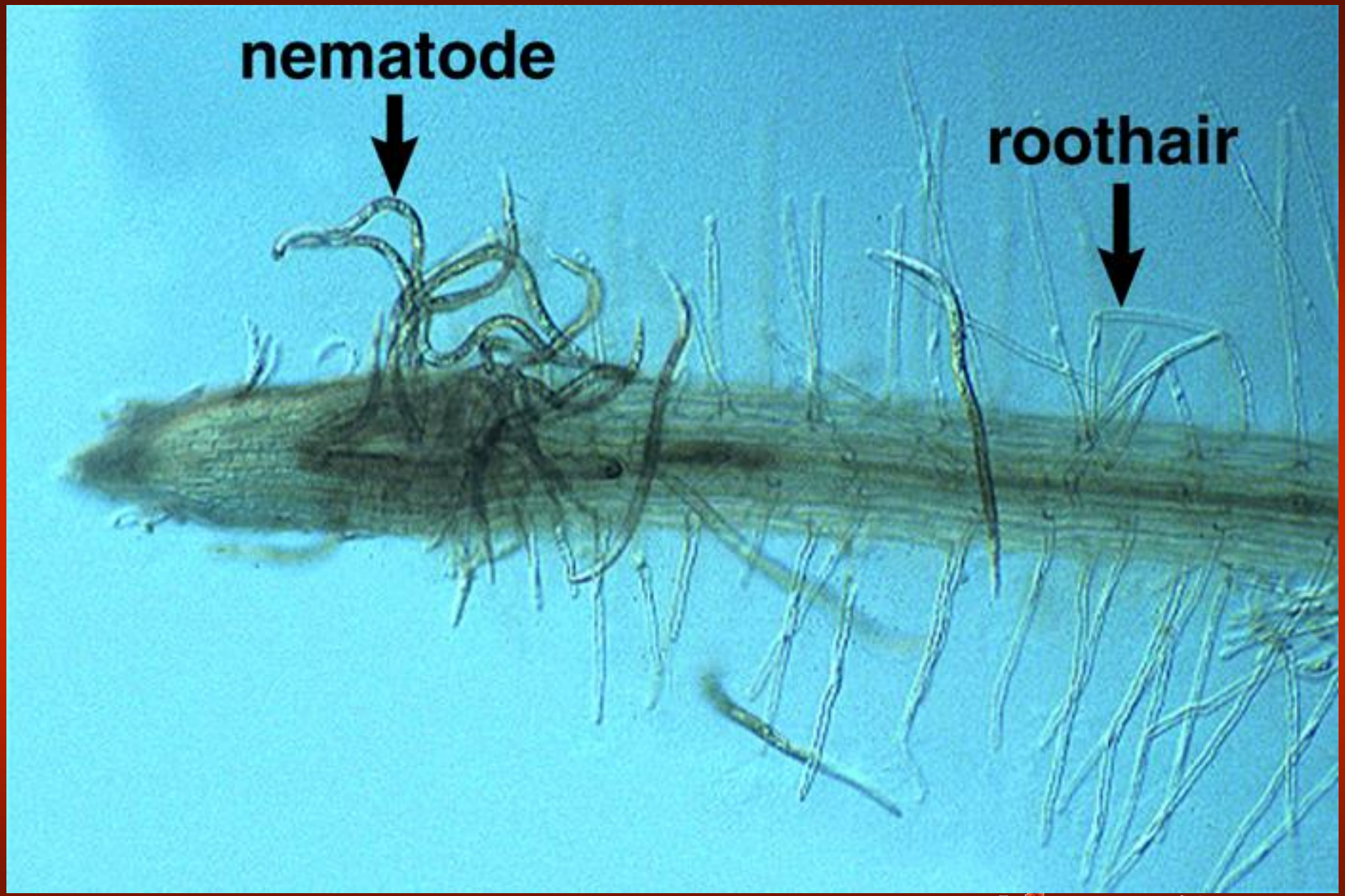
- Insecticides
- Border Plantings/Removal of Weeds
- Rogueing Infected Plants
- Resistant Varieties
- Clean Tools and Materials
- Avoid Wounds.

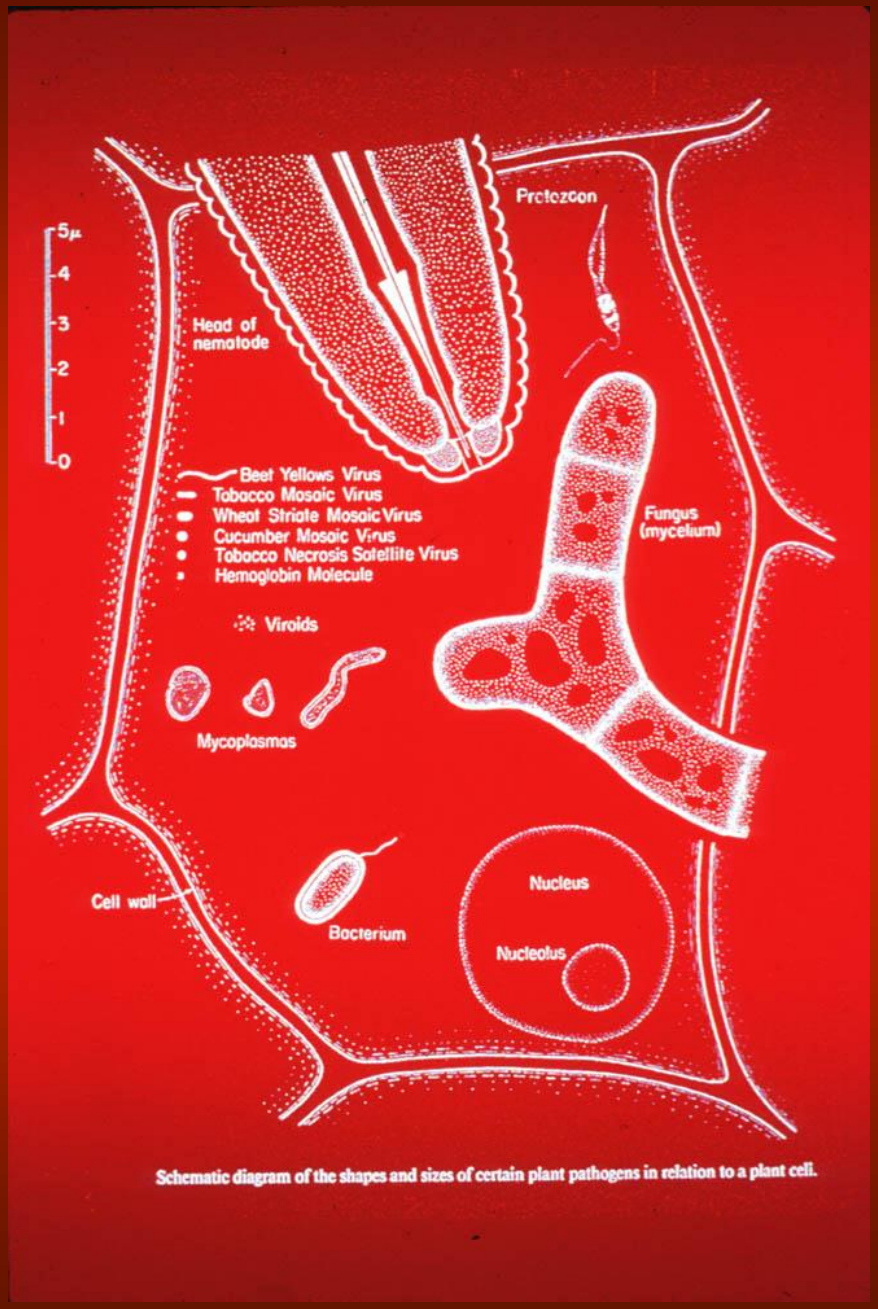
Nematodes

A nematode (nematodes=plural) is a microscopic, worm-like animal that lives saprophytically in water and soil or as parasites of plants and animals

Nematode Size




nematode
roothair



Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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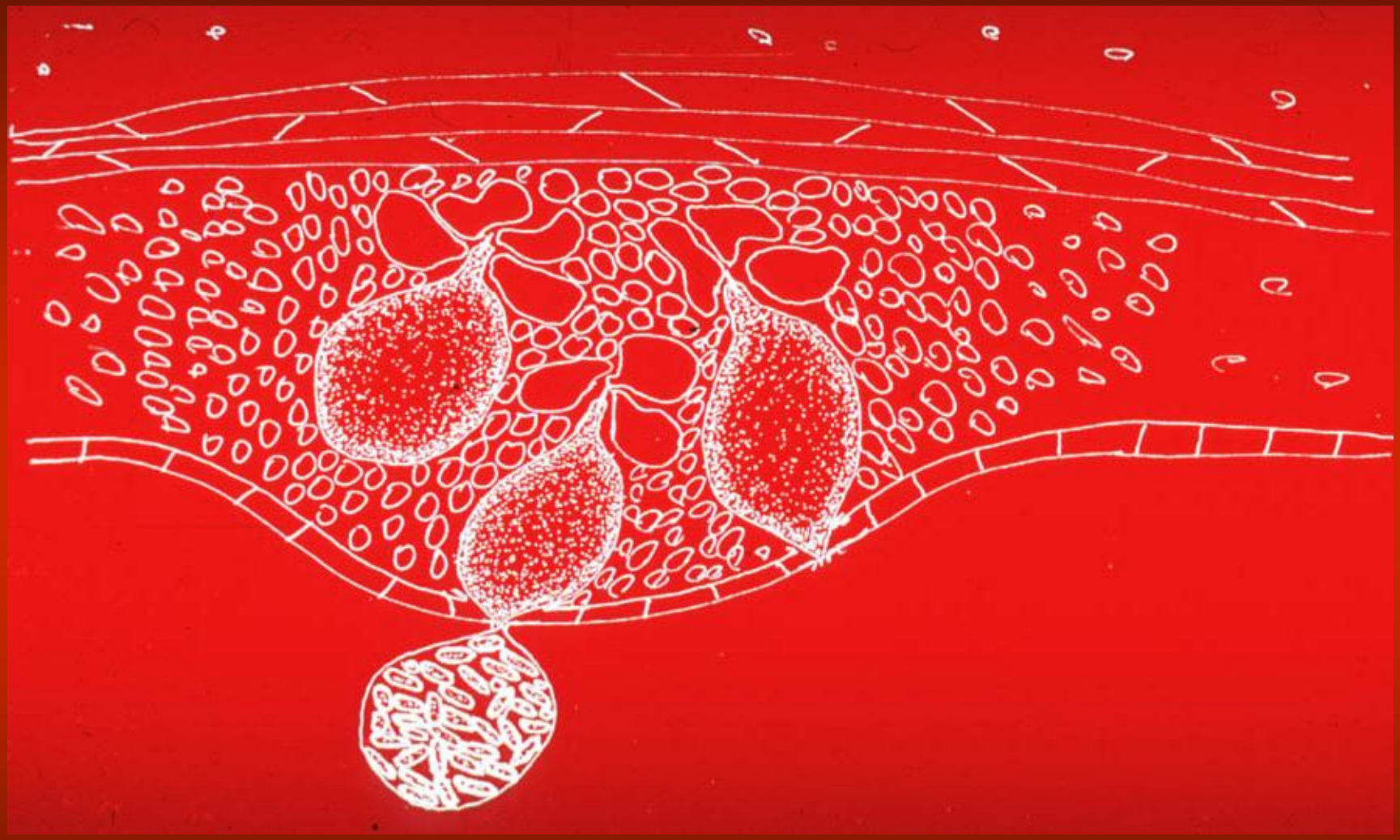

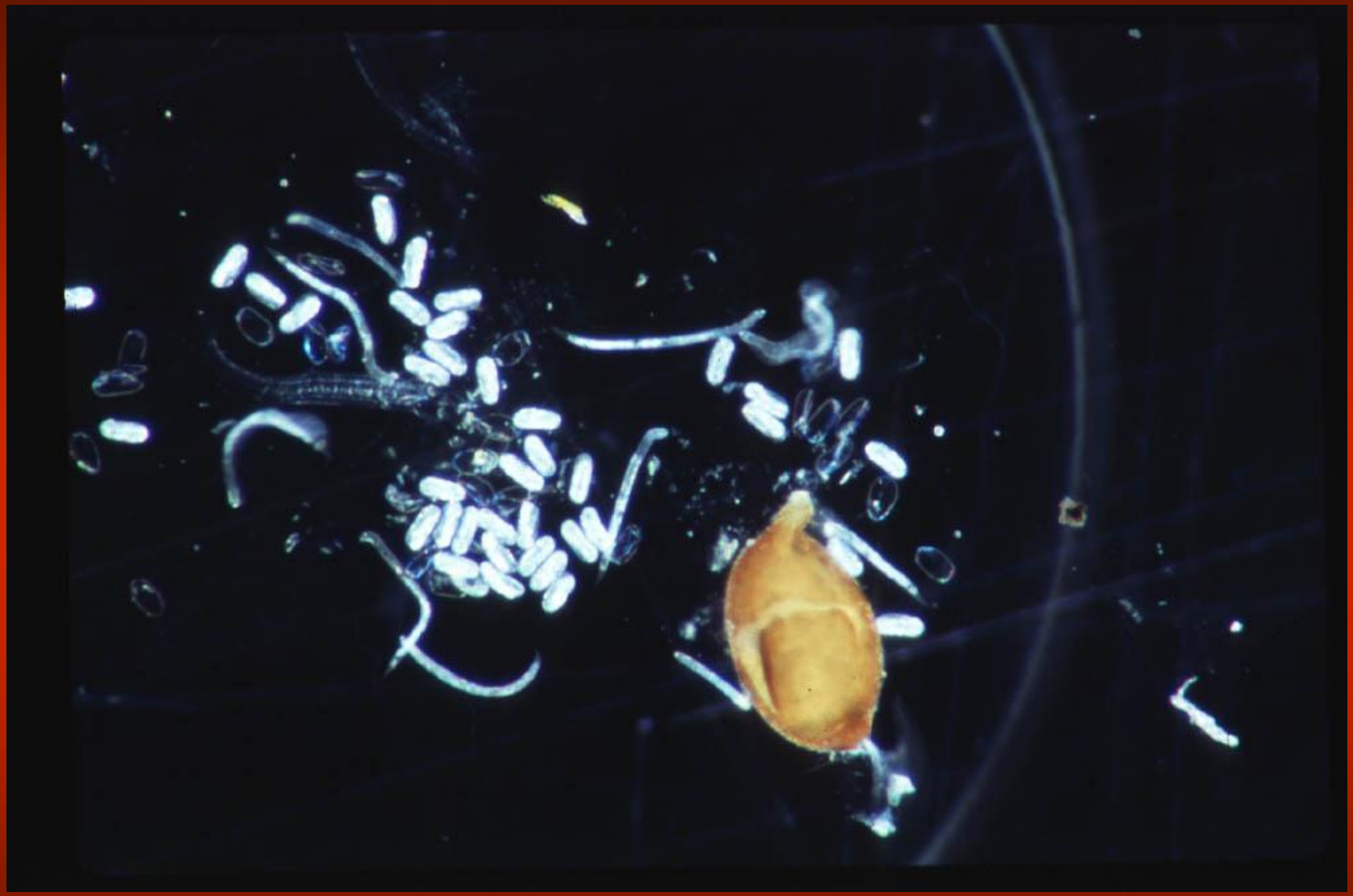

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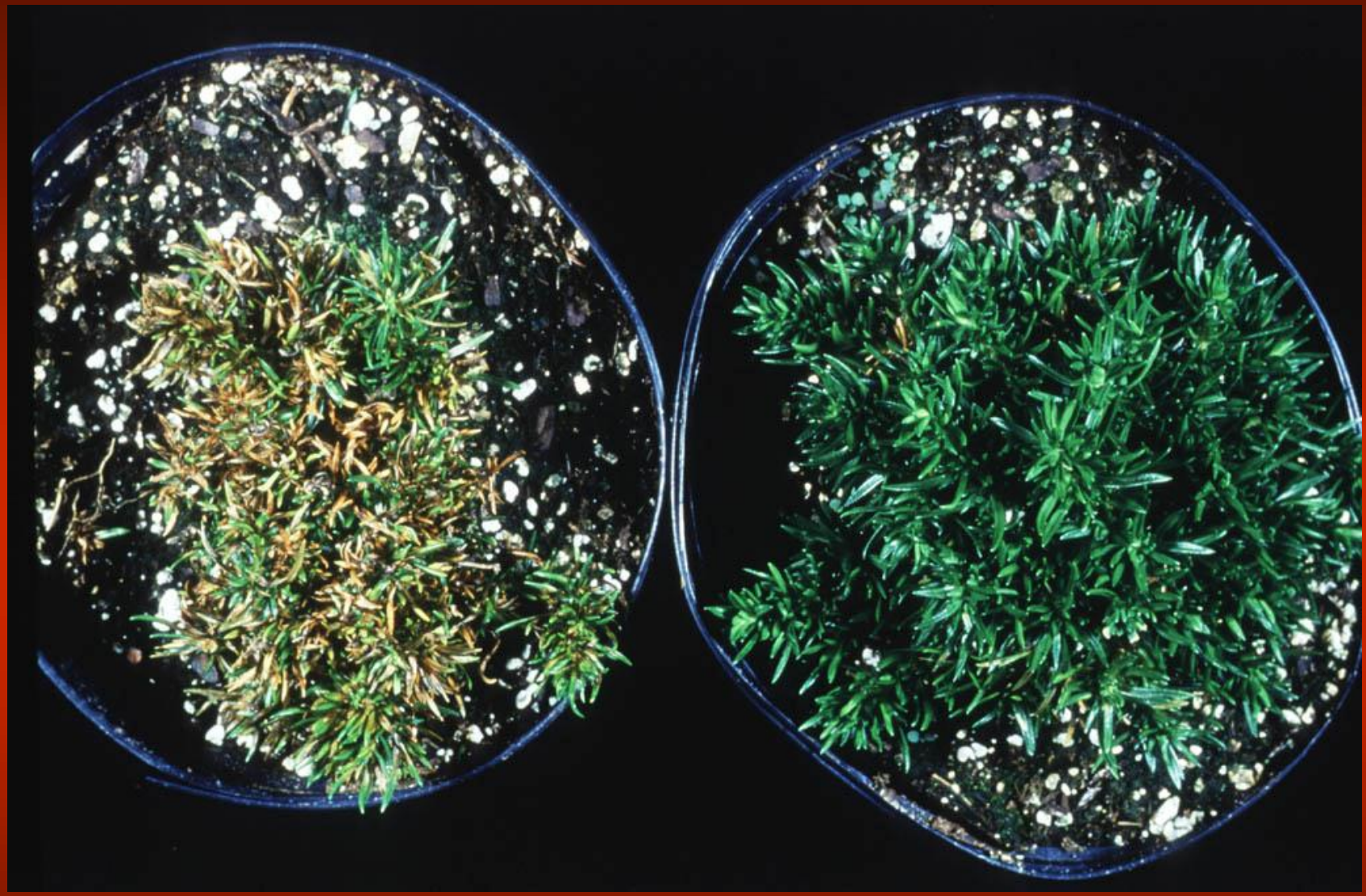

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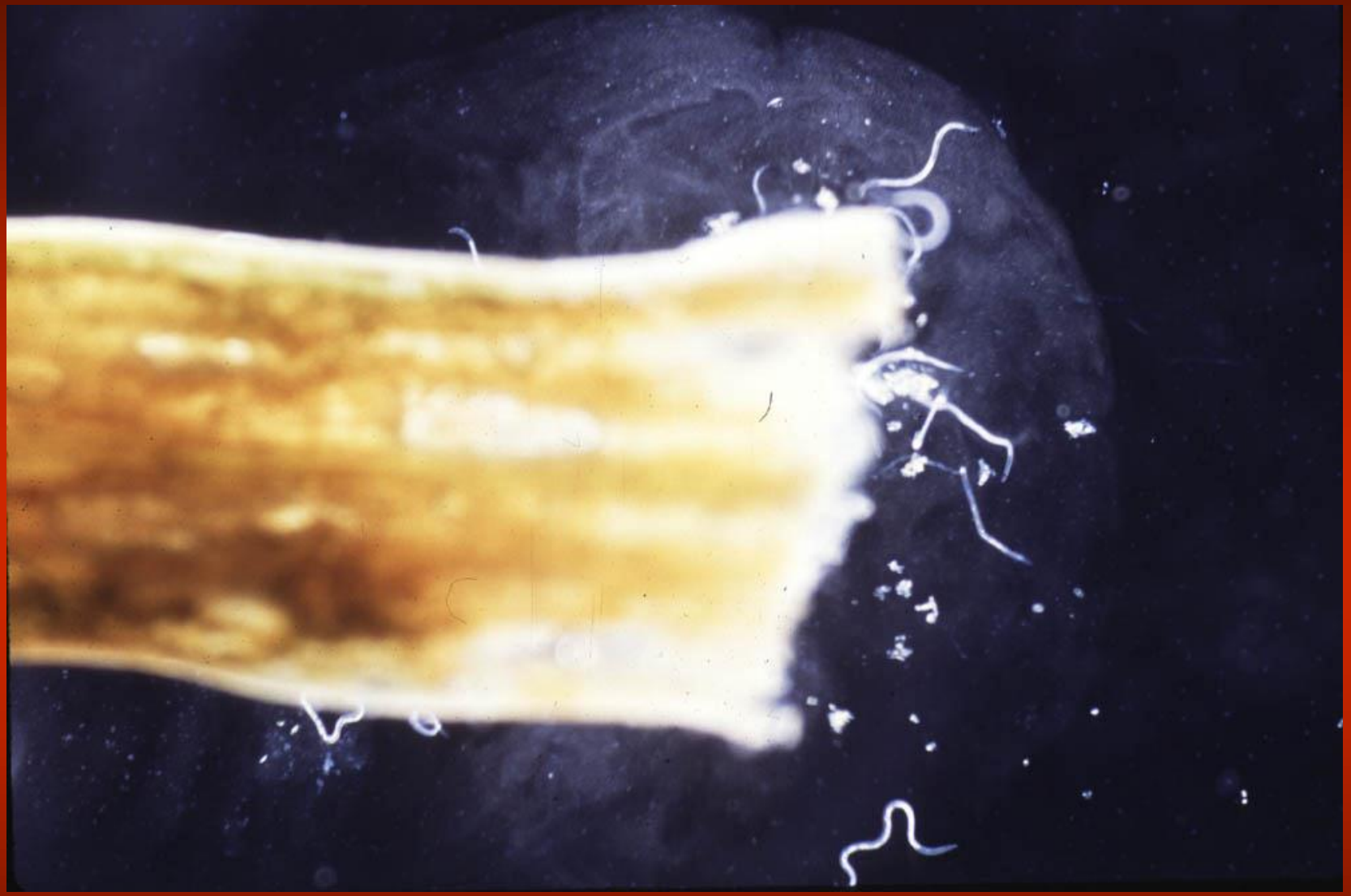

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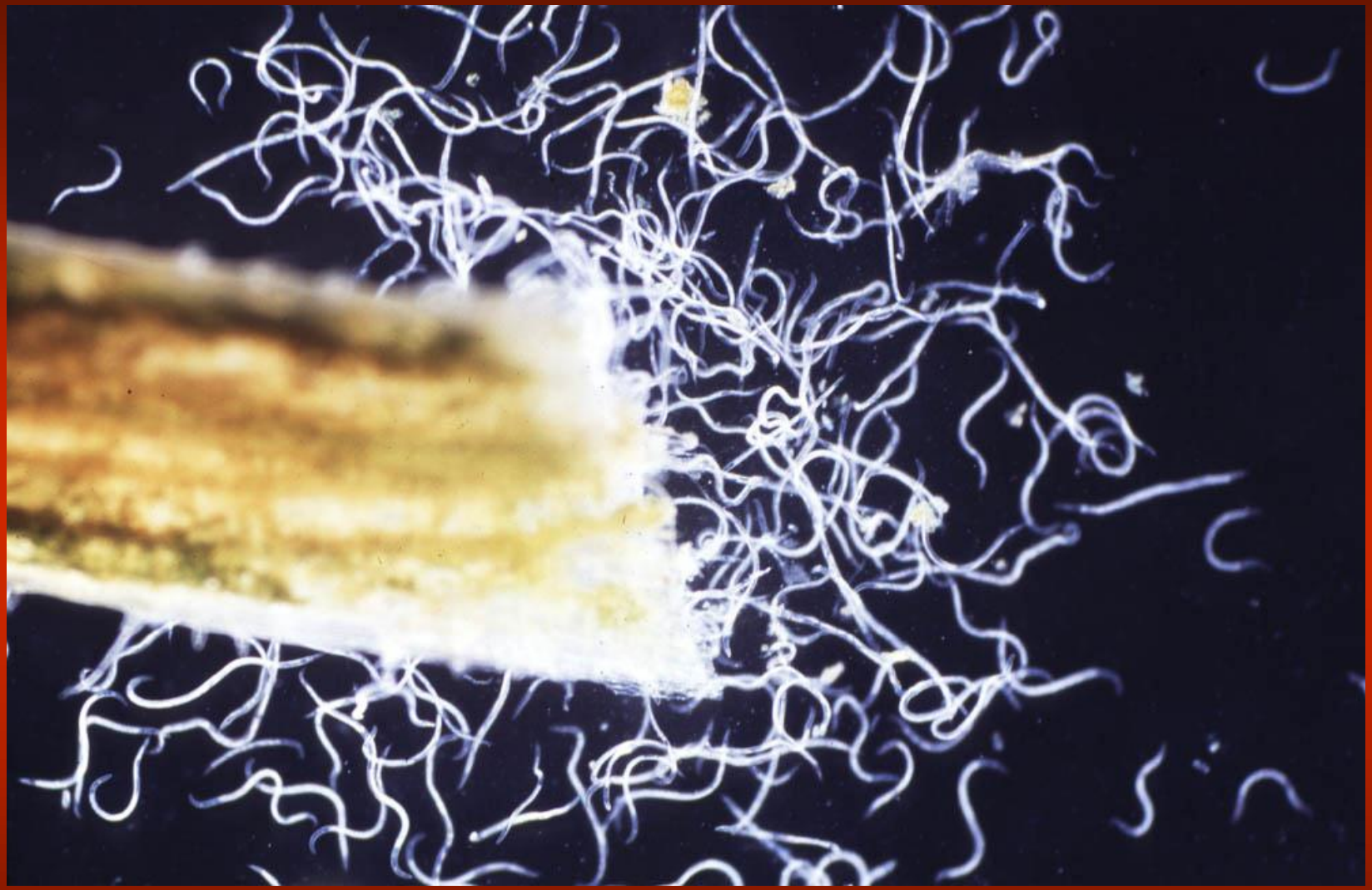
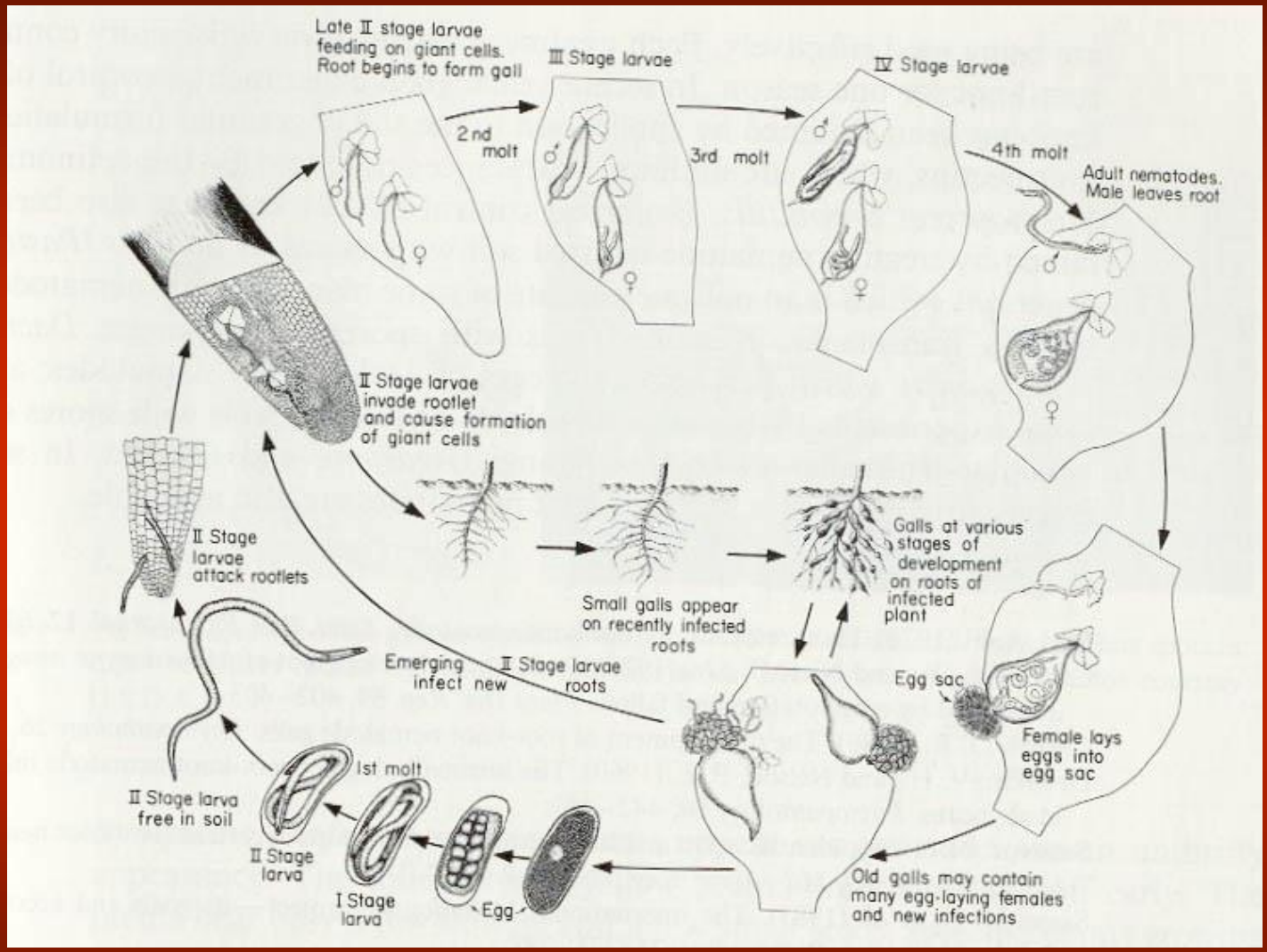


Root Knot Life Cycle



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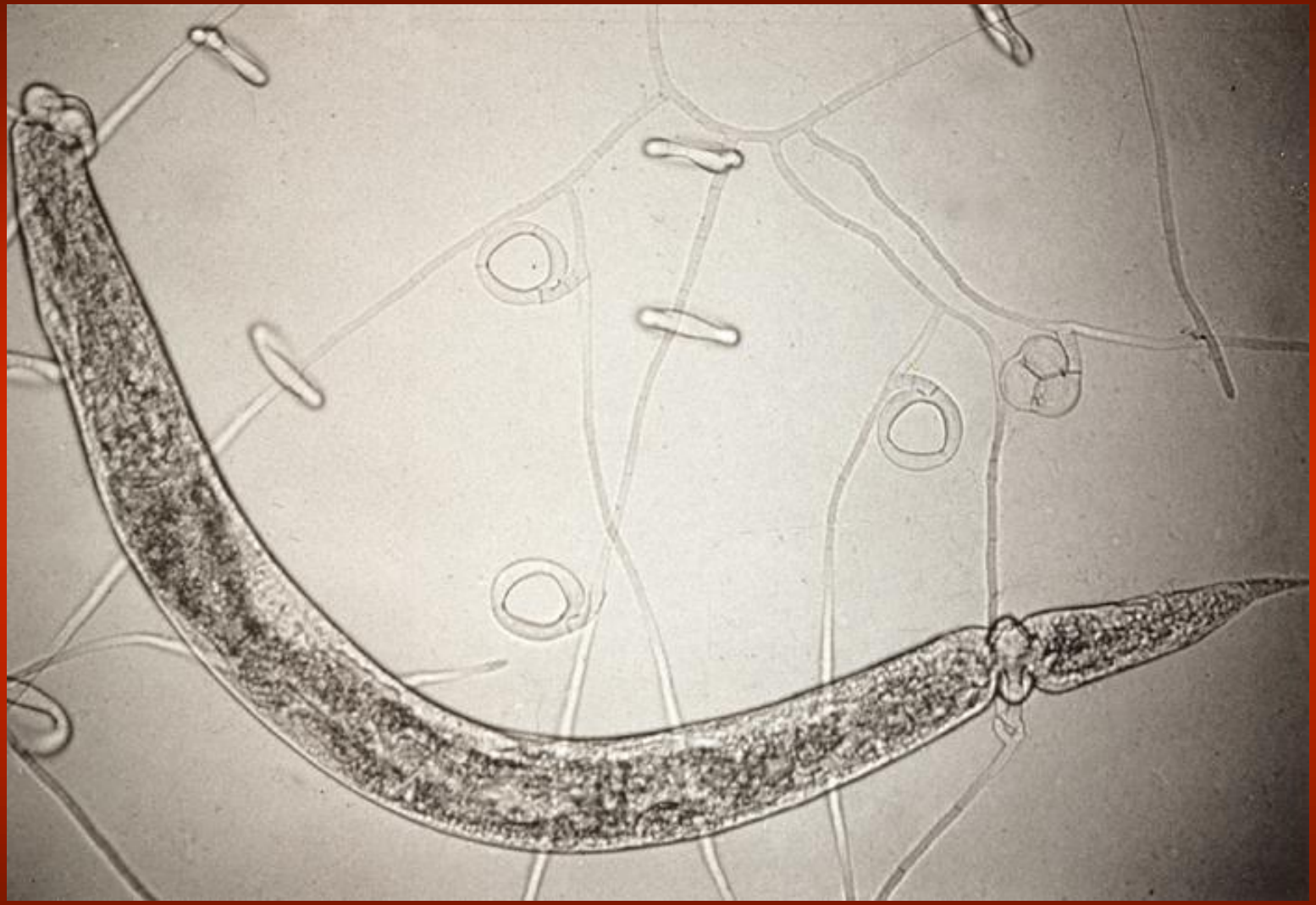
Nematode Spread

- Environmental Conditions
  - Splashing Rain, can swim short distances
- Vectors
  - People and Animals moving soil and plant parts, Insects within their bodies
- Planting Material
  - Vegetative parts

Nematode Management Techniques

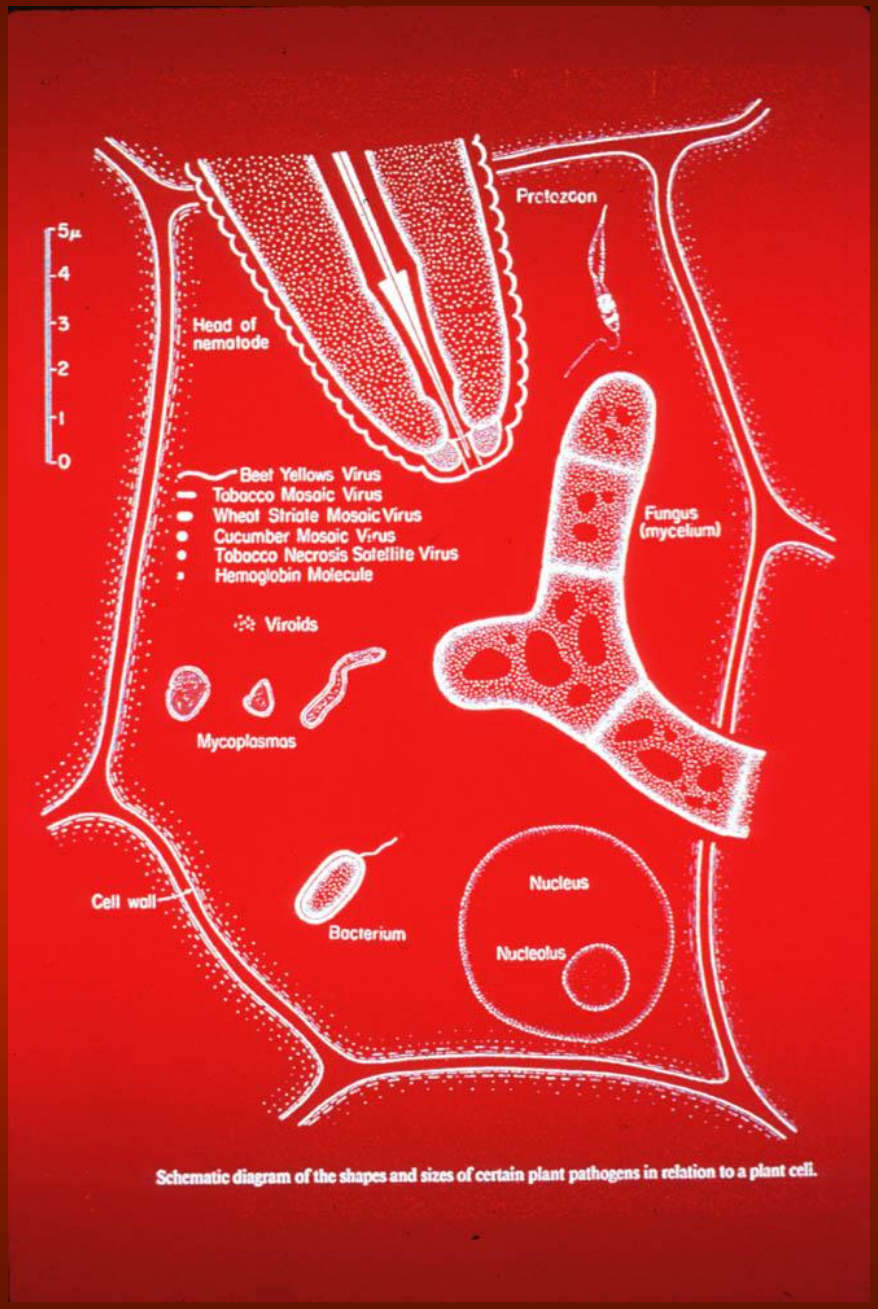
- Nematicides
- Exclusion
- Eradication
- Resistant Varieties
- Clean Tools and Materials
- Avoid Wounds, Stress

Biological Control Measure



Phytoplasmas

- Phytoplasmas are organisms that infect plants and cannot be grown in culture. Phytoplasmas cause the “yellows” diseases.



Schematic diagram of the shapes and sizes of certain plant pathogens in relation to a plant cell.

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History of Phytoplasmas

- 1967-Japanese researchers associated MLOs with “yellows” diseases.
- MLOs occupy sieve tubes.
- Graft and insect transmittable.
- Tetracycline causes remission and temporary disappearance of MLOs.

Major Phytoplasmal diseases in North America.

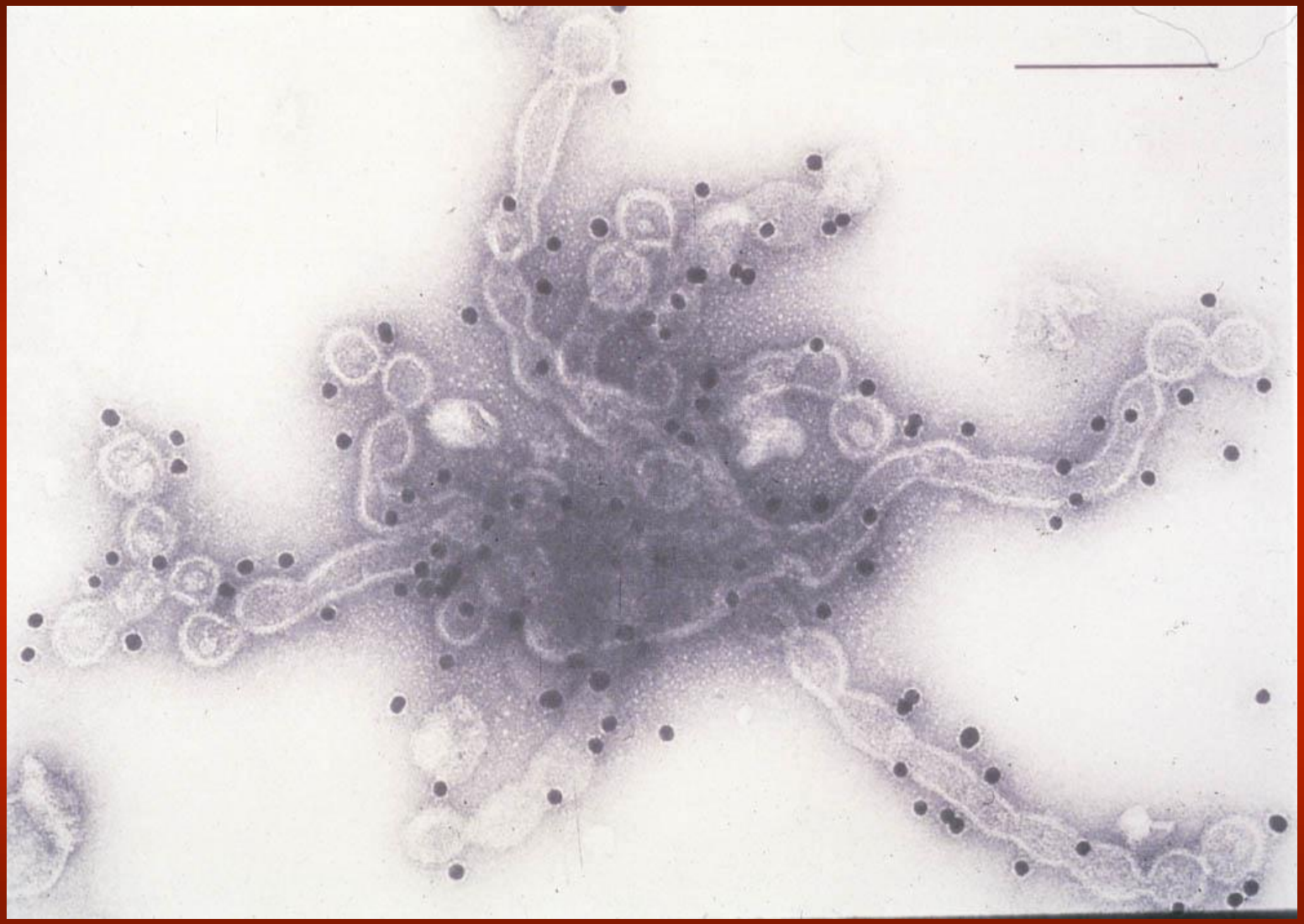
- X disease of peaches and cherries.
- Lethal yellows of palm.
- Pear decline.
- Elm Yellows.
- Ash Yellows.
- Lilac witches broom.
- Aster Yellows.
- Blueberry witches broom.
- Bunch disease of pecan and walnut.
- Grapevine yellows.

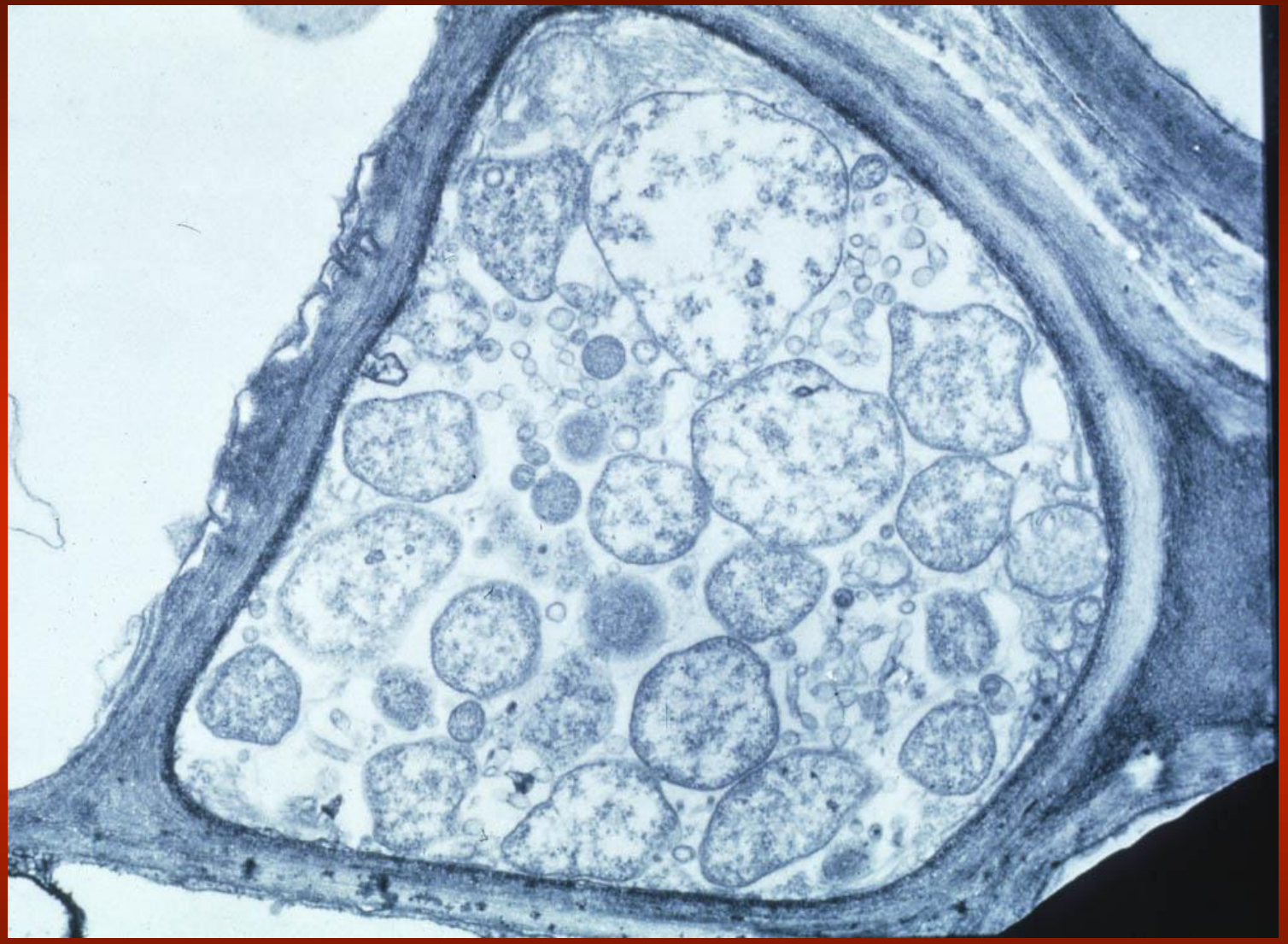
Phytoplasma-induced symptoms

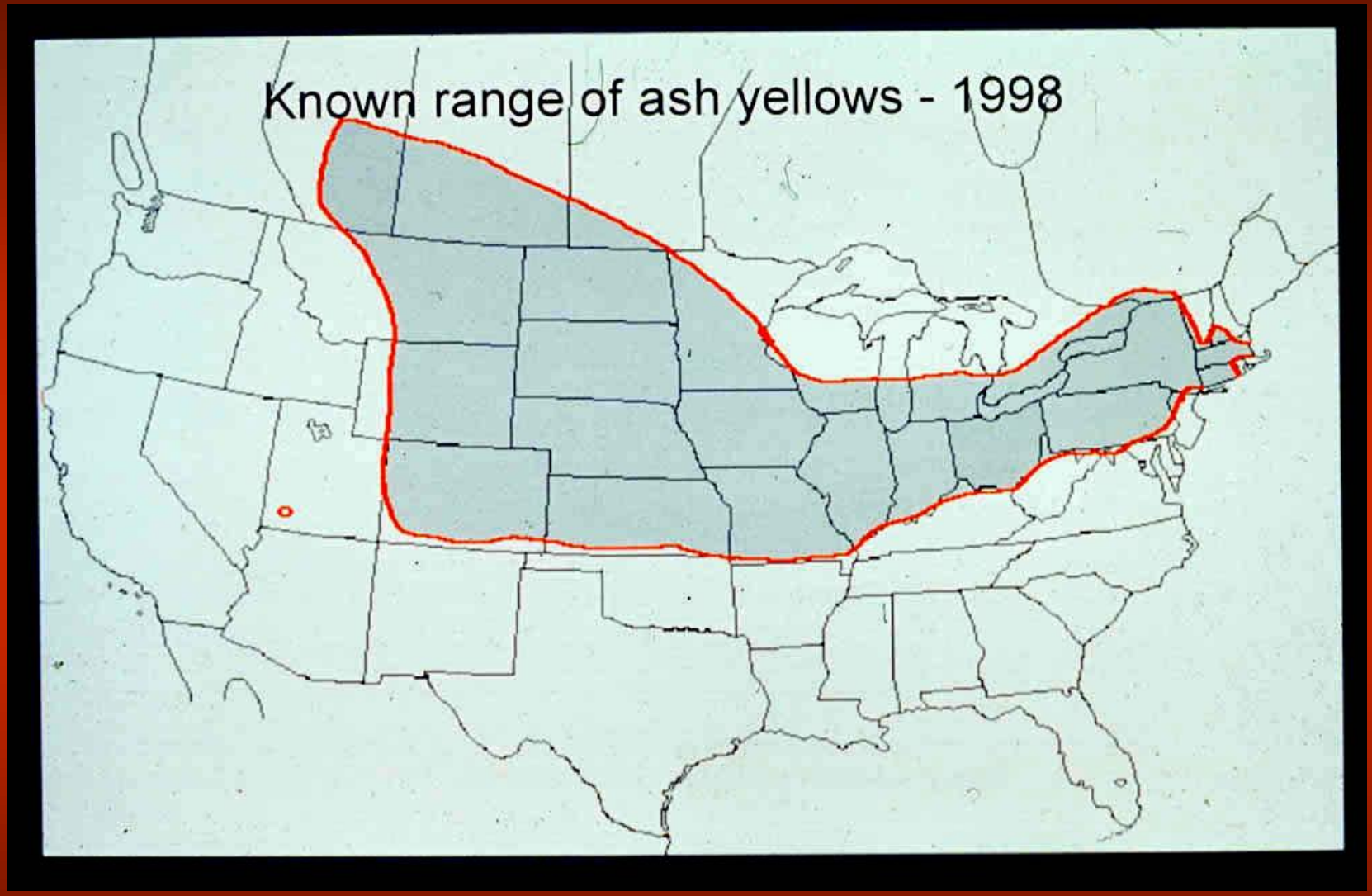
- Slow to feeble growth
- Loss of apical dominance
- Witches broomes
- Dwarfing
- Sterility
- Yellowing

- Rootlet Necrosis
- Phloem Necrosis
- Phloem hyperplasia
- Leaf malformation
- Impaired gas exchange

Diagnostic symptoms can be absent!!






Known range of ash yellows - 1998

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Phytoplasma Vectors

- Primarily Leafhoppers.
- Other known vectors include planthoppers, psylids, a froghopper, and stinkbugs.
- Phytoplasmas circulate and multiply within their vectors.

Phytoplasma Management Techniques

- Chemotherapy.
- Heat Treatments.
- Insecticides.
- Weed Control.
- Resistant Varieties.

Abiotic Damage

- Herbicide Injury.
- Chemical Spills.
- Soil Compaction.
- Freeze Injury.
- Nutrient Deficiency.
- Air Pollution.
- Snow Damage.


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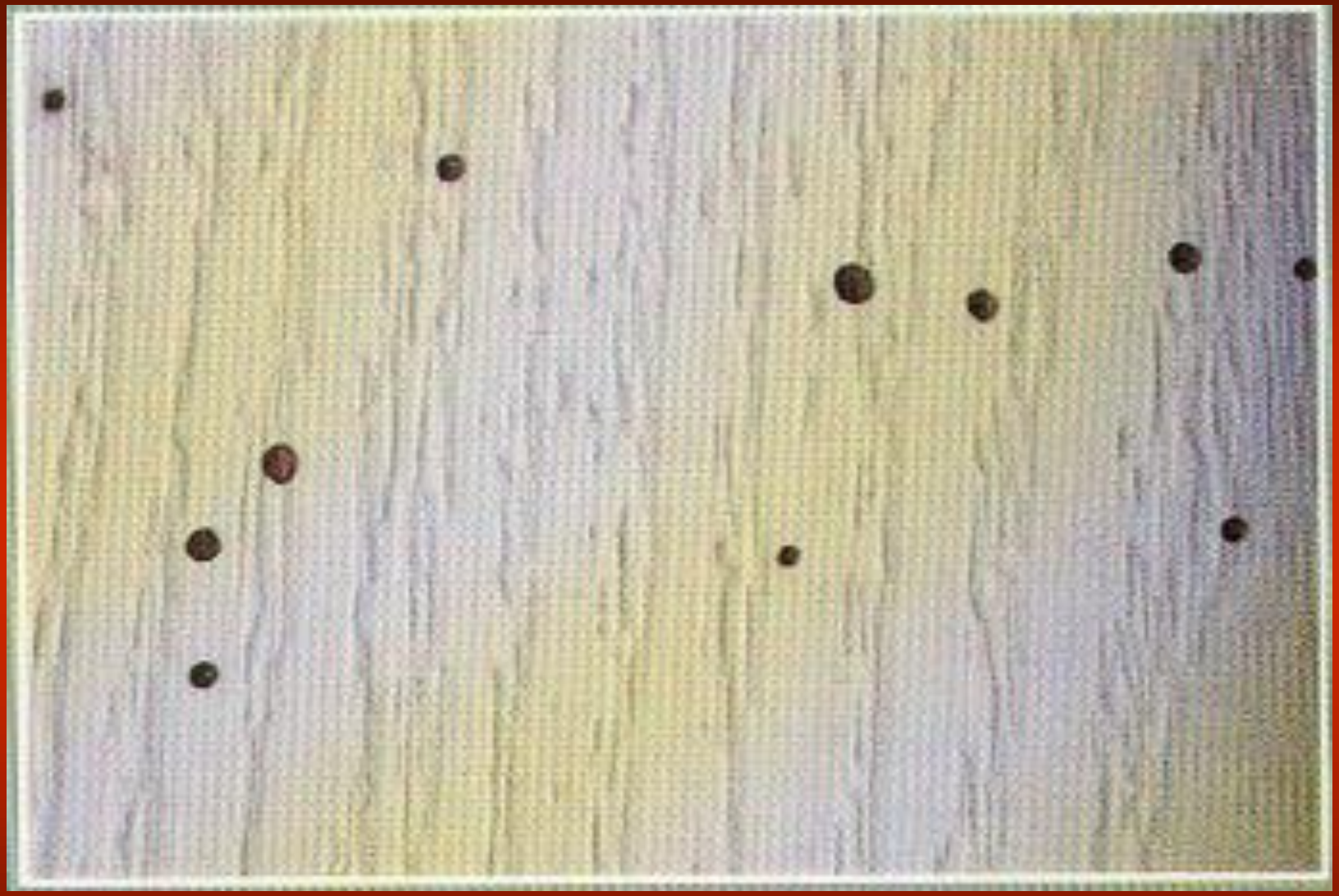

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Disease Pyramid