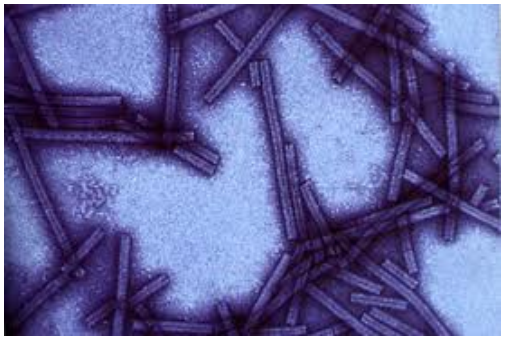
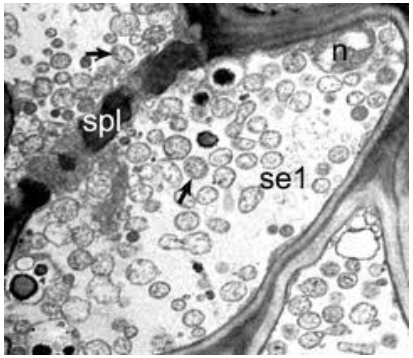
# Molecular plant pathology



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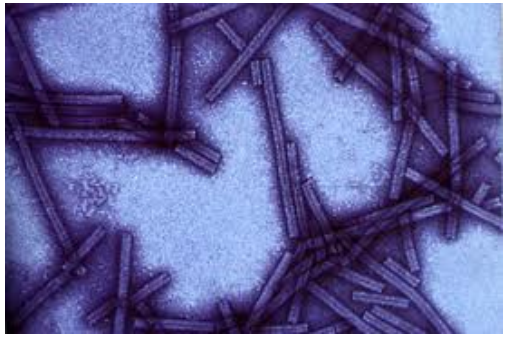
acad. year 2016/17

# PATHOGENESIS – DEVELOPMENT OF A DISEASE IN PLANTS

- parasitism vs. pathogenicity
- parasite – an organism that lives in or on another organism (the host) obtaining from him nutrients and water ; symbiont
- pathogen - an infectious agent - causes the disease
- obligate parasites , parasites neobligatni , facultative parasites
- differ in the way they attack the plant host
- parasitism may play a role in pathogenicity



- the progress of the disease development depends on three factors :

  - the pathogen
  - the host
  - environmental conditions

- each factor is variable - a change in one of them influences the development of the disease and the " quantity " of the disease

- their interaction - triangular relatioship – ”the disease triangle concept"

- the incidence of the disease occurs only when none of the three factors is “zero”

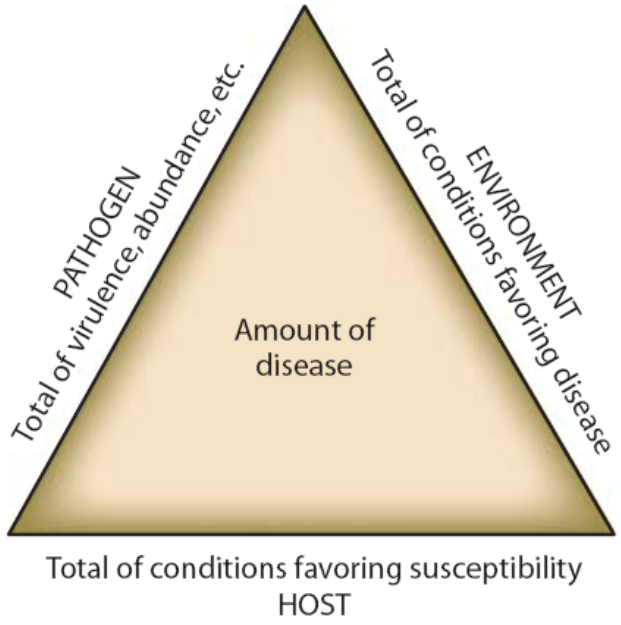
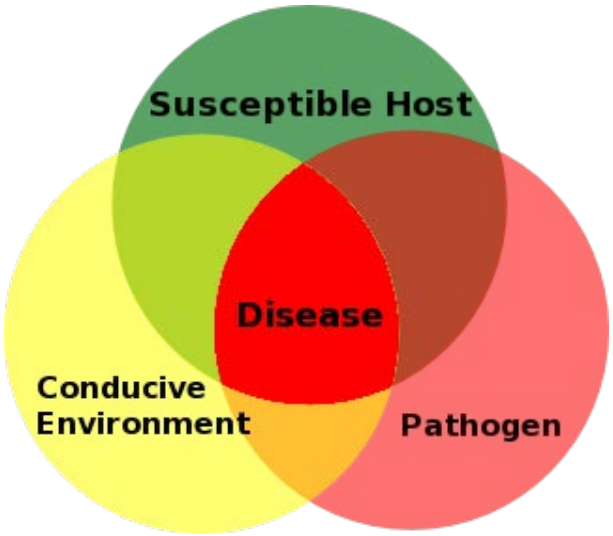
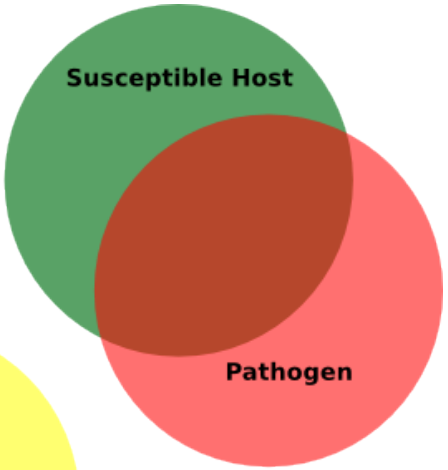
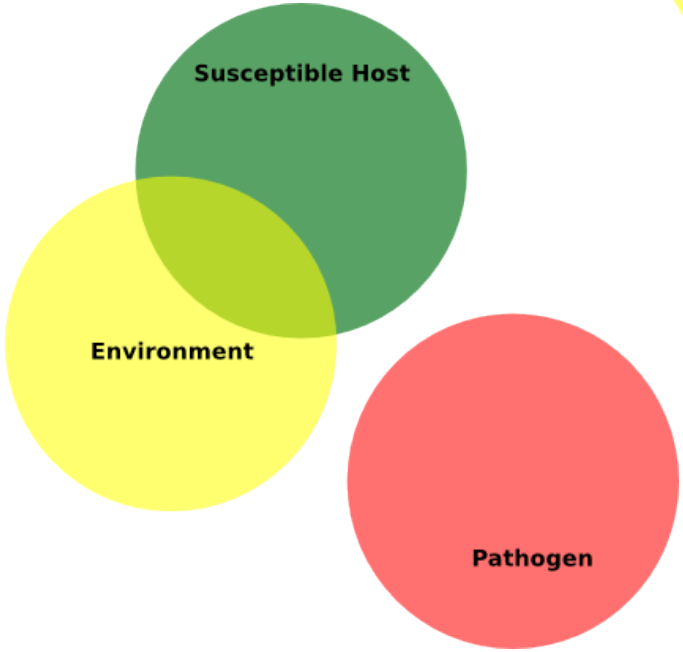



FIGURE 2-1 The disease triangle.


Susceptible Host
Disease
Conducive
Environment
Pathogen


Susceptible Host
Pathogen


Environment


Susceptible Host
Environment
Pathogen

# DISEASE CYCLE: STAGES IN DEVELOPMENT OF A DISEASE

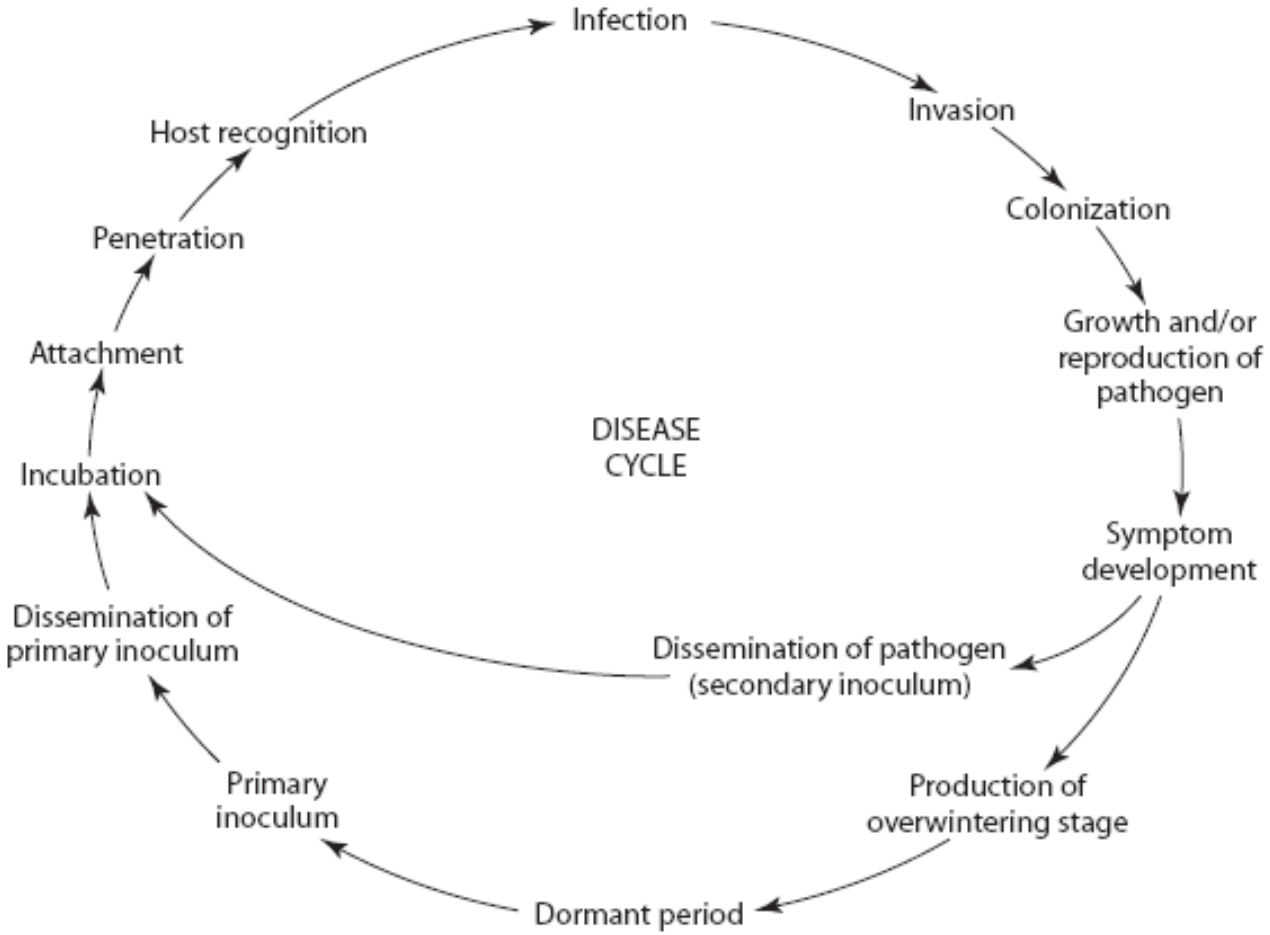



FIGURE 2-2 Stages in development of a disease cycle.

# DISEASE CYCLE: STAGES IN DEVELOPMENT OF A DISEASE

- primary events:

- Inoculation (primary infection)

- penetration

- infection establishment

- pathogen colonization (invasion)

- growth and reproduction of the pathogen

- spread (dissemination) of the pathogen

- survival of the pathogen in the absence of the host

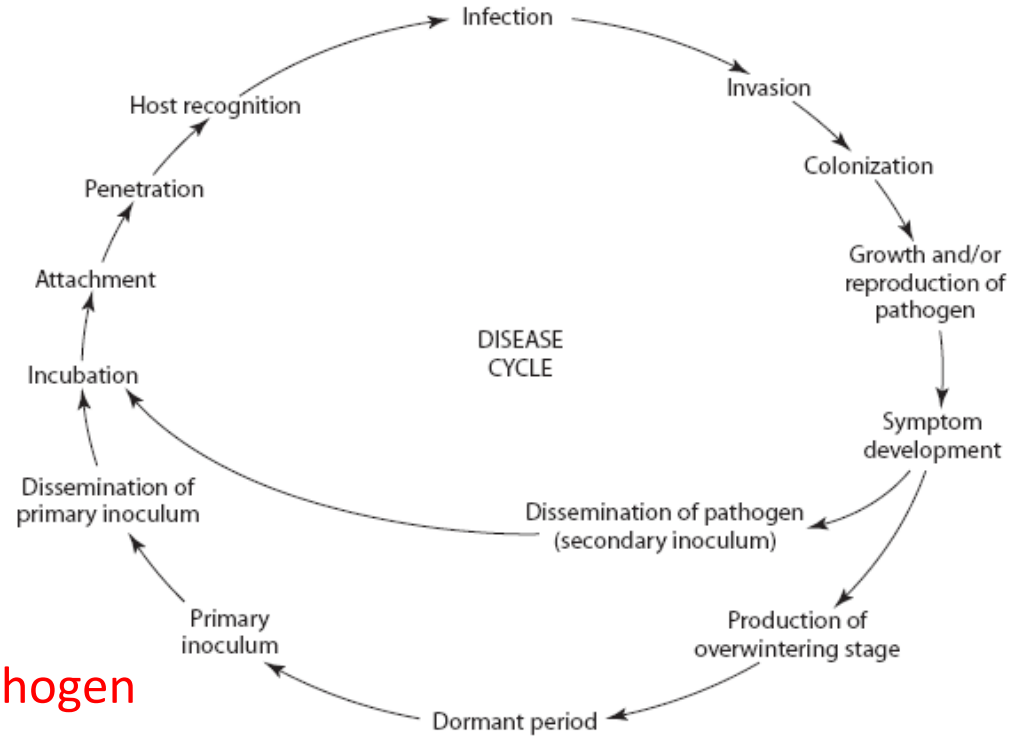
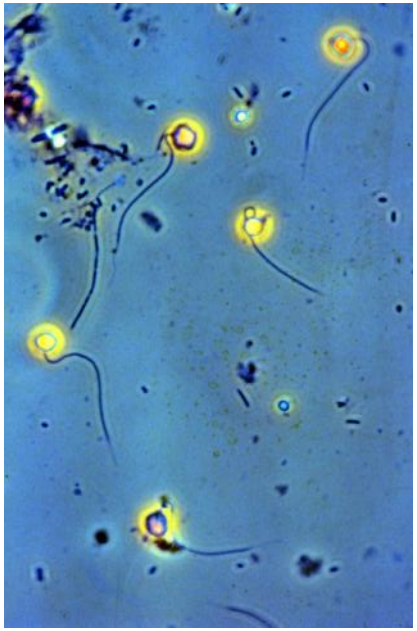
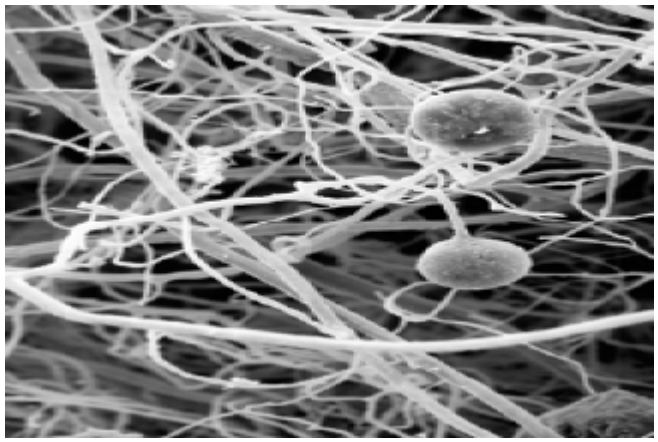



FIGURE 2-2 Stages in development of a disease cycle.

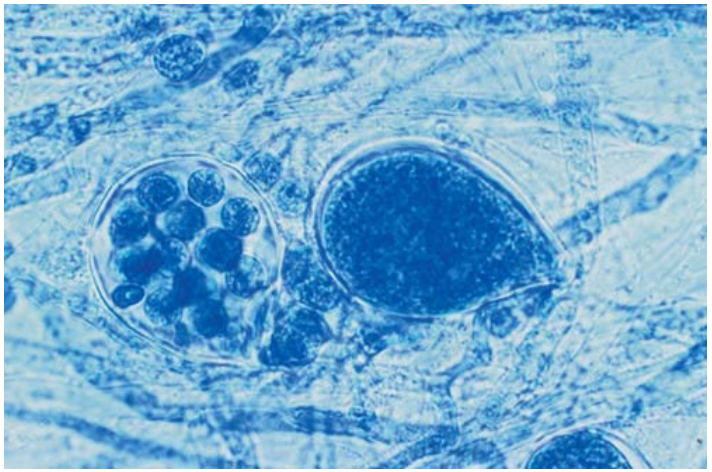
- (PRIMARY) INOCULATION- initial contact of the pathogen with the location (site) of the host plant where infection is possible
- INOCULUM - infective material of the pathogen needed to achieve successful infection when transferred to a favourable location
- species ( types ) of inoculum
- fungi - propagative spores (zoospores, ascospores , conidia ... )

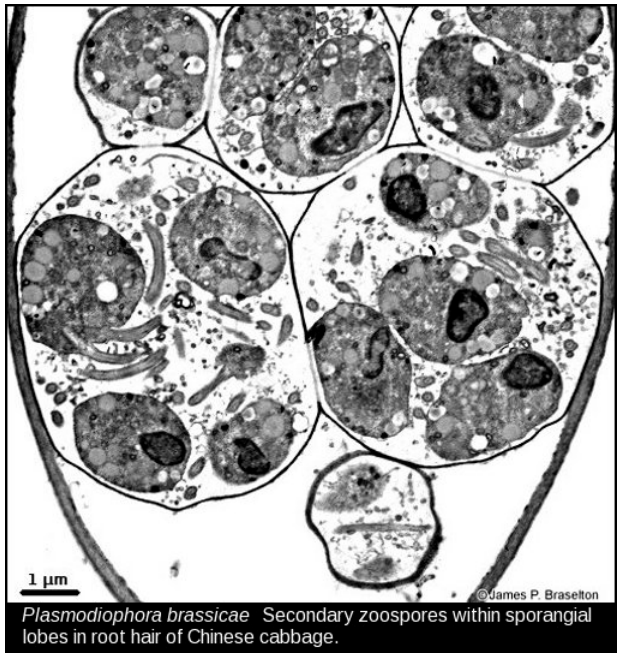


- fungi – vegetative parts - hyphae - mycelium….



- oomycetes, protists – zoospores , plasmodia






*Plasmodiophora brassicae* Secondary zoospores within sporangial lobes in root hair of Chinese cabbage.

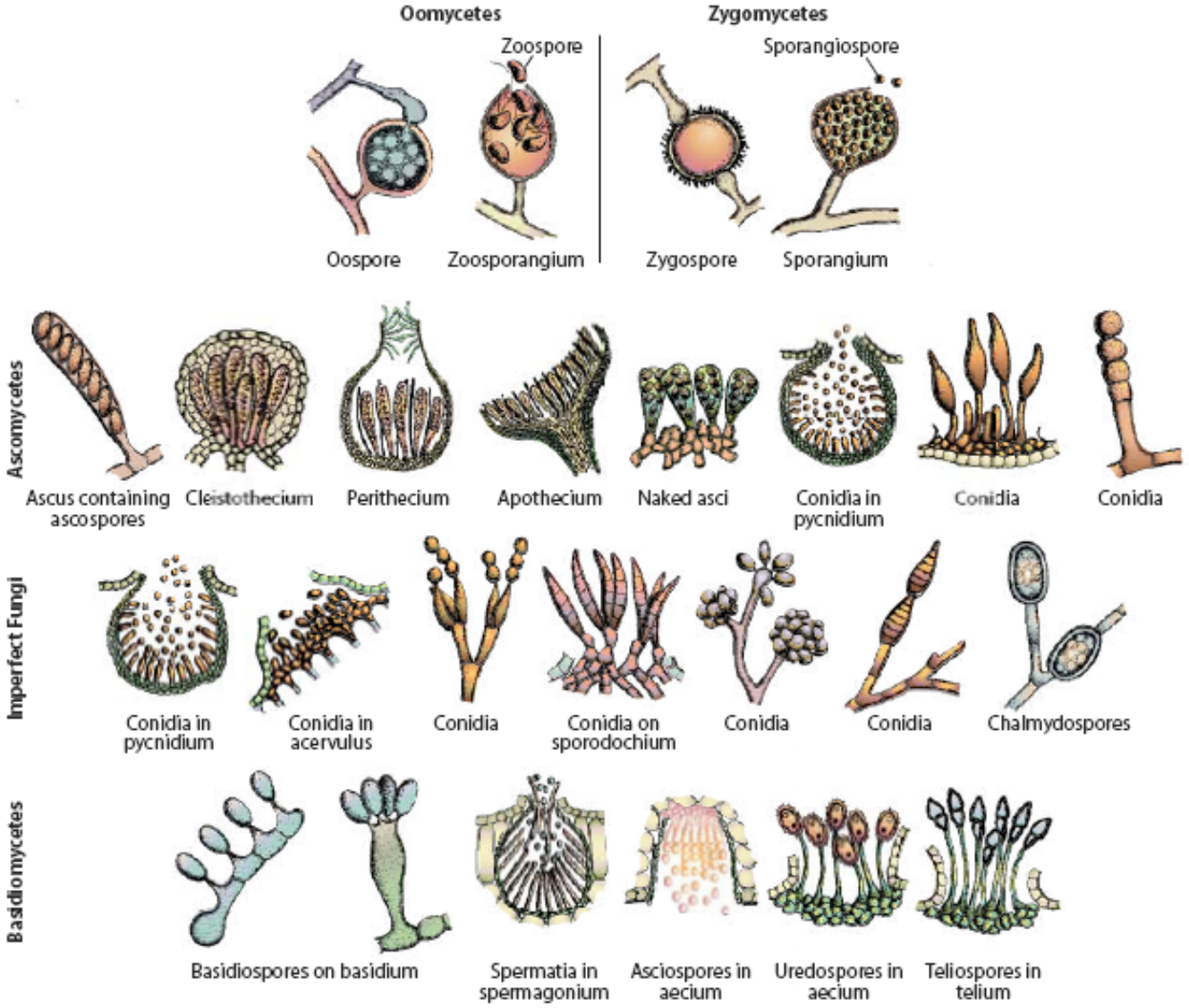
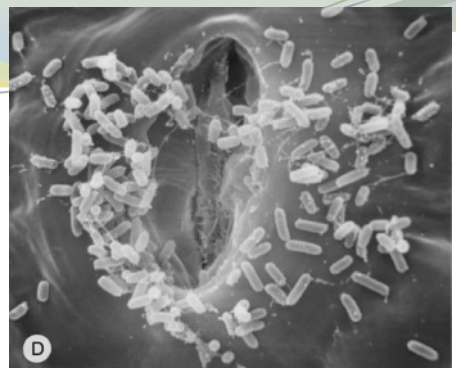
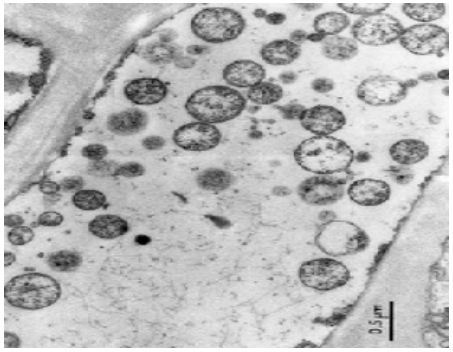



**FIGURE 11-2** Representative spores and fruiting bodies of the fungal-like Oomycetes and the main groups of fungi.

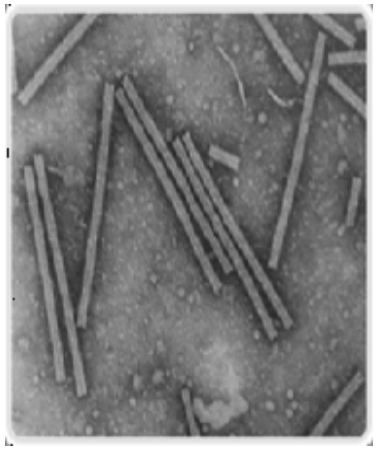
- bacteria – cells




- phytoplasmas and spiroplasmas – cells



- viruses – infective and complete virus particles– virions



• transmission to the host – depending on the means of dissemination – by vectors, by air, by water….

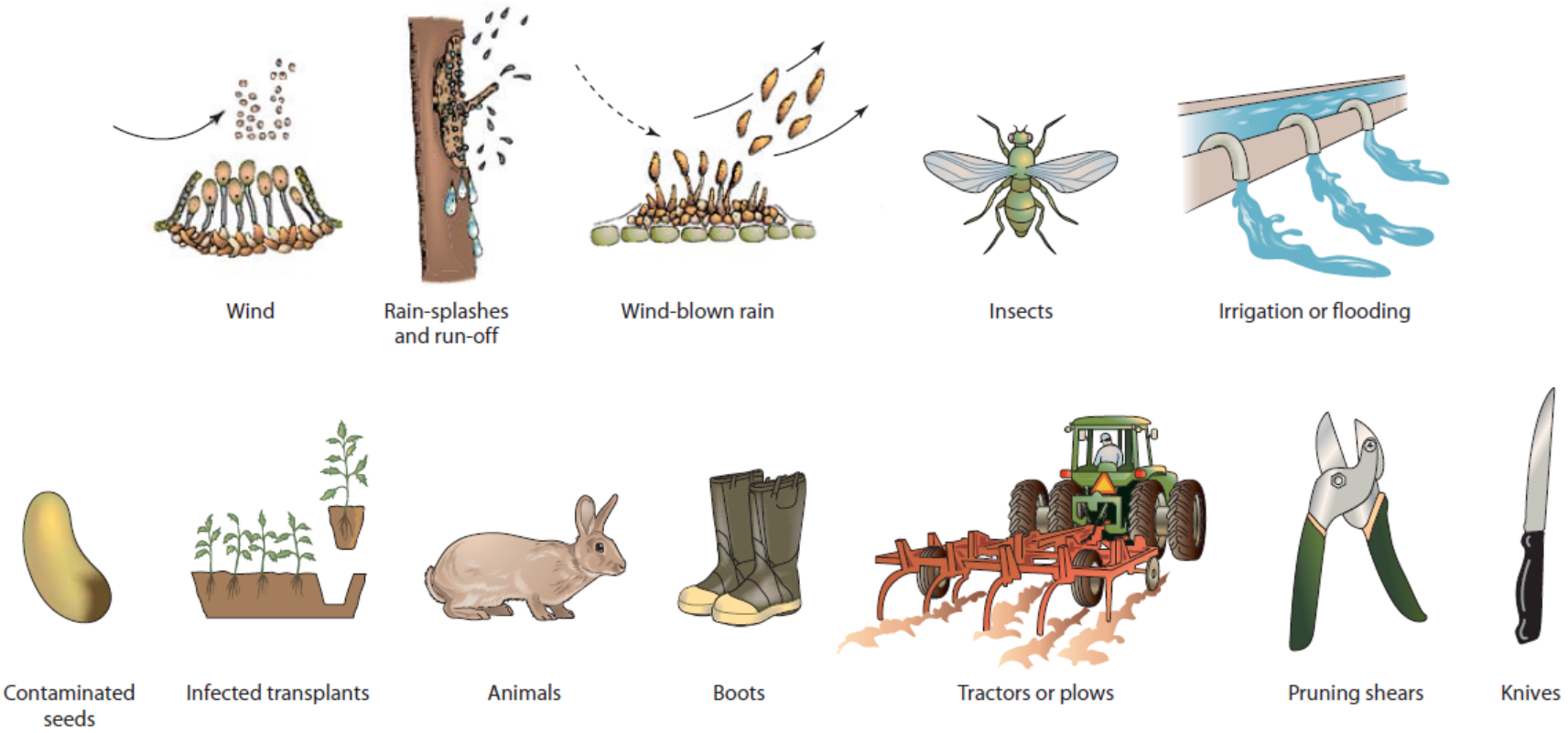
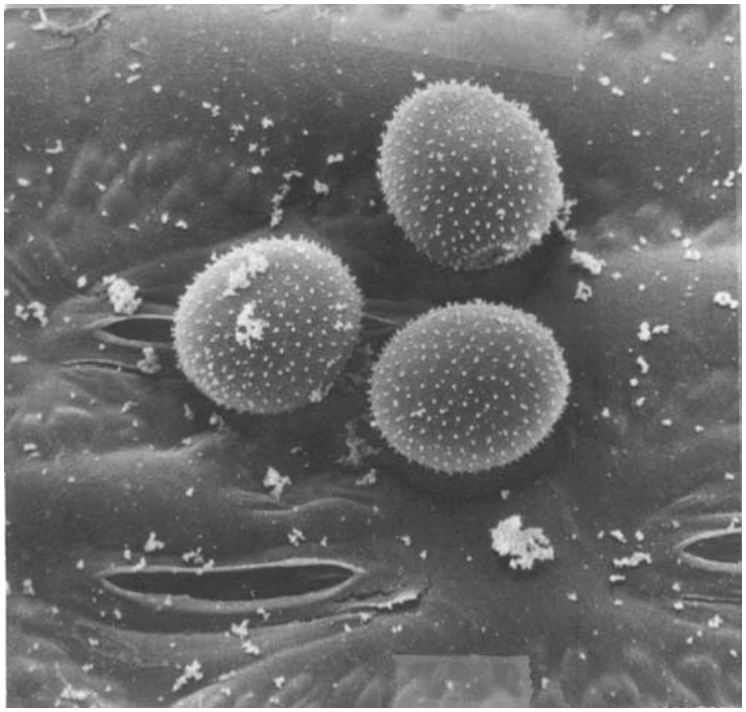



FIGURE 2-15 Means of dissemination of fungi and bacteria.

- attachment of pathogens to host cells - pathogens that are not transmitted by insect vectors

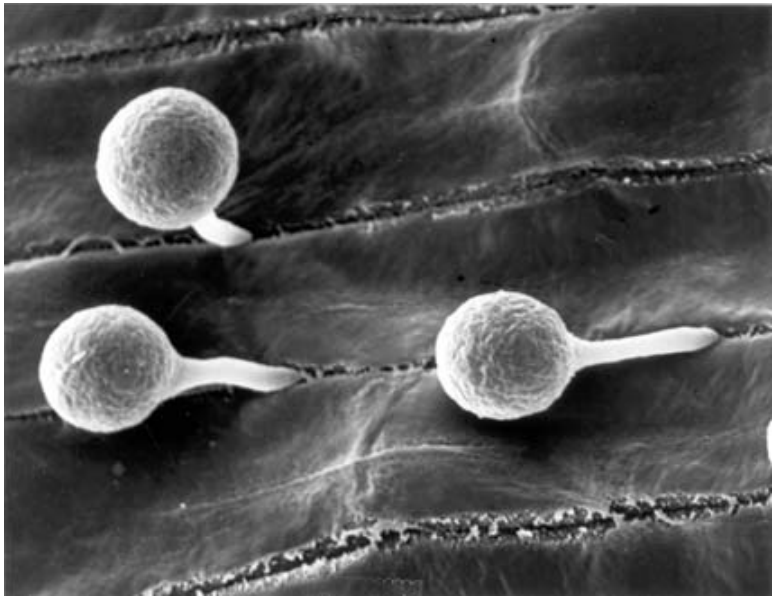
  - adhesion of bacterial cells and spores



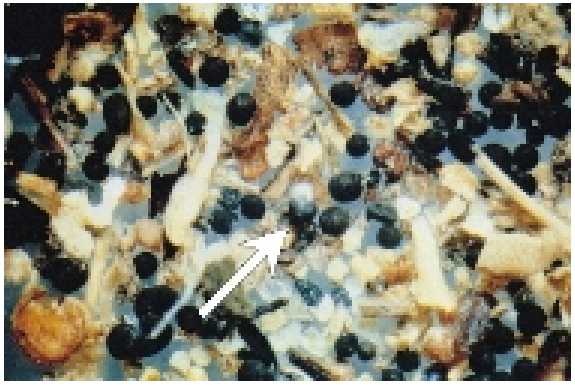
Urediospores of the causing agent of Rust diease (order *Pucciniales)*

- on the surface of their cells they have molecules like polysaccharides, glycoproteins and lipids which become sticky in contact with moisture and enable adhesion
- urediospores of causing agents of rusts (order *Pucciniales*) have spines on the surface that are involved in the early contact with the host

• chemotaxis – characteristic of pathogens transmitted through the soil that enter the host through the root system - Oomycetes and some fungi and bacteria



• *Phytophtora sojae* – motile zoospores attracted by isoflavones daidzein and genistein produced and released by soybean roots



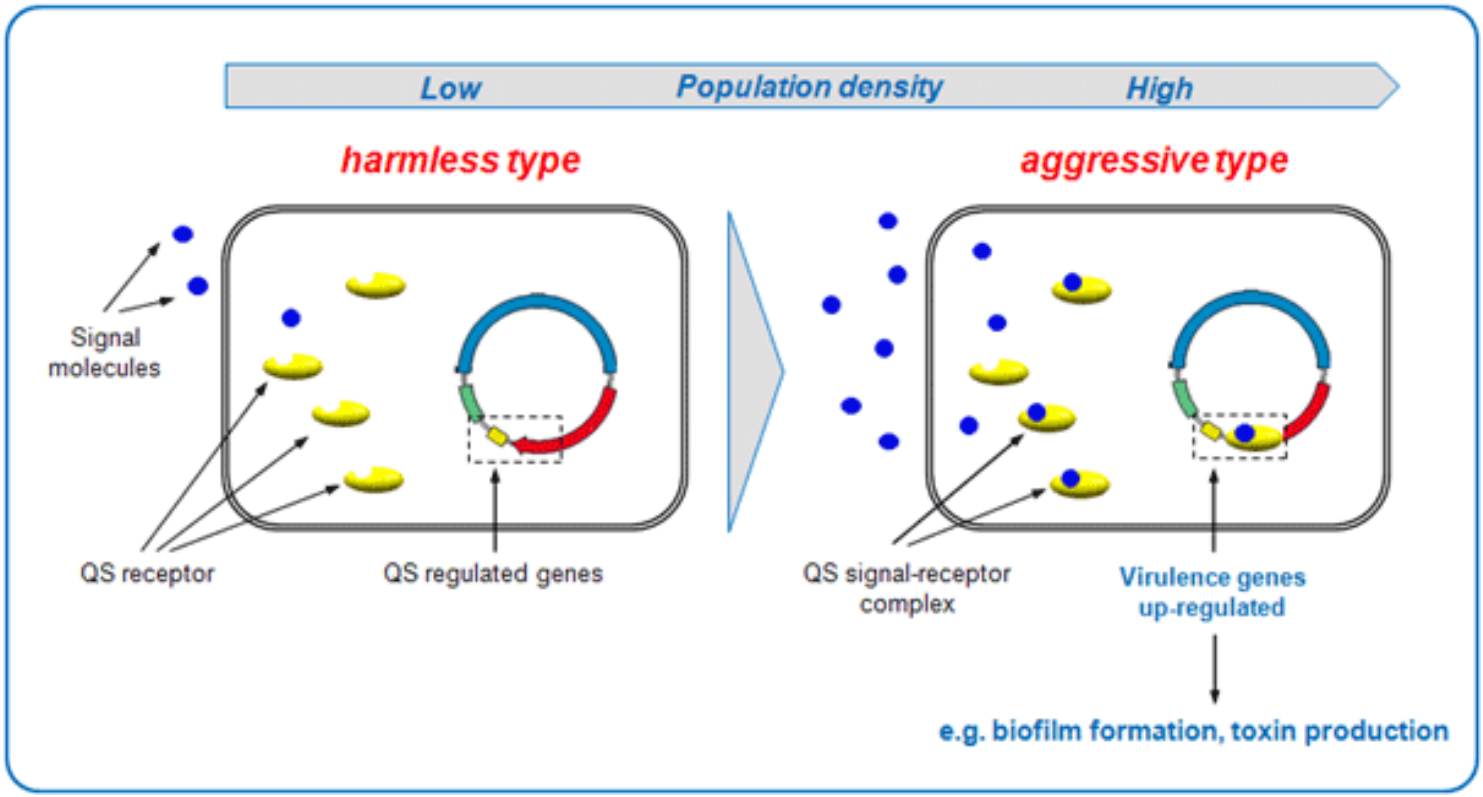
• *Sclerotium cepivorum* – n-propyl and alkyl sulfides released by the roots of plants of the genus *Allium*

- bacteria of genus *Xanthomonas* - chemotactic movement towards hydathodes through which they enter into the host plant
- bacteria from the soil - *Agrobacterium tumefaciens* and *Ralstonia solanacearum* - chemotaxis towards the wound on the plant
- *Agrobacterium tumefaciens* - acetosyringone (phenol compound) and sugars – recognize VirA (transmembrane histidine kinase) or ChvE proteins - combined activity which includes also VirG protein leads to the activation of transcription of the *vir* - region

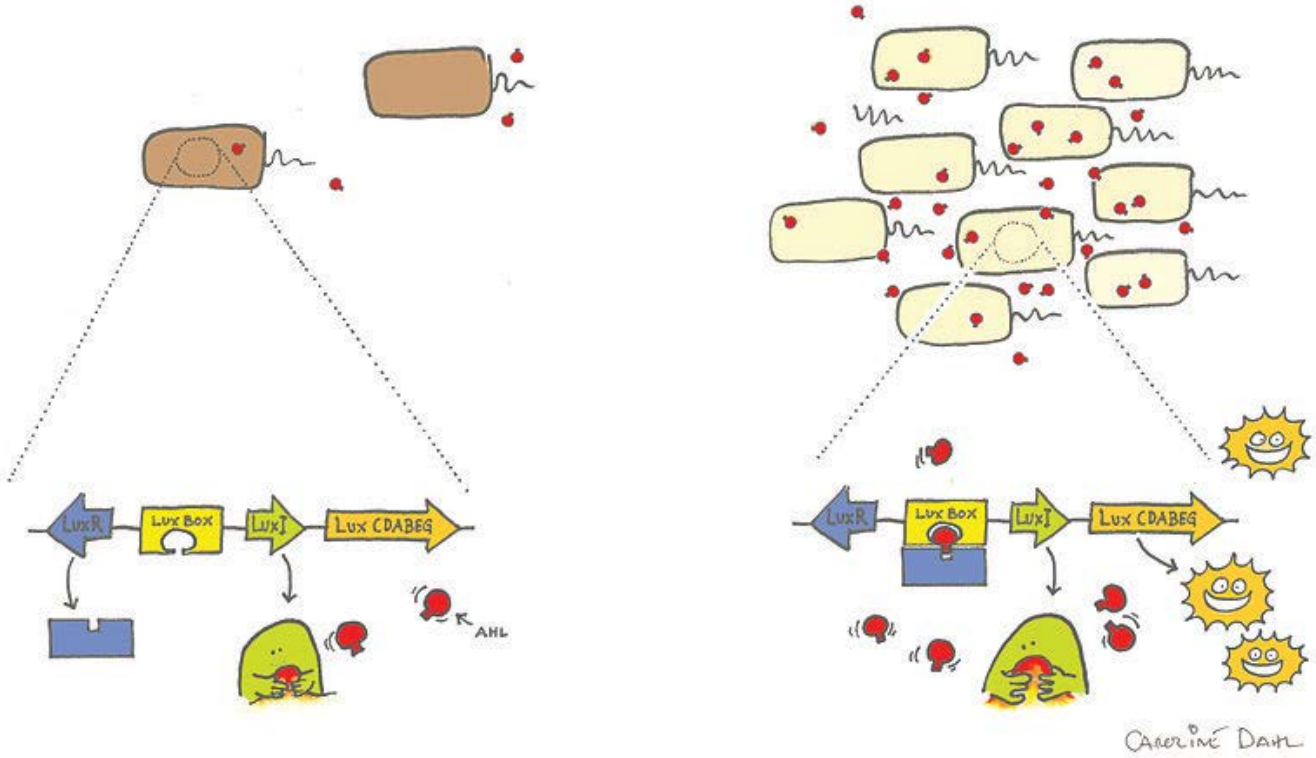
Adhesion of bacteria from genus *Agrobacterium* to carrot cells

- synthesis of cellulose fibrils– involvment of *chvA, chvB* and *pscA* genes*;* protein rhicadhesin
- pre-penetration event – Ti plasmid conjugation – increase in the number of pathogenic isolates

- communication among bacteria - *the quorum sensing*
- sense of population density of bacteria and response control expression of specific genes or activities
- production of signaling molecules – autoinductors
- a phenomenon first discovered in *Vibrio fisheri*



• symbiosis of bacterium *Aliivibrio fischeri* (*Vibrio fischeri*) and bobtail squid *Euprymna scolope* within photophores (special light organs )– bioluminescence

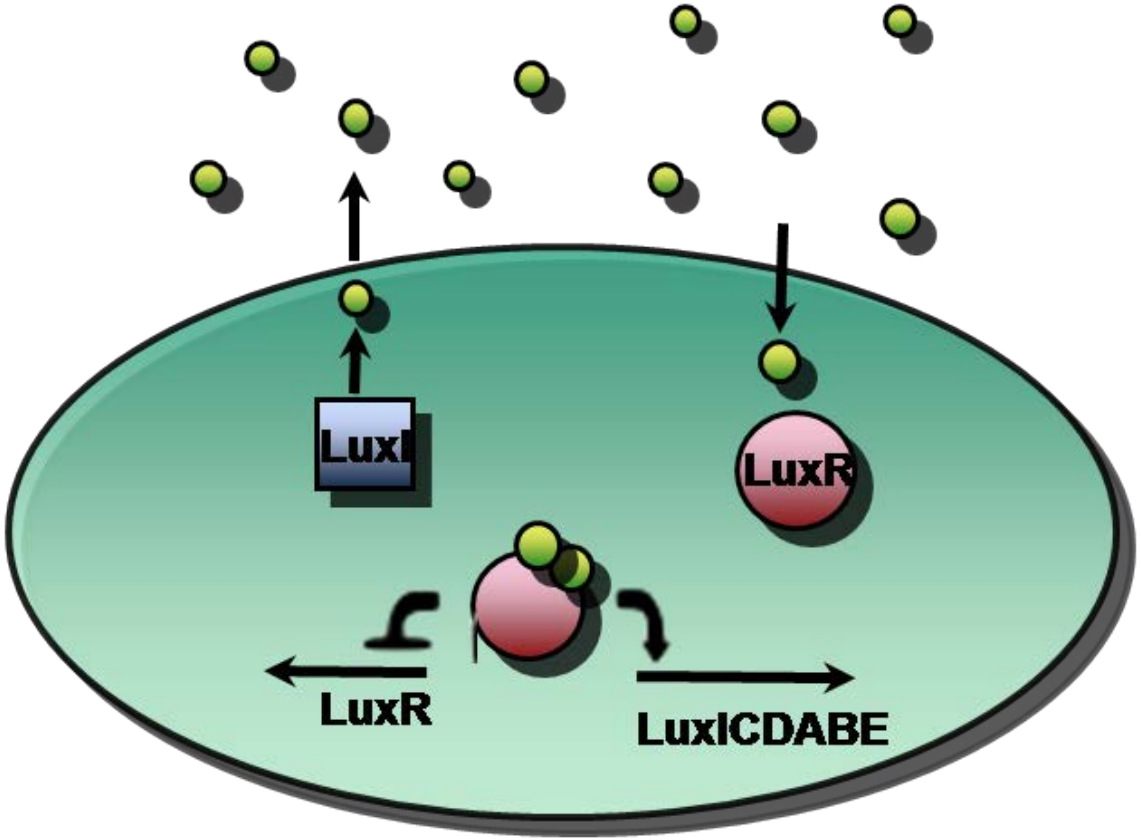



https://www.youtube.com/watch?v=x5-VcJyZRc4

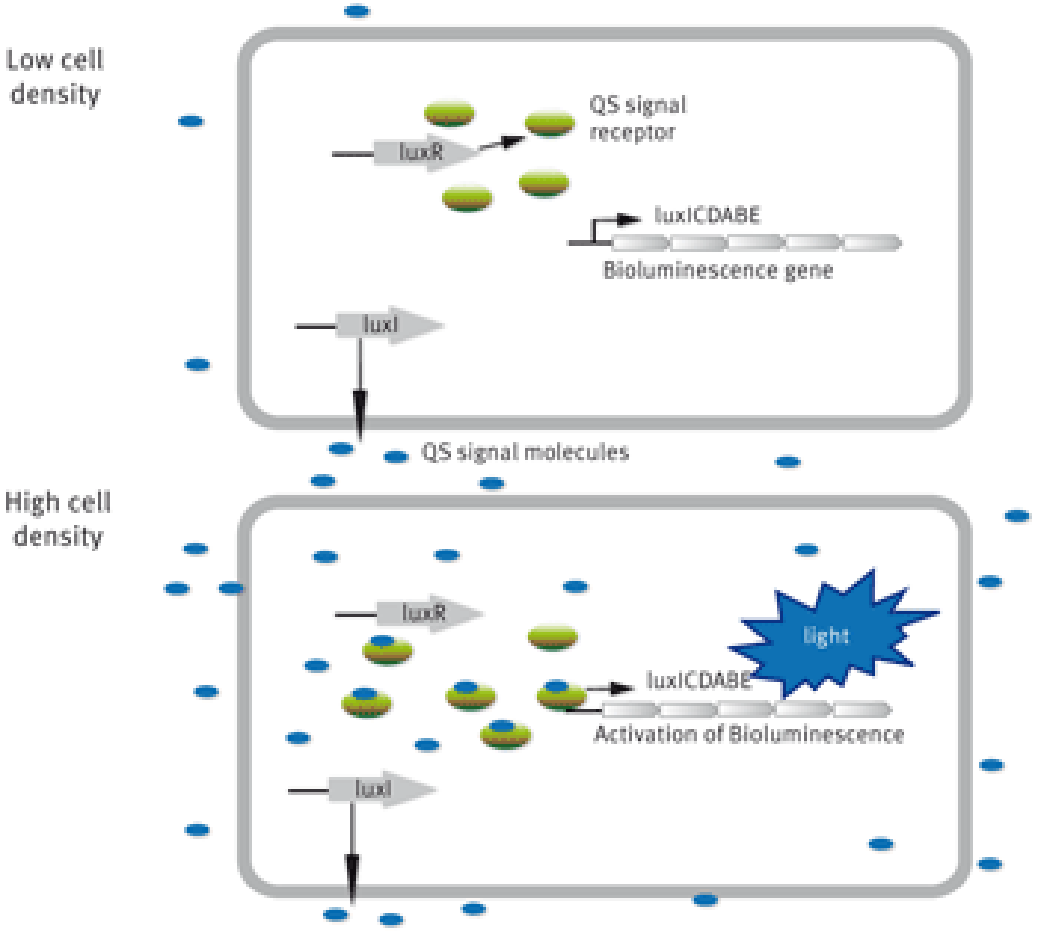
luciferin luciferase oxyluciferin

$$\mathrm{L} + \mathrm{O_2} + (\mathrm{ATP}) \xrightarrow[(\mathrm{Mg^{2+}})]{\textbf{Luciferase}} \mathrm{oxy\text{-}L} + \mathrm{CO_2} + \mathrm{AMP} + \mathrm{PP} + \mathrm{light}$$

• bioluminescence - the emission of visible light characteristic of many marine organisms - fish, dinoflagellates, planktonic beamers, cephalopods, but also bacteria, fungi and fireflies - mimicry, defense, warning, attracting .... a chemical reaction in which the oxidation of the pigment luciferin by the enzyme luciferase occurs the emission of visible light

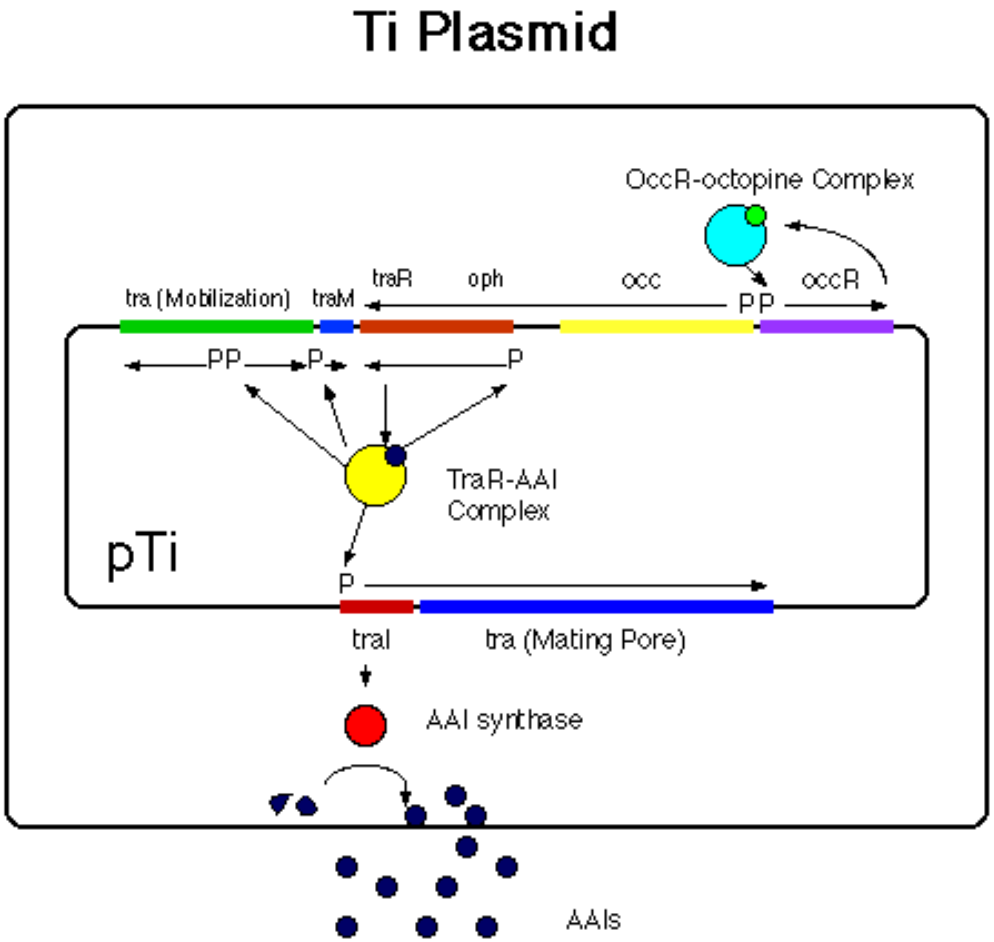


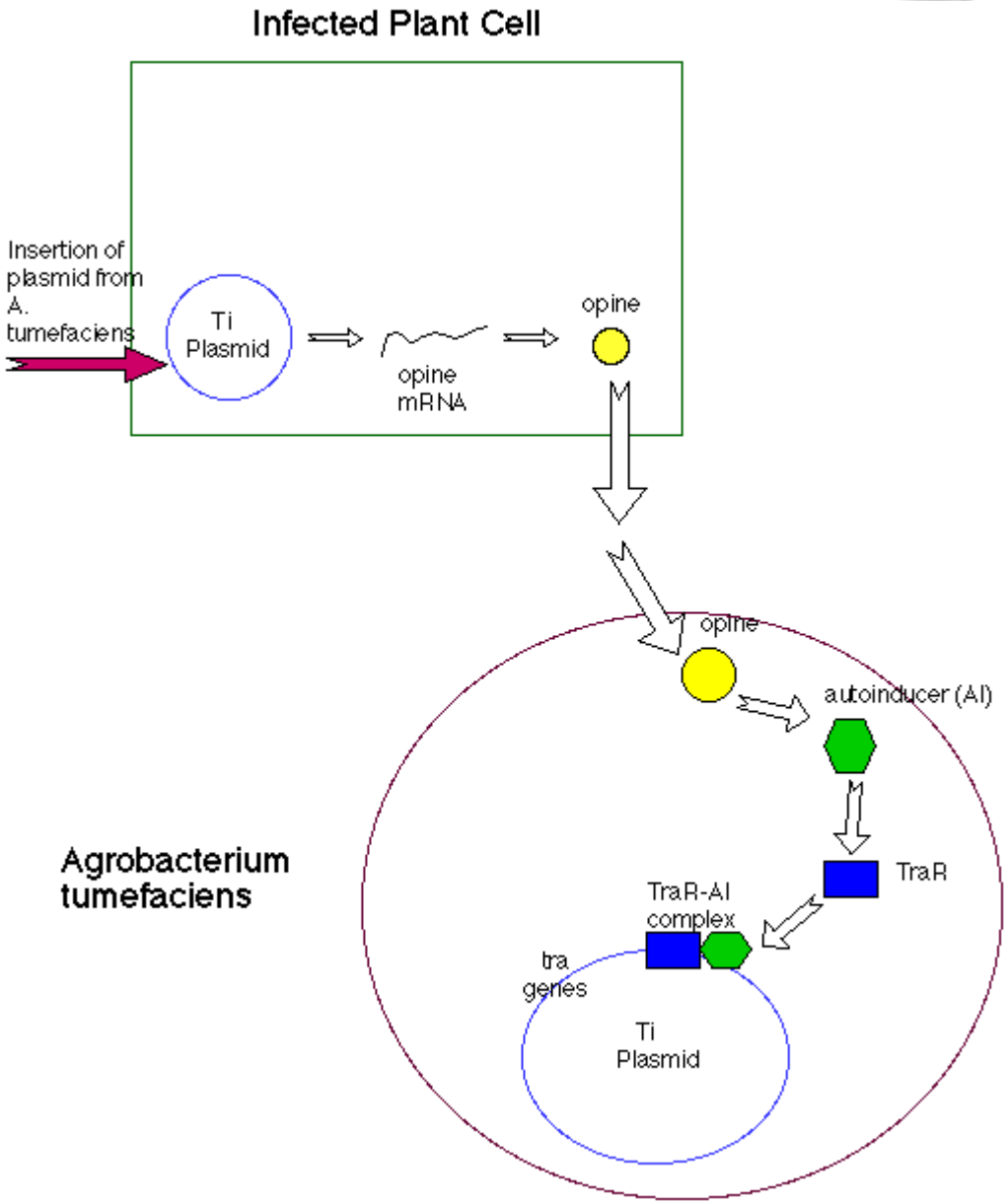
- diferent mechanisms in Gram-positive and Gram-negative bacteria
- Gram-positive bacteria – oligopeptides – via ABC-transport system
- Gram-negative bacteria – AHL (N-acyl-homoserine-lactone) – *LuxI*/*LuxR* system

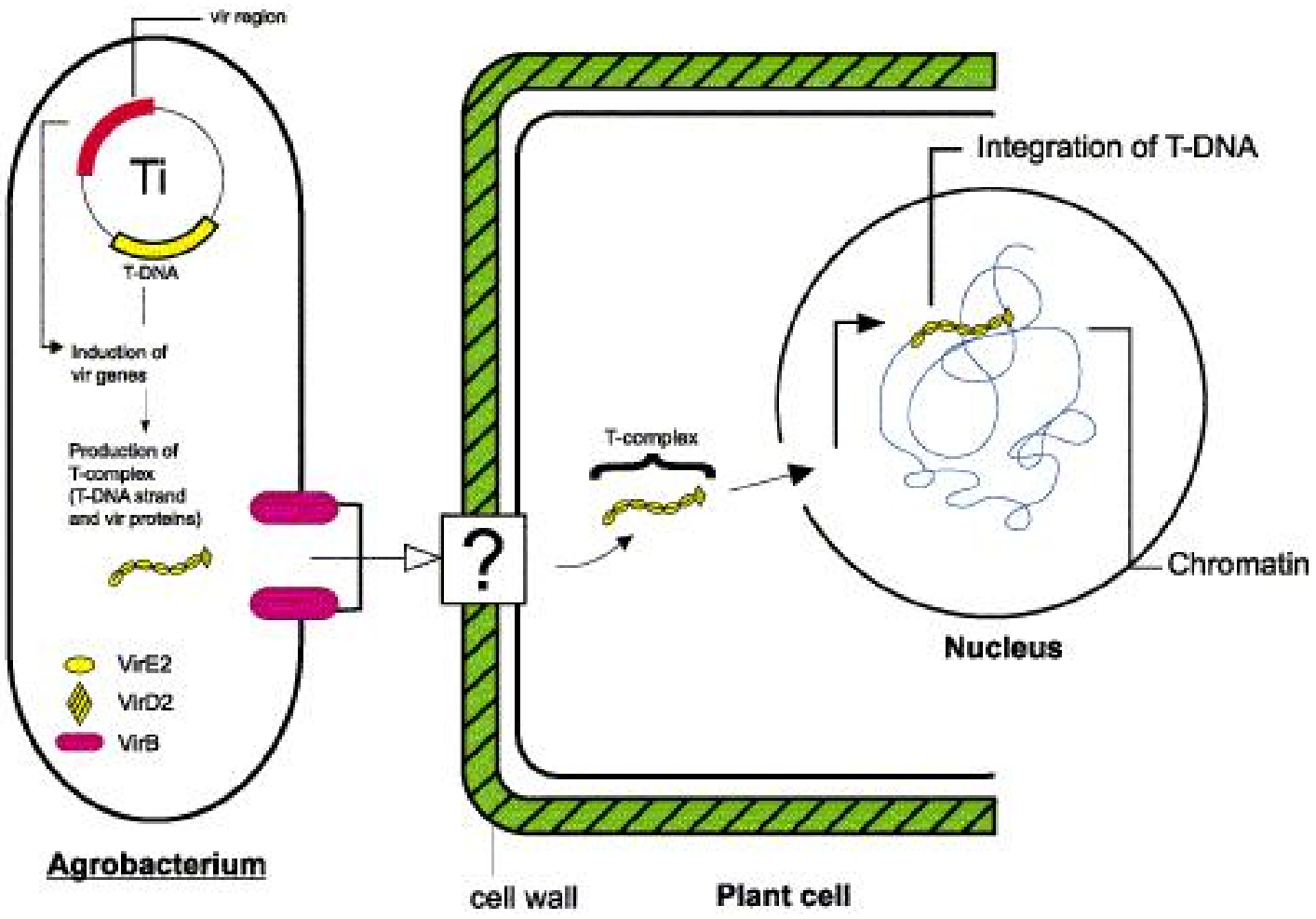


• *Ralstonia solanacearum*, *Erwinia caratovora,* genus *Xanthomonas, Pantoea* – regulation of secretion of cell wall degrading enzymes (CWDE)

• *Agrobacterium tumefaciens* – regulation of transfer of Ti plasmid by conjugation




Infected Plant Cell
Insertion of plasmid from A. tumefaciens
Ti Plasmid
opine mRNA
opine
opine
autoinducer (AI)
TraR
TraR-AI complex
tra genes
Ti Plasmid
Agrobacterium tumefaciens

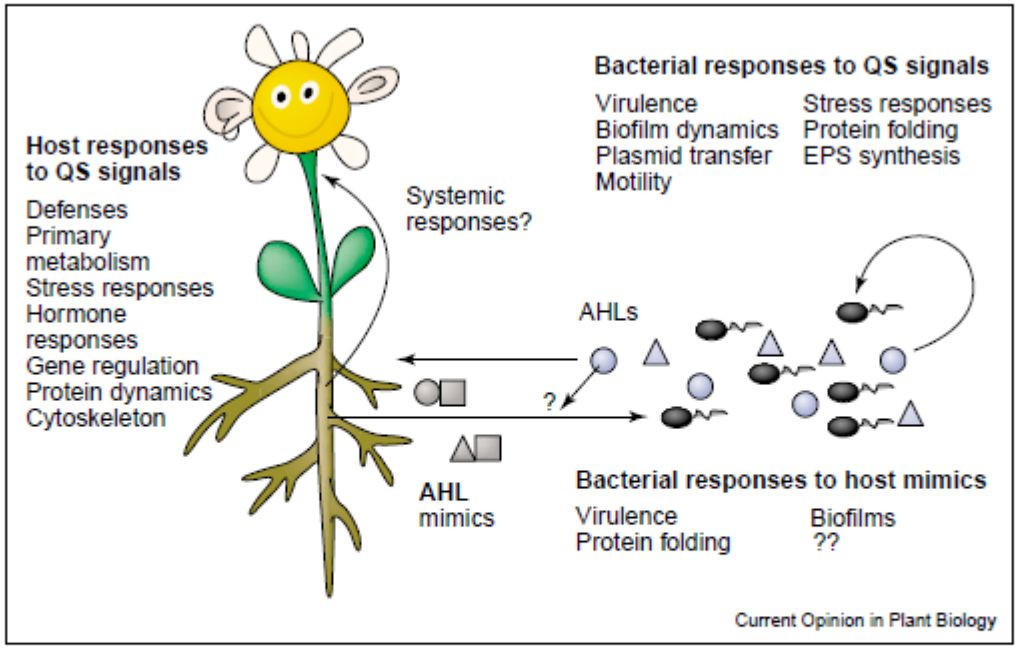



**T-DNA transfer into the Plant's Genome**

Adapted from Zupan et al 2000

• plants respond to *quorum sensing* signals by secretion of compounds that mimic bacterial signals and distract bacterial regulation by *quorum sensing* mechanism

**Figure 2**




Schematic model of QS-related interactions between plants and bacteria. AHL QS signals (triangles and circles) from bacteria (ovals) affect QS-regulated behaviors in the bacteria and also elicit a diversity of responses in the plant. The plant produces and secretes AHL mimic compounds (circle/square, triangle/square) that disrupt or manipulate QS-regulated behaviors in the bacteria. Plant responses to bacterial AHLs might affect the secretion of AHL mimic compounds. AHL mimics from the plant may also affect synthesis of AHLs in the bacteria.

# PENETRATION

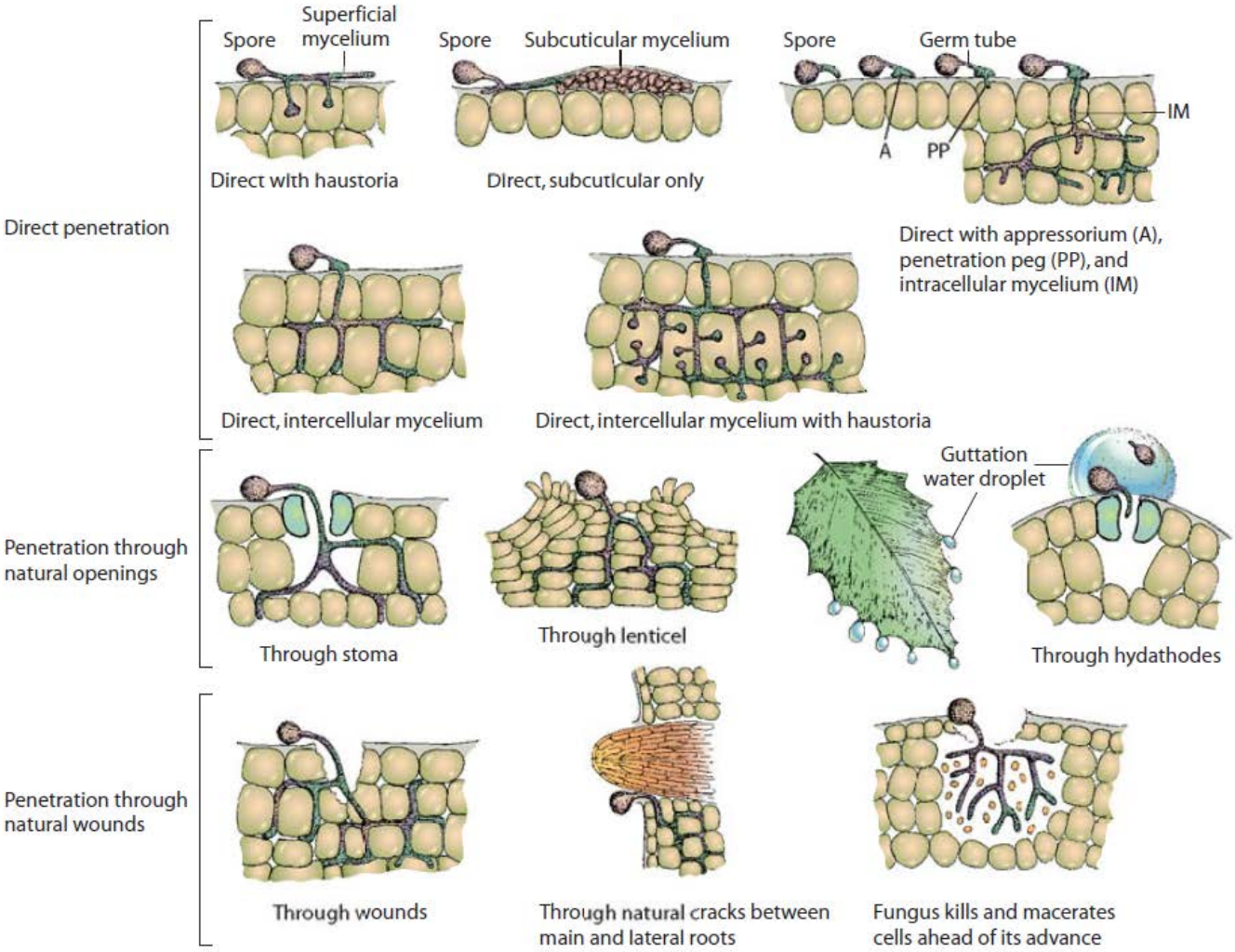
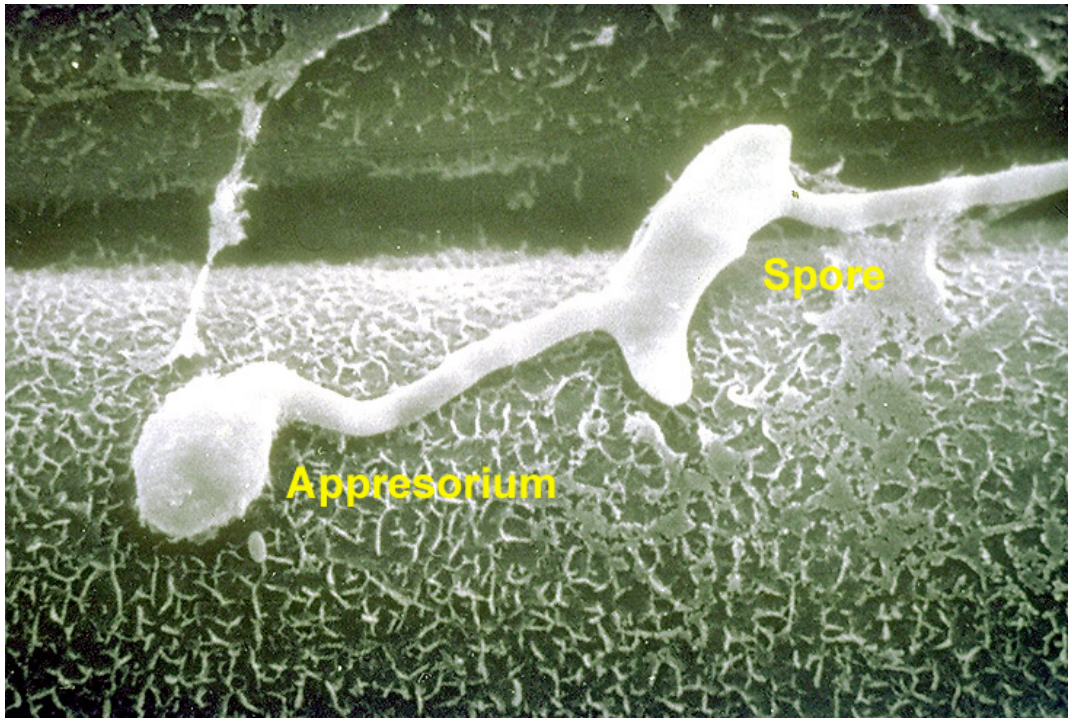


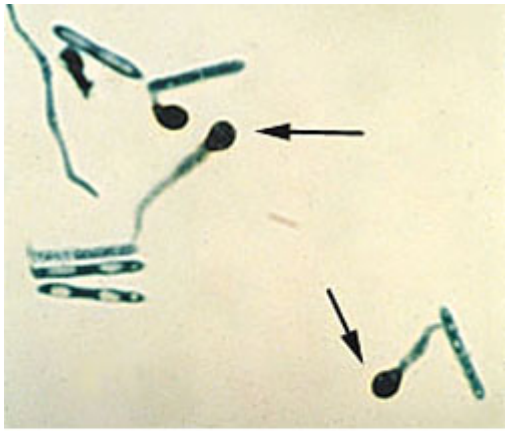

FIGURE 2-5 Methods of penetration and invasion by fungi.

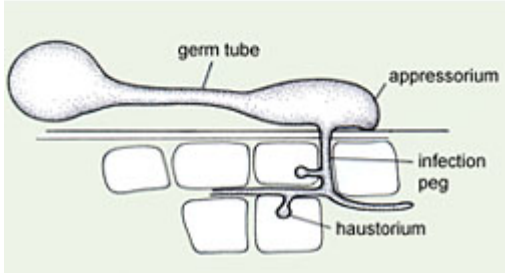
• germination of spores - molecular mechanisms of induction in pathogenic fungi are not thoroughly elucidated

• signaling pathways guided by MAPK and cAMP, PKA

• forming of appresorium (“pressing” organ) – firm attachment to the host surface - the emergence of infectious hyphae





• secretion of cell wall degrading enzyme (*CWDE):*

- pectinases – endo and exo-polygalacturonase, pectate-lyase…
- celullases
- cutinases
- ligninases
- proteases
- lipases
- amylases

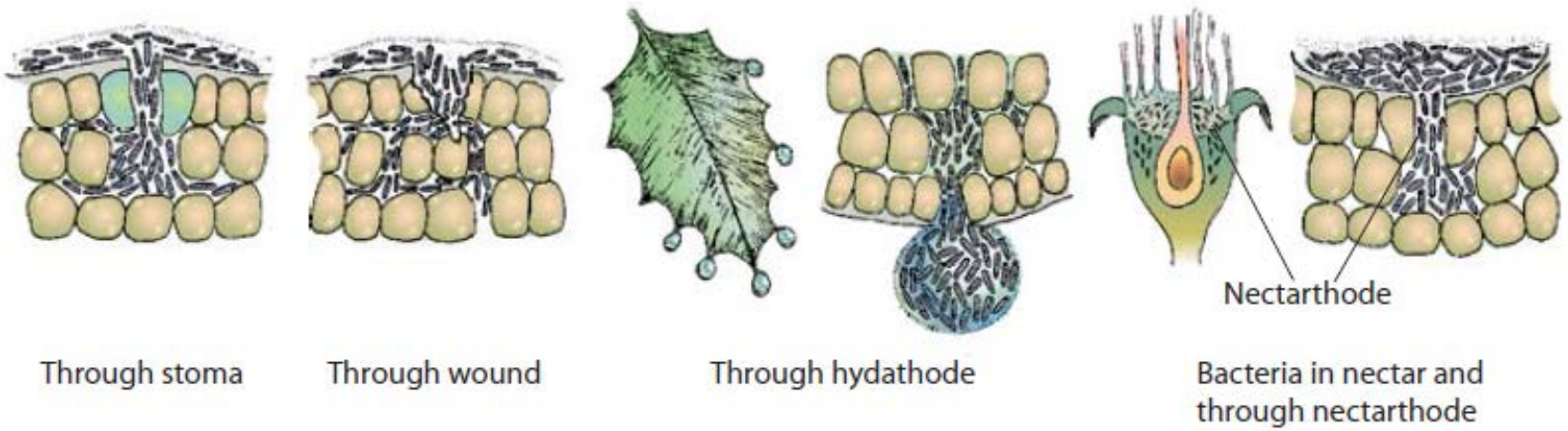
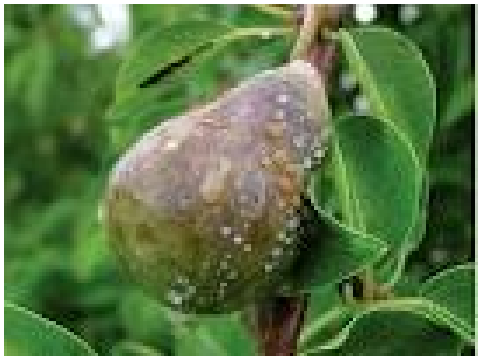



FIGURE 2-7 Methods of penetration and invasion by bacteria.

• secretion of cell wall degrading enzyme (*CWDE)* in necrotrophic bacteria (for example in genus *Erwinia)*



- host-pathogen recognition

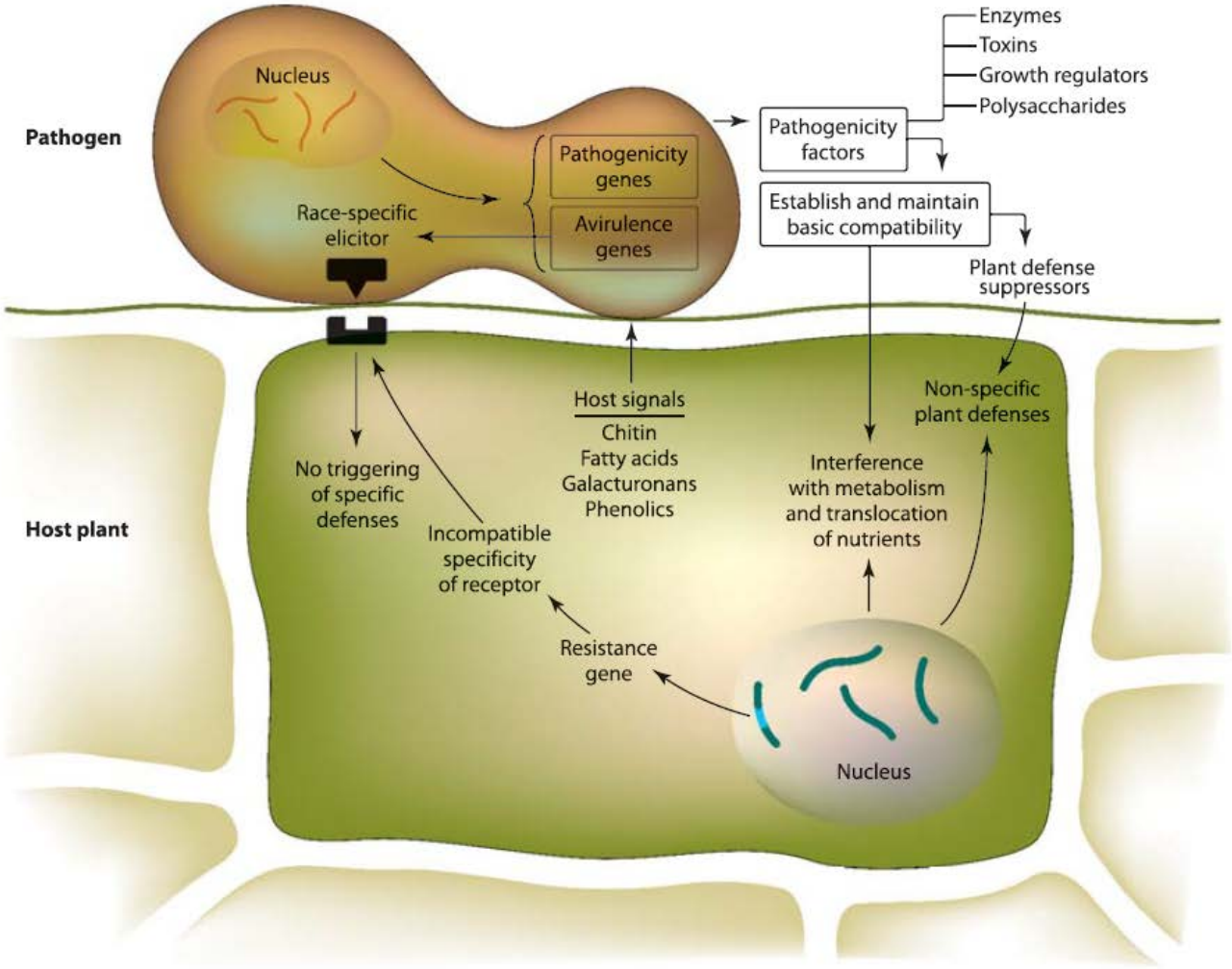



FIGURE 2-6 Establishment of infection in a compatible reaction between a pathogen and its host plant.

- infection - the process by which the pathogen makes contact with a susceptible host cells and obtains nutrients
- invasions – inter - or intracellular growth - local or systemic
- colonization - the growth and replication of the pathogen in the host – spread through plasmodesmata, phloem, xylem; production of spores
- incubation period - the appearance of external symptoms

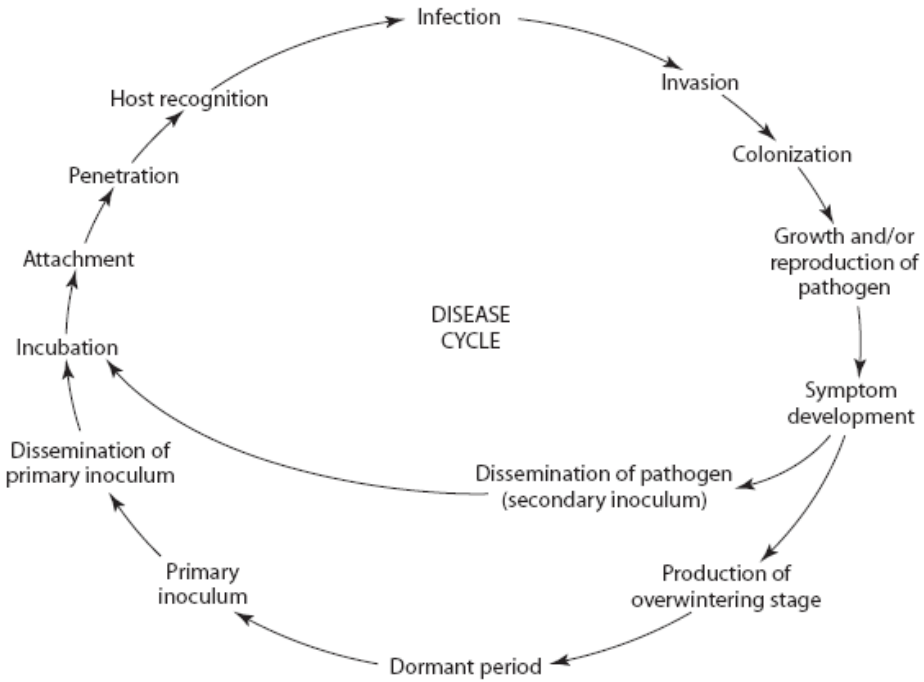



FIGURE 2-2 Stages in development of a disease cycle.

- dissemination of pathogens

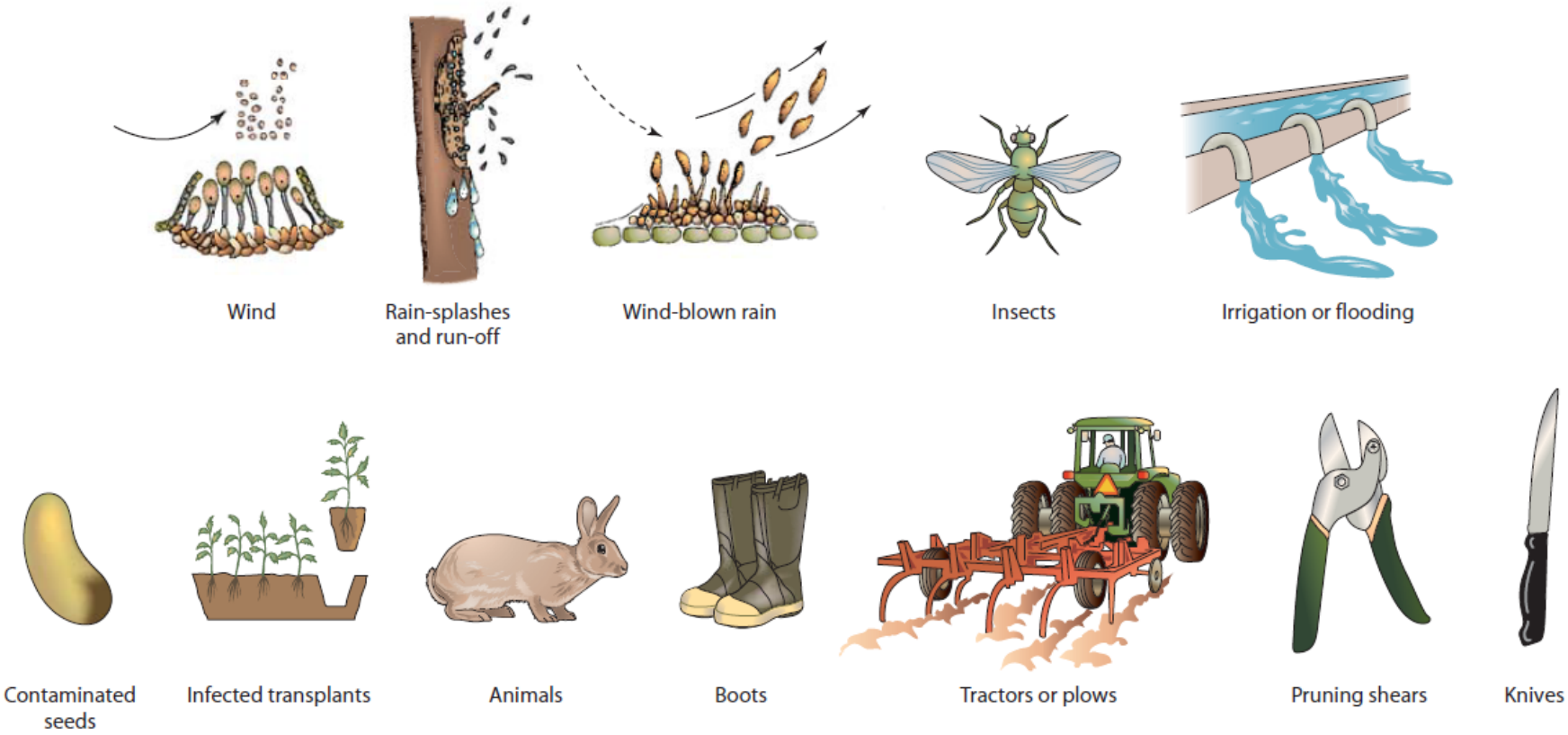



FIGURE 2-15 Means of dissemination of fungi and bacteria.

- overwintering and survival of pathogens

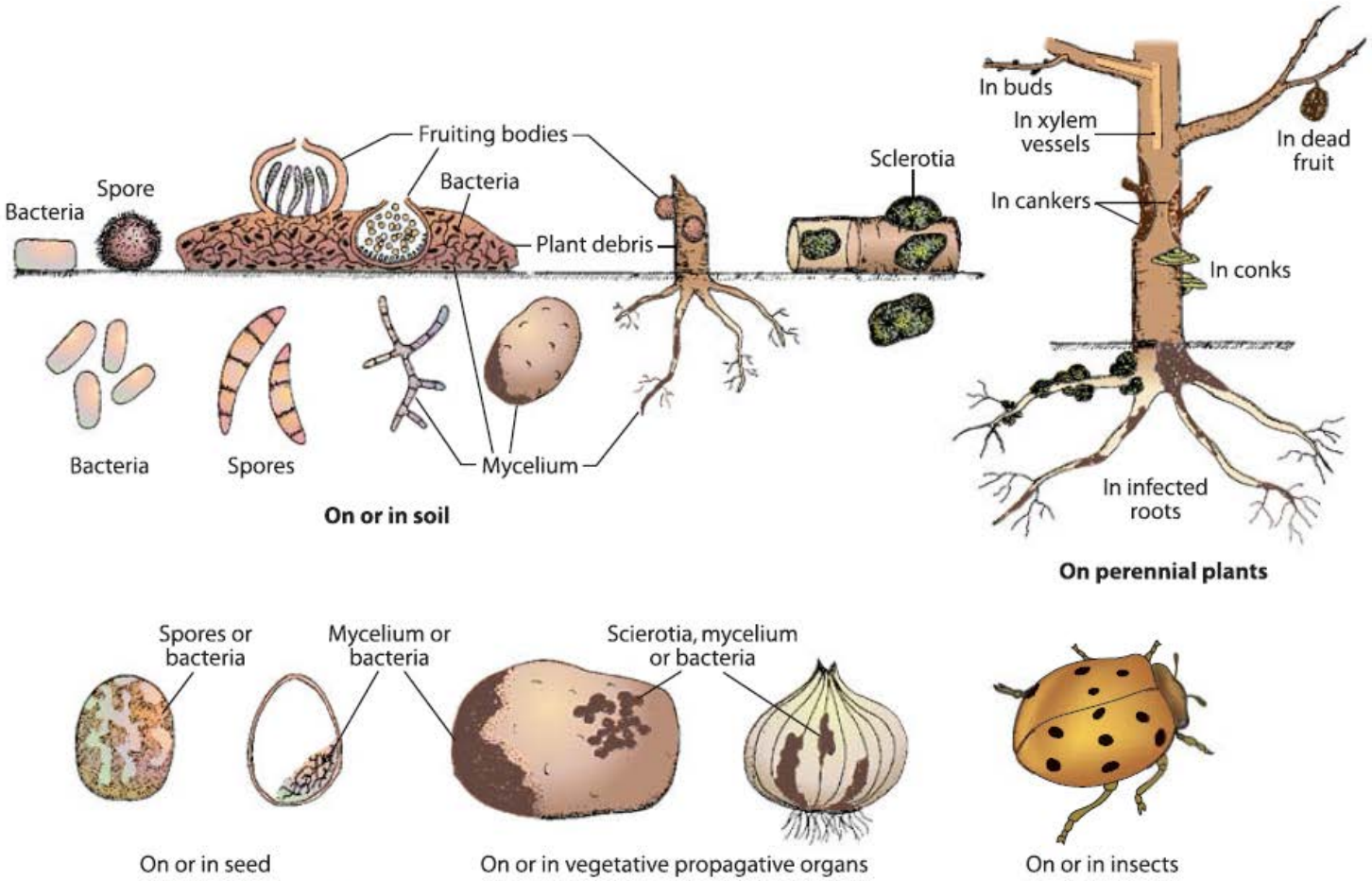



FIGURE 2-21 Forms and locations of survival of fungi and bacteria between crops.

- polycyclic disease – pathogen has more than one generation per season
- monocyclic disease – only one generation of pathogen per season – some phytoplasmal and viral diseases of woody plants

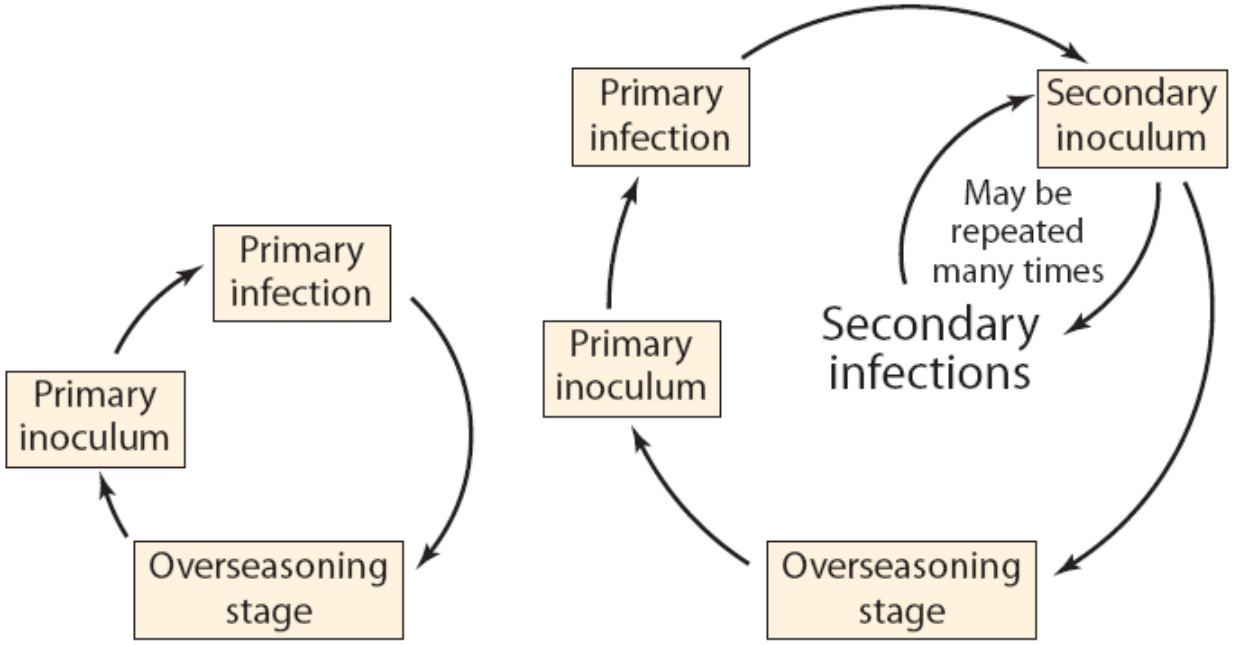



**FIGURE 2-22** Diagrams of (left) monocyclic and (right) polycyclic plant diseases. Monocyclic diseases lack secondary inoculum and secondary infections during the same year.