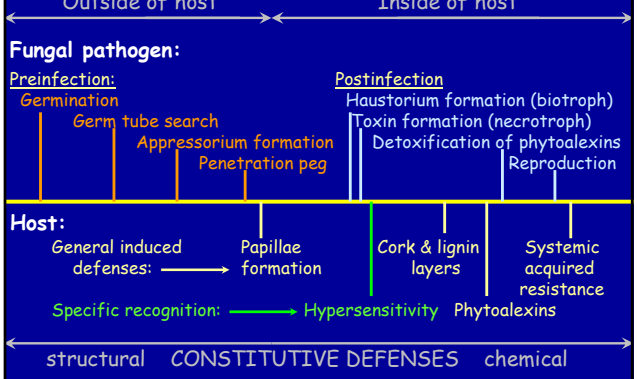
Websites to brush up on Anamorphic Ascomycetes

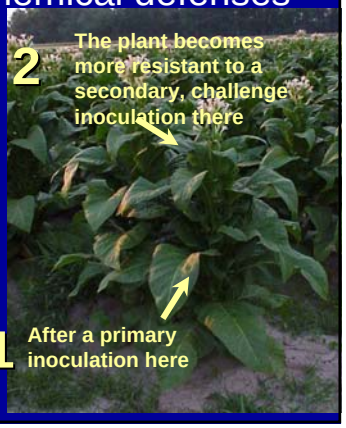
- Early blight of potato and tomato (condiophore)
  http://www.apsnet.org/education/LessonsPlantPath/PotatoTomato/default.htm
- Verticillium wilt (microsclerotia)
  http://www.apsnet.org/education/LessonsPlantPath/Verticillium/default.htm
- Leucostoma canker of stone fruits (pycnidium)
  http://www.apsnet.org/education/LessonsPlantPath/LeucostomaCanker/default.htm
- Anthracnose of turfgrass (acervulus)
  http://www.apsnet.org/education/LessonsPlantPath/anthracnoseturf/default.htm

TIME-LINE OF INFECTION



Induced biochemical defenses

- **Systemic Acquired Resistance** is the activation of defenses in distal, non-infected parts of the plant.



Induction of Systemic Acquired Resistance

1- Plant is 'primed' to rapidly produce reactive oxygen species (e.g. H_2O_2) plus antioxidants

Hydrogen peroxide is directly toxic to invading pathogens

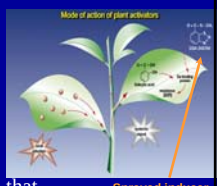
2 - Thickening of plant cell walls

Production of phenolics (lignin, tannic acid) that strengthen walls and inhibit pathogen enzymes

3- Accumulation of pathogenesis related proteins

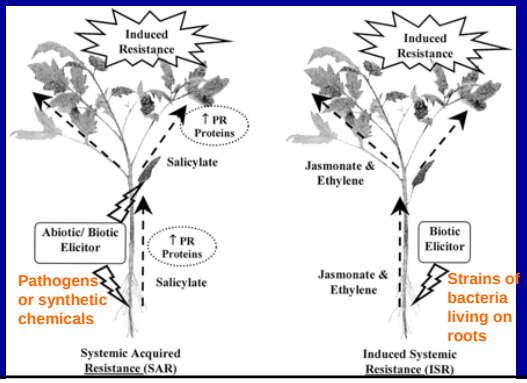
"PR-proteins" enzymes that degrade fungal cell walls: chitinases, ß-1,3 Glucanases

These enzymes accumulate in vacuole of plant cell. Upon attack, they directly degrade fungal cell walls. Indirectly, their action results in the release of fungal wall components that elicit additional defense reactions



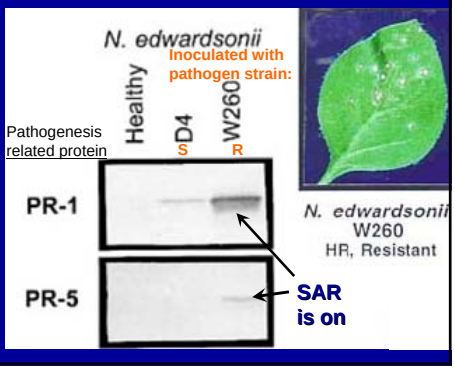
Sprayed inducer (activator) that mimics salicyclic acid

Plants can have more than one type of acquired resistance



How do we know when systemic acquired resistance is turned on?

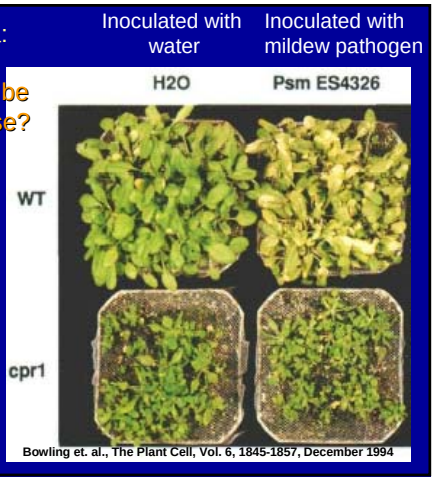
Presence /absence of pathogenesis-related proteins in the host is commonly used as an indicator /'marker' of SAR induction



A plant's dilemma:
How much of its resources should be devoted to defense?

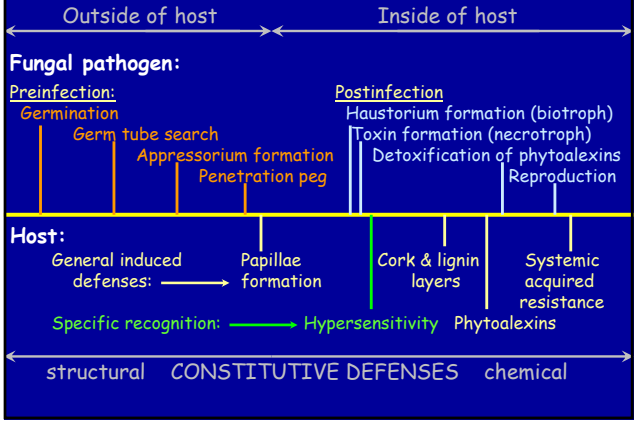
Wild type plant with inducible SAR

Mutant plant with constitutive SAR



Bowling et. al., The Plant Cell, Vol. 6, 1845-1857, December 1994

TIME-LINE OF INFECTION



All of the defenses we have talked about so far are likely operative in most plants most of the time

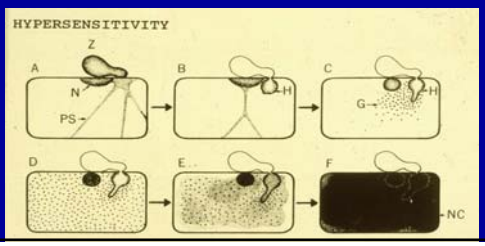
- Constitutive structural – cuticle thickness
- Constitutive biochemical – wall lignifications
- Induced structural – cellular papillae, tyloses, gums, suberin and abscission layers
- Induced biochemical - local (phytoalexins, systemic (SAR: reactive oxygen species, PR-proteins such as chitinases)

Collectively, we will refer to the above as the 'concert of defenses'

A final 'Induced biochemical defense'

The hypersensitive response (HR) is a localized death of host cells at the site of infection. It is the result of a specific recognition of a pathogen attack by the host.

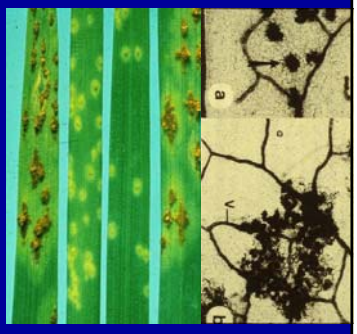
The HR is considered to be a a type of 'programmed cell death'. It can be a very! effective form of resistance against obligate parasites.



Hypersensitivity- Specific Recognition

Some host cultivars can recognize certain pathogen isolates and trigger an HR whereas others can not. In this picture, the two inner cultivars are exhibiting an HR.

Combinations of two or more HR-inducing recognition events can give rise to pathogen 'races' (more on this later).

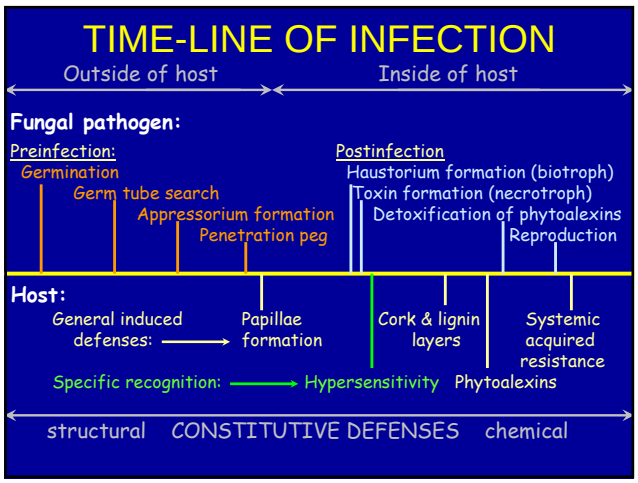


S HR HR S Localized cell death

Important point:

In addition to disease, a hypersensitive response also triggers:

- Induced local defenses in nearby cells
  - e.g., phytoalexins
- Systemic acquired resistance
  - e.g. enhanced levels of PR-proteins



Course Content Up To Now

Theme 1: What is a disease?

What do the symptoms (& signs) tell us about the host's condition?

Theme 2: Disease cycles (Oomycetes & Ascomycetes)

How, specifically, does the pathogen turn the primary cycle?
Does the pathogen turn a secondary cycle?

Theme 3: Pathogen life strategies

How does the pathogen cope in the world of the living?
... of the dead?

Theme 4: Timeline of infection events

The dynamic struggle of attack and counterattack

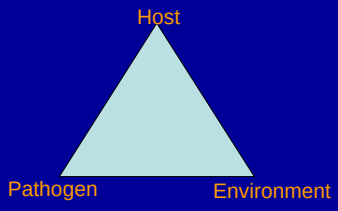
Significance of Plant Disease

Current Situation –

- 10% of all food production is lost to disease (30% to all pests)
- The introduction of exotic plant pathogens has caused great losses: American elm & chestnut
- Many additional exotic threats: sudden oak death, soybean rust
- Each year, suppression of plant disease costs billions of dollars worldwide
- Plant pathogens can restrict trade
- Pathogens continually evolve:
  - break resistance in host crops
  - develop insensitivity to chemicals

Disease defined

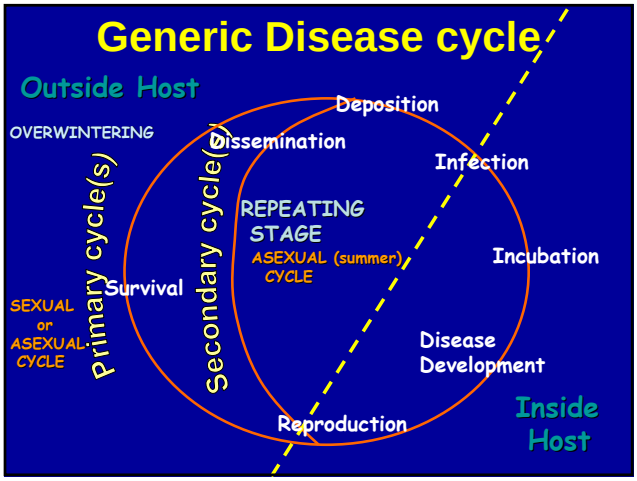
Disease is the *injurious* alteration of one or more physiological processes in a living system (in our case, a plant) caused by the *continuous irritation* of a primary *causal factor* or factors.



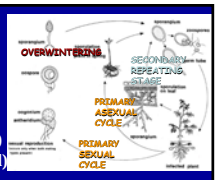
Disease Diagnosis

- Know What is Normal
- Collect Background Information
- Check for Symptoms and Signs
- Observe Patterns
- Ask Questions
- Know what is possible
- Laboratory Tests
- Final Diagnosis

Generic Disease cycle



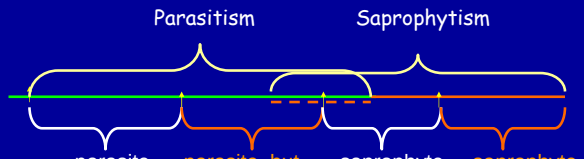
Disease Cycle Terminolology



- **Disease cycle diagrams:**
  - 'conventions' of the diagrams were described
  - a primary cycle(s) was defined (sexual or asexual)
  - a secondary (repeating) cycle was defined (asexual)
- **Diseases can be categorized into two types of cycles:**
  - monocyclic - initiated by primary inoculum only
  - polycyclic - additional infection cycle(s) initiated by secondary inoculum
- **Terms to help understand the time required to turn a cycle:**
  - incubation period – from infection to symptom expression
  - latent period (generation time) – from infection to new infectious propagule
  - quiescent infection – post-infection pathogen dormancy

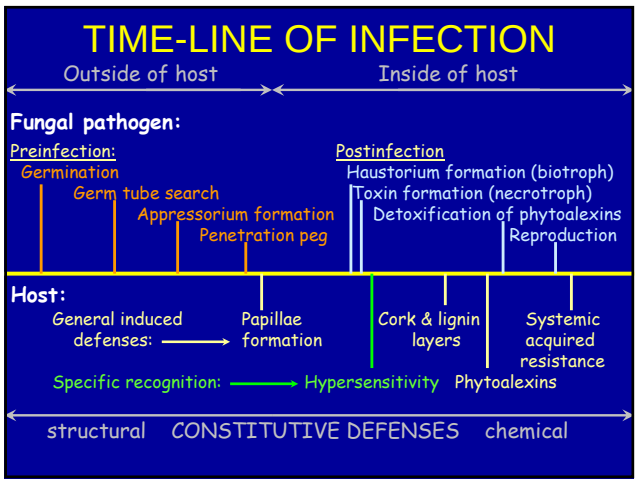
You need to know how to apply these terms to the life cycle and biological structures of Oomycete and Ascomycete pathogens

Life strategies of plant pathogens



parasite only	parasite, but saprophyte occasionally	saprophyte, but parasite occasionally	saprophyte only
OBLIGATE PARASITE	FACULTATIVE SAPROPHYTE	FACULTATIVE PARASITE	OBLIGATE SAPROPHYTE

Def^{n} : obligate *adj.* - restricted to a particular style of life
facultative *adj.* - optionally but not preferred


TIME-LINE OF INFECTION
Outside of host
Inside of host
Fungal pathogen:
Preinfection:
Germination
Germ tube search
Appressorium formation
Penetration peg
Postinfection
Haustorium formation (biotroph)
Toxin formation (necrotroph)
Detoxification of phytoalexins
Reproduction
Host:
General induced defenses:
Papillae formation
Cork & lignin layers
Systemic acquired resistance
Specific recognition:
Hypersensitivity
Phytoalexins
structural
CONSTITUTIVE DEFENSES
chemical