


## Ecology of Disease

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Theme: AGRICULTURE  
HORTICULTURE



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## Horticulture

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- Cultivated crops such as vegetables, fruits, flowers, ornamentals, turf-grasses, herbs and medicinal plants.
- Australian horticultural industry
  - gross annual production value ~\$6 billion
  - ranks 1/3<sup>rd</sup> behind grain and meat industries
  - export value ~\$1,540 million (fresh and processed)
  - ~60,000 people employed growing fruit/vegetables
  - ~12,000 employed in fruit/vegetable processing

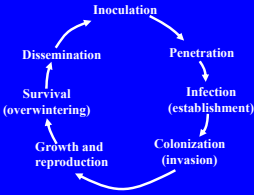
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## Horticultural Diseases

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**DISEASE CYCLE**

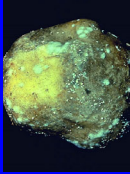

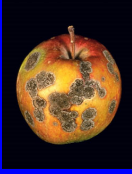
- Life-cycle of pathogen in association with host
- Chain of events leading to disease
  - inoculation
  - penetration
  - infection/establishment
  - colonization (invasion)
  - growth and reproduction of pathogen
  - survival of pathogen (e.g. overwintering or oversummering)
  - dissemination



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## Exemplars – Horticultural diseases

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<p><b>Late blight</b></p> <ul style="list-style-type: none"> <li>■ potatoes</li> <li>■ oomycetes</li> <li>■ necrotic patches</li> <li>■ moisture</li> </ul> 	<p><b>Citrus canker</b></p> <ul style="list-style-type: none"> <li>■ oranges</li> <li>■ bacterial</li> <li>■ rind blemishes</li> <li>■ wind/rain</li> </ul> 	<p><b>Fire blight</b></p> <ul style="list-style-type: none"> <li>■ apples</li> <li>■ bacterial</li> <li>■ blossoms/shoots</li> <li>■ temperature</li> </ul> 
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## Potatoes

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- world's 4<sup>th</sup> most important crop
- modified stem storage tissue
- *Solanaceae* family
- first domesticated thousands of years ago in Andes Mountains
- modern potato cultivars have been bred to emphasize asexual reproductive capacity

Australia's largest vegetable industry

- ~1.3 million tonnes annually
- farm gate value ~\$414 million
- main growing regions in Victoria, N. Tasmania, S-E Sth. Aust.
- export 15,000 tonnes worth \$11m
- processed potato products - \$9 m






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## Potato Diseases

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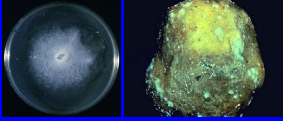

- Bacterial (5)
  - Soft rot/Black leg
- Fungal (30)
  - Late Blight
- Viral (>30)
  - Potato leaf-roll virus
- Nematodes (6)
  - Potato cyst

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## Potato Late Blight

- Caused by oomycete *Phytophthora infestans*
- oomycetes closely related to protists
- Potato and tomato hosts
- Lesions start out as "fuzzy" white patches
- then become necrotic
- increase in number
- finally kill whole plant


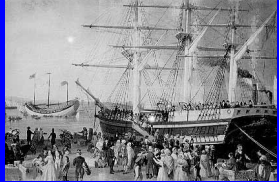



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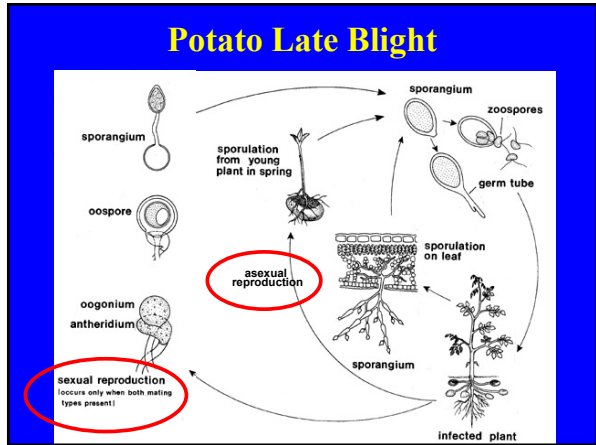
## Potato Late Blight

### Irish Potato Famine

- spring 1846, healthy potato crop fine warm weather
- heavy rain in June weather turns wet and cold
- outbreak of Late blight
- potato crops failed for years ("hungry '40s")
- Disease impact
  - ~1 million die from 1845-1860
  - mass migration (esp. to US)

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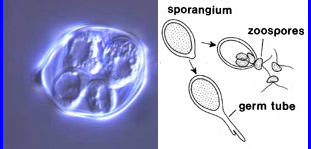


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## Potato Late Blight

### Role of environment

- Temperature
  - 18-22°C required to produce sporangia that initiate infection
  - 21-27°C sporangia germinate directly
  - <16-18°C sporangia produce 6-8 zoospores
  - >30°C inhibits growth




Temp	Percent direct germination	Percent zoospore production
4	0	41
12	1	63
16	16	14
20	42	2
27	39	0

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## Potato Late Blight

### Role of environment

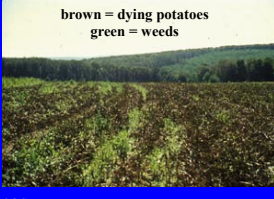
- Moisture
  - relative humidity >90% required to produce sporangia that initiate infection
  - <80% sporangia die
  - free water on plant surface allows zoospores (if produced) to swim
  - rain splash helps disseminate organism



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## Potato Late Blight

- Cool nights, warm days, extended wet conditions (rain and fog) can result in epidemics where entire fields destroyed <3 weeks
- Control traditionally relied on copper-based fungicides (Bordeaux mixture) despite copper being potentially phytotoxic
- Disease forecasting for spraying
  - "temperature-humidity rule" predicts blight will develop in 15-22 days after period when temperature not < 10°C and relative humidity >75% for 2 consecutive days
  - radio stations broadcast warnings



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## Potato Late Blight

- Introduction of pathogen
- Mating types present

- Presence of Susceptible hosts

- Moisture
- High RH
- Temperature
- Low → worst disease
- Wind - dissemination

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## Oranges

- native to Southeast Asia
- *Rutaceae* family
- introduced into Europe in late Middle Ages
- most important commercial citrus crop in temperate zone

- Australian Citrus Industry
  - one of largest horticultural industries and exporters in Australia
  - Gross value of \$5.5 billion
  - 4<sup>th</sup> largest citrus producing country in Southern Hemisphere (16<sup>th</sup> in world)
  - (1% of global citrus production)

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## Citrus diseases

- Bacterial (5)
  - e.g. Citrus Canker
- Fungal (>50)
  - e.g. Alternaria brown spot
- Viral (11)
  - e.g. Tristeza
- Nematode (11)
  - e.g. Slow decline

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## Citrus canker

- Caused by bacterium *Xanthomonas axonopodis* pv. *citri*
  - Gram negative
  - rod-shaped
  - flagellate
- Host Range
  - citrus and relatives
- Disease
  - leaf-spotting
  - fruit rind-blemishing
  - defoliation shoot dieback
  - fruit drop

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## Citrus canker

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## Citrus canker

- Bacteria spread by wind and rain over short distances
  - within trees or to neighbouring trees
  - heavier infections on windward side of tree
- Bacteria spread by storms over longer distances (several km)



<b>Promotive Factor</b>			
High temperature 35-25>>25-20>>20-14°C Wetness	Wetness Rainfall Wind-blow	Wetness	High temperature 35-25>>25-20>>20-14°C Wetness
Multiplication in lesions	Dispersal and invasion	Establishment	Lesion development (incubation period)
<b>Repressive Factor</b>			
Low temperature < 13°C High temperature > 35°C Low humidity	Dryness	Low humidity	Low temperature

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## Citrus canker

- Disease control
  - Exclusion (quarantine)
  - Eradication (cull)
  - Management
    - wind breaks
    - avoid working in infected orchards when trees are wet
    - apply copper-containing bactericide sprays
      - young fruit particularly susceptible

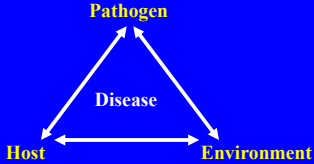
**Emerald outbreak 2004** →  
500,000 trees, ~\$70 m

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## Citrus canker

- Introduction of pathogen




- Presence of susceptible hosts
- Growth stage
  - older growth is resistant
- Environment
  - Moisture
    - Rainfall
  - Temperature
  - Wind
    - ≥8 m/s aid in the penetration of bacteria

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## Apples



- native to Eurasia
- Rosaceae family
- domesticated <1,000 B.C
- first grafted by Greeks and Romans
- modern cultivars are highly heterozygous
- Major growing regions in Australia
  - Victoria – Goulburn Valley
  - New South Wales – Orange
  - Western Australia – Donnybrook
  - Tasmania – Huon Valley
  - South Australia – Adelaide Hills
  - Queensland – Stanthorpe
- Gross value over \$100 million
- Export value over \$21 million (0.8% of worlds production)

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## Apple diseases

- Bacterial (4)
  - e.g. Fire Blight
- Fungal (>50)
  - e.g. Apple Scab
- Viral (7)
  - e.g. Apple chlorotic leafspot
- Nematode (5)
  - e.g. root knot

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## Apple Fire Blight

- Caused by bacterium *Erwinia amylovora*
  - Gram negative
  - rod-shaped
  - flagellate
- Wide host range
  - 180 species *Rosaceae*
- First observed in North America in late 18th Century
- Now known to occur in North America, Europe and New Zealand
- Important quarantine pest for Australia




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## Fire Blight

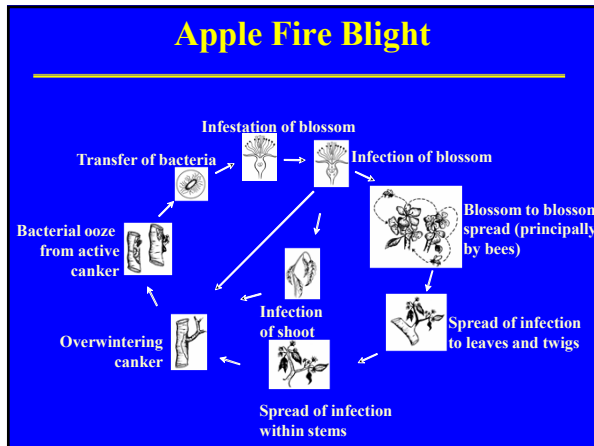
- 5 types of infection
  - canker blight
  - blossom blight
  - shoot blight
  - trauma blight
  - rootstock blight







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### Apple Fire Blight

**Blossom Blight**

- **Temperature and Host**
  - cultivar Williams not sensitive to disease because blooms when temperatures are too low (cf. decimation of var. Laxton)
- **Moisture**
  - no water → no disease
  - rain/dew ↑ relative humidity → water film
  - nutrient gradient
  - bacteria attracted to nutrients (chemotaxis)
  - <16°C bacteria not attracted to nutrient
  - >16°C colonisation within minutes

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### Apple Fire Blight

- **Shoot Blight**
  - **Wind**
    - Light gusty winds can cause “whiplash” injury
    - Even damage to leaf hairs along the midrib can give access to xylem
- **Trauma blight**
  - **Wind**
    - High winds can shred leaves
    - Bacteria, already present on leaves, can enter

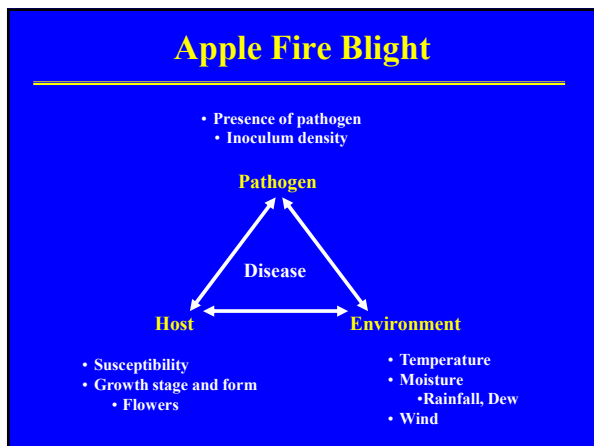
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### Apple Fire Blight

**Disease Management**

- **Understand ecology of disease**
  - timely application copper and antibiotic sprays (use disease prediction software - daily min/max temperatures, rainfall, stage of blossom development)
- **Minimize spread**
  - prune branches at least 12 inches below visible signs
- **Minimize host susceptibility**
  - breed resistant varieties
  - avoid monoculture
  - reduce planting density

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### What's examinable?

**Horticulture**

- fruit/vegetable crops
  - intensive production
  - crowded conditions

Understand ecology of disease, esp. INTERACTIONS of

- Pathogen
- Host
- Environment

Control through:

- prevention (quarantine very important)
- treatment (timely applications, models)
- eradication (culling, compensation)

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