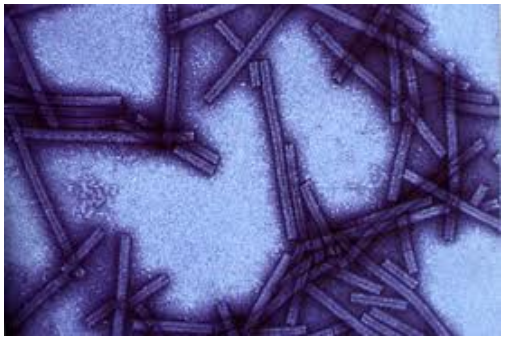
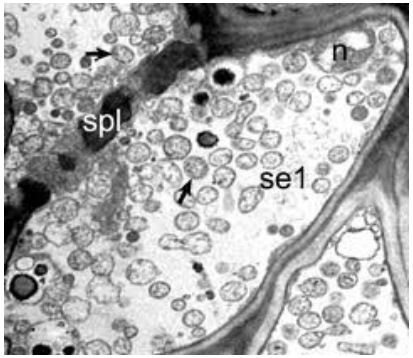
Molecular plant pathology



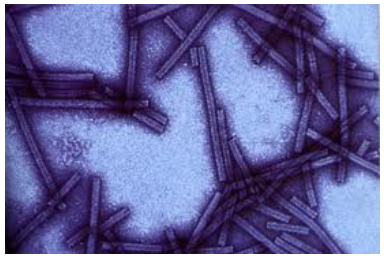


Assist. Prof. Martina Šeruga Musić

acad. year 2016/17

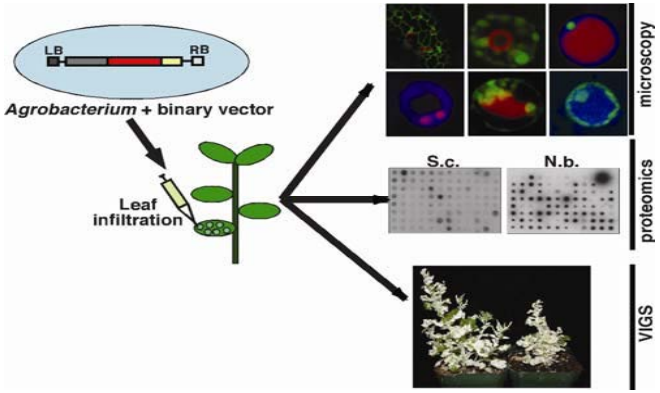
INTRODUCTION TO PLANT PATHOLOHY

• short definition: the study of organisms and environmental conditions that cause diseases in plants



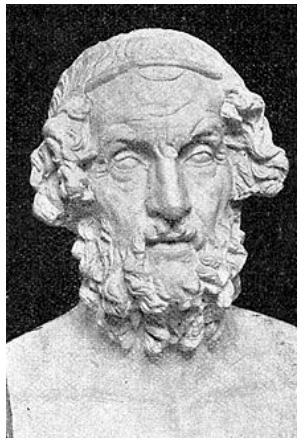
• molecular plant pathology

- the study of mechanisms by which plant diseases occur, on the molecular nad chemical level, as well as the pathogen - plant interactions and the molecular analyses of pathogens and their genomes



HISTORICAL OVERVIEW

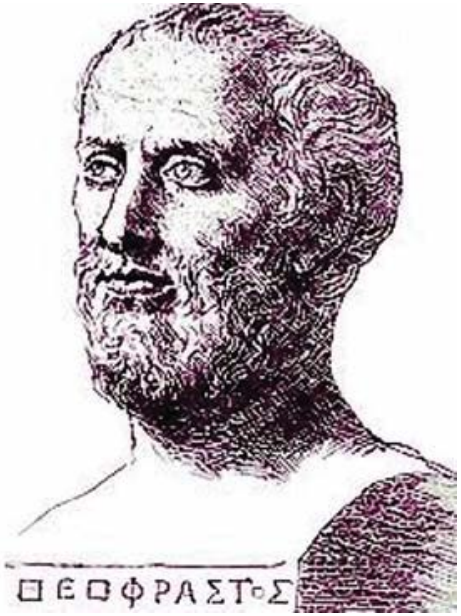
- even when humans lived as hunters or nomads and their food consisted only of meat or leaves, fruit, and seeds which they picked wherever they could find them, plant diseases took their toll on hunted animals and on humans – Paleolithic era
- Neolithic era (from approx. 9500 BC) – beginning of farming and agriculture – neolithic revolution
- domestication and cultivation of plants: cereals (wheat, barley, rye), rice, corn, Leguminosae, figs, grapevine...
- mentioned in some of the oldest written testaments such as Homer's work, Old testament etc.



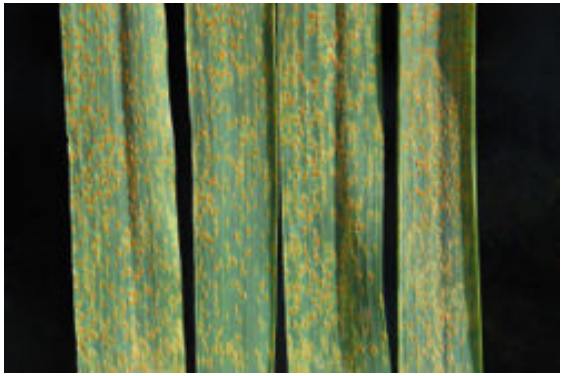
Common smut disease on barley (A) and wheat (B) – caused by fungus from the genus *Ustilago*, sp.

Wheat rust disease caused by fungus *Puccinia tritici*

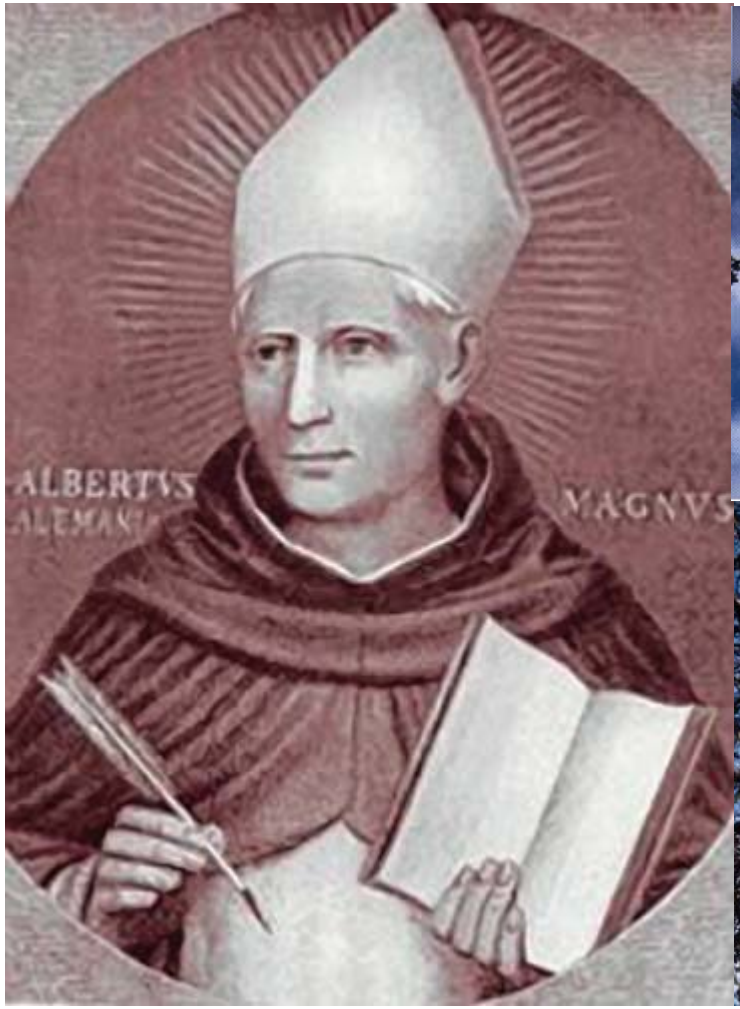
- Greek philosopher Democritus (470 BC) – describes plant blights and measures to control diseases
- Theophrastus (300 BC) – “father of botany”



- plant diseases – Gods’ curses and punishment to people because of their sins and bad deeds
- 4th century BC in ancient Rome – God named Robigus and festivities named Robigalia celebrated in his honor – to prevent wheat rust diseases that were responsible for great hunger and famine

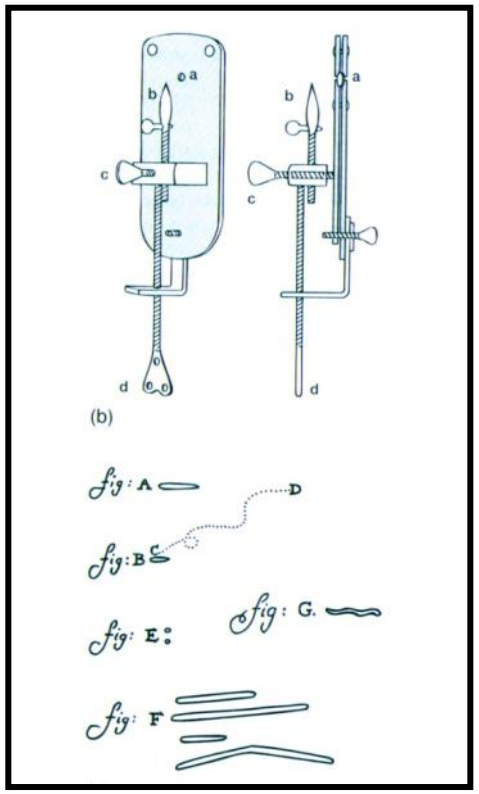


• around 1200, Albert Magnus described mistletoe as a first known plant parasite (genus *Viscum*)

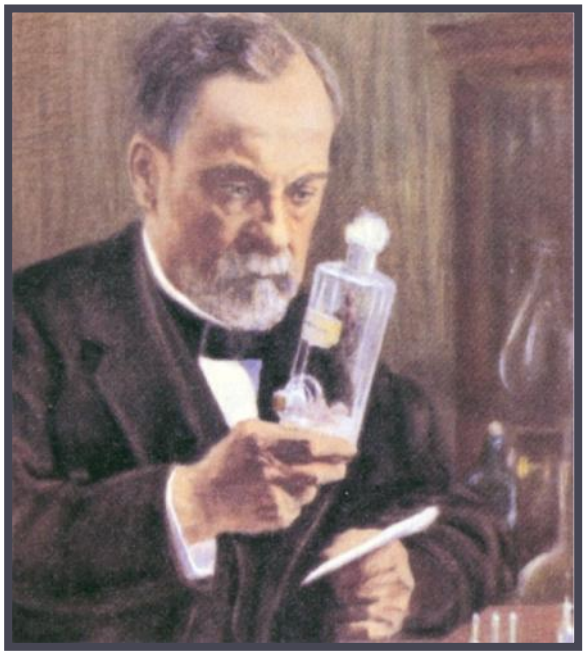


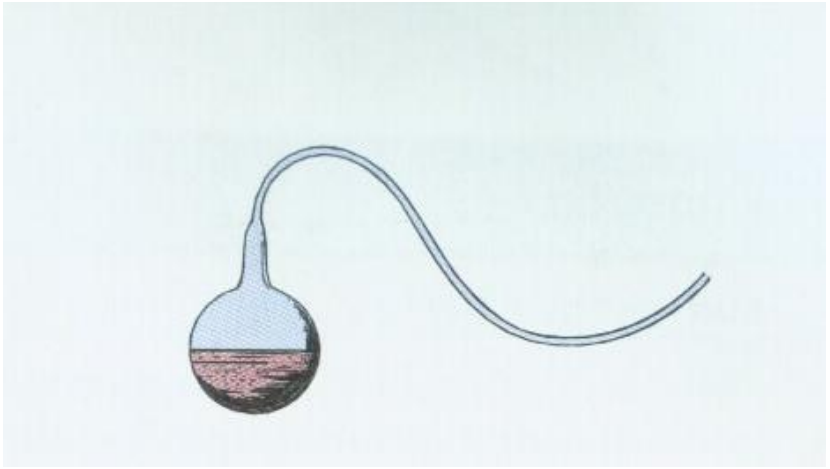
• belief in the ordinary formation of living organisms without descent from similar organisms (the doctrine of spontaneous generation)

• Antony van Leeuwenhoek (17th century) – observation of microorganisms through simple microscope



- Louis Pasteur (mid 19th century) – definitive disconfirmation of spontaneous generation doctrine





- mid 19th century (1845-1852) – potato infection caused *Great Famine* (so called *Irish Potato Famine*) in Ireland

- more than 1 million people died and 1.5 million emigrated, mostly to USA

- causing agent remained unknown at the time

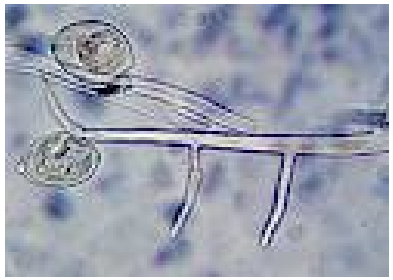
http://www.teachertube.com/video/irish-potato-famine-115330

https://www.youtube.com/results?search_query=irish+potato+famine

• causing agent remained undefined until 1861 when Anthony deBary showed that the infection is spread by infective spores

• Oomycete *Phytophtora infestans* (*phyto* = plant, *phtora* = destruction, *infestans* = infective), class *Oomycota* (*Oomycetes*)

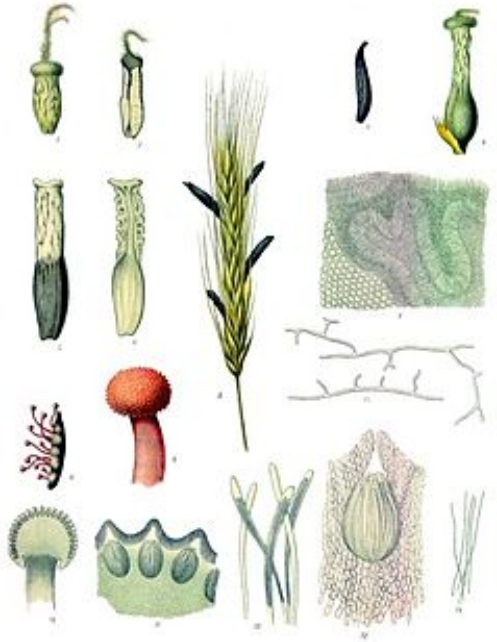
• potato blight



- ergotism (ergot poisoning) – long-term poisoning by alkaloid ergotamine produced by fungus *Claviceps purpurea* infecting rye

- symptoms – convulsive (similar to the effect of LSD) and gangrenous ("Saint Anthony's fire"– Middle Ages)

- connection with accusations of bewitchment that and Salem witch trials (17th century)

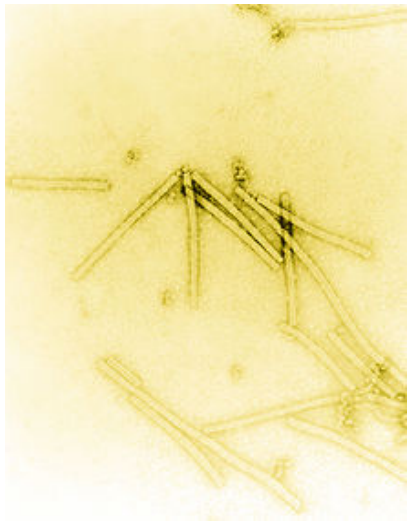


• tobacco mosaic virus (TMV)

• in 1946, Stanley received Nobel prize in the Chemistry field for the investigation of crystallization of viruses

• its genome was sequenced in 1982

• very often used as an experimental model virus



THE CONCEPT OF DISEASE IN PLANTS

• it is accepted that a plant is healthy, or normal, when it can carry out its physiological functions to the best of its genetic potential.

• definition of a plant disease:

- *series of plant cell responses to the pathogen and environmental factors that result in a change of function, shape or integrity of the plant and could cause partial damage or death of plant tissue or the whole plant*

TYPES OF PLANT DISEASES

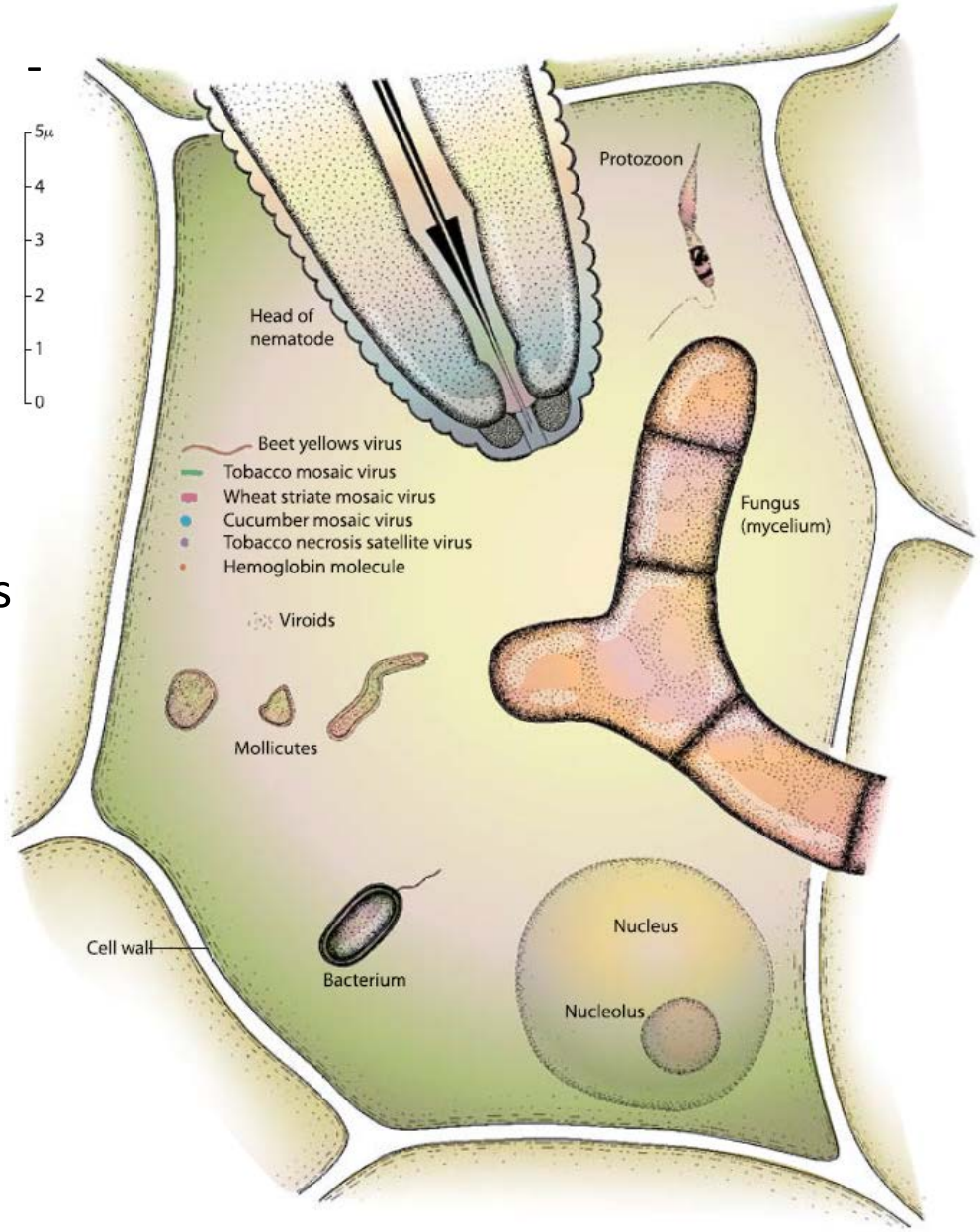
- noninfectious – caused by abiotic factors of physical, chemical od mechanical nature – disorders due to unfavorable environmental condition that are not transmittable from plant to plant

  - temperature extremes
  - lack or excess of light
  - lack or excess of moisture
  - lack or excess of nutrients
  - presence of mineral toxicities in soil or air
  - soil acidity or alkalinity….

• infectious – caused by biotic factors - plant pathogens

• from the smallest to the largest:

- subviral pathogens (viroids, satellite RNA)
- viruses
- phytoplasmas, spiroplasmas (*Mollicutes*)
- bacteria
- protozoa
- fungi and oomycetes
- nematodes
- parasitic green algae
- parasitic higher plants



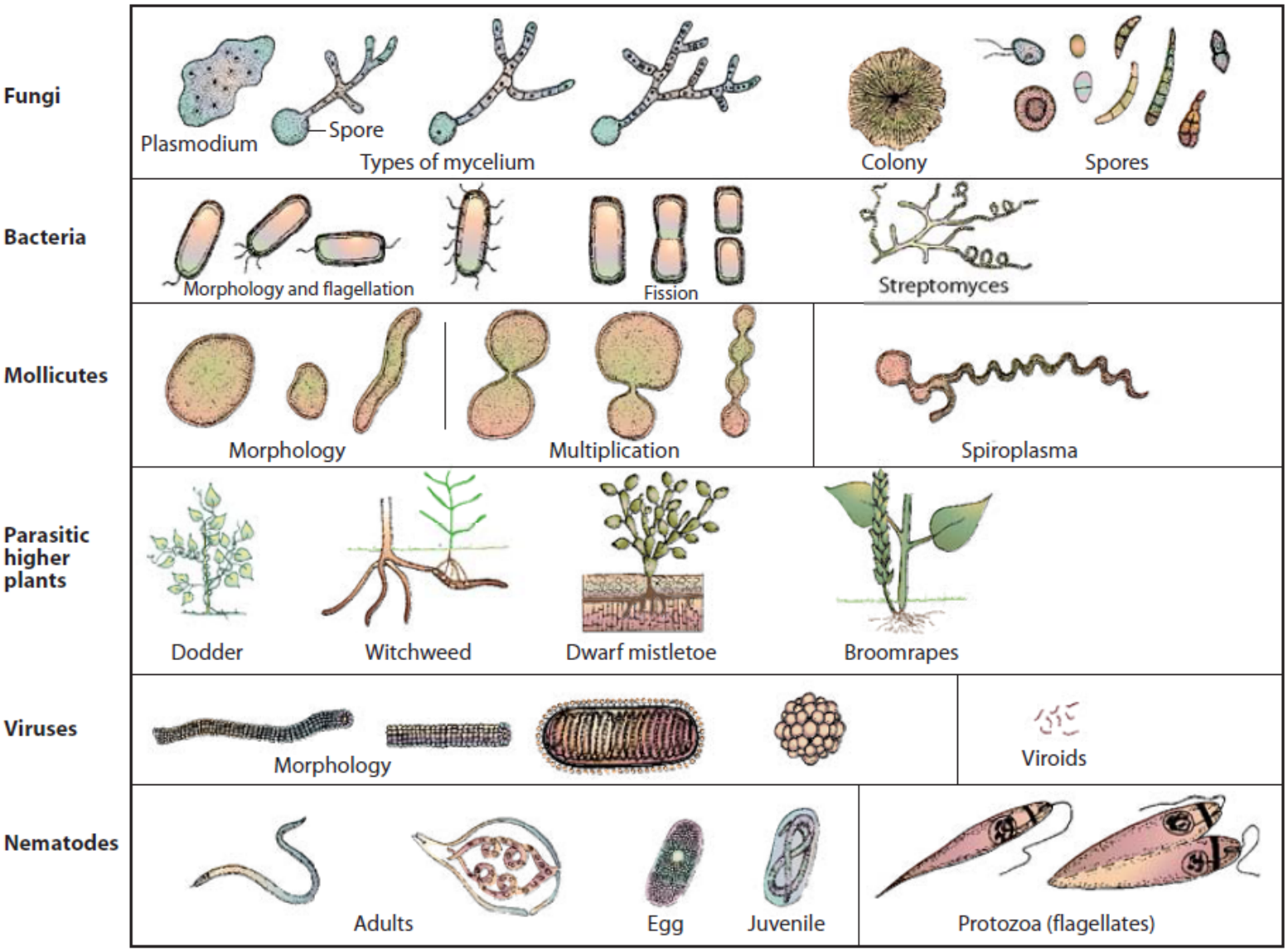
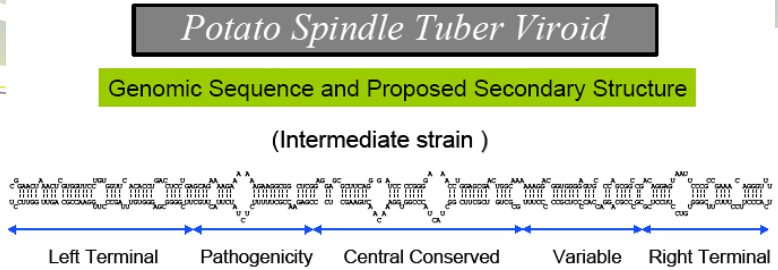


FIGURE 1-3 Morphology and ways of multiplication of some of the groups of plant pathogens.

VIROIDS



- plant pathogens <u>only</u>
- naked infective RNA molecules of several hundred nucleotides
- some possess ribozyme activity (secondary structure) - *Pospiviroidae*
- symptoms similar to viral
- the most important diseases: potato spindle tuber, citrus exocortis, cadang-cadang disease of coconut….
  - PSTVd - potato spindle tuber viroid
  - HSVd – hop stunt viroid
  - CEVd – citrus exocortis viroid
  - PLMVd – peach latent mosaic viroid
  - ASBVd – avocado sunblotch viroid…

PLANT VIRUSES

- the total number of viruses known to date exceeds 2000, and new viruses are described almost every month – more than 1000 are described as plant viruses
- different morphology and size
- rod-shaped - 15x300 nm, filamentous viruses – up to 13x2000 nm
- isometric polyhedral – diameter - 17-100 nm
- fragmented genomes – multicomponent viruses
- around 80% of all plant viruses (+)ssRNA
- different size and organization of genome

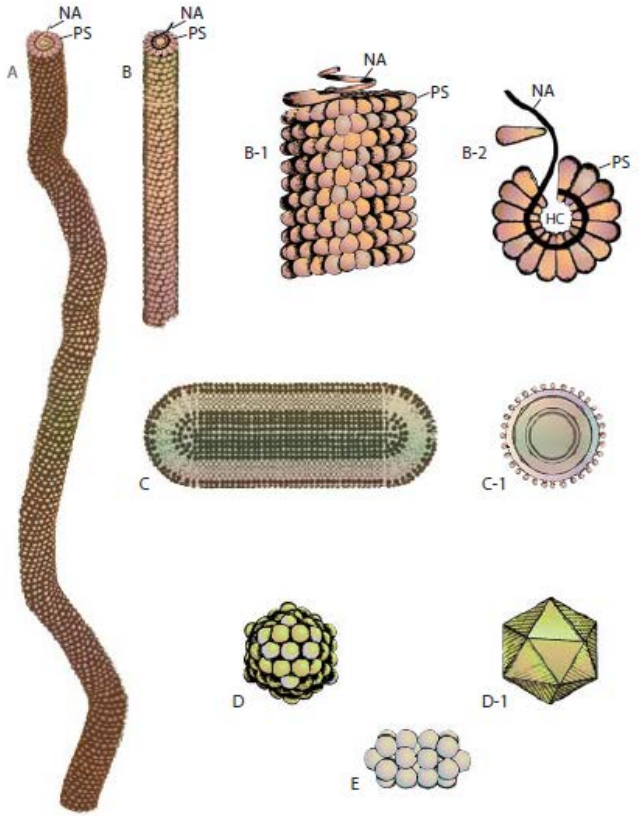


FIGURE 14-5 Relative shapes, sizes, and structures of some representative plant viruses. (A) Flexuous thread-like virus. (B) Rigid rod-shaped virus. (B-1) Side arrangement of protein subunits (PS) and nucleic acid (NA) in viruses A and B. (B-2) Cross-section view of the same viruses. HC, hollow core. (C) Short, bacillus-like virus. (C-1) Cross-section view of such a virus. (D) Isometric polyhedral virus. (D-1) Icosahedron representing the 20-sided symmetry of the protein subunits of the isometric virus. (E) Geminivirus consisting of twin particles.

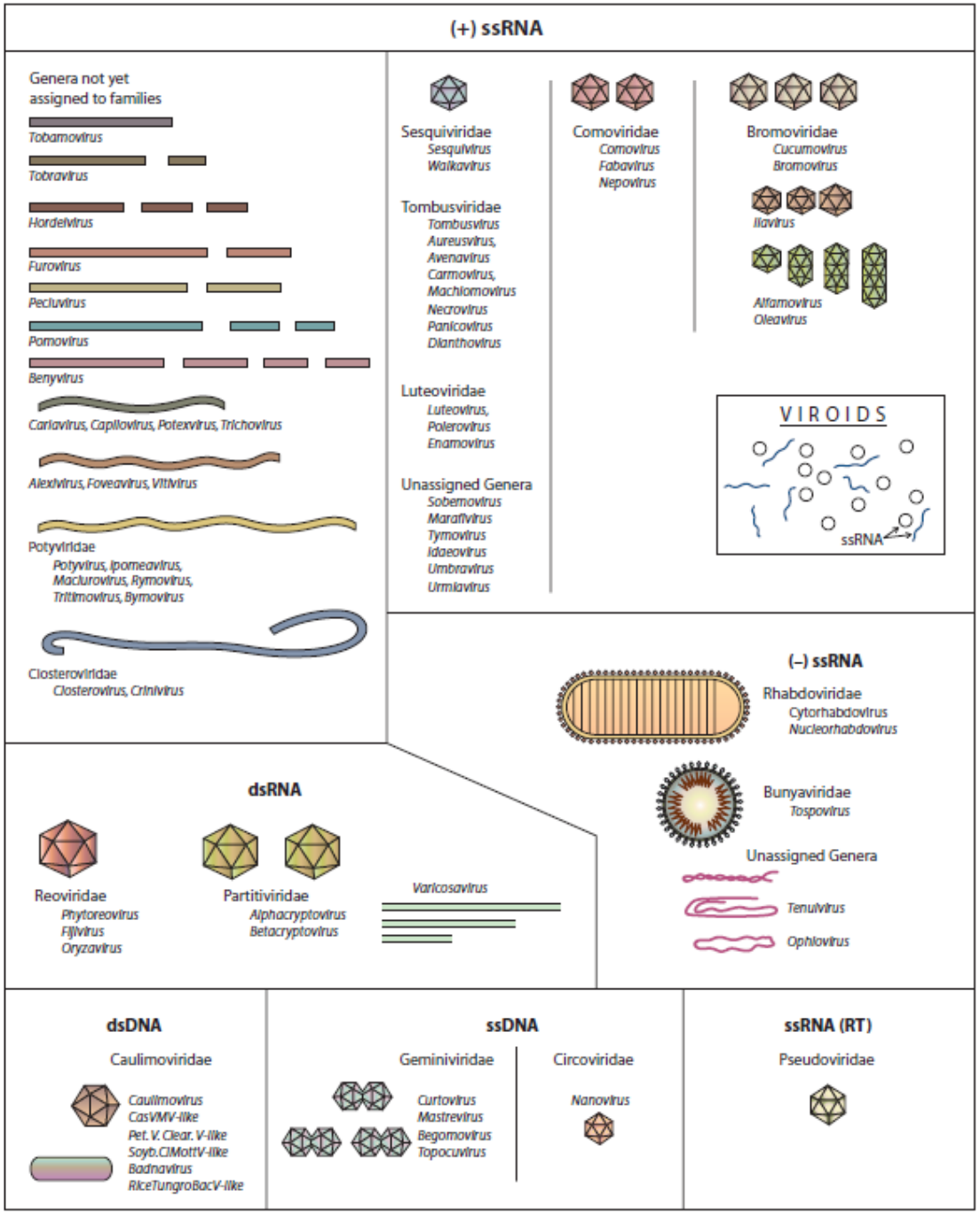


FIGURE 14-24 Schematic diagram of families and genera of viruses and of viroids that infect plants.

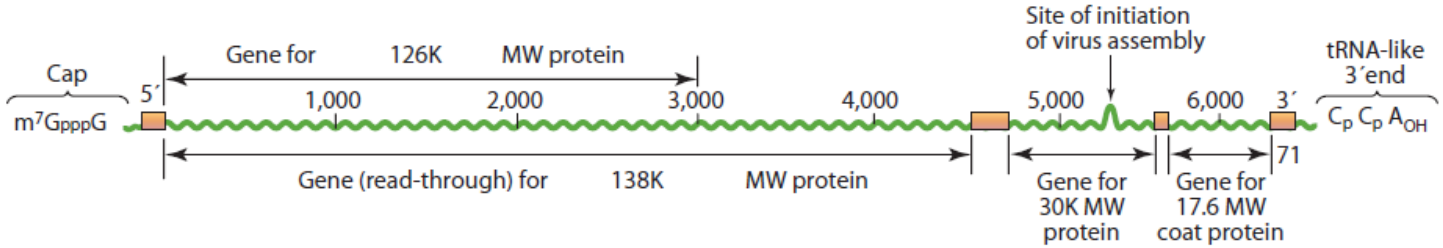
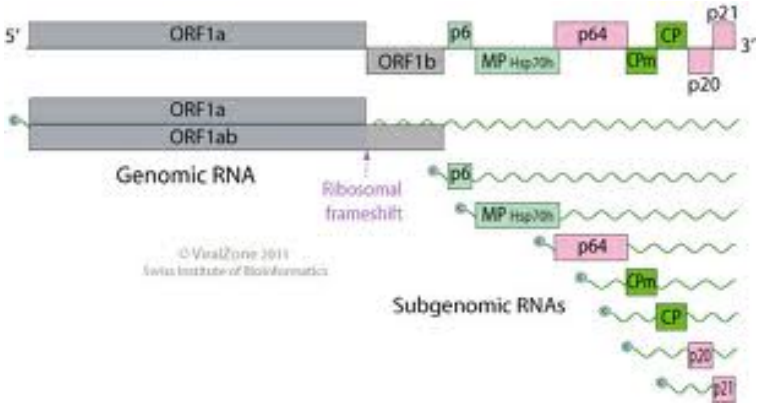
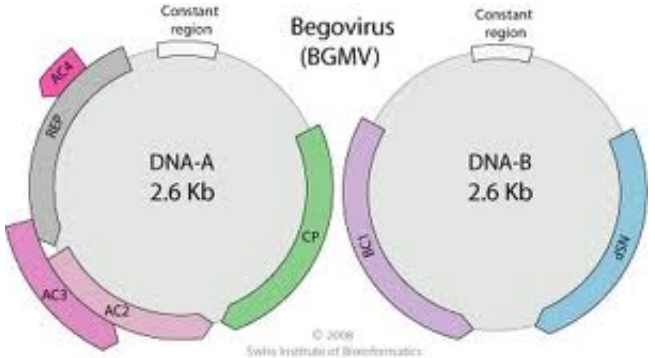


FIGURE 14-7 The 6,400 nucleotide genome of *tobacco mosaic virus* (TMV). Four genes are translated and produce proteins of 126, 183, 30, and 17.6 K molecular weight, respectively. The two largest proteins function as the viral replicase(s), the 30 K protein facilitates cell-to-cell movement of the virus, and the 17.6 K protein makes up the coat protein of the virus. Translation of the viral genome is from left (5′ end) to right (3′ end). Four short segments of the genome (hatched boxes) are not translated. They include signals for initiation, promotion, and termination of translation. The site of the genome at which assembly with coat proteins takes place to produce complete viruses is shown, as are the 5′ end cap of the genome and the transfer RNA-like 3′ end. Numbers along the RNA indicate nucleotides.



Closteroviridae



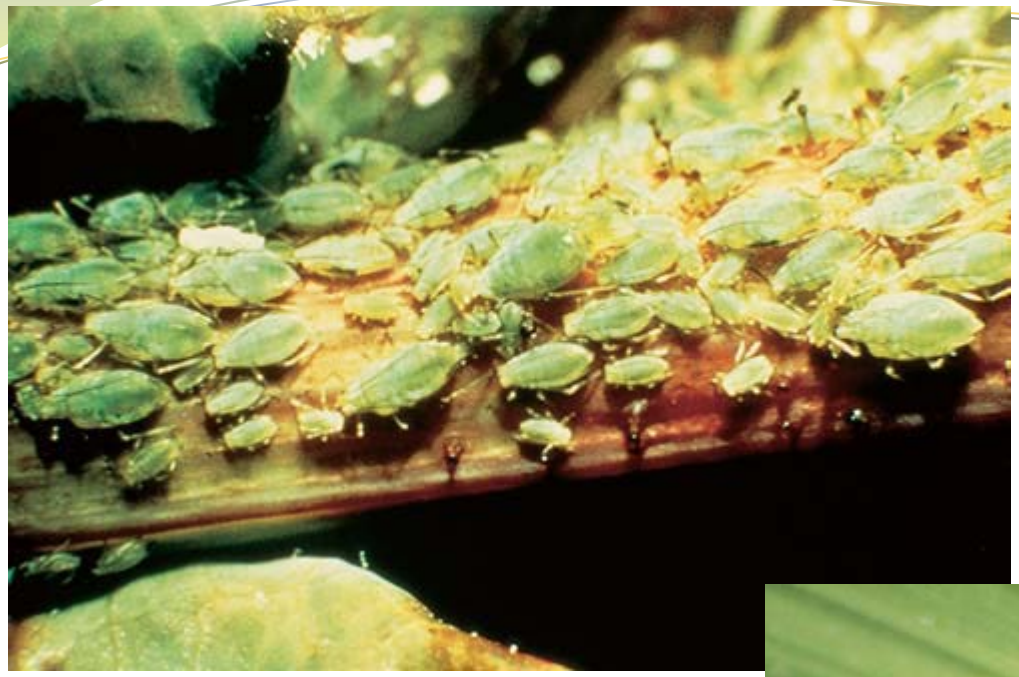
Geminiviridae

In nature, viruses are most commonly transmitted by INSECT-VECTORS

- *Homoptera*
  - *Aphididae* (sucking mouthparts - stylets)
    – aphids

- *Coleoptera* (mandibles – tooth-like mouthparts)
  -beetles

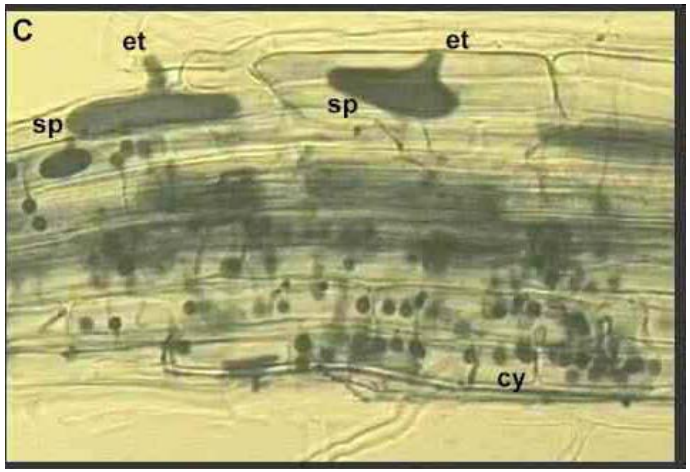
Myzus persicae

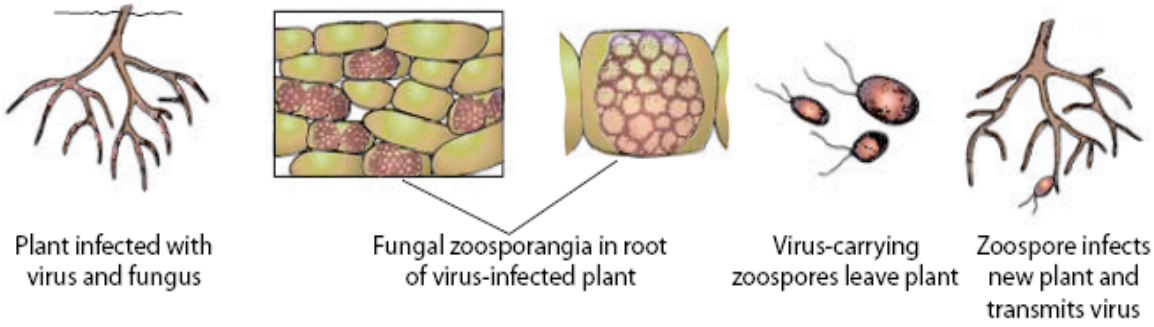


- Acarina – mites and ticks
- Nematodes – feed on a root system
- Fungi – attack the roots; motile zoospores

  Olpidium brassicae

Virus transmission by nematodes





• parasitic higher plants (haustoria – vascular bridge)

genus *Cuscuta* – dodder

Through dodder

SYMPTOMS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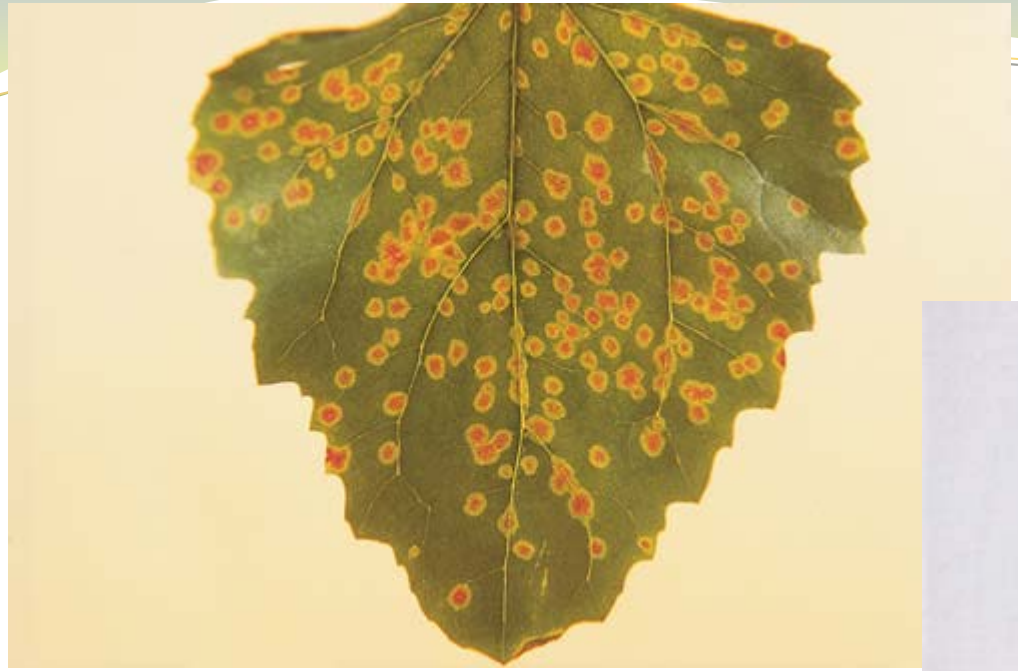
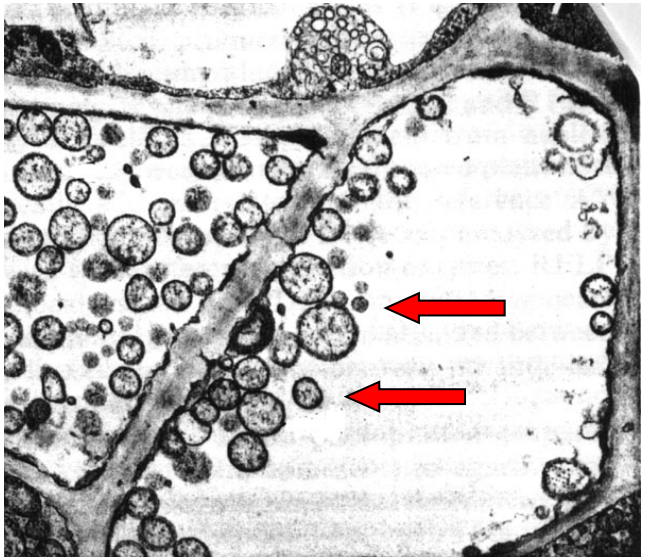
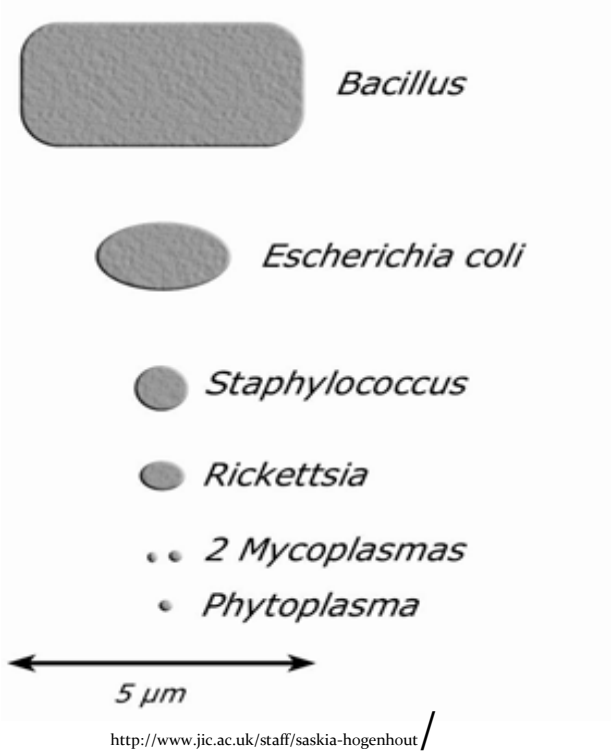


PHYTOPLASMAS AND SPIROPLASMAS

- phytoplasmas – wall-less bacteria (class *Mollicutes)* inhabiting plant phloem and insects
- pleiomorphic cells ø 200-800 nm

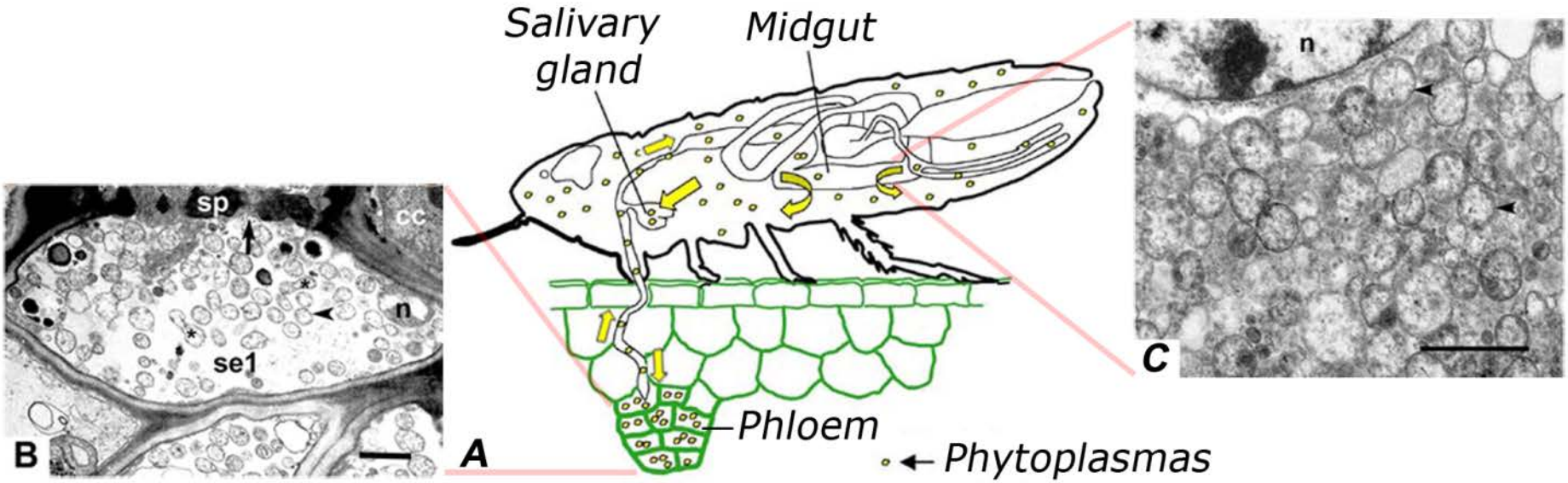




http://www.jic.ac.uk/staff/saskia-hogenhout/

- cannot be cultivated *in vitro*

- transmitted by insects from order Hemiptera

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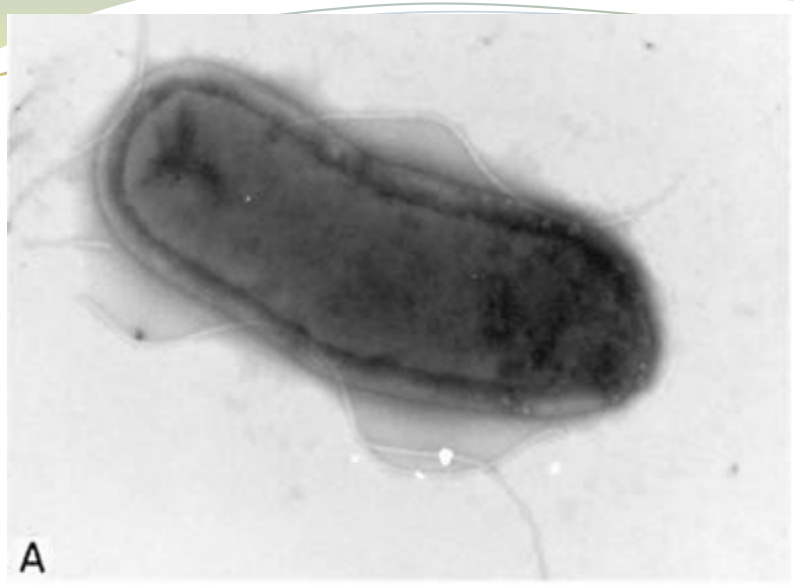
b

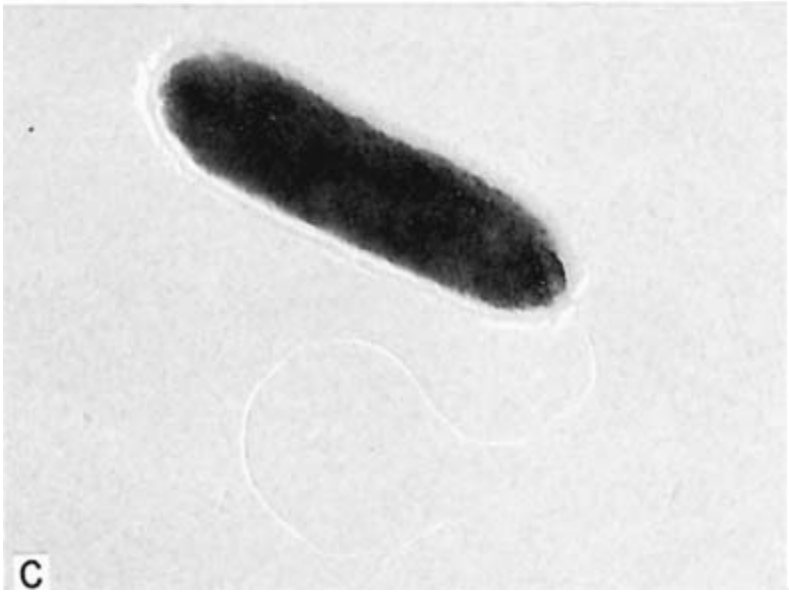
PHYTOPATHOGENIC BACTERIA

- around 100 species
- genus *Agrobacterium*, *Erwinia*, *Ralstonia, Pseudomonas, Xanthomonas, Rhizomonas, Clavibacter, Bacillus, Clostridium, Streptomyces, Xyllela*….
- mostly Gram-negativne
- mostly rod-shaped, except the genus *Streptomyces* – filamentous



genus *Agrobacterium*

genus *Erwinia*



genus *Pseudomonas*

genus *Xanthomonas*

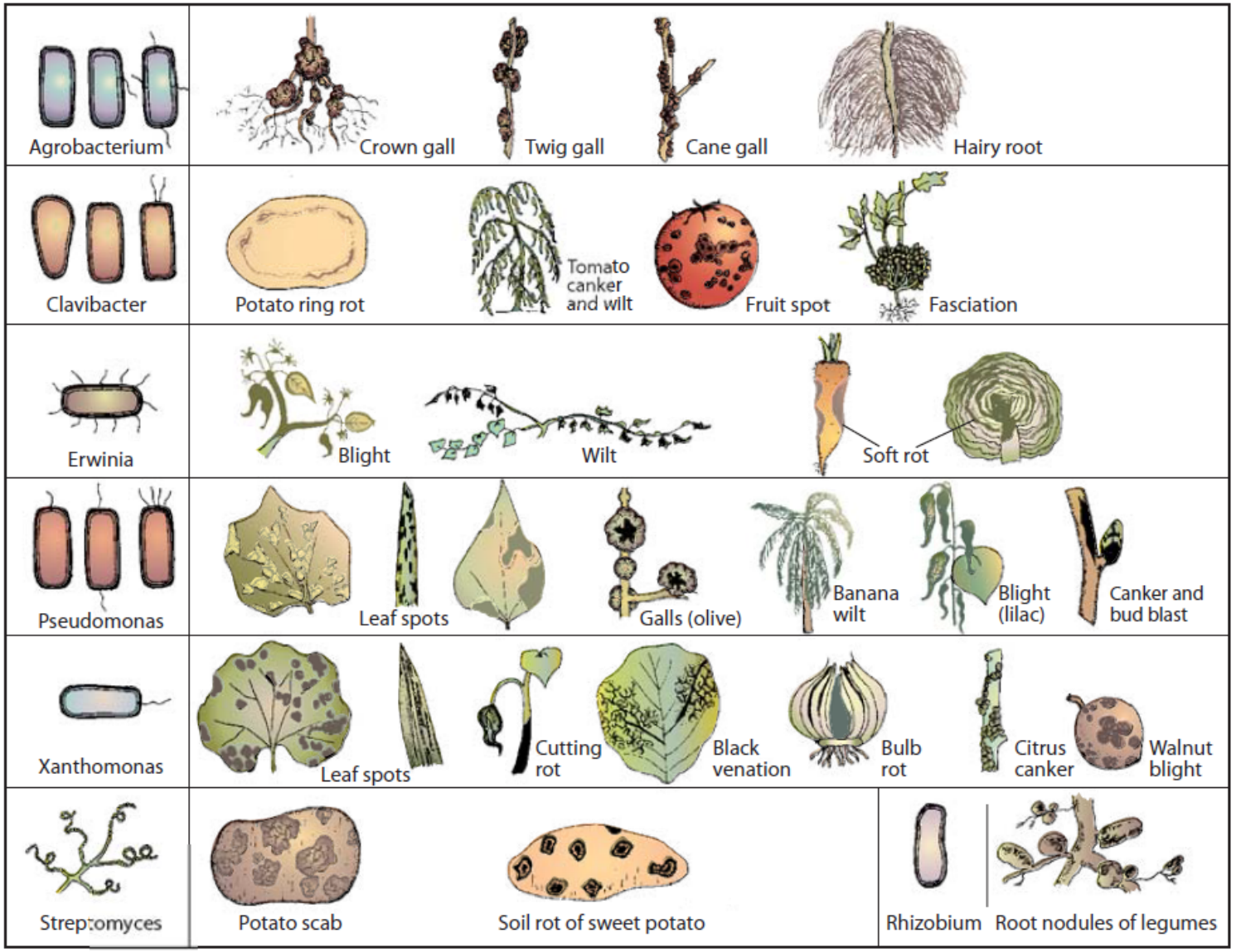


FIGURE 12-4 The most important genera of plant pathogenic bacteria and the kinds of symptoms they cause.

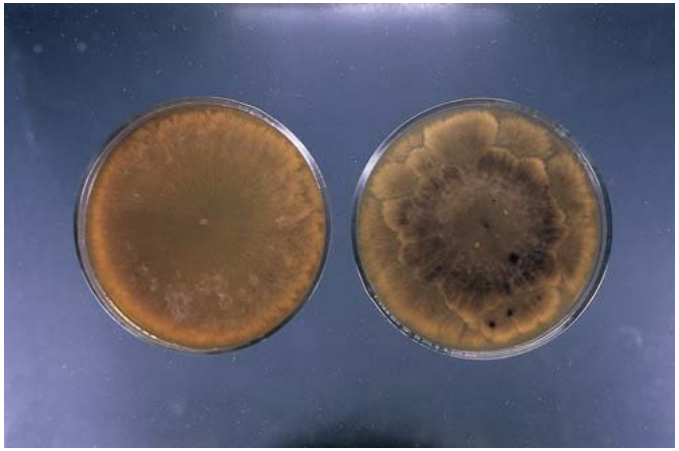
Pseudomonas tabaci

Xanthomonas phaseoli

Acidovorax avenae

Erwinia amylovora

FUNGI



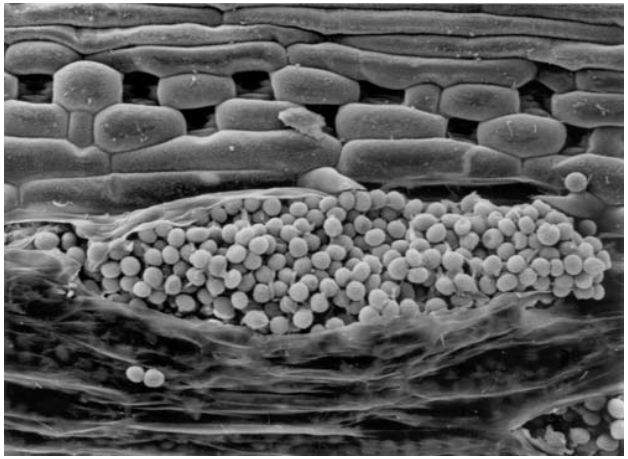
- Kingdom Fungi or Mycota
- around 15 000 species of phytopathogenic fungi – the most numerous plant pathogens
- fungi life style – parasites, saprophytes, symbionts
- taxonomy – changing very often
- important orders:

Ascomycotina order *Erysiphales (powdery mildews)*

order *Sclerotiniales (rots)*

Basidiomycotina order *Ustilaginales (smuts)*

order *Pucciniales (rusts)*



Erysiphales – powdery mildews

Erysiphe graminis

Microsphaera alphitoides

Uncinula necator

Pucciniales - rusts

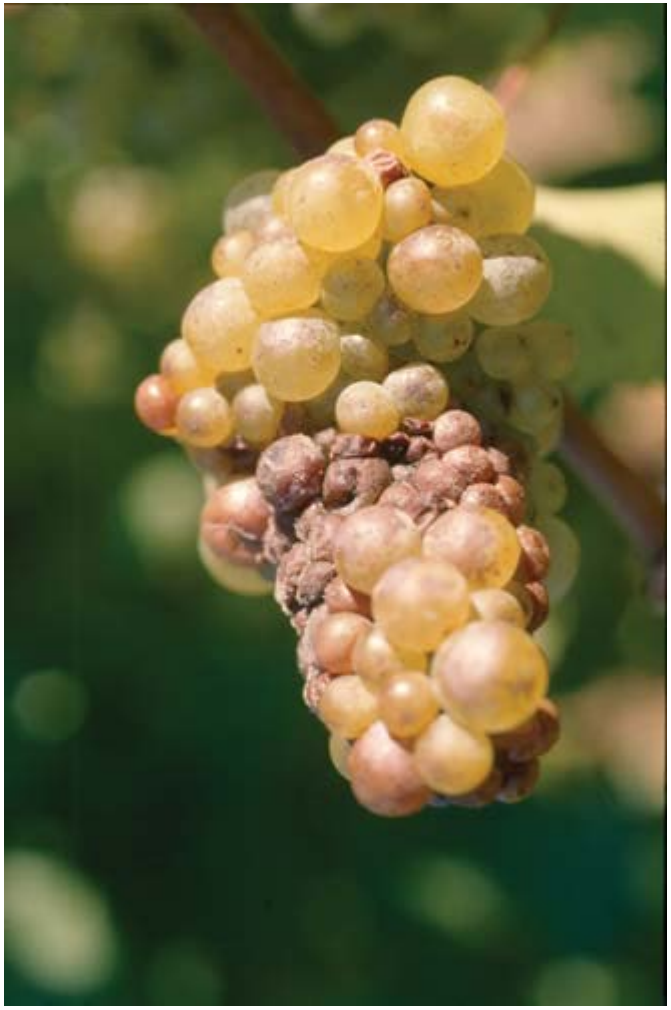
Puccinia graminis

Ustilaginales - smuts

Ustilago maydis

Sclerotiniales - rots

Botrytis cinerea – grey mold or botrytis bunch rot



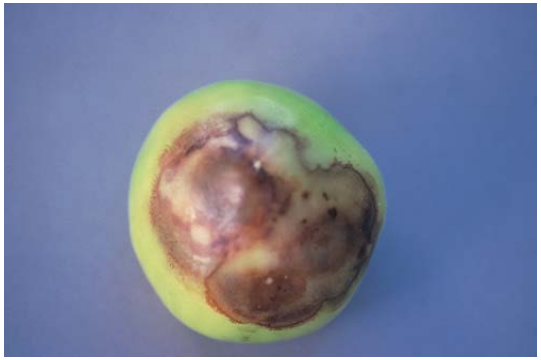
OOMYCETES

- previously considered as fungi
- fungi-like eukaryotes
- Kingdom Chromalveolata (Chromista)

- Class *Oomycetes* – zoospore fungi

  Genus *Pythium*
  Phytophthora
  Plasmopara
  Peronospora

genus *Pythium*



Phytophtora capsici

PROTISTS

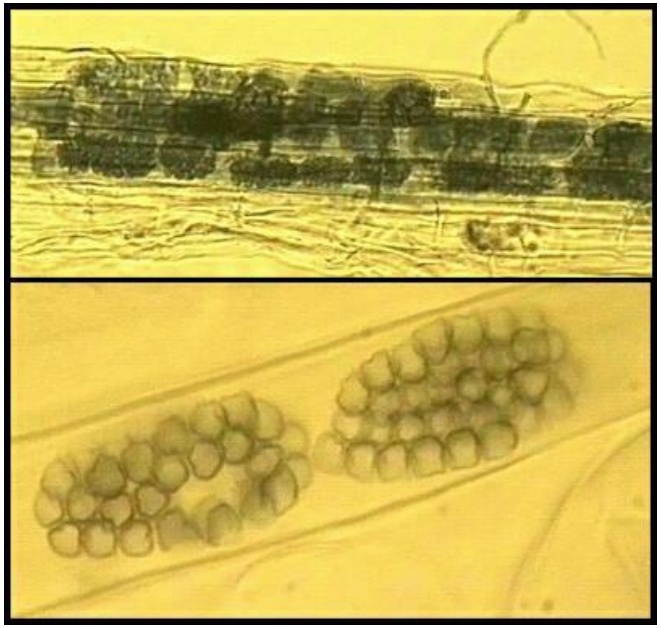
- Kingdom Rhizaria

  Phylum Cercozoa

  Genus *Plasmodiophora*

  Polymyxa

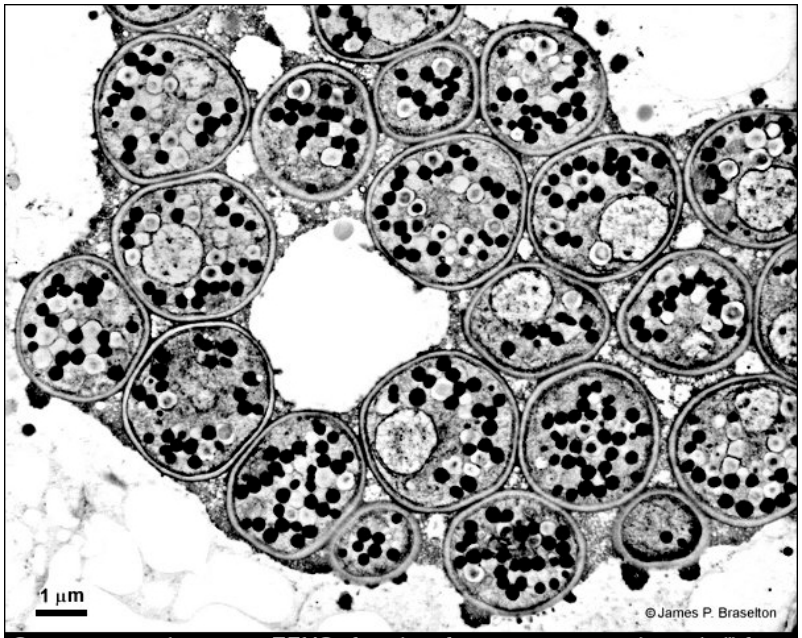
  Spongospora



Polymyxa graminis

Plasmodiophora brassicae

Spongospora subterranea



Spongospora subterranea TEMG of portion of mature sporosorus (spore ball) from powdery scab lesion on potato tuber.