

AGC 3342: PLANT PATHOLOGY COMPONENT



Paul W. Kachapulula

paul.kachapulula@unza.zm (room 33)

Instructor

❖ **Name:** Dr. Paul W. Kachapulula

❖ **Qualifications**

- BSc Agricultural Sciences – UNZA
- MSc Crop Science – Makerere University
- PhD Plant Pathology – Uni. of Arizona

❖ **Contact:**

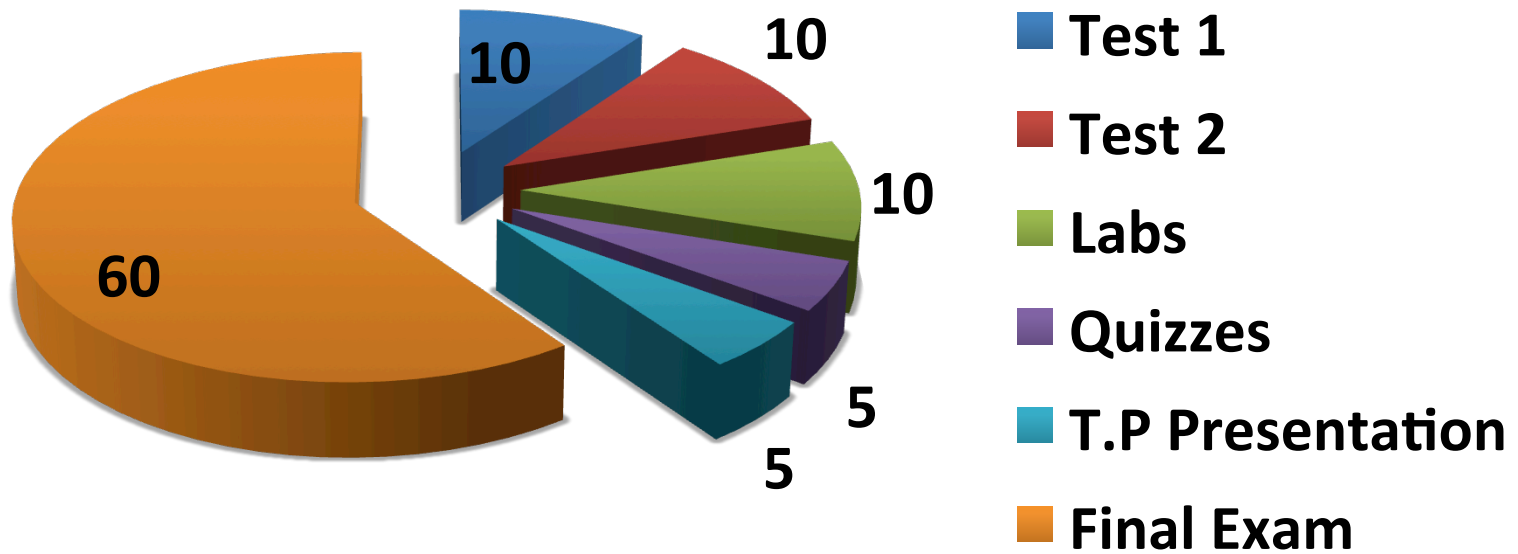
- Office: 33, Department of Plant Science
- HOD – Plant Science
- Email: paul.kachapulula@unza.zm

APPROACH TO THE COURSE

1. Class lectures (PowerPoint slides will be posted on moodle)
2. Notes (pasted on moodle)
3. Assessment:
 - a) Final Exam
 - b) Test 1
 - c) Test 2
 - d) Quizzes
 - e) Labs

Resource: Agrios, 2005 (Soft copy to be given)

ASSESSMENT POINTS (to be revised)

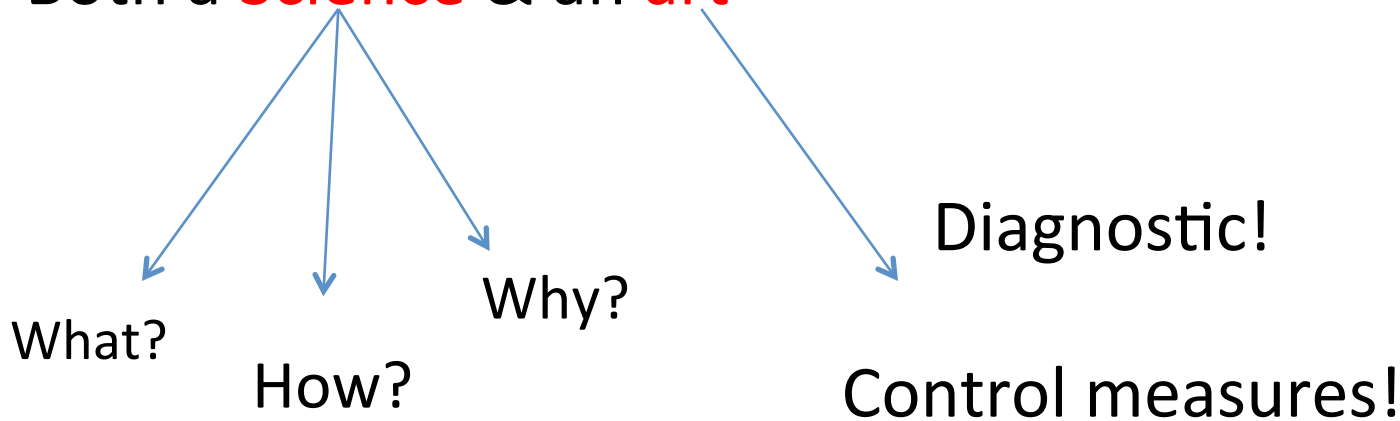


PLANT PATHOLOGY

What is Plant Patho-logy?

Greek - Pathos (suffering) + Logos (study) = The study of the suffering plant

Both a **Science** & an **art**



Deuteronomy 28:22

The LORD will strike you with wasting disease, with fever and inflammation, with scorching heat and drought, with blight and mildew, which will plague you until you perish.

- Diseases have been a challenge for thousands of years

2 Chronicles 6: 28

If there be dearth in the land, if there be pestilence, if there be blasting, or mildew, locusts, or caterpillars; if their enemies besiege them in the cities of their land; whatsoever sore or whatsoever sickness there be:

- Diseases have been a challenge for thousands of years

DEFINITIONS IN PLANT PATHOLOGY

Make sure you look in the book below for any terms mentioned but not defined in powerpoint slides or handout:

Plant Pathology 5th ed - G. Agrios (Elsevier, 2005)

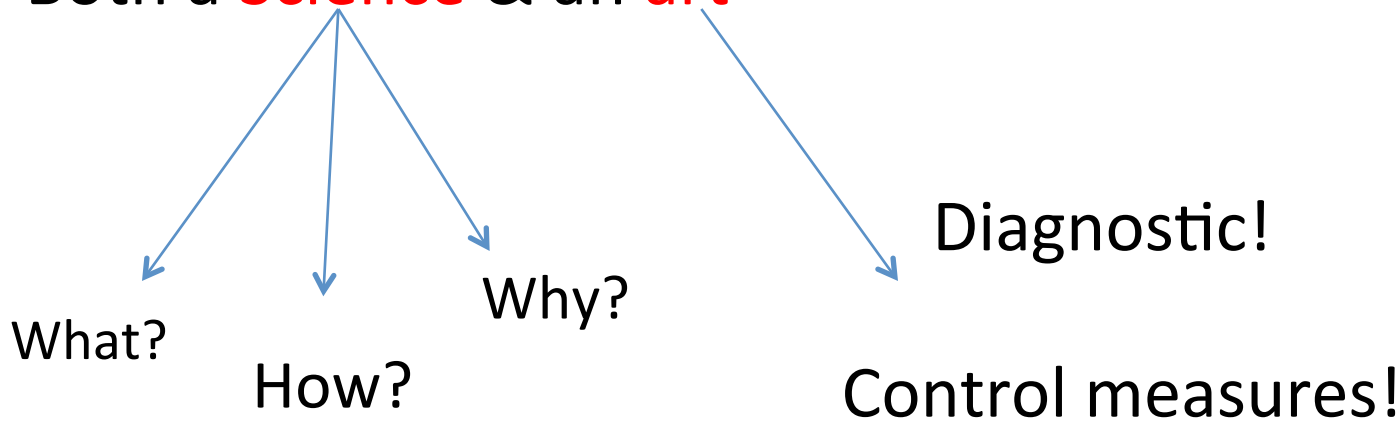
(an electronic copy of the book will be given out.
Handout containing these definitions will also be given out)

PLANT PATHOLOGY

What is Plant Patho-logy?

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Pathology is a study of:

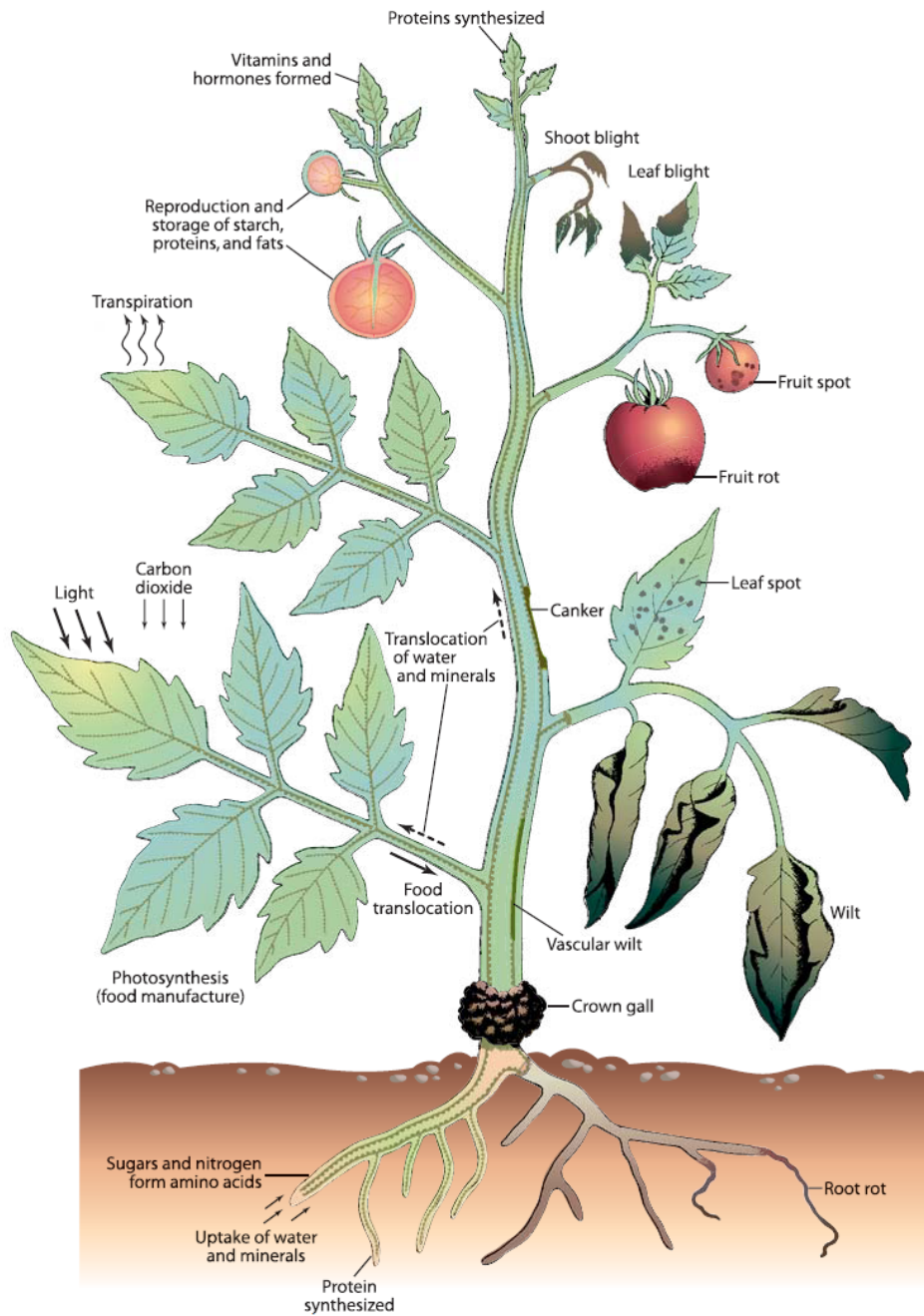
1. living entities and the environmental conditions that cause disease in plants
2. mechanisms by which these factors produce disease in plants
3. interactions between the disease-causing agents and the diseased plant; and
4. methods of preventing or controlling disease and alleviating the damage it causes.

Plant disease

Disease is a condition involving abnormal changes in the form, physiology, integrity or behaviour of a plant, resulting in partial impairment or death of the plant or its parts.”



Agrios G.N



Page 6 of text book

FIGURE 1-1 Schematic representation of the basic functions in a plant (left) and of the kinds of interference with these functions (right) caused by some common types of plant diseases.

Disease is not a pathogen!!!

➤ Pathogens are the causal agents of disease.....

➤ It's wrong to say:

“*Phytophthora infestans* is Late Blight of Potato”



Sign vs Symptom of disease

The pathogen or its parts or products seen on a host plant.

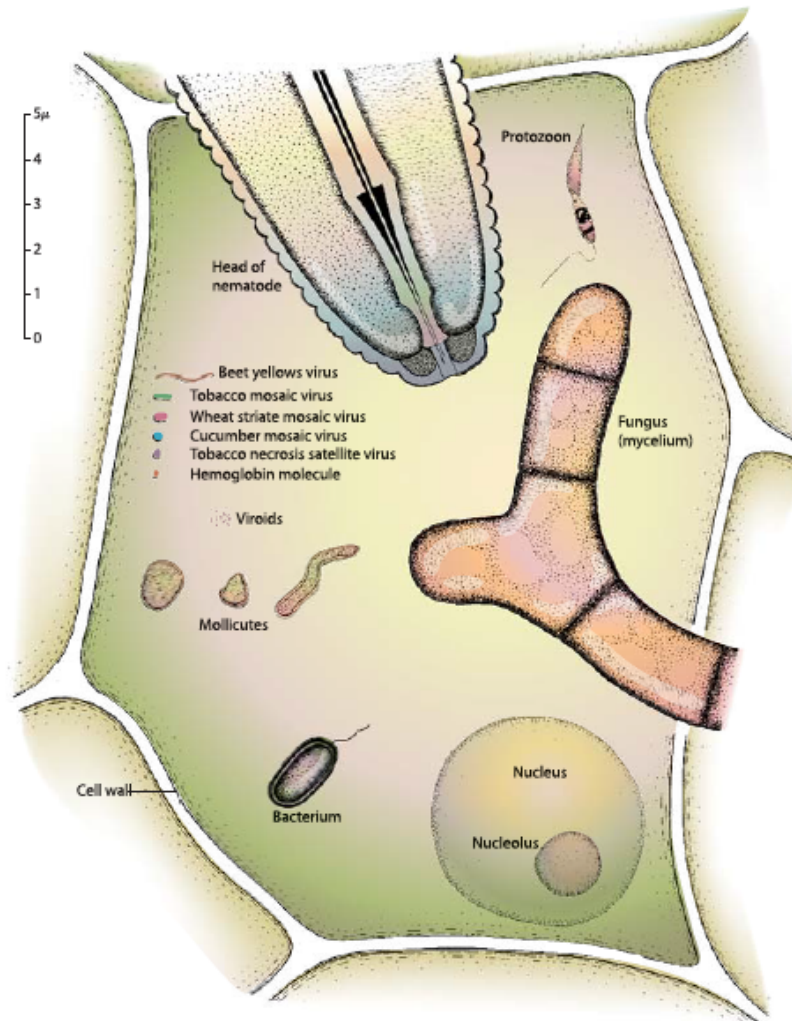
The external and internal reactions or alterations of a plant as a result of a disease



Plant pathology comprises 4 main disciplines

1. Mycology- study of fungi
2. Bacteriology- study of bacteria
3. Virology- study of viruses & viroids
4. Nematology- study of nematodes
5. Molecular plant pathology

DISEASE-CAUSING AGENTS: RELATIVE SIZES



Fungi
Bacteria
Viruses and viroids
Nematodes

Page 7 of text book

Why are plant diseases important?

1. Plant Diseases Reduce the Quantity and Quality of Plant Produce
2. Plant Diseases May Limit the Kinds of Plants and Industries in an Area
3. Plant Diseases May Make Plants Poisonous to Humans and Animals
4. Plant Diseases May Cause Financial Losses

Plant Diseases Reduce the Quantity and Quality of Plant Produce

Depending on weather, pathogen and/or host, yield loss can be up to 100%



Phytophthora infestans



Rhizopus sp

Plant Diseases May Limit the Kinds of Plants and Industries in an Area

➤ Some crops may not grow in certain regions of the country due to diseases.

Plant diseases may also determine the kinds of agricultural industries and the level of employment in an area by affecting the amount and kind of produce available for local canning or processing

Plant Diseases May Make Plant Products Poisonous to Humans and Animals

Mycotoxins are produced by microbial activity. These mycotoxins may end up in food and animal feed, causing diseases and even death.



Plant Diseases May Cause Financial Losses

- Farmers may have to plant varieties or species of plants that are resistant to disease but:
 - ✓ less productive
 - ✓ More costly
 - ✓ commercially less profitable than other varieties
- Costs of spraying fungicides
- Costs of refrigeration during transportation

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- ✓ **Pathogen:** An entity that can cause disease
- ✓ **Pathogenicity:** the capability of a pathogen to cause disease
- ✓ **Virulent:** Capable of causing a severe disease; strongly pathogenic
- ✓ **Virulence:** the degree or measure of pathogenicity of a given pathogen; relative capacity to cause disease (Virulence is recessive-a)
- ✓ **Avirulence:** Inability of a pathogen to cause disease on a certain plant variety that carries genetic resistance (avirulence is dominant-A)
- ✓ **Disease Incidence:** the number of plants affected by a disease within a population
- ✓ **Disease Severity:** the measure of damage done by a disease

- **Inoculum (pl. Inocula)**: a pathogen or its parts which can cause infection when transferred to a favourable location; the population of microorganisms introduced in an inoculation. Inoculum could either be
- **Primary inoculum**: an inoculum that survives in the field and infects a crop cultivated the following growing season (causing primary infection)
- **Secondary inoculum**: inoculum produced from secondary infection and capable of causing disease within the same growing season (causing secondary infection).
- **Inoculation**: coming together of host and parasite, to introduce a microorganism or virus into host plant or into a culture medium

Spore: a specialised reproductive body in fungi (and some other organisms), containing one or more cells, capable of developing into an adult.

Hypha (pl. hyphae): a single branch of a mycelium

Mycelium (pl. Mycelia): a mass of hyphae that forms the body of a fungus.

Parasite: organism that lives in intimate association with another organism on which it depends for its nutrition; not necessarily a pathogen

Resistance: Inherent ability to resist or restrict establishment of subsequent stages of a pathogen in a host to cause disease

Susceptibility: Inability of the host to resist the effects of the pathogen. It is quite variable due to a wide range of factors which are introduced to express it.

Infection: the establishment of a parasite within a host

Invasion: The spread of a pathogen into the host

Host: A plant that is invaded by a parasite and from which the parasite obtains its nutrients

Epidemic: A disease increase in a population; usually a widespread and severe outbreak of a disease

Epidemiology: The study of factors affecting the outbreak and spread of infectious diseases.

Modern farming practices and plant diseases

✓ Under natural conditions, plants occur in mixed stands, Plant types compete for space, light, moisture and nutrients. Under these conditions – there's minimal attack of infectious disease agents on one plant type.

✓ However, modern farming is typified by:

- High plant density
- Monoculture
- High fertilizer inputs
- Heavy use of pesticides

High plant density increases disease pressure:

✓ Creates micro-climate

➤ high humidity- fungal diseases

➤ Contact spread

➤ Continued leaf wetness

Monoculture increase disease pressure through:

- when the single genetic variant or cultivar becomes susceptible to a pathogen

High fertilizer inputs:

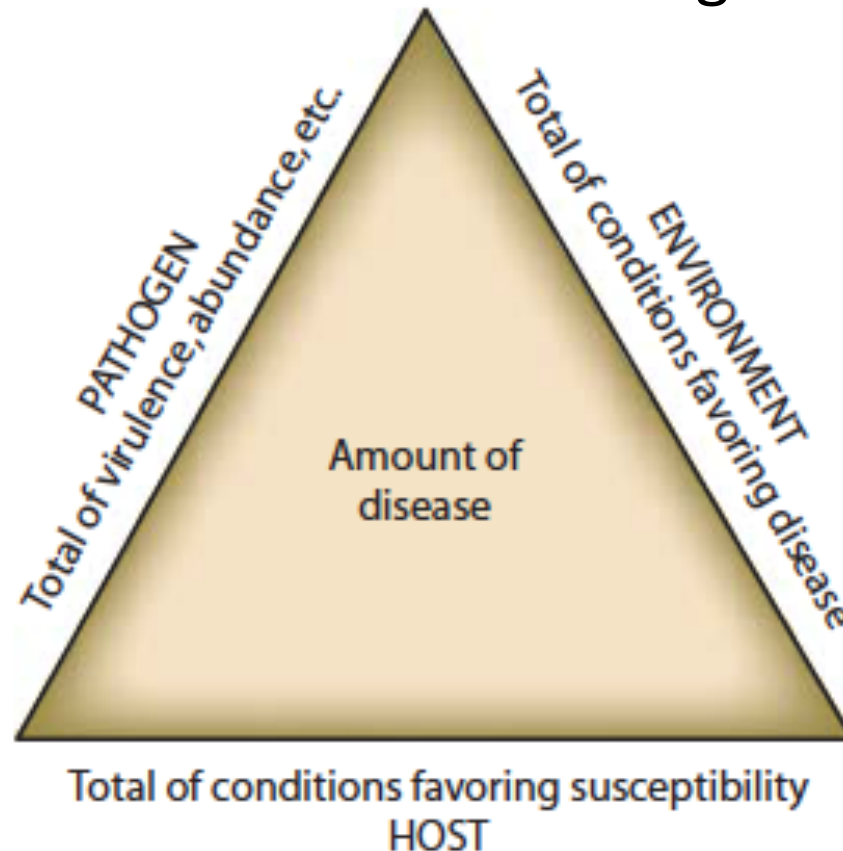
- increase weed populations in the current and subsequent crops
- incidence of fungal and bacterial diseases by increasing tissue susceptibility and tiller density.
- tissues become more succulent and prone to pathogen attack.

High pesticides:

- Development of resistance to the chemical by the pathogens
- Resistance in vectors of diseases

Disease triangle

Optimal combinations of virulent pathogen, susceptible host and favorable environmental conditions are needed for disease to occur. This determine whether disease will occur and the amount of disease that will occur or degree of damage



PLANT DISEASE TRIANGLE

1. Pathogen

2. Host

3. Environment

PATHOGEN FACTORS

- ❖ Pathogens are disease-causing organism
- ❖ Living, thus biotic
- ❖ Fungi, Bacteria, Viruses, Nematodes, Parasitic higher plants, Mycoplasmas...
- ❖ Most are host specific
- ❖ Virulent pathogens cause disease

HOST FACTORS

- A susceptible host is needed for disease to occur.
- Resistant variety is one with genetic mechanism to prevent advance of a disease.
- Could be due to physical, chemical or growth characteristics.
- May be tolerant.
- Host has to be in right stage of development for disease to occur.

ENVIRONMENTAL FACTORS

1. *Moisture*

- ❖ Humidity, dew, rainfall, irrigation water.
- ❖ May promote development & spread of diseases
- ❖ e.g Damping-off

2. *Temperature*

- ❖ Each pathogen has preferred temperature range
- ❖ Affects growth & development of the pathogen
- ❖ e.g many powdery mildews are warm temperature diseases
- ❖ May stress the plant and make predispose it to pathogen attack.

ENVIRONMENTAL FACTORS

3. *Wind & Sun*

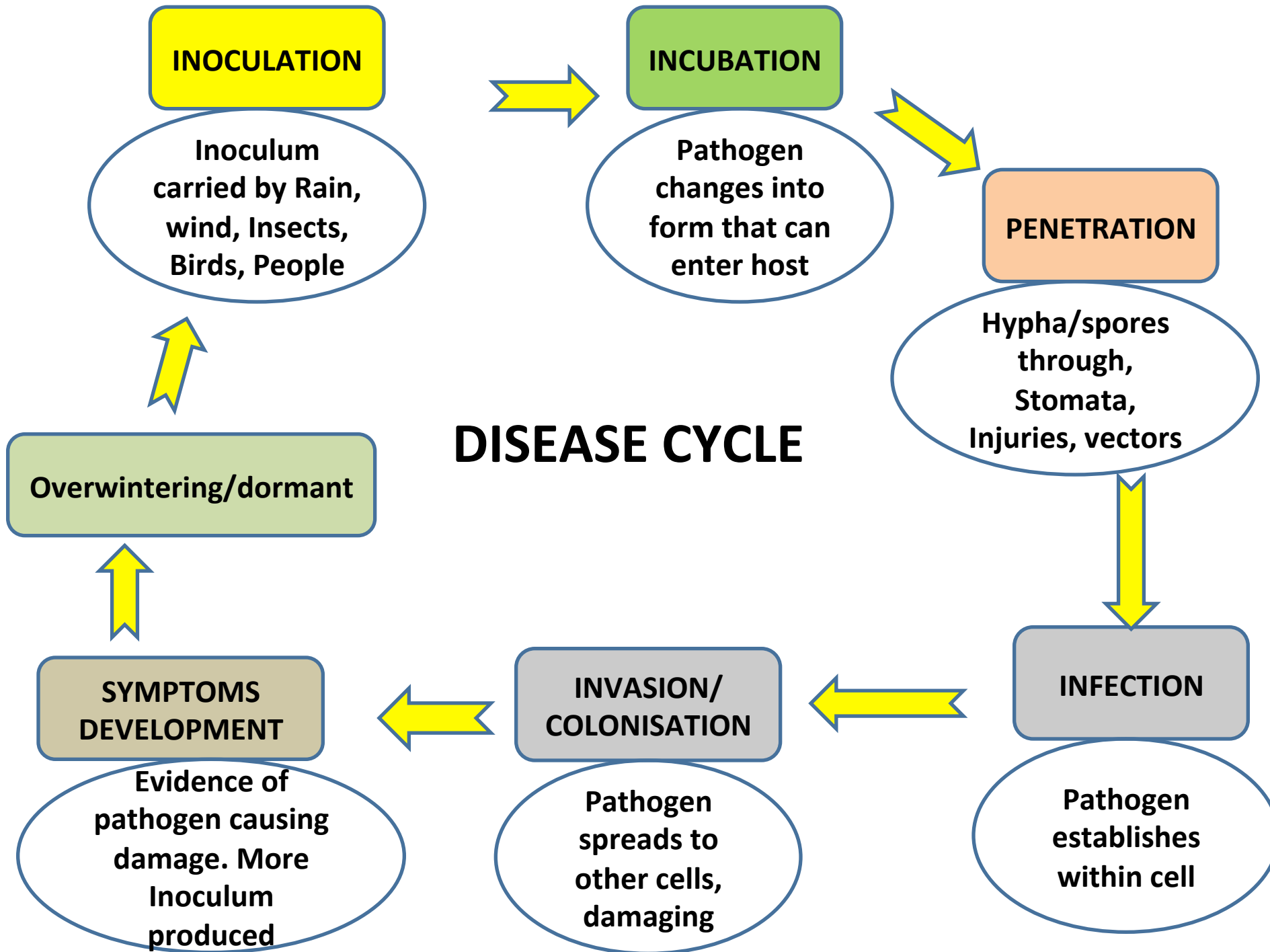
- ❖ Combination affects speed of drying on plant surfaces
- ❖ Wind can spread spores over long distances
- ❖ Inadequate sunlight lowers photosynthetic rates predisposing the plant to pathogen attack

4. *Soil type & fertility*

- ❖ Light sandy soil low in OM- Nematodes
- ❖ Heavy, cold waterlogged soils- Damping-off
- ❖ Acidic soils- Club root of cabbage
- ❖ Soil fertility affects plant growth rates & ability to defend themselves against diseases
- ❖ Poor fertility soils – *Striga asiatica*

Disease cycle

The chain of events involved in disease development including the stages of development of the pathogen and the effects of the disease on the host



HOW DO PATHOGENS CAUSE DISEASE???

1. Enzymatic degradation of the host
2. Production of toxins
3. Growth regulators: from pathogen or host
4. Genetic manipulation: viruses & some bacteria

PLANT DISEASE SYMPTOMS

- Rot
- Blight
- Leaf spot
- Streak
- Wilt
- Yellowing
- Abnormal color (e.g purple)
- Stunting
- Galls / swellings (leaves, roots, stems)
- Die-back
- Drying
- Leaf blotch/mosaic
- Blister
- Distortion (leaf/stem/root/fruit/grain)
- Little leaves
- Witches broom
- Cankers (stem lesions)
- Staining (stem/root/fruit)
- Leaf fall/Fruit drop

Leaf/fruit spot – localized tissue death/ necrosis



https://www.pioneer.com/CMRoot/pioneer/US/images/agronomy/crop_protection/corn_fungicide_decisions

Cercospora zeae-maydis - Grey leaf spot

Bacterial spot
on tomato

caused by
Xanthomonas
campestris pv.
vesicatoria.



Bacterial speck
on tomato

caused by
Pseudomonas
syringae pv.
tomato.





Blight – widespread
tissue death/
necrosis

*Phytophthora
infestans*
(Late blight of
tomato)



Bean halo blight
caused by bacterium
Pseudomonas
phaseolicola.



Streak: Band of
discoloration or
necrosis

Maize streak
caused by
Maize streak
virus



Wilt – dropping of leaves and young stems due to lack of water in them
(bacteria/fungi)

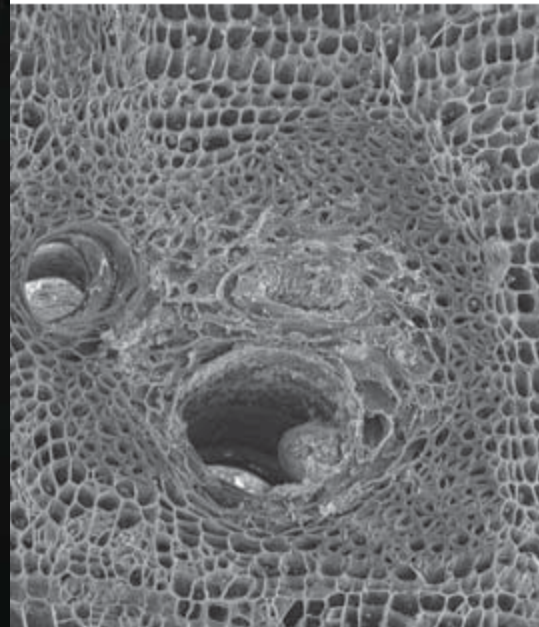
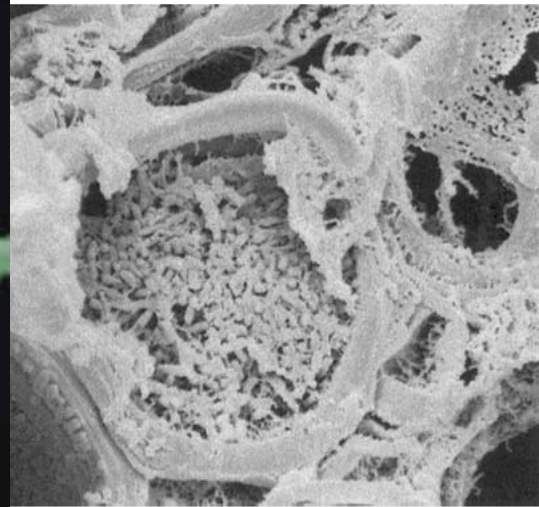


Ralstonia solanacearum
(Bacterial wilt of potato)

Tomato spotted wilting virus is the only recorded virus causing wilt as a symptom



Source:bugwood.org



Bacterial wilt of cucurbits caused by *Erwinia tracheiphila*

Mosaic – patchy variation of normal green color in leaves



Cassava mosaic disease caused by Cassava mosaic virus

Mosaics on tobacco
leaves caused by
Tobacco mosaic
virus



White rot of soyabeans (Sclerotinia stem rot of soyabeans)

Sclerotinia sclerotiorum



Rot: disintegration of tissue, often caused by enzymes or toxins produced by pathogens (bacteria/fungi)



Soft rot of
potato

*Pectobacterium
carotovorum*

Rot: disintegration of tissue, often caused by enzymes or toxins produced by pathogens (bacteria/fungi)



Dry rot of potato

Fusarium sambucinum,

F. solani,

F. culmorum,

F. Avenaceum

Gall: abnormal growth or swelling (bacteria/
nematodes)



Root galls on bean plant infected with the root-knot nematode *Meloidogyne* sp.



Root galls: tomato, carrot, potato (*Meloidogyne* sp.)



Multiple small shoots on one plant



Banana bunchy top disease - by banana bunchy top virus



Die-back

a condition in which a tree or shrub begins to die from the tip of its leaves or roots backwards, owing to disease or an unfavourable environment.



http://ucanr.edu/blogs/Topics//blogfiles/52261_original.jpg

Stunting:

Abnormally slow growth/prevention from growth/dwarfing and loss of vigor.



Leaf edge scorch:

death of tissue along the edge of the leaf.



Distortion: abnormal shape in roots, leaves, fruits



Witches broom:

An abnormal brushlike cluster of dwarfed weak shoots arising at or near the same point



Small/little leaves:



Sweet potato little leaf, caused by the Phytoplasma called *Phytoplasma aurantifolia*

Warts



Potato wart disease, also called dark scab, caused by the fungus *Synchytrium endobioticum*, from the phylum Chytridiomycota

PLANT DISEASE SYMPTOMS

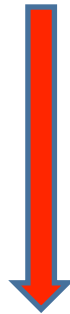
| | |
|-----------------------|---|
| Blight | A disease characterised by widespread death of plant tissue. |
| Local necrosis | The necrosis sites are limited and only involves a part or a few plant cells/tissues. |
| Canker | A sunken necrotic lesion often of a main stem, branch or root. |
| Damping-off | Collapse and rot of seedlings near soil level before emergence or soon after emergence caused by <i>Pythium</i> spp., <i>Phytophthora</i> spp., <i>Fusarium</i> spp., and <i>Rhizoctonia</i> spp. |
| Dieback | Partial defoliation, twig and branch death and even complete death of plants. |
| Downy mildew | White or grey 'bloom' on leaves and stems caused by production of sporangiophores and sporangia by members of the Peronosporales (downy mildew fungi). |
| Gall | An abnormal growth or swelling produced as a result of pathogenic invasion. |
| Mosaic | Patchy variation of normal green colour in leaves, usually light and dark green mosaic, symptomatic of many viral diseases. |
| Powdery mildew | White powdery 'bloom' on the plant surface caused by the production of fungal mycelium, conidiophores and conidia by members of the Erysiphales (powdery mildew fungi). |
| Pustule | A blister-like spore mass breaking through a plant epidermis. |
| Rot | Disintegration of tissue, often caused by enzymes or toxins produced by pathogens. |
| Rust | Rust-coloured pustules formed by members of the Uredinales (rust fungi). |
| Scab | A discrete, superficial roughened lesion. E.g: Citrus scab – <i>Elsinoe fawcettii</i> , Powdery scab of potatoes – <i>Spongospora subterranea</i> |
| Smut | A disease characterised by black spore masses on leaves, stems or inflorescences, caused by members of the Ustilaginales (smut fungi). |
| Vascular wilt | A disease in which the pathogen is confined to the vascular system of the host and in which wilting is a characteristic symptom; plants lose their turgidity and become flaccid, leaves collapse. |

PATHOGEN SURVIVAL

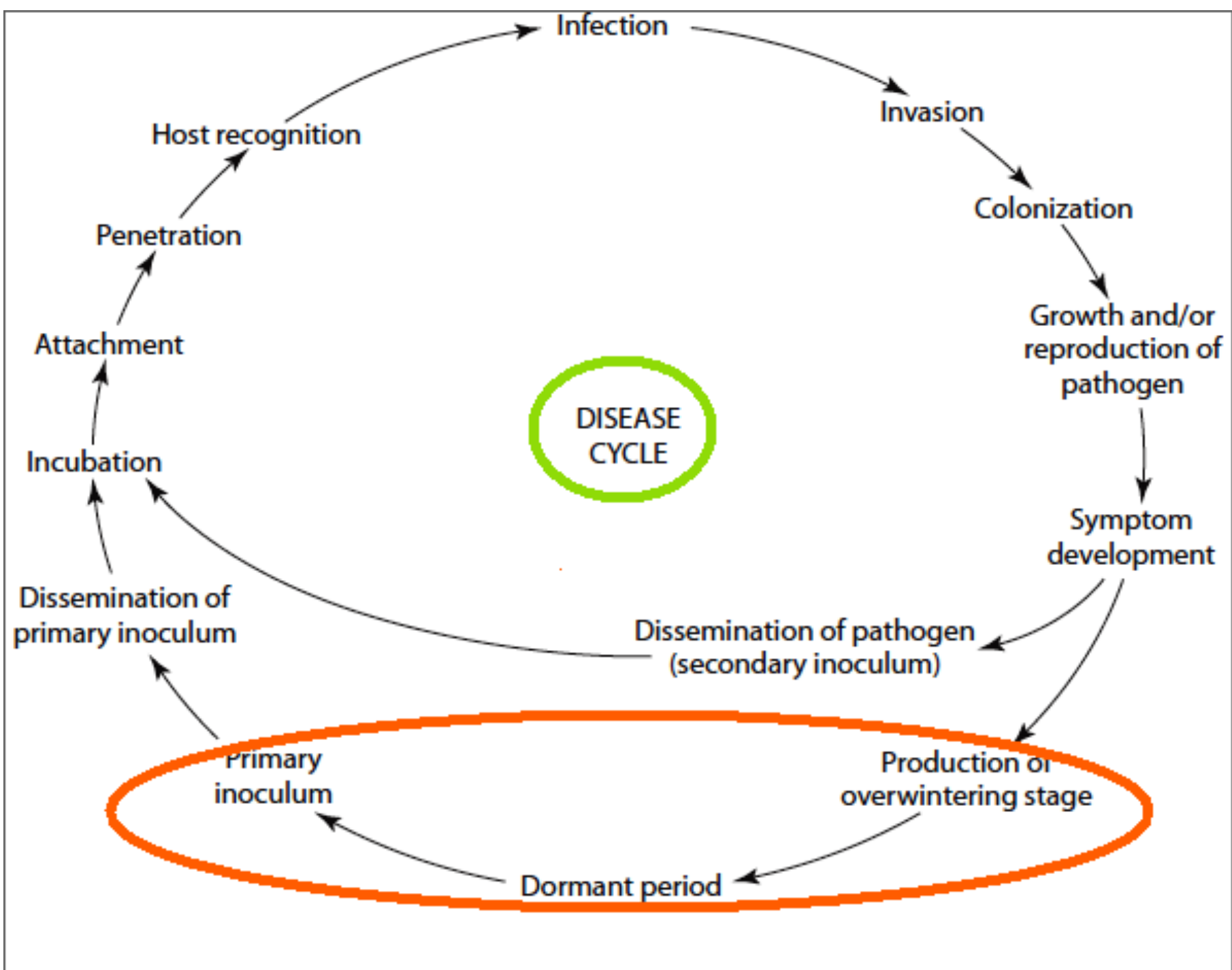
- Survive on debris, seeds, alternate hosts, soil

IMPORTANCE

- Survival ensures:
 - Perpetuation of the disease from one season to another.



- Thus availability of spores/inoculum overtime/season



HOW DO PATHOGENS SURVIVE

Mechanisms of Survival

A. Continuous infection chains

- I. Continuously infecting hosts of the same species, or
- II. Infect alternative hosts or insects in absence of host, or
- III. Both

- For some, a second host is a must (even with host present-alternate)
- (Disease carrier, no resting structures, not epiphytic, not saprophytic)

B. Discontinuous infection chain

Mechanisms of Survival cont...

B. Discontinuous infection chain

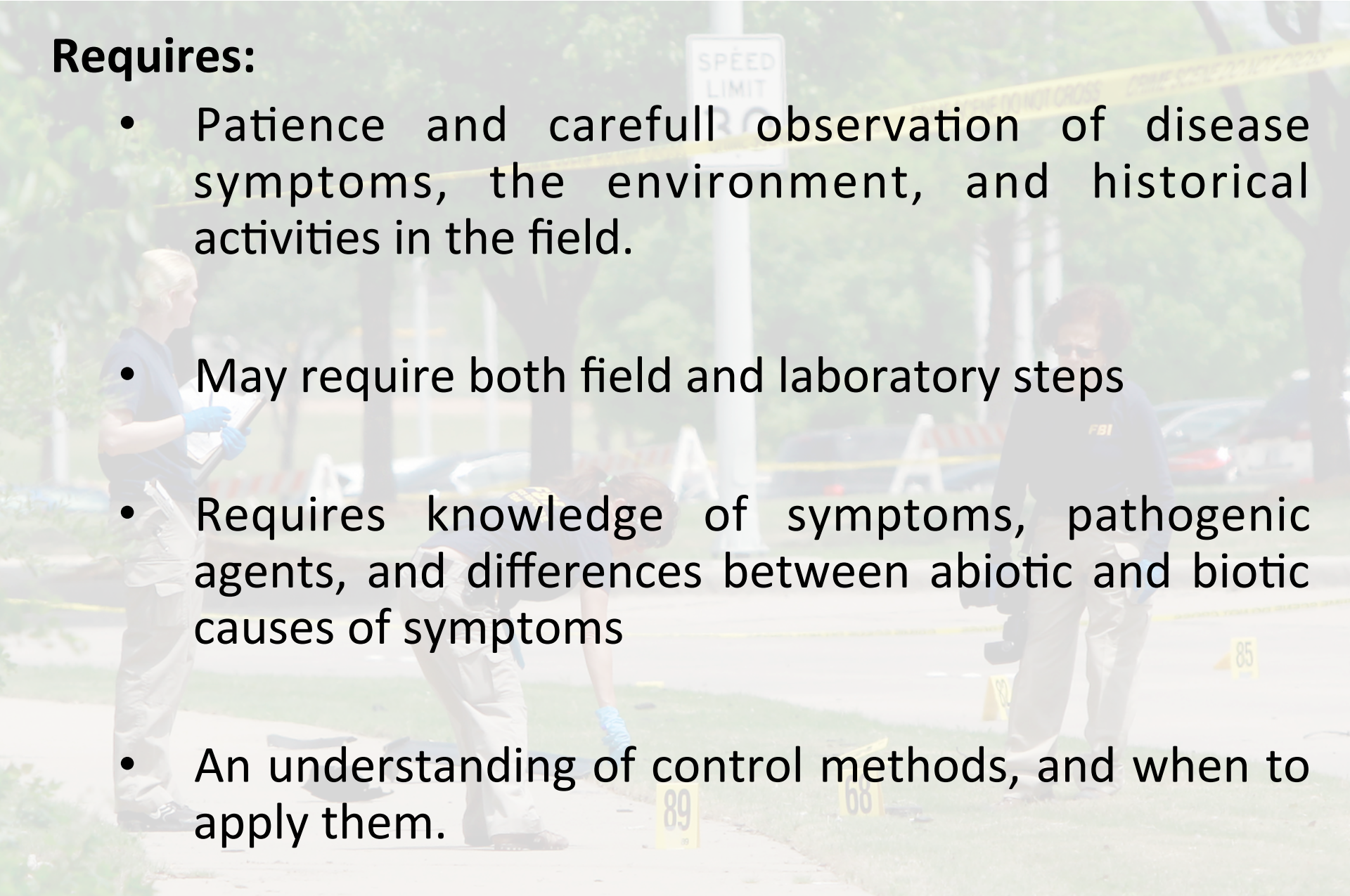
- I. Epiphytic - survive on surface of host or other plant in non-parasitic manner
- II. Saprophytic - Feeding on decaying host, or organic matter
- III. Resting stage - specialized structures:
 - a. Resting spores (e.g oospores, teliospores, chlamydospores)
 - b. Sclerotia
 - c. Latent infection



PLANT DISEASE DIAGNOSIS

Requires:

- Patience and careful observation of disease symptoms, the environment, and historical activities in the field.
- May require both field and laboratory steps
- Requires knowledge of symptoms, pathogenic agents, and differences between abiotic and biotic causes of symptoms
- An understanding of control methods, and when to apply them.



PLANT DISEASE DIAGNOSIS

STEPS

1. Take a close-up view of the diseased plant
2. General view of the field and environment
3. Establish cropping and management history
4. Observe patterns/speed of spread or lack thereof
5. Apply your knowledge of plant pathogens/diseases and consult repositories
6. Provide recommendations for control

PLANT DISEASE DIAGNOSIS

Take a close-up view of the diseased plant

- all parts, hand lens, microscopes
- Look for signs of pathogen
- Take photos and samples

General view of the field and environment

- weather, soil, cultural practices, fertiliser, chemicals

Establish cropping and management history

- Ask questions: Irrigation? Herbicide management

PLANT DISEASE DIAGNOSIS

Observe patterns/speed of spread or lack thereof

- What else happened? rainfall? Is it spreading? Other species affected

Apply your knowledge of plant pathogens/diseases and consult repositories

- Healthy vs diseased plant; signs & symptoms; primary causes; diagnosis manuals

Provide recommendations for control

- What control method to apply? Is it necessary to act?

IS IT BIOTIC OR ABIOTIC?

- Several abiotic effects could produce symptoms
- Check to see whether these have occurred
- Are symptoms spreading? (abiotic does not spread)
- Are symptoms appearing on the same day all-over the field? (not biotic)
- Random symptoms = biotic causes
- Uniform symptoms = abiotic causes
- Presence or absence of symmetry in disease pattern on leaf/plant (viruses a bit tricky!!!)
- E.G Maize streak virus may be similar to iron or zinc deficiency, but the streaks in viral disease are breaking lines....deficiency lines are continuous...
- For zinc the green veins are thicker than the green veins in iron

USING DISEASE SYMPTOMS IN PLANT DISEASE DIAGNOSIS

WILT– IN DIAGNOSIS

- Is the wilt only present in some branches and not other on the same plant?
- Is the pattern of wilting plants random in the field, or only a certain pattern?
- Is the wilting plant associated with necrotic tissue inside the vascular system?
- Is the wilting plant associated with ooze?

WILT– IN DIAGNOSIS

- Is the wilted plant having white fluffy growth on the wilted portions?
- Are the roots of the wilting plant blackened?

LEAF SPOT– IN DIAGNOSIS

- Are spots all the same size?
- Are they associated with leaf edge?
- Or if there is mycelia growing in there

LEAF SPOT– IN DIAGNOSIS

- Is there any structures inside the spot (fruiting bodies will be seen if it is fungi....they might even form in concentric rings) (fruiting bodies are structures in/on which spores are formed)



LEAF SPOT– IN DIAGNOSIS

- Is the leaf spot/blight starting from the leaf edge or spotted along the edge of the leaf?
- If all same size most likely they are caused by insect feeding or fungi
- Leafspots with clearly defined border region different in color from the leafspot itself, is most likely fungi (not the yellow hallow...but the border region)

LEAF SPOT– IN DIAGNOSIS

- Are the leaf spots/blights spreading down the leaf vein?
- Is there water-soaking around the blight/spot without mycelia or structures in the leaf spot/blight?
- Is there water-soaking around the blight/spot with mycelia or structures in the leaf spot/blight?
- Do the spots have arcs or rings (ring spots) with tissues in the center the same as other parts (health tissue in the center)?

LEAF SPOT– IN DIAGNOSIS

- Is there mycelia growth on the underside of the leaf below the spot?



LEAF SPOT– IN DIAGNOSIS

- Are the lesions/leafspots following the veins?



GALLS – IN DIAGNOSIS

- Are the galls uniform in size or not?
- Are the galls rough or smooth?
- Are the galls on the side of the root (as if just attached to roots) or are the galls in the root and making that portion of the root swollen?

STAINING/DISCOLORATION – IN DIAGNOSIS

- Is the discoloration of internal tissue occurring with or without softening of tissue?
- Is the discoloration of internal tissue occurring with or without watersoaking?

YELLOWING – IN DIAGNOSIS

- Is it upper or lower leaves alone or lower leaves alone?
- Is it whole leaf or veins alone that are green?

ROT – IN DIAGNOSIS

- Is there structures in the rot (fruiting bodies)?
- Is there any sporulation on the rot?
- Does the rot smell or not?

DISTORTED – IN DIAGNOSIS

- Is there an insect around?
- Is there webbing around the distorted tissue?
- Is it a mosaic pattern associated with the distortion

DIEBACK – IN DIAGNOSIS

- Are there larvae/holes in the dieback?

RED/REDDENING/PURPLING – IN DIAGNOSIS

- Is it upper or lower leaves alone?

DRYING – IN DIAGNOSIS

- Is drying preceded by a wilt?
- How rapidly did the plant tissue die (fast for herbicide and that caused by bacteria....and slow for that caused by fungi..)

MOSAIC – IN DIAGNOSIS

- Is there symmetry in the pattern?
- How blurred is the yellow and green are. (Sharp line = mosaic; sharp line = mottling)
- Restricted by leaf vein or not (nutrient deficiency)

STREAK – IN DIAGNOSIS

- Is the streak continuous or it breaks?

TRUE FUNGI AND FUNGUS-LIKE ORGANISMS (WATER MOULDS)

FUNGAL TAXONOMY

Domain *Eukaryote* – *Eukaryotic*

Kingdom *Fungi*

Phylum(Division) *Basidiomycota*

Class *Basidiomycetes*

Order *Uredinales*

Family *Pucciniaceae*

Genus *Puccinia*

Species ***Puccinia graminis***

MAJOR PHYLA OF FUNGI AND FUNGUS-LIKE ORGANISMS

Kingdom: Fungi

Kingdom: Chromista

1. Chytridiomycota
2. Neocallimastigomycota
3. Blastocladiomycota
4. Microsporidia
5. Glomeromycota (Former Zygomycota)
6. Mucoromycota (Former Zygomycota)
7. Entomophthoromycotina
8. Zoopagomycota (Former Zygomycota)
9. Kickxellomycotina
10. Ascomycota
11. Basidiomycota

1. Hyphochytriomycota
2. Labyrinthulomycota
3. Oomycota

Kingdom: Fungi

1. Chytridiomycota (*Sychytrium endobioticum*....Potato wart)
2. Neocallimastigomycota (Digestive tracts of herbivores)
3. Blastocladiomycota (Generally saprotrophs)
4. Microsporidia (Parasitic on animals and protists)
5. Glomeromycota (mycorrhizal fungi; Former Zygomycota)
6. Mucoromycota (Former Zygomycota)
7. Entomophthoromycotina (Insect pathogens)
8. Zoopagomycota (Endo and ectoparasites of nematodes, and others)
9. Kickxellomycotina (Mycoparasites)
10. Ascomycota (has the widest number and diversity of plant pathogens & nonpathogens)
11. Basidiomycota (several fungi, mushrooms, including rusts, smuts,)

Sclerotinia sclerotiorum:
White rot of soyabeans (Sclerotinia stem rot of
soyabeans)



Cercospora zeae-maydis



Gray leaf spot

Colletotrichum lindemuthianum
(Bean anthracnose)



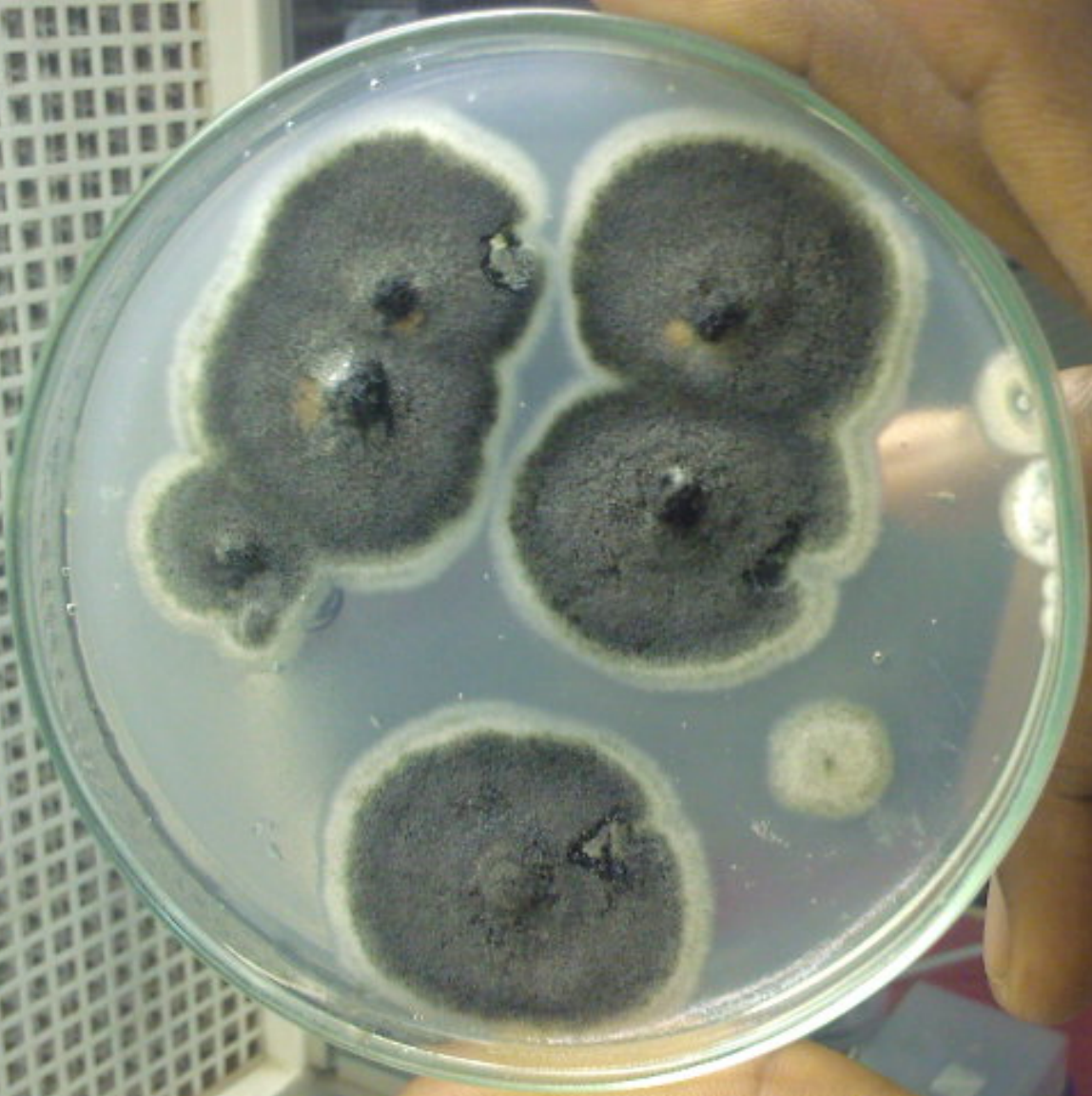


*Phytophthora
infestans*
(Late blight of
tomato)



Root rot of spinach:
Pythium spp,
Rhizoctonia solani,
Aphanomyces spp,





WHAT ARE FUNGI?

Fungi are eukaryotic, spore bearing, achlorophyllous organisms that generally reproduce sexually and asexually, and whose **usually** filamentous, branched somatic structures are typically surrounded by cell walls containing chitin or cellulose, together with many other complex organic molecules. They include microorganisms such as yeasts, molds and mushrooms.

TRUE FUNGI VS FUNGUS-LIKE MICRO-ORGANISMS (ALSO CALLED WATER MOLDS)

TRUE FUNGI

Fungi are eukaryotic, spore bearing, achlorophyllous organisms that generally reproduce sexually and asexually, and whose usually filamentous, branched somatic structures are typically surrounded by cell walls containing chitin ~~or cellulose~~, together with many other complex organic molecules. They include microorganisms such as yeasts and molds, as well as the more familiar mushrooms.

TRUE FUNGI VS FUNGUS-LIKE MICRO-ORGANISMS (ALSO CALLED WATER MOLDS)

WATER MOLDS

Are eukaryotic, spore bearing, achlorophyllous organisms that generally reproduce sexually and asexually, and whose usually filamentous, branched somatic structures are typically surrounded by cell walls containing ~~chitin~~ or cellulose, together with many other complex organic molecules. They include microorganisms such as ~~yeasts and molds, as well as the more familiar mushrooms.~~

TRUE FUNGI

- Chitin in cell wall
- Kingdom-Fungi
- Phylla: Ascomycota, Basidiomycota, Zygomycota, Chytridiomycota,
- Examples (genera):
 - *Alternaria, Rhizopus, Colletotrichum..*

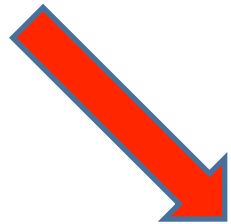
WATER MOLDS

- Cellulose in cell wall (like plants)
- Kingdom-Chromista
- Phylum: Oomycota
- Examples (genera):
 - *Phytophthora, Pythium, Peronospora, Plasmopara*



Spore

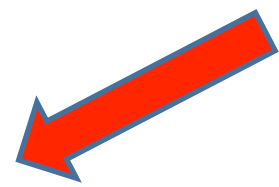
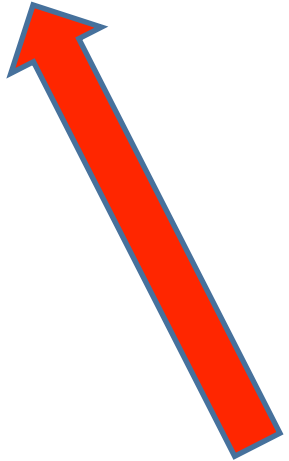
Types of mycelium



Colony

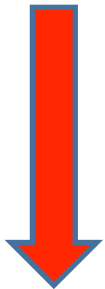


Spores





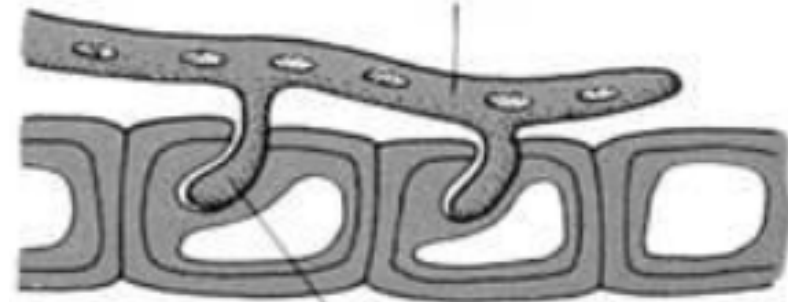
Spore



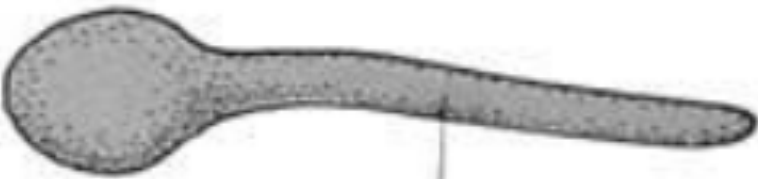
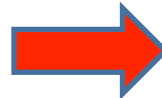
Mycelium



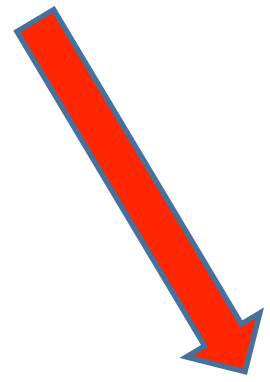
Hypha



Haustorium



Hypha



Coenocytic hypha



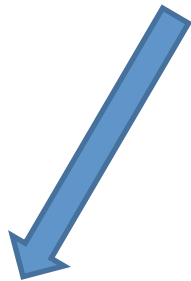
Septate hypha

FUNGAL NUTRITION

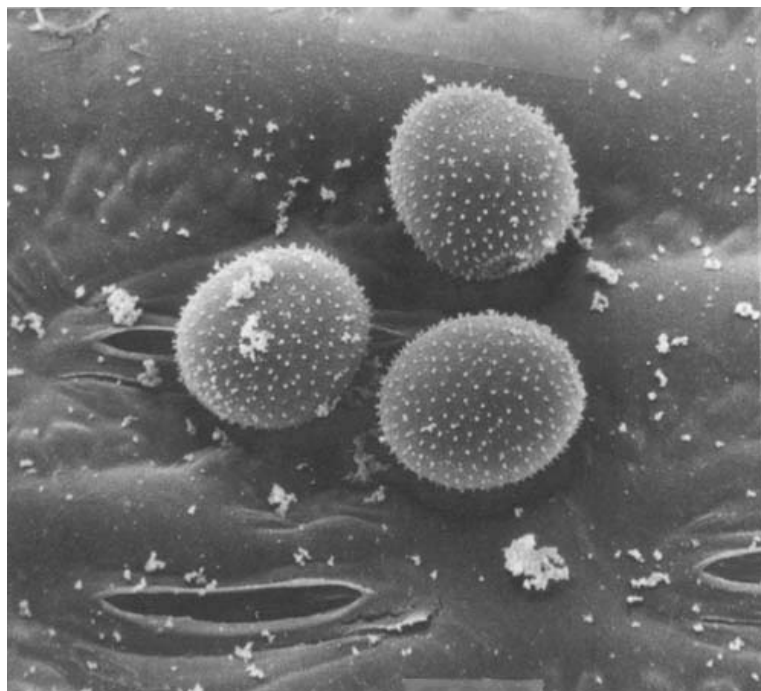
- Heterotrophic
- Absorptive nutrition
- Saprophytic, Symbiotic or Parasitic
- Predation & Parasitisation



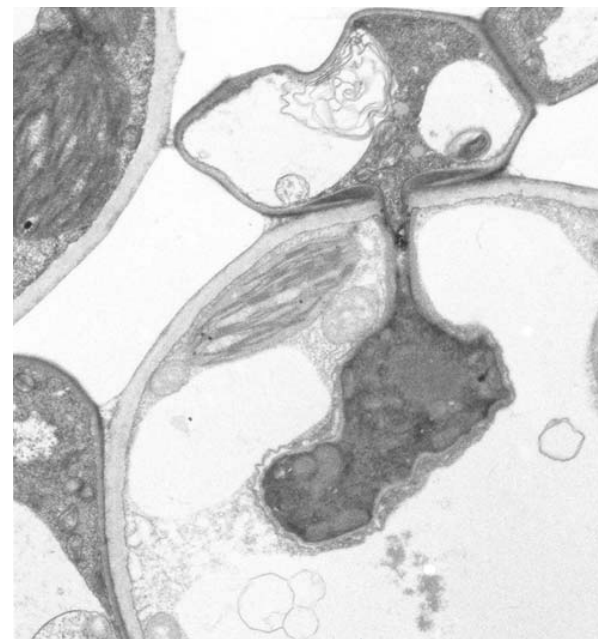
Appressorium



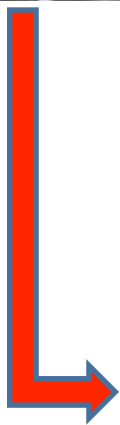
Necrotrophic or biotrophic



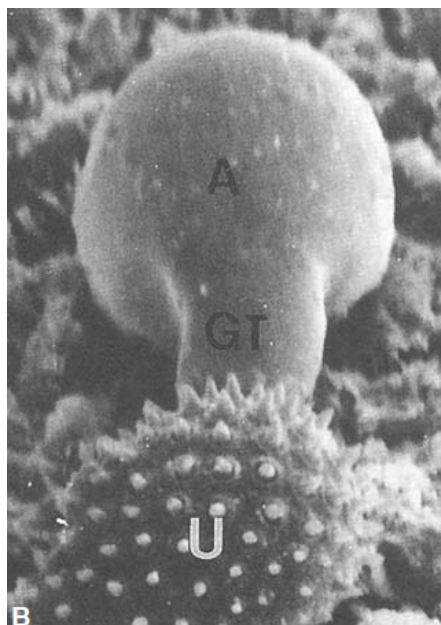
Spore near stomata



Penetration peg on appressorium



Appressorium emerging



FUNGAL REPRODUCTION

- Vegetative-Propagation from somatic parts
- Asexual-reproduction through production of spores without fusion of hyphae or gametes
- Sexual-reproduction through fusion of gametes, gametangia or hyphae

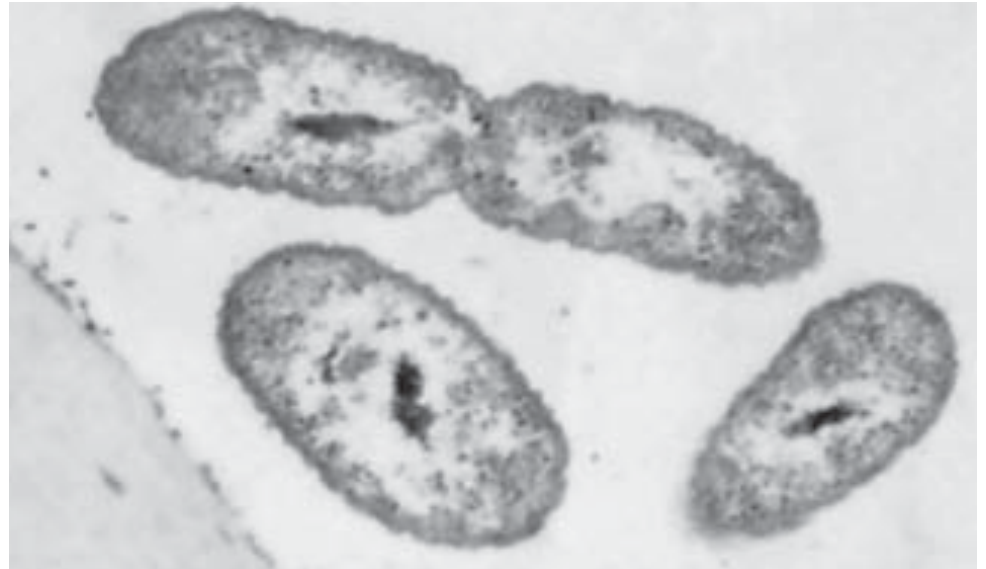
VEGETATIVE REPRODUCTION

Propagation from somatic parts

1. **Budding** (e.g peach leaf curl-caused by *Taphrina* sp)

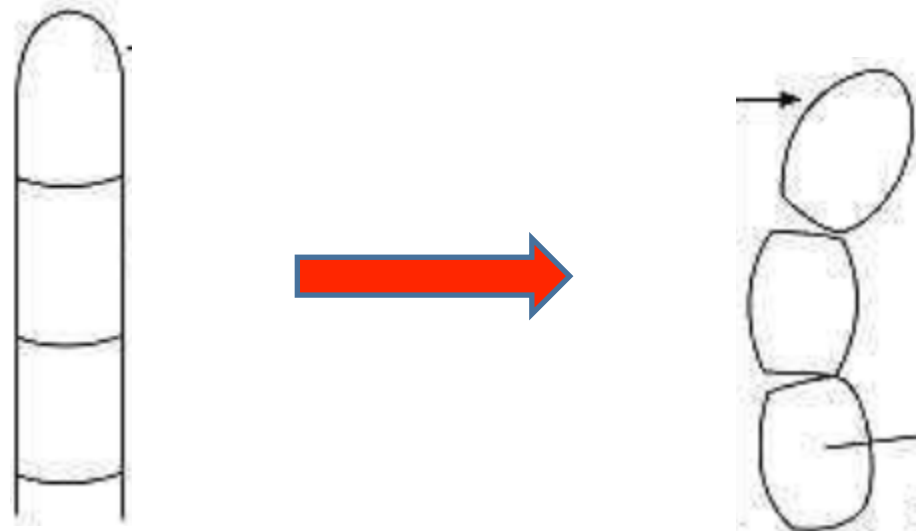


2. **Fission**



VEGETATIVE REPRODUCTION cont...

3. Fragmentation



4. Sclerotia: compressed, melanized mycelia

- remain dormant under unfavourable conditions and germinate into new mycelia on the return of favourable conditions.

ASEXUAL REPRODUCTION

Through asexual production of spores, in specialized structures called Fruiting bodies.

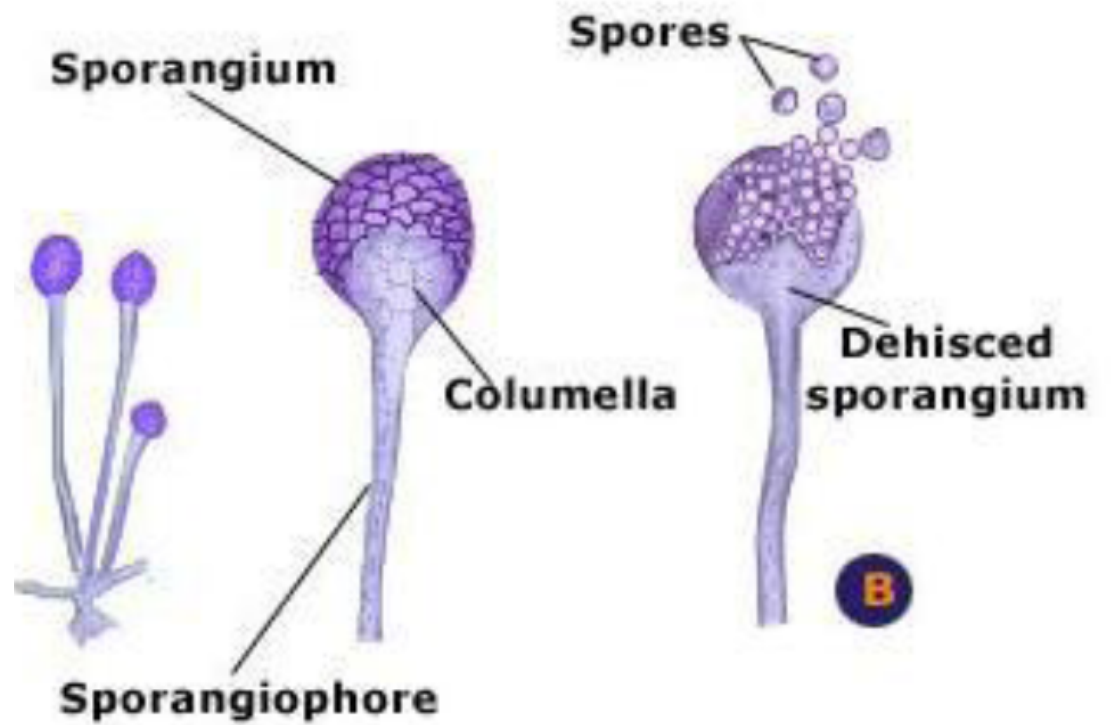
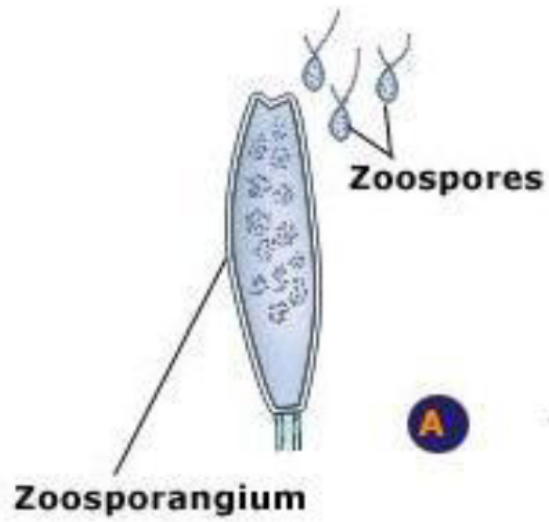
➤ Zoospores

➤ Sporangiospores

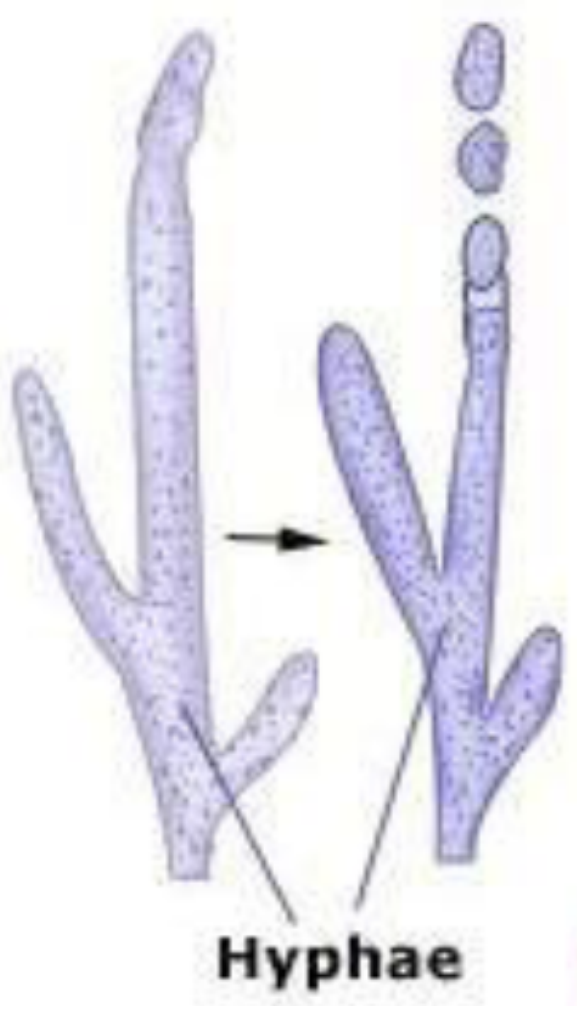
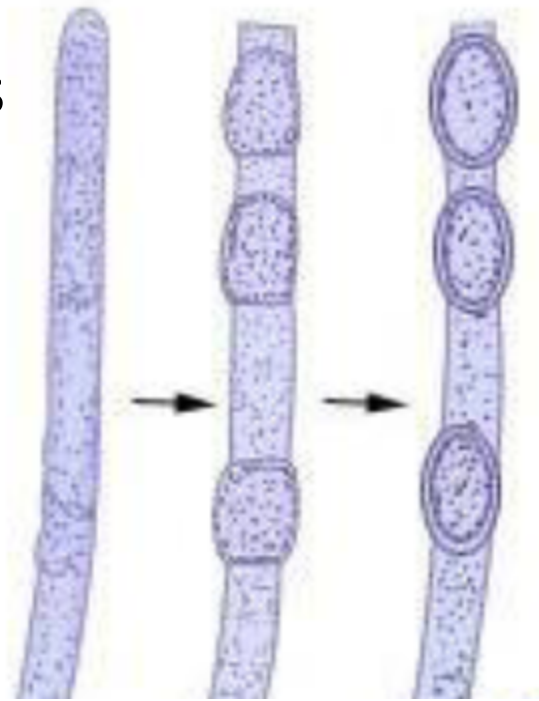
➤ Chlamydospores

➤ Oidia

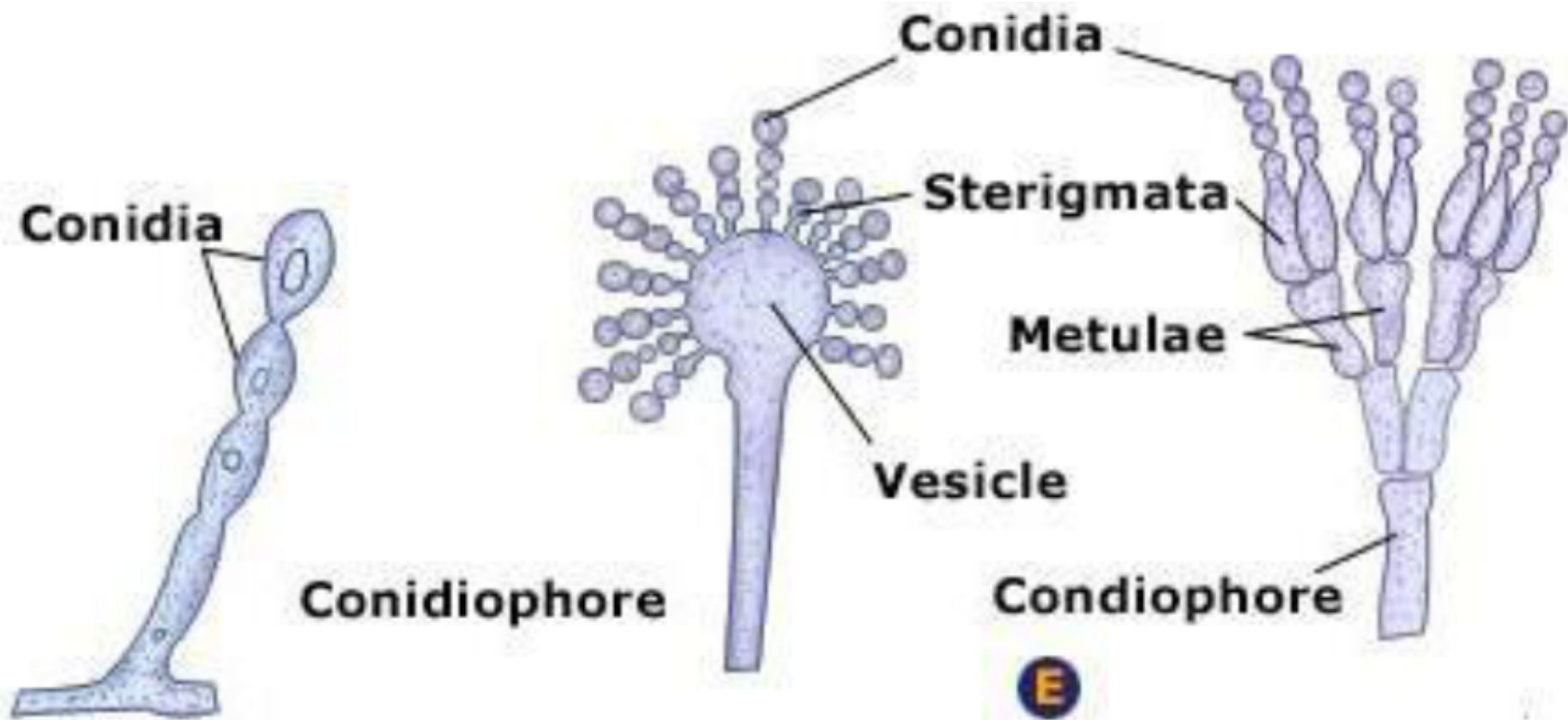
➤ Conidia



Chlamydospores



Oidia



SEXUAL REPRODUCTION

Fusion of gametes, gametangia or hyphae

The fusion may be:

- 1. fusion of cytoplasm (plasmogamy)**
- 2. fusion of nuclei (karyogamy), or**
- 3. production of meiotic spores (meiospores)**

FUNGAL TAXONOMY

Domain *Eukaryote* – *Eukaryotic*

Kingdom *Fungi*

Phylum(Division) *Basidiomycota*

Class *Basidiomycetes*

Order *Uredinale*

Family *Pucciniaceae*

Genus *Puccinia*

Species ***Puccinia graminis***

CLASSIFICATION OF FUNGI

The classification of fungi is generally based on the following criteria:

- ✓ Morphology of reproductive structures and/or spores
- ✓ Types of spores formed (sexual or asexual)
- ✓ Characteristics of the life cycle
- ✓ Morphology of the thallus (mycelia)
- ✓ DNA patterns: similarity/differences from known groups

MAJOR PHYLA OF FUNGI AND FUNGUS-LIKE ORGANISMS

Kingdom: Fungi

1. Chytridiomycota
2. Neocallimastigomycota
3. Blastocladiomycota
4. Microsporidia
5. Glomeromycota
6. Mucoromycota
7. Entomophthoromycotina
8. Zoopagomycota
9. Kickxellomycotina
10. Ascomycota
11. Basidiomycota

Kingdom: Chromista

1. Hyphochytriomycota
2. Labyrinthulomycota
3. Oomycota

Kingdom: Fungi

1. Chytridiomycota (*Sychytrium endobioticum*....Potato wart)
2. Neocallimastigomycota (Digestive tracts of herbivores)
3. Blastocladiomycota (Generally saprotrophs)
4. Microsporidia (Parasitic on animals and protists)
5. Glomeromycota (mycorrhizal fungi, Formerly called Zygomycota)
6. Mucoromycota (Formerly called Zygomycota)
7. Entomophthoromycotina (Insect pathogens)
8. Zoopagomycota (Endo and ectoparasites of nematodes, and others) (Formerly called Zygomycota)
9. Kickxellomycotina (Mycoparasites)
10. Ascomycota (has the widest number and diversity of plant pathogens & nonpathogens)
11. Basidiomycota (several fungi, mushrooms, including rusts, smuts,)

Kingdom: Chromista

1. Hyphochytriomycota – (parasites/saprophytes on fungi and algae)
2. Labyrinthulomycota (parasite/symbionts of plants and algae)
3. Oomycota (Phytophthora, Root rots, Downy mildew, and several non-pathogenic chromista)

MAJOR CLASSES OF PLANT PATHOGENIC FUNGI

1. Oomycetes-aseptate fungus-like organisms characterised by production of sexual spores called oospores
2. Ascomycetes-sexually and asexually reproducing fungi with varying morphological features. Sexually reproducing ones characterised by production of ascospores.
3. Basidiomycetes-mostly smuts and rusts, characterised by production of sexual spores called basidiospores (typically 4) on a basidium.
4. Zygomycetes (old name – organisms now moved into two new phyla – Mucoromycota and Zoopagomycota)-sexually and asexually reproducing fungi with varying morphological features and coenocytic hyphae. Sexually reproducing ones characterised by production of zygospores
5. Chytridiomycetes (Phylum = Chytridiomycota. Only 1 class here): sexually and asexually reproducing fungi, that do not produce mycelia, but are unicellular.

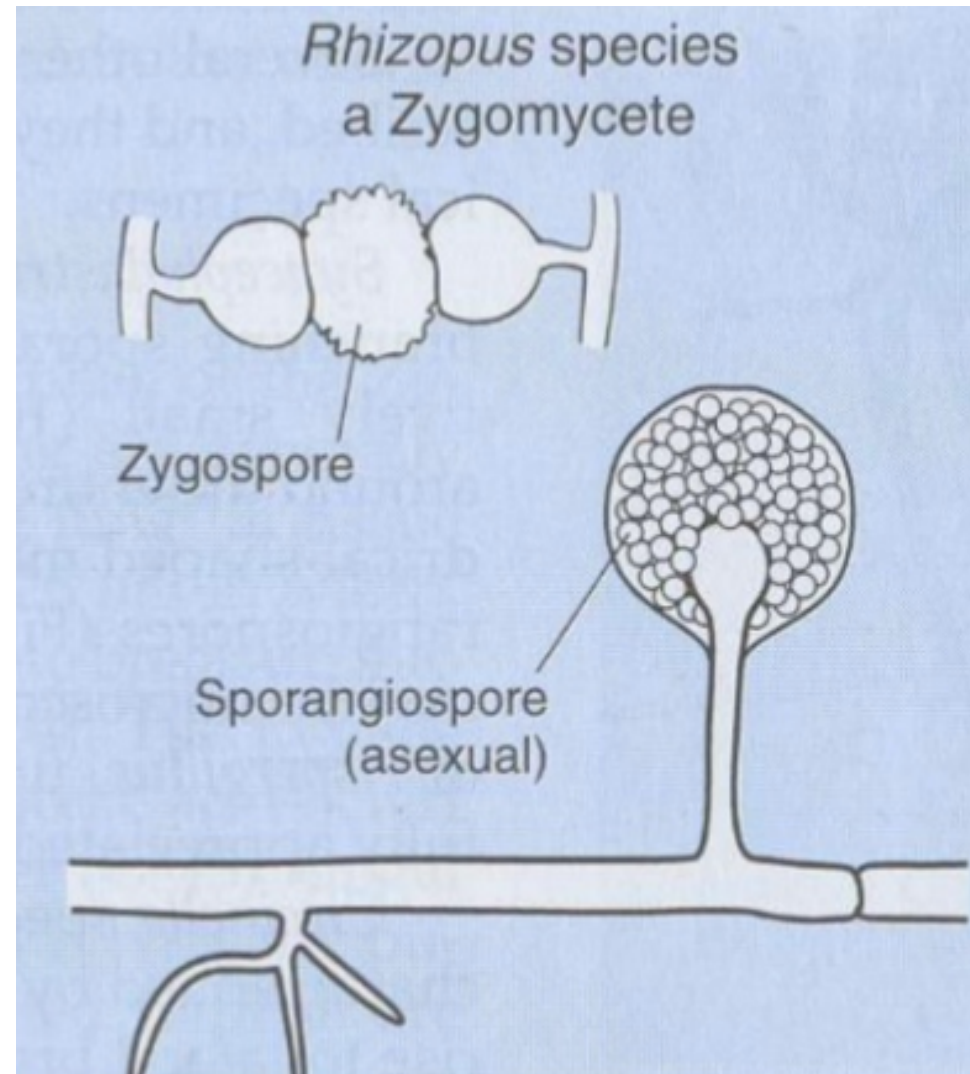
EXAMPLES

1. Oomycetes-*Phytophthora infestans* causing late blight of tomato and Irish potatoes. (Another example is *Pythium spp*, causing several root rots)
2. Ascomycetes-*Colletotrichum lindemuthianum* causing bean anthracnose disease
3. Basidiomycetes-Smuts and rusts - *Ustilago maydis* causing maize smut disease and *Uromyces appendiculatus* causing bean rust
4. Zygomycetes-*Rhizopus stolonifer* causing soft rot of sweet potato during storage, packaging and sale.
5. Chytridiomycetes – *Synchytrium endobioticum*, causing potato wart disease or black scab.

ZYGOMYCETES (Old name, now several groups)

Basic characteristics:

- Aseptate
- Asexual spores in sporangia
- Sexual spores called Zygosporangia:
 - Thick walled resting spore



ASCOMYCETES

Basic characteristics:

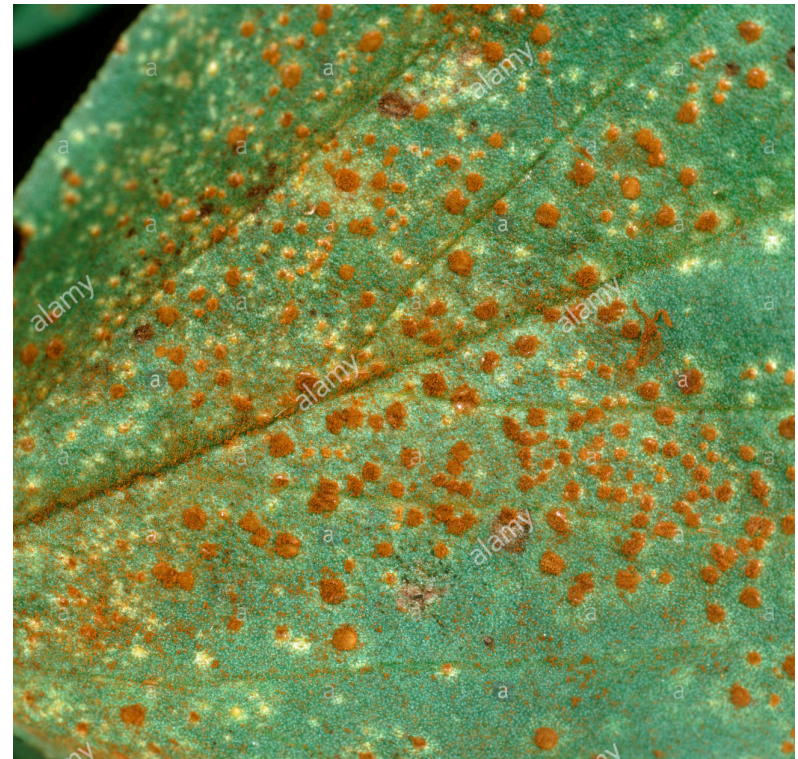
- Septate hyphae
- Haploid life cycle
- Asexual spores form on conidiophores of various shapes
- 8 sexual spores called ascospores formed in an ascus (asci)



Basidiomycetes

Corn/maize smut

Bean rust



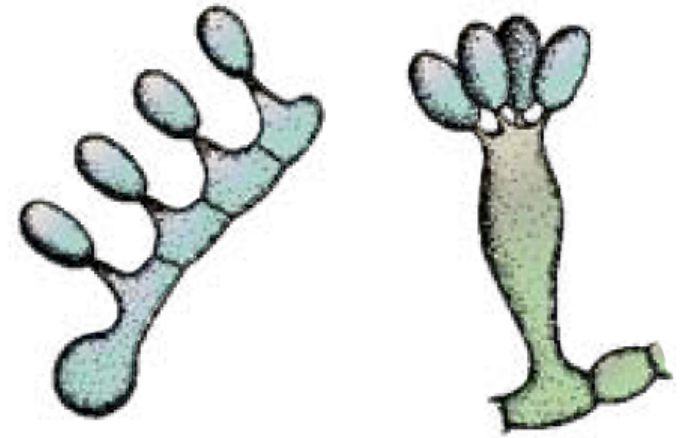
Ustilago maydis

*Uromyces
appendiculatus*

Basidiomycetes

Basic characteristics:

- Septate hyphae
- Asexual spores include uredospores, oidia
- 4 sexual spores called basidiospores formed on basidium

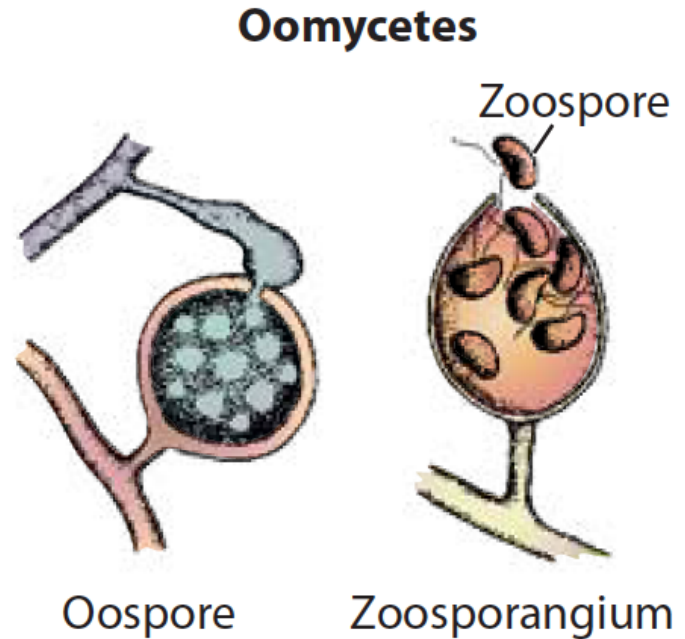


Basidiospores on basidium

Oomycetes

Basic characteristics:

- Aseptate
- Not True Fungi
 - Cellulose cell walls (not chitin)
 - Bi-flagellate zoospores (as opposed to chytridiomycota which has 1)
 - Tinsel – anterior, pulling
 - Whiplash – posterior, steering
 - Tubular cristae in mitochondria
 - Diploid life style
 - Different lysine biosynthetic pathway



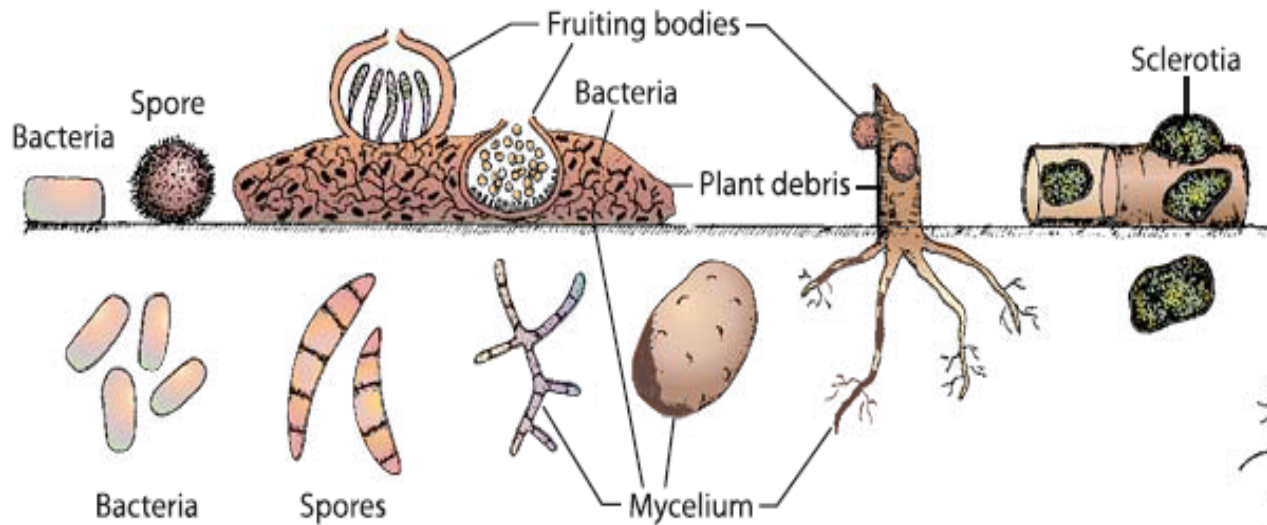
Chytridiomycetes

Basic characteristics:

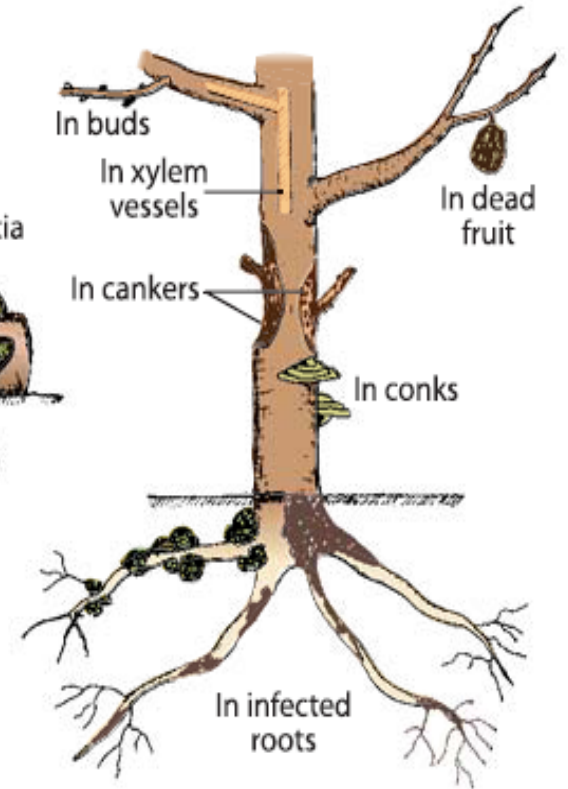
- Unicellular (similar to yeasts) or filamentous (aseptate)
- Both sexual (zygote which infects, then turns into resting spore) and asexual (zoospores) reproduction
- 1 posterior whiplash flagellum on zoospore (monoflagellate)
- True fungi



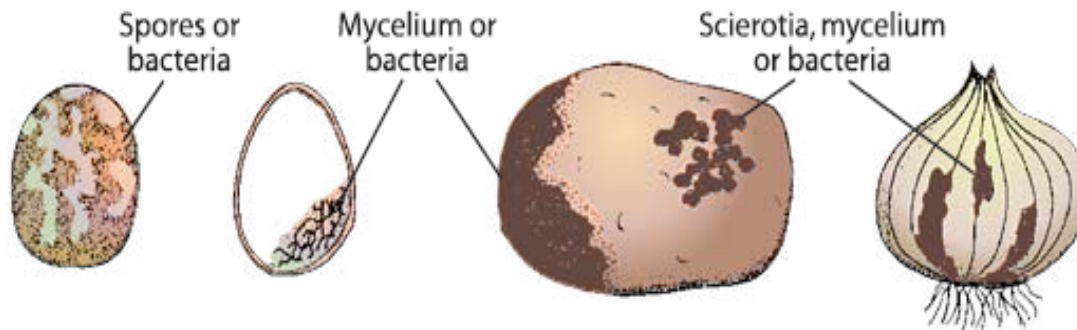
FUNGAL/PATHOGEN SURVIVAL



On or in soil



On perennial plants



On or in seed

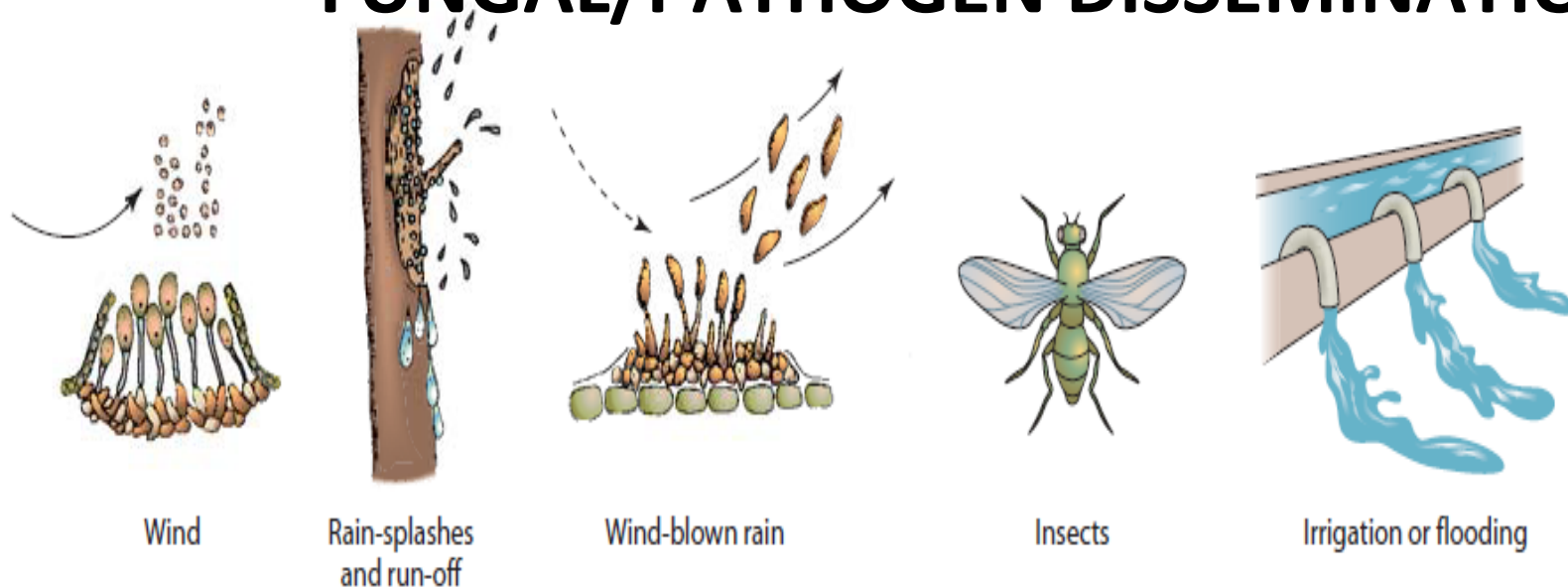
On or in vegetative propagative organs



On or in insects

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

FUNGAL/PATHOGEN DISSEMINATION



UNZALARU



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

CONTROL OF FUNGAL PATHOGENS

Choice of most effective means of control of a fungus disease depends on detailed knowledge of the crop and the pathogen and a consideration of the economic factors.

CONTROL OF FUNGAL PATHOGENS CONT...

Exclusion- Plant quarantine, port inspection, restriction of movement, certification.

Eradication- destruction of alternative hosts, roguing, excision of infected parts, and other sanitary measures, rotation, sterilization or disinfection

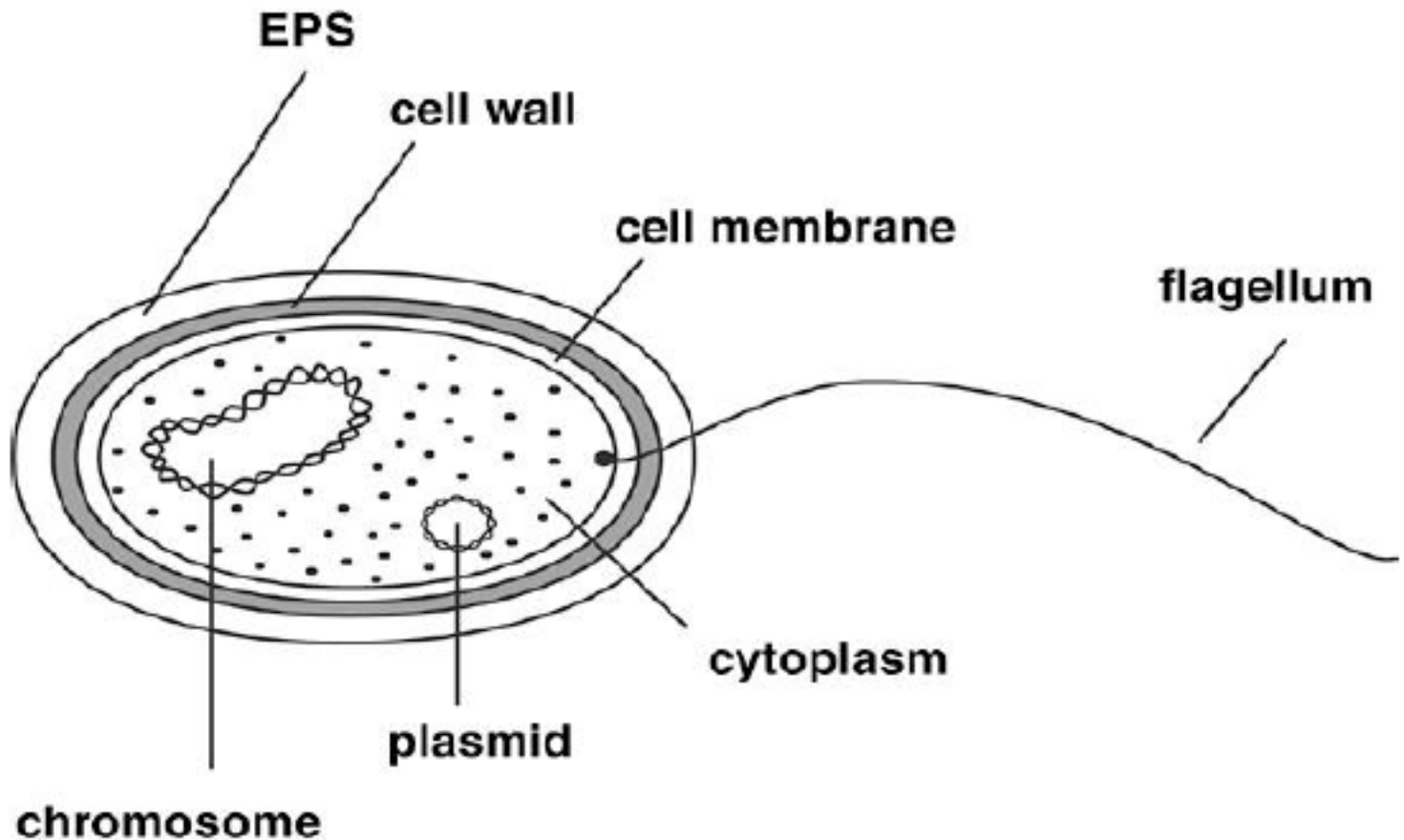
Protective measures- spraying or dusting plants exposed to disease outbreaks, seed treatment, treatment of stored products

Cultural measures- timing of planting and harvest, modification of soil conditions

Plant Resistant cultivars

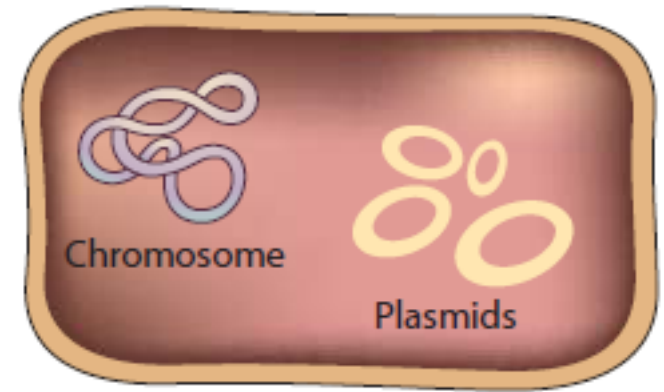
WHAT ARE BACTERIA?

Microscopic prokaryotes with a cell membrane, rigid cell wall and one or more flagella

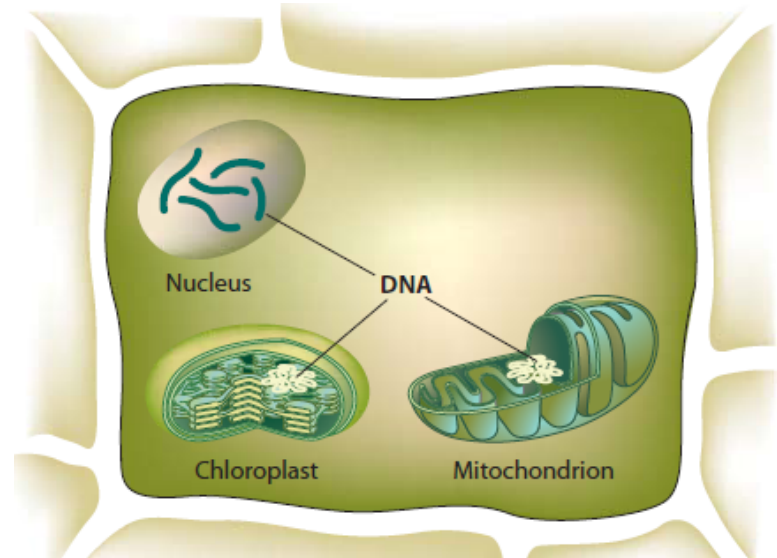


Bacteria

- prokaryotic
- single-celled
- Genetic material single stranded.
- No true nucleus
- Some have plasmids (small gene carrying entities)



↓ Unlike



Plant Pathogenic Bacteria cont...

➤ Some have Flagella

e.g most *Pseudomonas sp*
▪ monotrichous

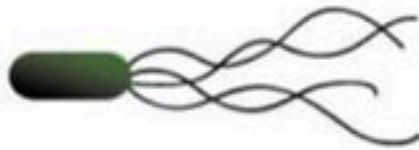


e.g *Erwinia sp*
▪ peritrichous

Types of Flagellar Arrangement



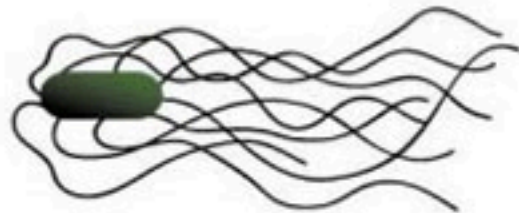
Polar/ Monotrichous – single flagellum at one pole



Lophotrichous – tuft of flagella at one pole



Amphitrichous – flagella at both poles



Peritrichous – flagella all over



Amphiloophotrichous – tuft of flagella at both ends

4 Classes of Bacteria (shape)

1. Coccus (spherical)

2. Bacillus (rod shaped)

- Most plant pathogenic bacteria: e.g. *Pseudomonas syringae*, *Xanthomonas campestris* (black rot in crucifers), *Erwinia amylovora* (fire blight of apples)... e.t.c

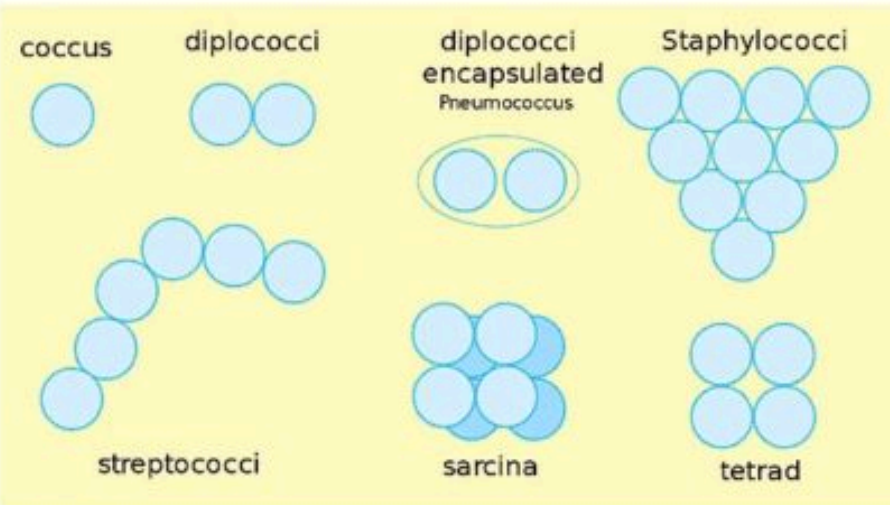
3. Spirochetes (spiral shape)

4. Filamentous (thread-like, filiform)

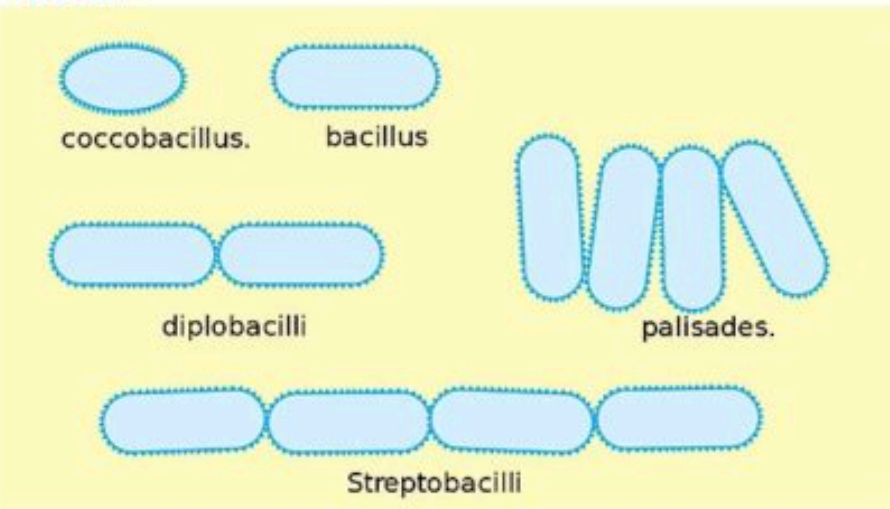
- *Streptomyces scabies* (potato scab), *S. ipomoeae* (Soft rot of???)

Bacteria: Shape

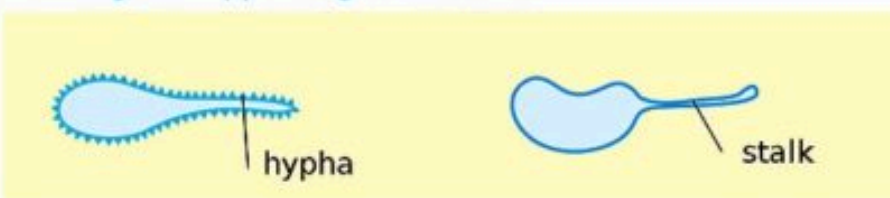
Cocci



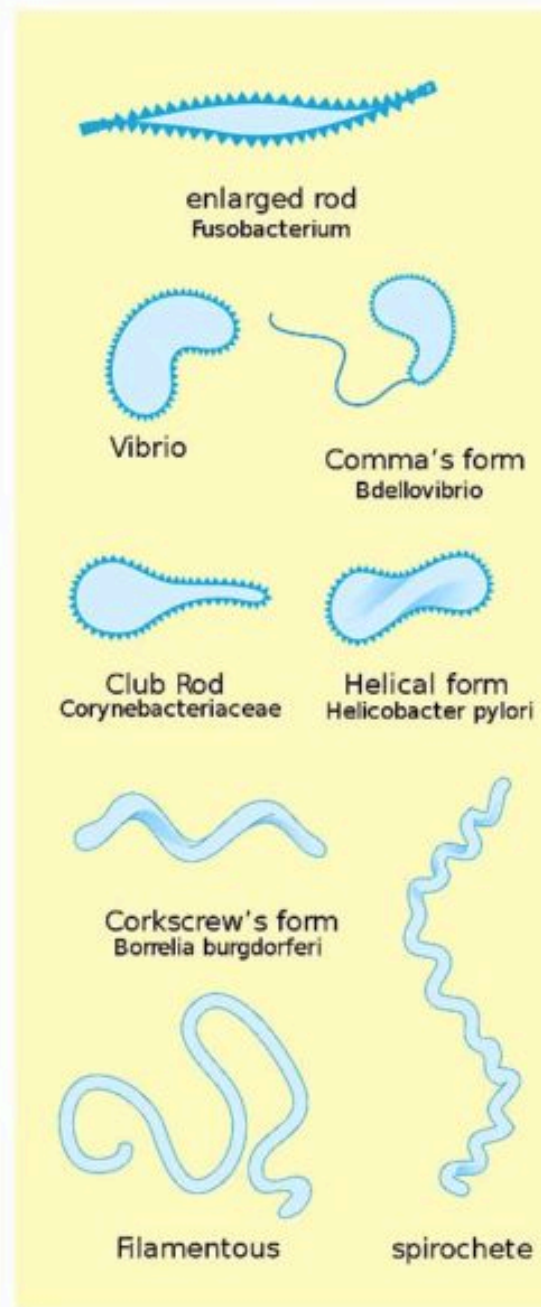
Bacilli



Budding and appendaged bacteria



Others



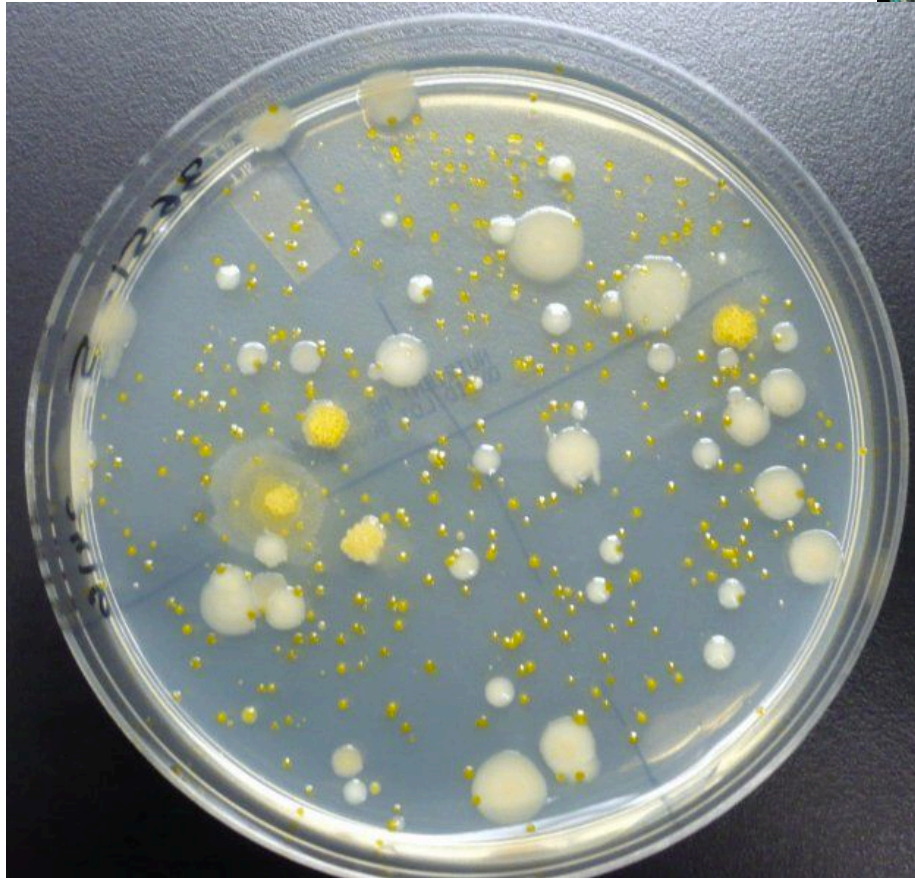
Bacteria vs Fungi – Colony morphology

Fungal colonies

Bacterial colonies



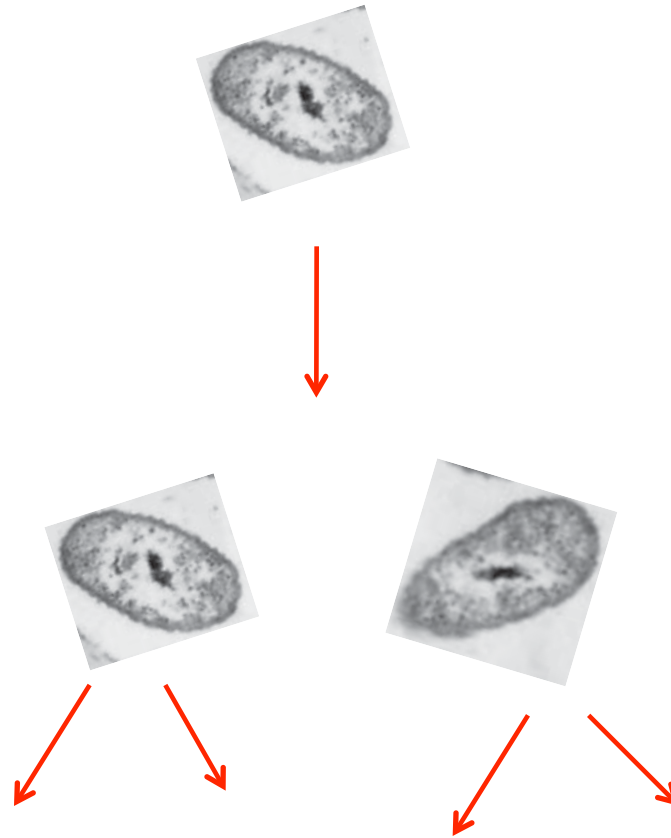
Bacteria vs Fungi – Colony morphology



Bacteria cont...

- Nitrogen fixation
 - *Rhizobium spp. and Cyanobacteria spp.*
- Aerobic and other are facultative anaerobic (can grow with or without oxygen).
- Gram positive vs gram negative bacteria (ability to retain “gram’s stain” in wall)

Bacteria Reproduction



- Reproduce by binary fission (20 minutes, 1 million < 24hrs, conducive environment)

Survival, Dissemination & infection of Bacteria

- Knowledge on this is crucial for mgt of bacterial diseases:
 - ✓ Survive in the plant, on the surface, in debris or in the soil as saprophytes.
 - ✓ Survive on inanimate surfaces, in water, inside insects
 - ✓ Transmission: Air, insects, water, soil movement, humans, swimming (flagella).

Survival, Dissemination & infection cont..

- Wounds facilitate infection
 - ✓ (weeding, irrigation, pruning)
- Once inside:
 - Enzymes that degrade cell walls
 - Growth regulators that alter the plants normal growth, toxins that degrade cell membranes and
 - Complex sugars that plug water conducting tissue.

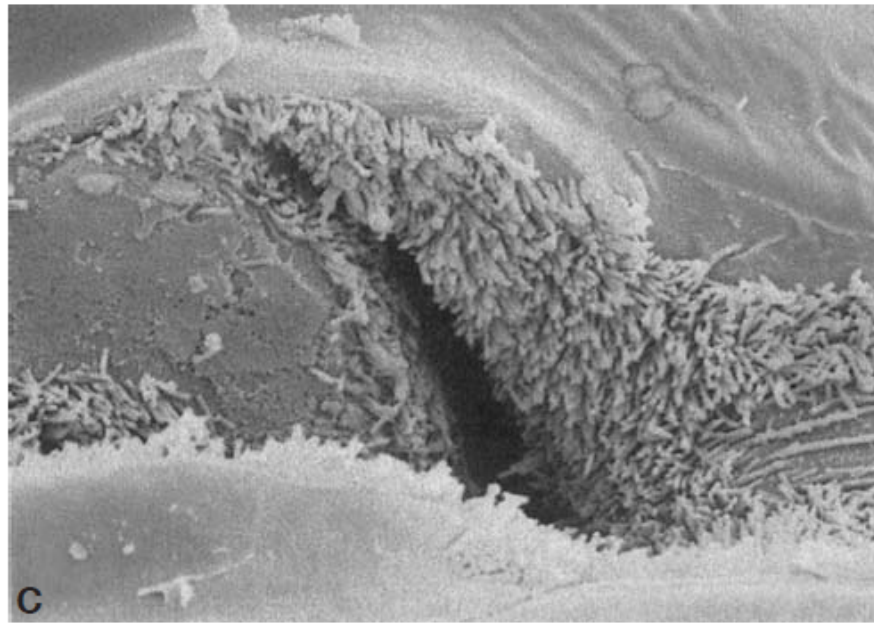
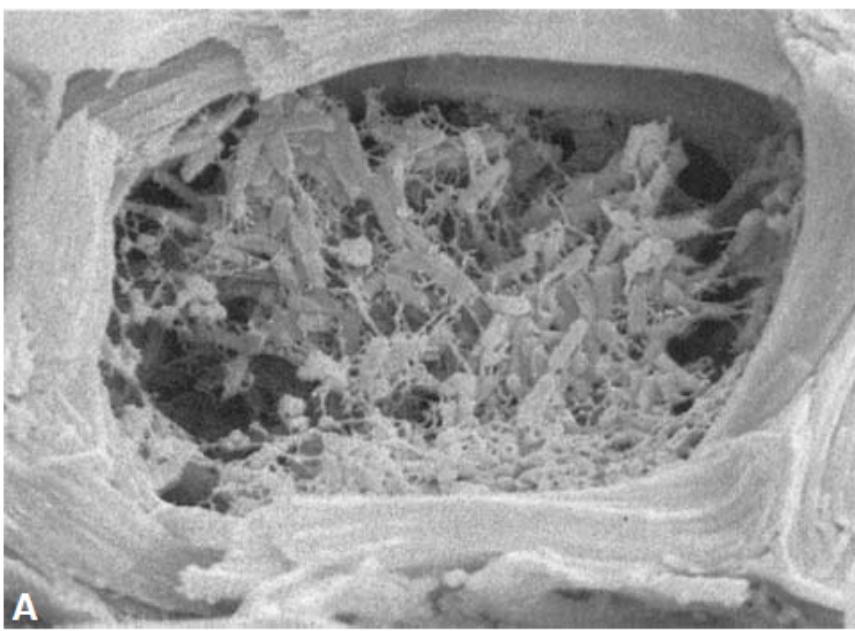


FIGURE 12-47 (A) *Xylella* bacteria exhibiting numerous thread-like connections in xylem vessel of coffee plant. (B) *Xylella* bacteria clogging a xylem vessel of a grape leaf. (C) *Xylella* bacteria in a tissue of its sharpshooter insect vector. Photos courtesy E. Alves, Federal Univ. Lavras, Brazil

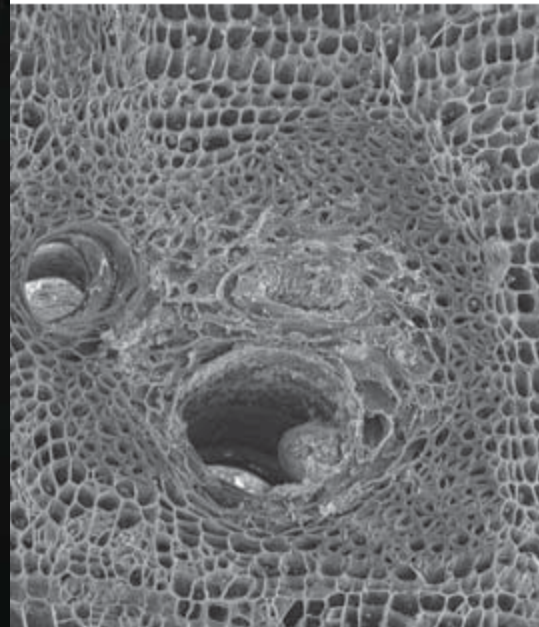
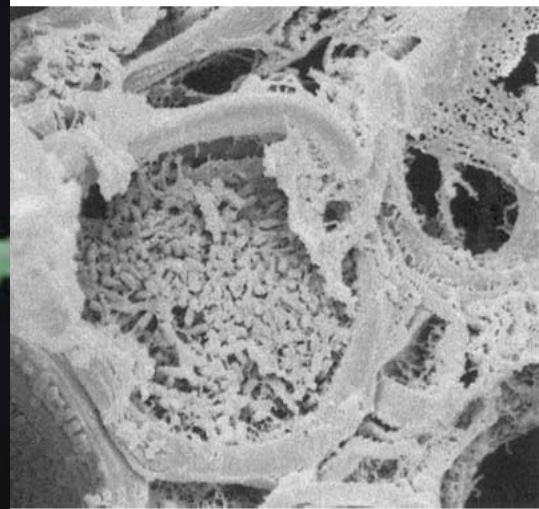
Diagnostics Symptoms of Bacterial Infections

- Leaf spots (with yellow hallow....vs fungi?)
- Rots (wet.....vs fungi?)
- Blights....(fungi vs bacteria???)
- Wilts
- Scabs
- Cankers and soft rots of roots, storage organs and fruit
- Overgrowth/galls

Diagnosics Symptoms of Bacterial Infections



Wilting & discoloration of vascular tissue



Bacterial wilt of cucurbits caused by *Erwinia tracheiphila*.



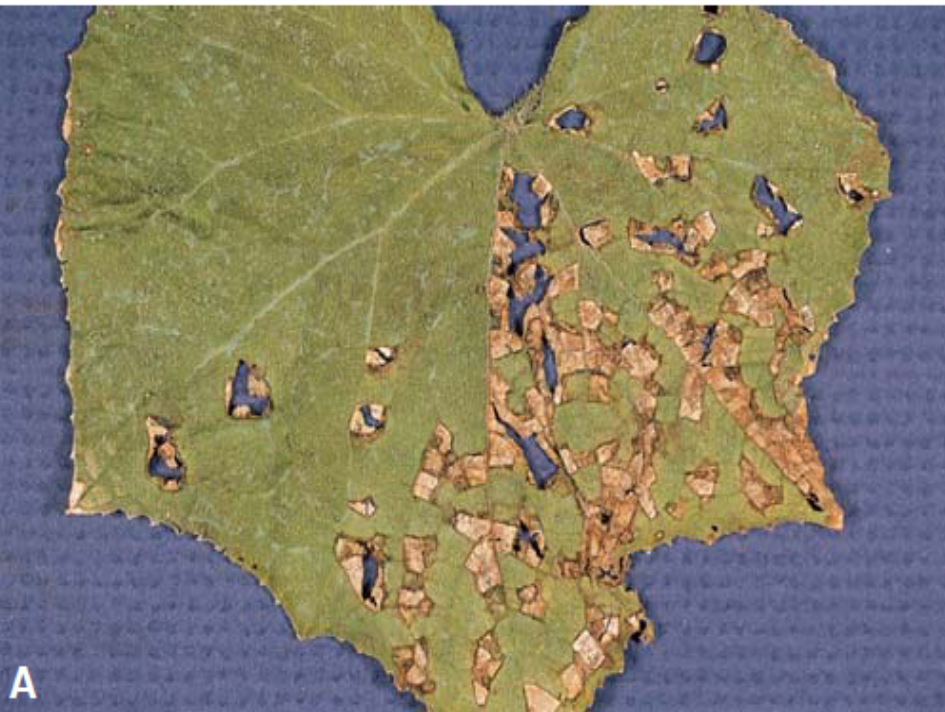
Halo surrounding lesion/leaf spot on leaf of plant-fungi usually no yellow hallow



Bean common blight
caused by the
bacterium
Xanthomonas
phaseoli

Bean halo blight
caused by bacterium
Pseudomonas
phaseolicola.





Angular leaf spots on cucumber leaf (A) and small **circular spots** with halo on cucumber fruit (B) caused by the bacterium *Pseudomonas lacrymans*.



Angular spots and necrotic veins on cotton leaves (A) and sunken circular spots on cotton bolls (B) caused by the cotton blight bacterium *Xanthomonas campestris* pv. *malvacearum*.

Bacterial spot
on tomato

caused by
Xanthomonas
campestris pv.
vesicatoria.

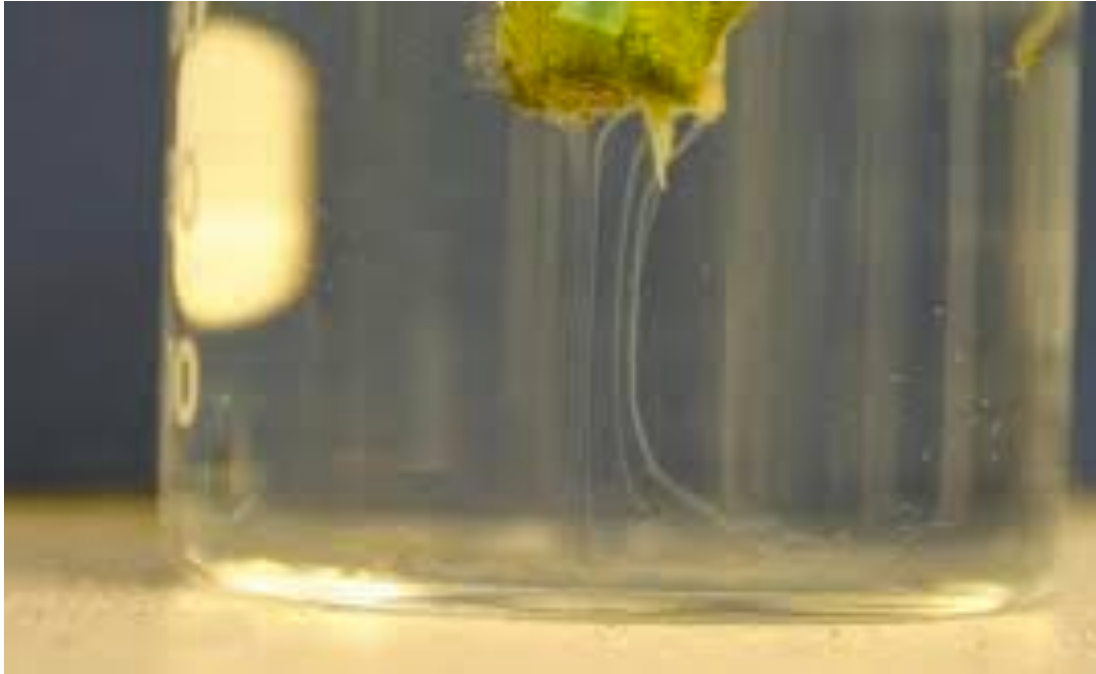


Bacterial speck
on tomato

caused by
Pseudomonas
syringae pv.
tomato.



OOZE TEST FOR BACTERIA



MANAGEMENT OF BACTERIAL DISEASES

1. Genetic host resistance

- ✓ resistant varieties (most important control measure)

2. Cultural Practices

- ✓ Bacteria-free planting material
- ✓ Sanitation (tools)
- ✓ Crop rotation
- ✓ Prevent surface wounding

MANAGEMENT OF BACTERIAL DISEASES cont...

3. Chemical applications (Bactericides)

- ✓ copper-containing compounds or Bordeaux mixture (copper sulfate and lime)

- ✓ Antibiotics
 - Streptomycin and/or oxytetracycline (prior to infection)

 - Tetracycline

- ✓ Applications to be made in the early stages of infection

- ✓ Eliminate vectors or reduce feeding wounds that can provide points of entry.

MANAGEMENT OF BACTERIAL DISEASES cont...

4. Biological control

- ✓ Antagonistic or biological control products

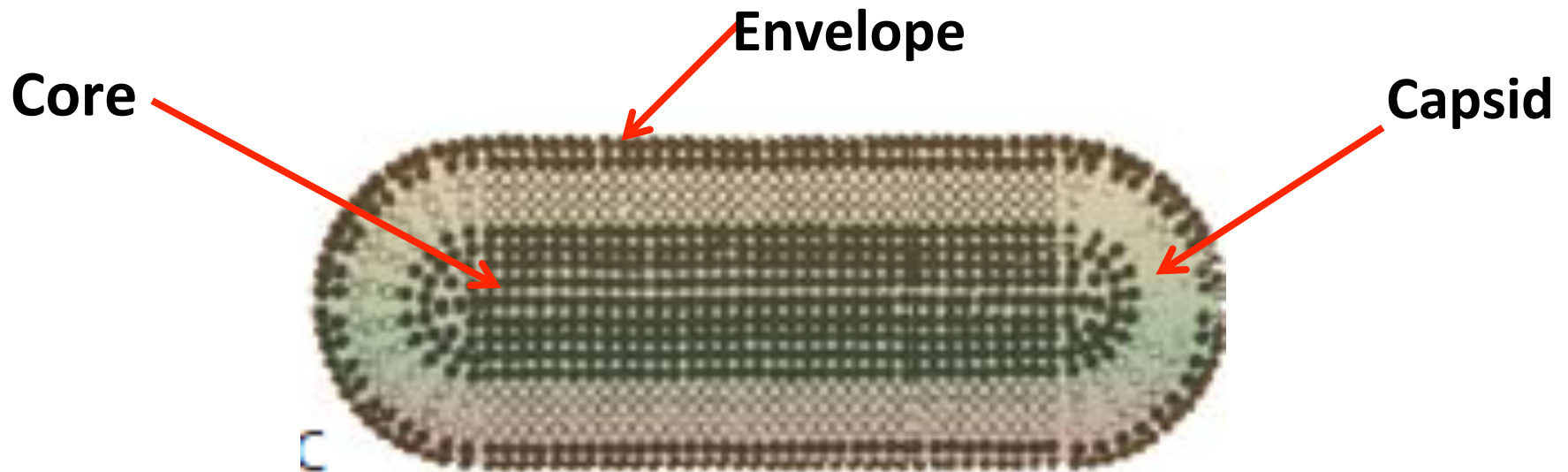
5. Exclusion

- ✓ Strict quarantine that exclude or restrict the introduction or movement of pathogens or infected plant material.

PLANT VIRUSES

Definition: A virus is a set of one or more nucleic acid template molecules, normally encased in a protective coat or coats of protein or lipoproteins, that is able to organize its own replication only within suitable host cells.

Virus: A **nucleoprotein** that multiplies only in living cells (obligate parasites) and has the ability to cause disease



VIRAL STRUCTURE

CORE

- ✓ DNA or RNA
- ✓ Contains genetic information
- ✓ Mostly RNA, except Cauliflower mosaic virus

CAPSID

- ✓ Outer protein coat
- ✓ Functions
 - Protects core
 - Shape of the virus
 - Attachment to host cell membrane

VIRAL STRUCTURE cont...

ENVELOPE

- ✓ Membrane around capsid (for enveloped viruses)
 - Virus without envelope-naked virus

- ✓ Bilayer of phospholipids and proteins, derived from host cell membrane

- ✓ Functions
 - Protection from drying (enhances transmission)
 - Attachment to host cell membrane (by means of spikes)
 - Makes virus more susceptible to chemicals that dissolve lipids

CLASSIFICATION OF VIRUSES

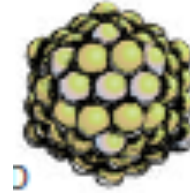
A combination of characters are used, some of the most important include:

1. Particle morphology
2. Genome properties
3. Biological properties
4. Serological properties

1. Particle morphology

Shape and size of particles as seen under the microscope.

1. Isometric



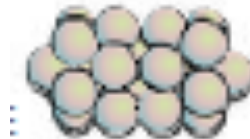
2. Rod-shaped



3. Filamentous



4. Geminate



5. Bacilliform



2. Genome properties

1. Nature of genome (ssDNA, dsDNA, ssRNA, dsRNA,)

3. Biological properties

Type of host

Mode of transmission (aphids, mites, whiteflies)

4. Serological properties

1. Relatedness of protein

SYMPTOMS OF VIRAL INFECTION IN PLANTS

Mainly mimic genetic abnormalities

1. Vein banding
2. Mosaic
3. Yellows
4. Flecking or spotting on foliage
5. Distortions
6. Abnormal growth and death

Mosaics on tobacco leaves caused by Tobacco mosaic virus

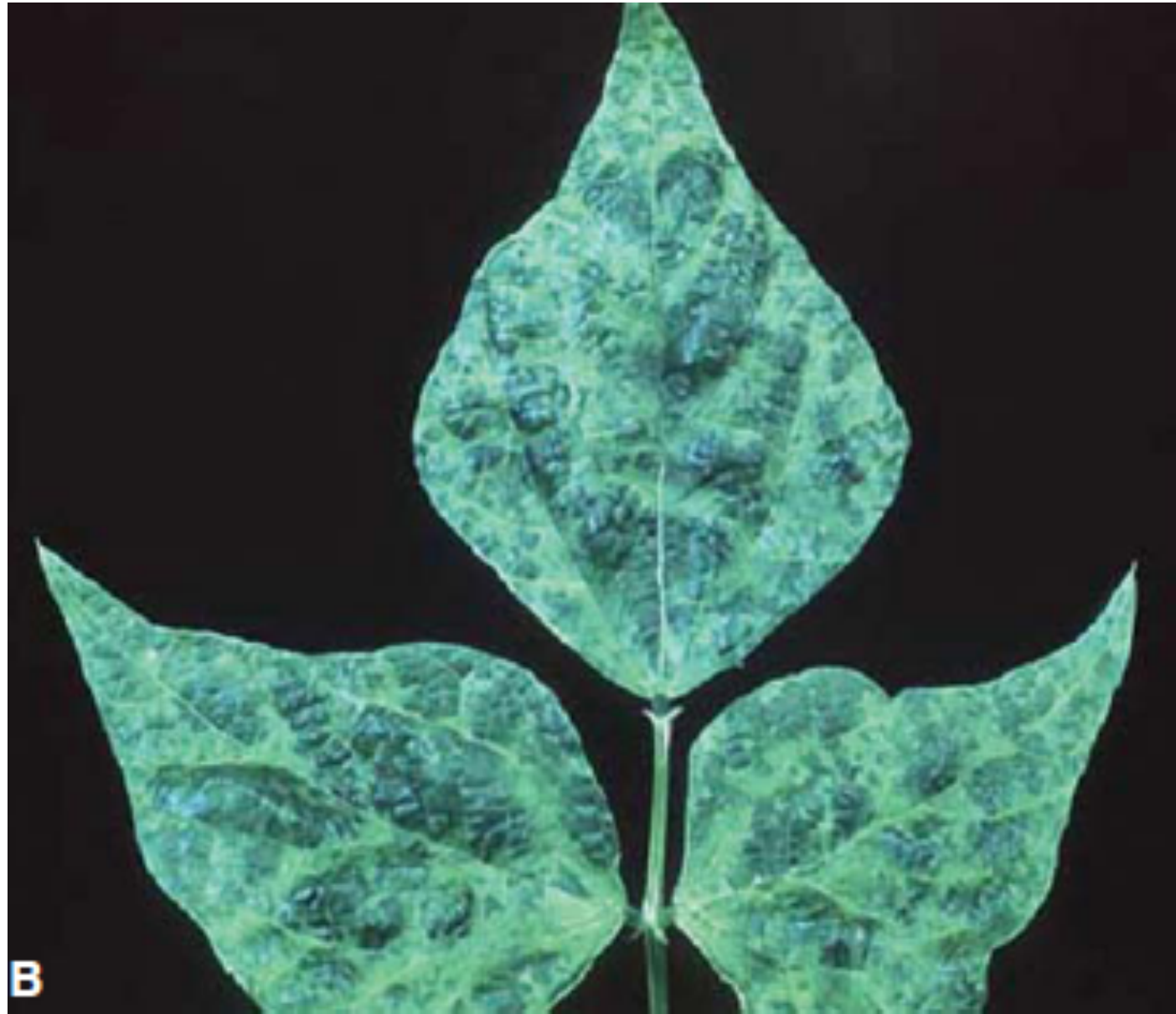


Papaya ringspots
caused by
P a p a y a
ringspot virus





Mosaics
caused
by Bean
common
mosaic
virus





Malformation and mosaics formed by Watermelon mosaic virus

Maize streak
caused by
Maize streak
virus



Banana bunchy top disease - by banana bunchy top virus



HOW TO IDENTIFY A PLANT VIRUS

- Quick leaf-dip
- Routine screening
- Test plants
- DNA/PCR-based approaches

TRANSMISSION OF PLANT VIRUSES

Understanding the mode of transmission helps us in the control of the viruses

1. Vertical transmission

2. Horizontal transmission

- Insects, Nematodes, Humans, Mechanical means, Seed

MANAGEMENT OF PLANT VIRUSES

- Curing virus-infected plants is difficult/impossible
 - On small-scale: Chemotherapy, Thermotherapy, and Meristem-tip culture has been successful but not on large-scale.

- In general: prevent, delay viral infection or ameliorate its effects:
 - Phytosanitation (quarantine, eradication, crop hygiene, virus free planting material)
 - Pesticides to control vectors
 - Mild strain protection

- Singly or in combination

Cassava brown streak disease



Vein chlorosis and streak symptoms on leaves and stems and necrosis of storage roots



Cassava brown streak disease



- Streak symptoms on root: constriction at multiple point and **rots (only virus known to cause rots in plants)**
- Transmitted by infected stem cuttings and also by whiteflies

Maize lethal necrosis disease (MLN)



- Yellowing, **necrosis** and drying
- Transmitted by leaf hoppers
- **Combination of 2 viruses:** Maize Chlorotic Mottle and Sugarcane Mosaic Virus (SCMV)



**MAIZE LETHAL NECROSIS DISEASE (MLN) AND
CASSAVA BROWNSTREAK DISEASES ARE THE
ONES KNOWN TO CAUSE DEATH TO PLANT
TISSUE**

**TOMATO BUSHY STUNT VIRUS IS THE ONLY VIRUS
KNOWN TO CAUSE STUNTING**

NEMATODES

NEMATODES

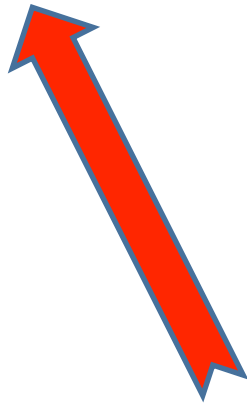
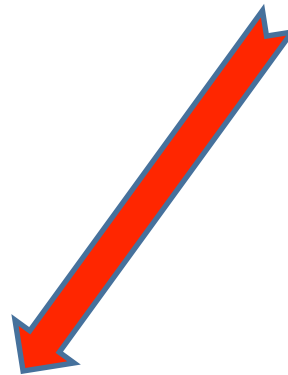
- Generally microscopic, worm-like animals that live saprophytically in water or soil, or as parasites of plants and animals.



Egg

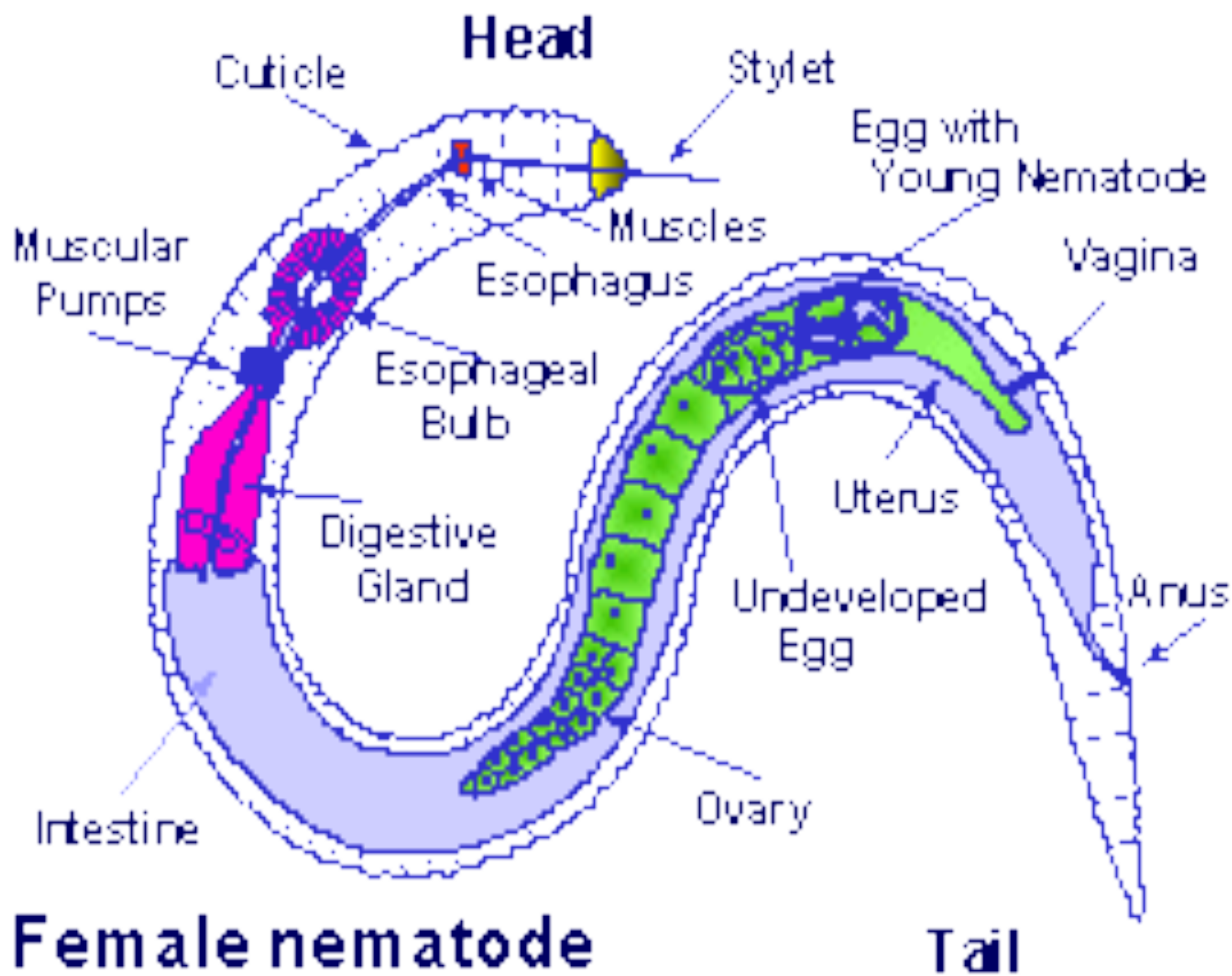


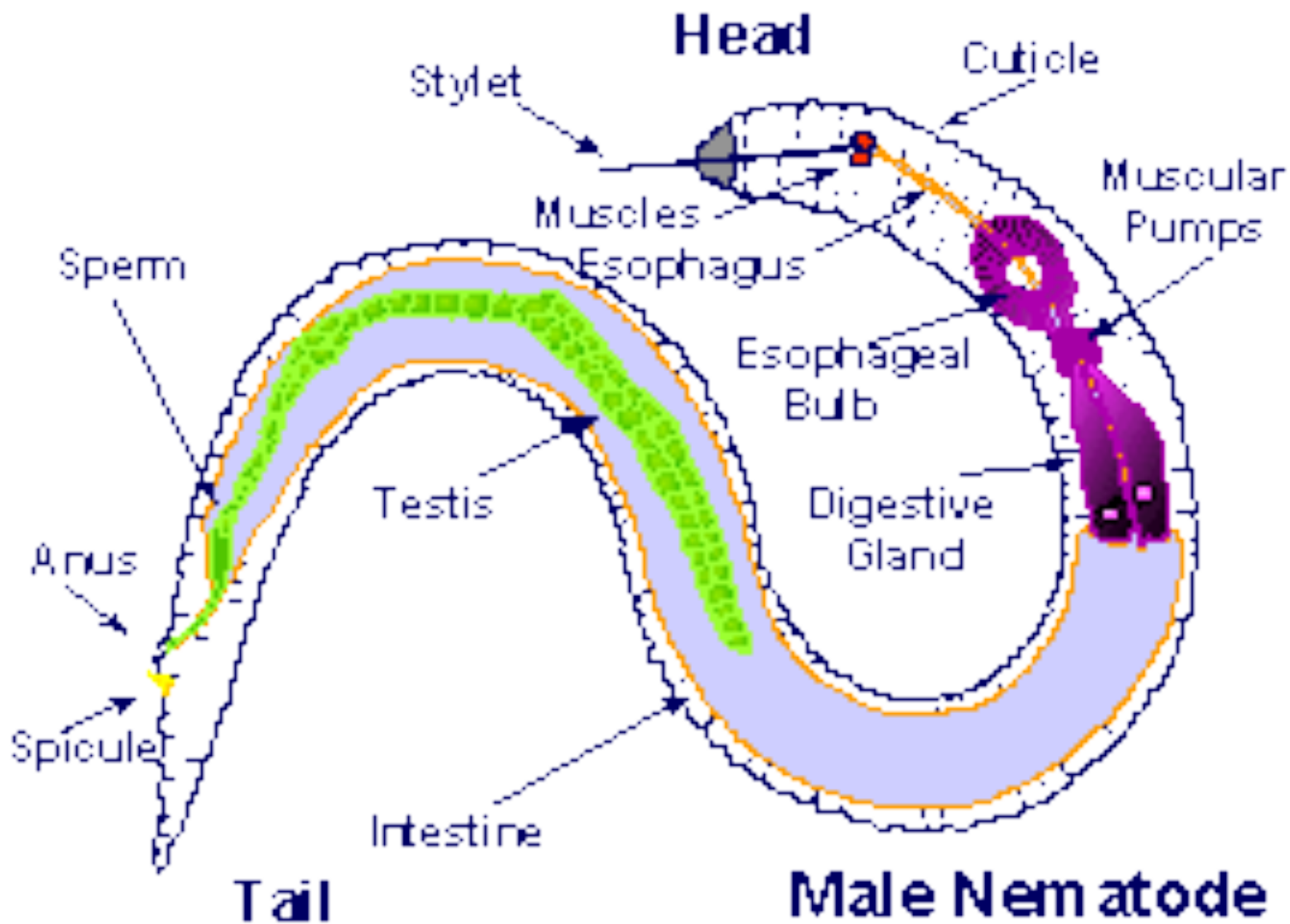
Juvenile

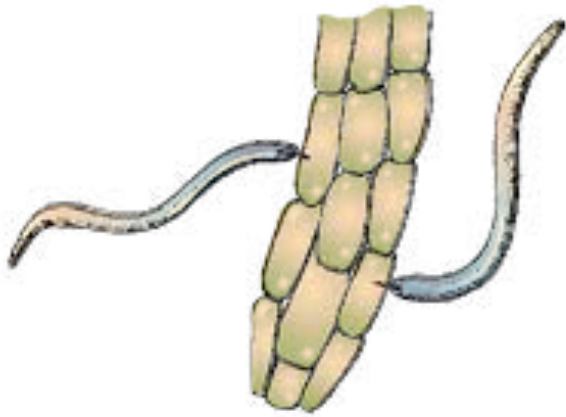


Adults

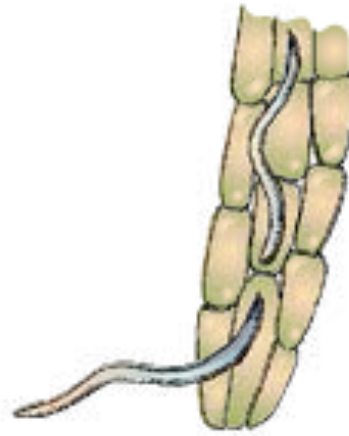




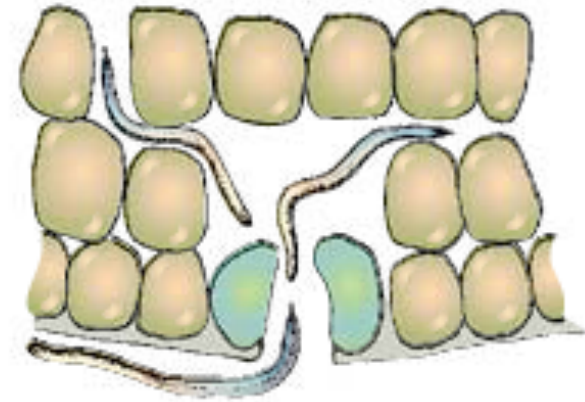




Direct penetration
Ectoparasitic nematode



Direct penetration
Endoparasitic nematode



Penetration through stoma
Endoparasitic nematode

FIGURE 2-10 Methods of penetration and invasion by nematodes.

- Nematodes secrete a saliva which contains enzymes & toxins

FORAGING/FEEDING HABIT:

- ◆ Ectoparasites
- ◆ Endoparasites
 - ◆ Sedentary endoparasites
 - ◆ Migratory endoparasites (more damaging)
- ◆ Root knot nematodes (Galls, polyphagous)
- ◆ Cyst nematodes (specific, narrow host range)
- ◆ Stem and bulb nematodes
- ◆ Other Symptoms: patchy growth/stand
- ◆ On their own, they cannot go beyond 1m, biggest dissemination is by human activity

MAJOR GROUPS OF NEMATODES

- Root knot nematodes (Genus: *Meloidogyne sp*)
- Cyst nematodes (Genera: *Heterodera* and *Globodera*)
- Burrowing nematode-Burrowing nematode disease (*Radopholus*)
- Lesion nematodes-Lesion nematode disease (*Pratylenchus sp*)
- Citrus nematode (*Tylenchulus semipenetrans*)
- Stem and bulb nematode (*Ditylenchus*)
- Pine wilt disease
- Sting nematode (*Belonolaimus*)

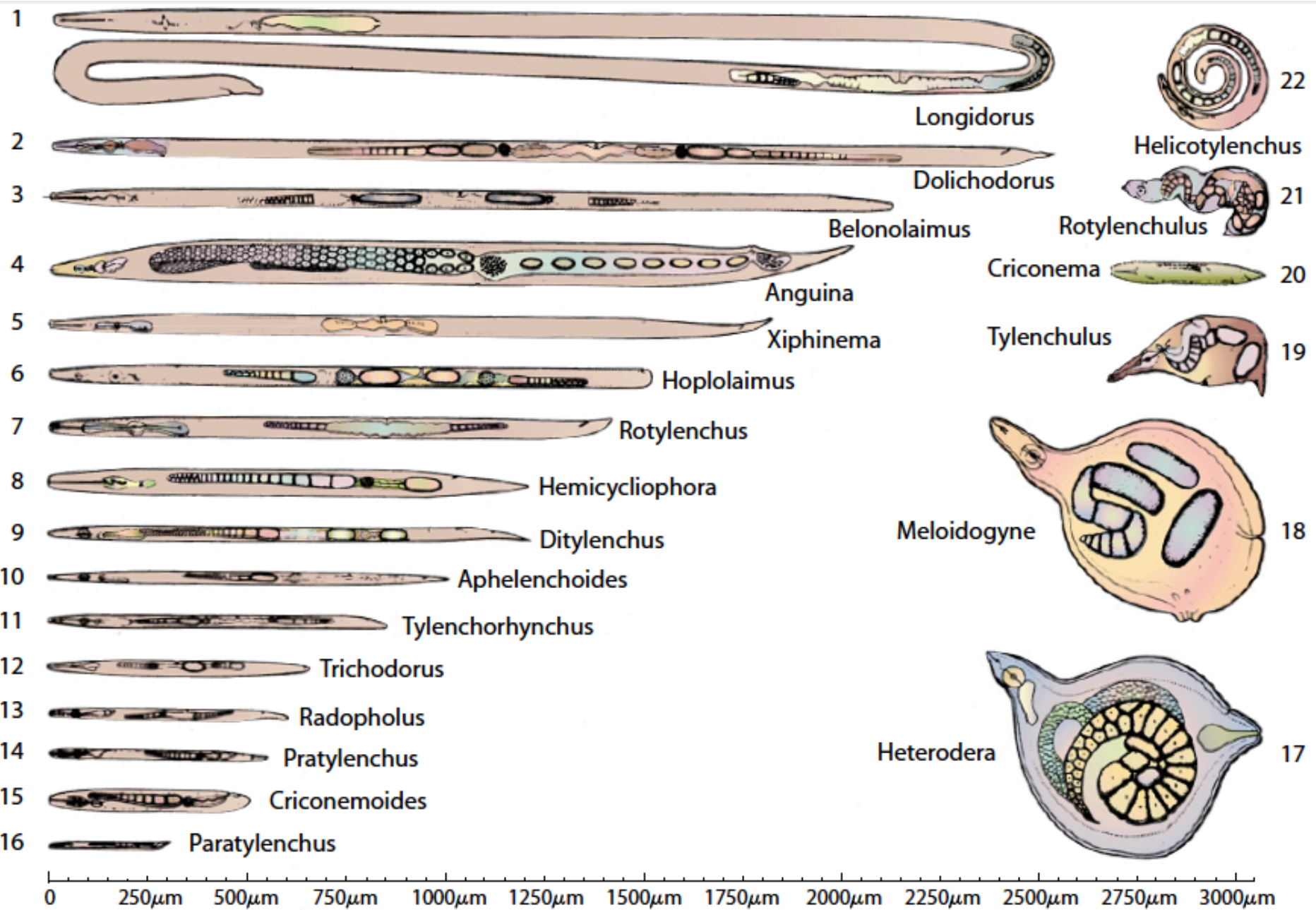
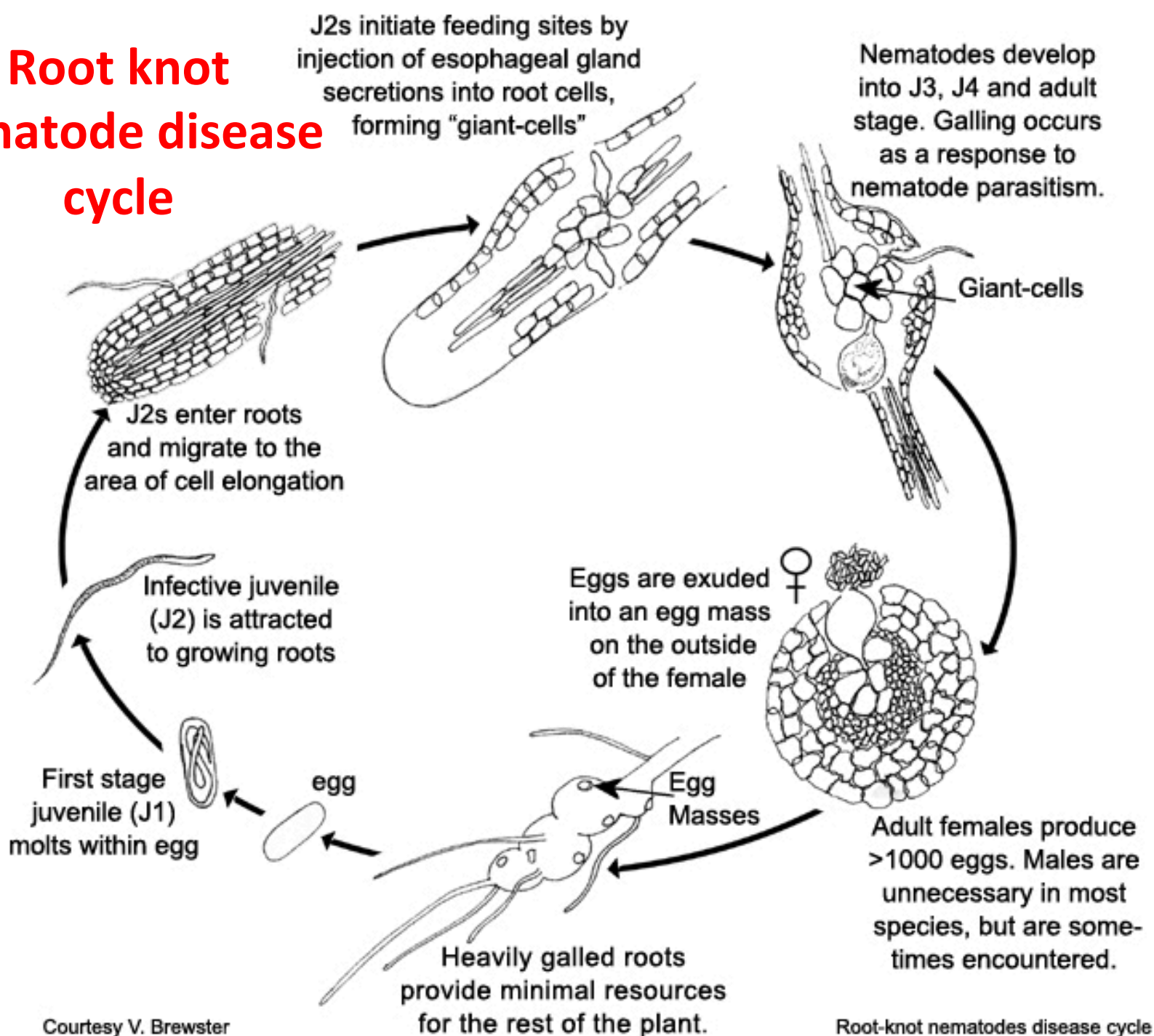
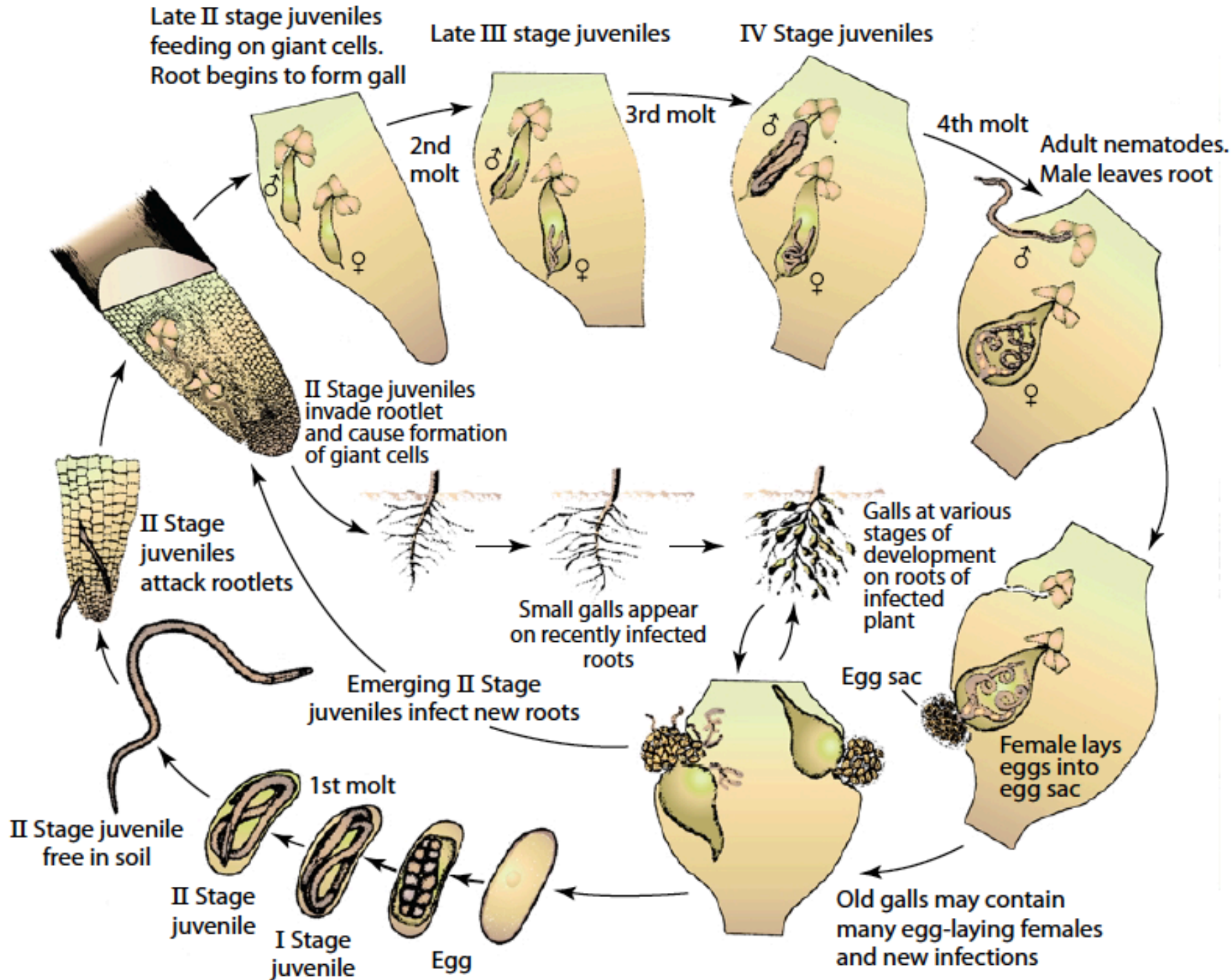


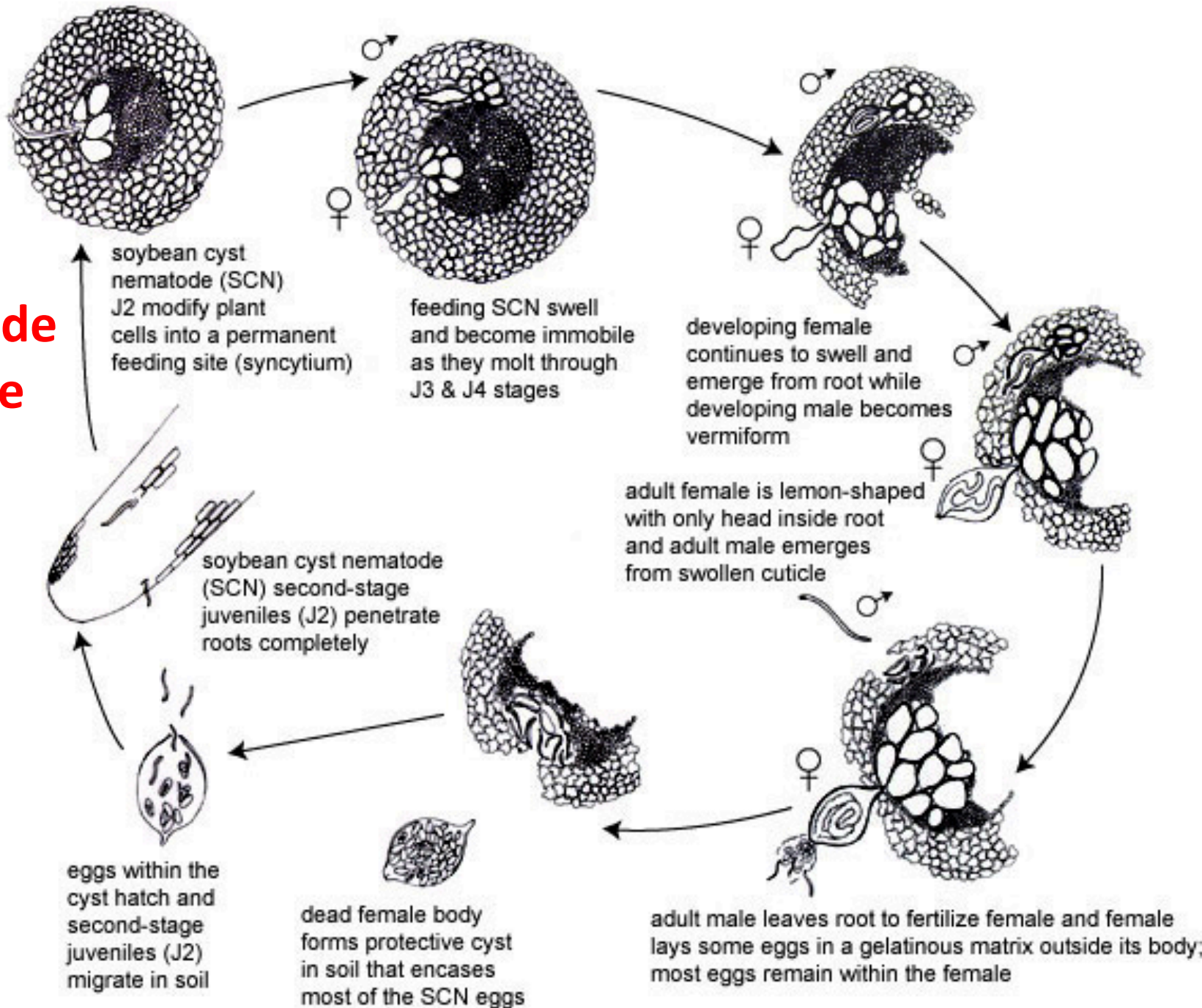
FIGURE 15-3 Morphology and related sizes of some of the most important plant parasitic nematodes.

Root knot nematode disease cycle





Cyst nematode disease cycle



Nematode Reproduction

1. All nematodes produce eggs. Therefore, all reproduction is sexual. Eggs develop into juveniles (one per egg) that hatch from the egg and develop into adults.
2. Most nematodes are **oviparous**. Eggs develop outside the female body.
3. Very few nematodes are **viviparous**. Eggs -- without an obvious egg shell -- complete development inside the uterus and functional juveniles emerge from the female.

Nematode Reproduction

- **Amphimixis:** Male and female gametes produced in separate individuals. Copulation required. (Most common form of reproduction)
- **Hermaphroditism:** Male and female gametes produced in same individual. Copulation not required, but may also occur. (*C. elegans*)
- **Parthenogenesis:** Only female gametes produced. May be either mitotic (no reduction division) or meiotic in which the diploid condition is restored by fusion of the egg pronucleus with a polar body nucleus. (Most *Meloidogyne* species)
- **Pseudogamy:** A type of parthogenesis or hermaphroditism in which a sperm penetrates the oocyte and activates further development of the ovum but then degenerates and does not enter into the formation of a zygote. (Some *Meloidogyne* species)

Symptoms Induced by Plant-Parasitic Nematodes

Above Ground – very non-specific

- Reduced yield
- Stunting
- Wilting
- Chlorosis
- Lesions
- Galls

Symptoms (above and below ground) often are mistaken for damage from compaction, iron deficiency chlorosis and other nutrient deficiencies, drought stress, herbicide injury, or other plant diseases. Symptoms may be masked by the presence of secondary organisms that follow the nematodes

Symptoms Induced by Plant-Parasitic Nematodes

Below Ground

- Reduced root system
- Stubby Roots & “Witches Broom”
- Lesions
- Galls
- Rotting (when secondaries are present)

SYMPTOMS

- Often non-specific (depends on species)
 - ✓ Stunting
 - ✓ Poor growth
 - ✓ Wilting
 - ✓ Distortion
- Nematodes secrete a saliva which contains enzymes & toxins
- Damage is done to the host by removal of nutrients & by the deleterious effects of the components of the saliva

Root galls on bean plant infected with the root-knot nematode *Meloidogyne* sp.



Root galls: tomato, carrot, potato (*Meloidogyne* sp.)



Soyabean Cyst nematode damage



Nematode damage in maize



MORE EXAMPLES OF NEMATODES

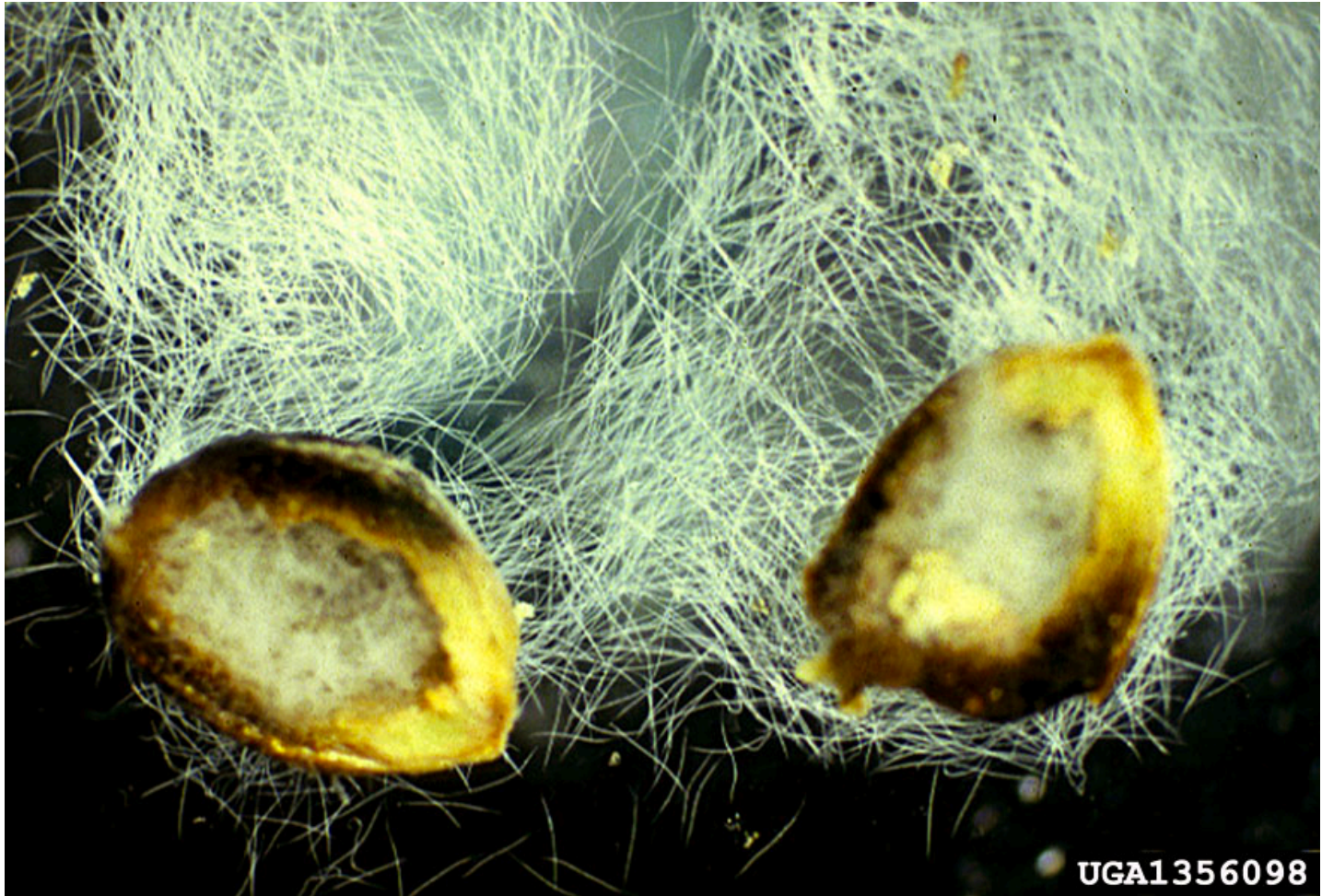
Anguina tritici (Seed gall nematode) – causes ear-cockle in wheat



Grain are replaced by cockles

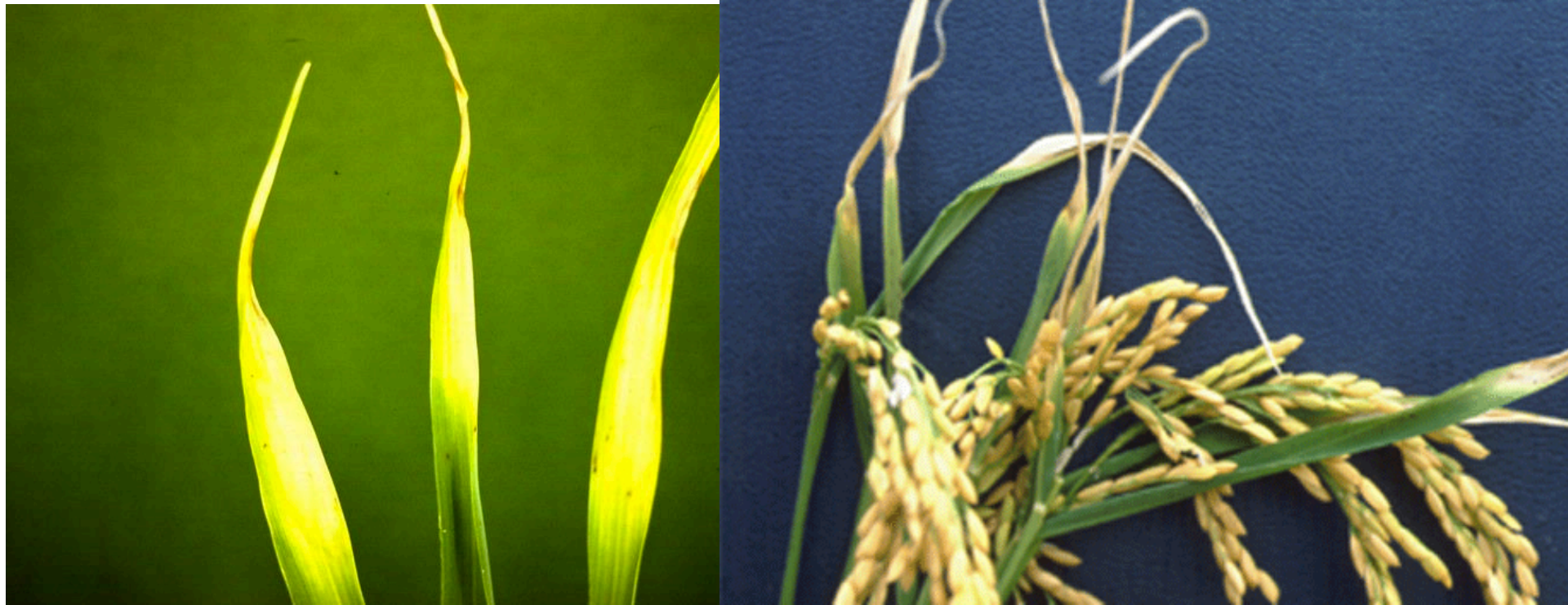
MORE EXAMPLES OF NEMATODES

Anguina tritici (Seed gall nematode) – causes ear-cockle in wheat



MORE EXAMPLES OF NEMATODES

Aphelenhoides besseyi (Rice white tip or spring dwarf nematode) – causes rice white tip disease



Physical, Biological, Cultural, and Chemical Control of Nematodes

Physical

- Heat
- Electrical
- Microwave
- Irradiation
- Flooding
- Osmotic

Biological

- Organisms
- Reasons for failure

Cultural

- Resistance
- Rotation
- Clean Culture
- Fallow
- Allelopathic Plants
- Legislative (Quarantines)

Chemical

- Chemicals
 - Fumigant
 - Non-Fumigant
- Application Methods and Equipment

Biological control of nematodes

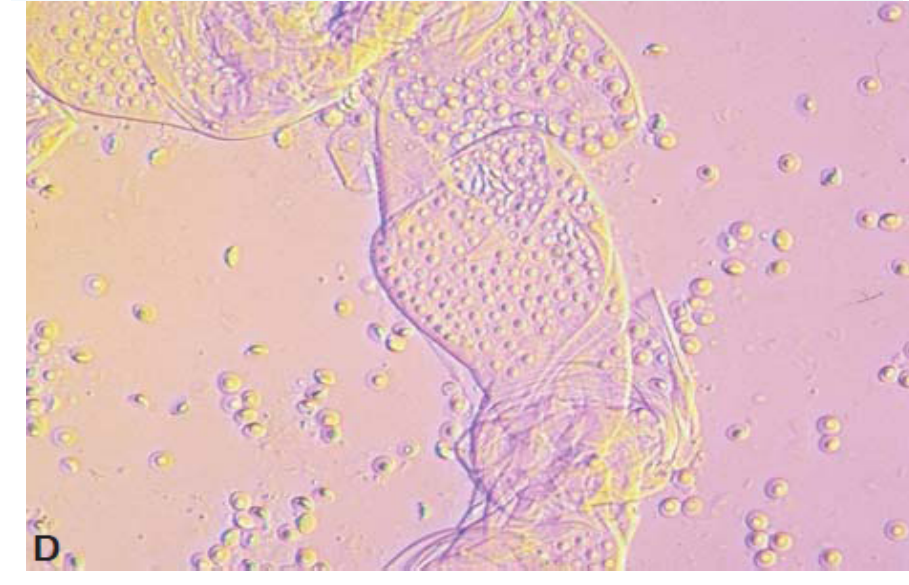
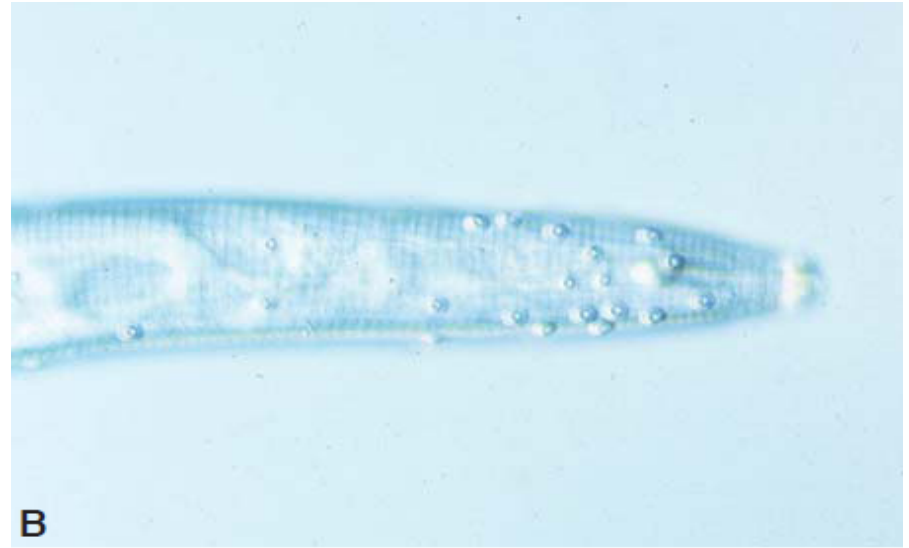
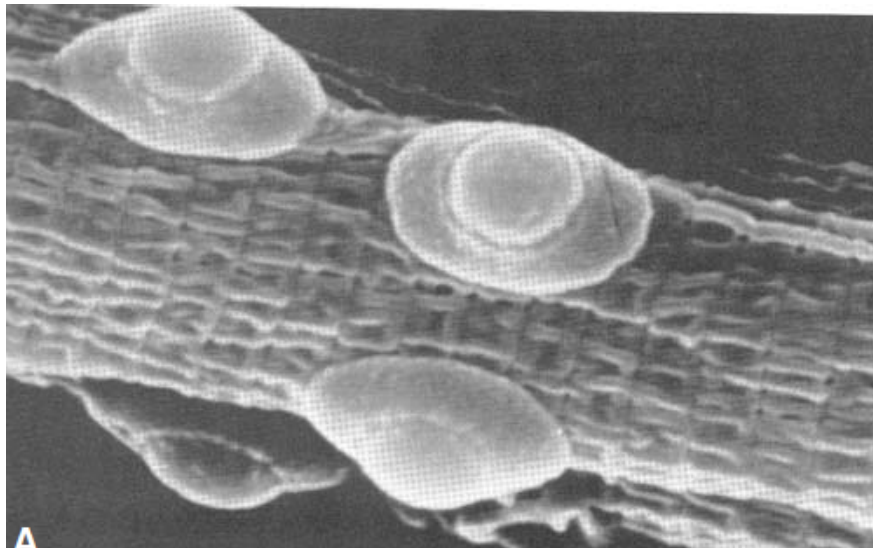


FIGURE 9-12 Biological control of nematodes. In (A, B, and C) *Meloidogyne* juveniles and (D) *Pratylenchus* sp. are attacked by the bacterium *Pasteuria penetrans* and in (E) a *Heterodera* cyst by the fungus *Verticillium lecanii*. [Photographs courtesy of (A) K. B. Nguyen, (B and D) R. M. Sayre, and (C and E) D. J. Chitwood.]

Solarisation



Cutworms vs Nematodes

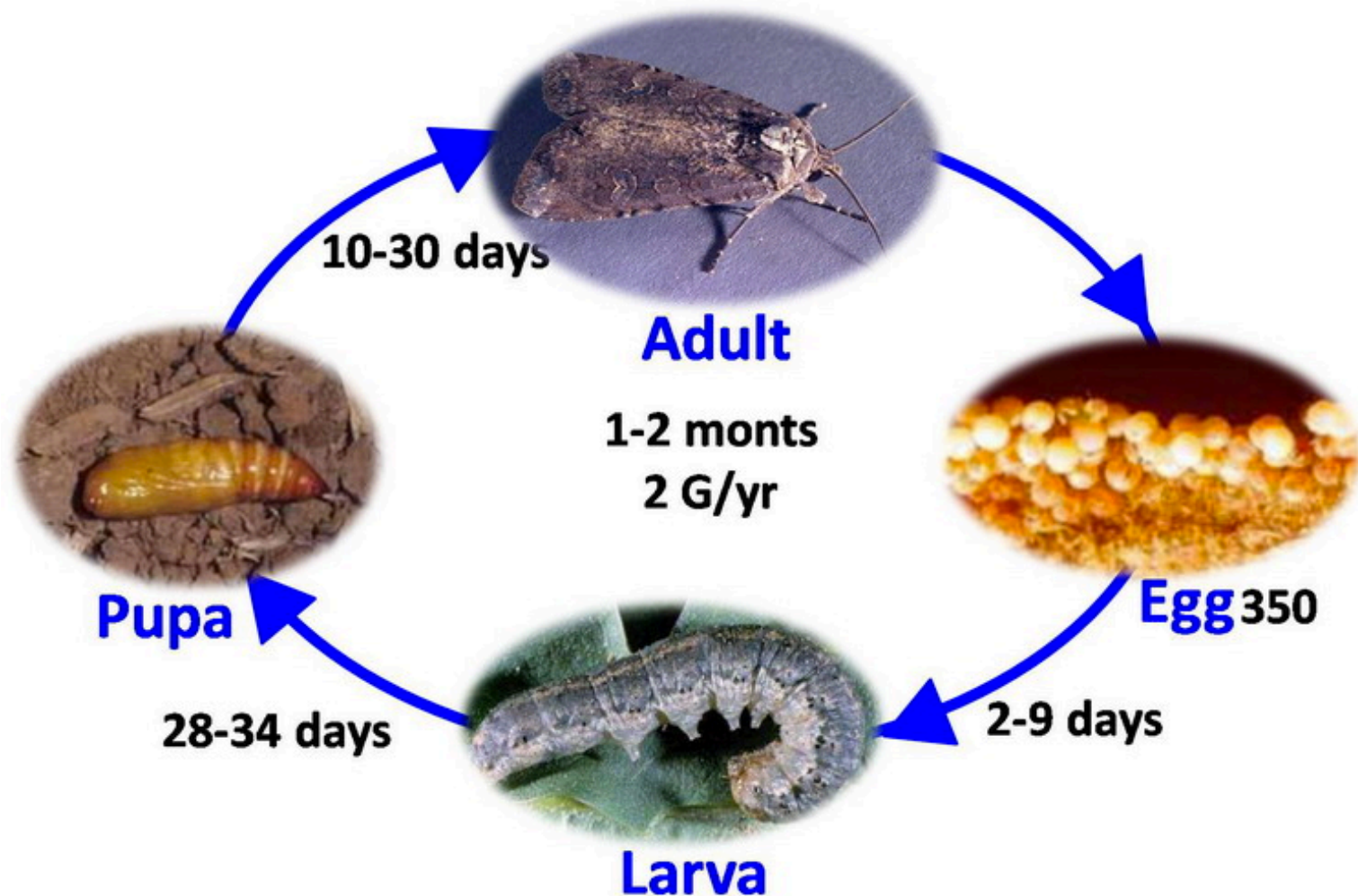


Fig. Life cycle of Potato Cut worm

NON INFECTIOUS DISORDERS

- Brought about by abnormal temperatures, light, atmosphere, disturbance of water relationship, nutritional imbalance, toxic action of pesticides or other applied chemicals, or by injury from such physical causes like lightning and wind
- No parasite involved
- Symptoms may be confused with pathogenic ones
- May make plants too weak to defend themselves against pathogens
- Remember what we discussed under diagnosis of abiotic causes of disease

NON INFECTIOUS DISORDERS cont...

- **Low Temperature effects (frost damage)**
- **High Temperature effects (wilting, death)**
- **Soil-moisture disturbance (waterlogging, wilting)**
- **Effects of Atmospheric pollution (burning at tips and/or leaf margins; twig dieback, early leaf drop)**
- **Lightning injury (physical damage)**
- **Nutritional disorder (deficiency)**
- **Effects of Toxic chemicals (e.g herbicide damage...)**

POST HARVEST DISEASES

Refers to diseases that develop during:

- ❖ harvesting, grading, packing, transportation of crop to market;
- ❖ storage at shipping points or market and;
- ❖ the various handling operations required to move the crop from the grower to the wholesale dealer, to the retail store, and finally , to the consumer.

POST HARVEST DISEASES CONT...

- ❖ Mostly fungal & bacterial
- ❖ Usually soft rots or dry rots
- ❖ Perishables (fruits & vegetables)



POSTHARVEST LOSSES DUE TO MYCOTOXINS – (USUALLY IN GRAIN)

- Mycotoxins: fungal metabolites contaminating crops, food/feed & animal products.
- Mycotoxigenic fungi widely existing in nature (*Aspergillus*, *Fusarium*, *Penicillium*, *Stenocarpella* e.t.c).
- Hazardous to human and animal health and trade
- Warm regions & poor storage result in frequent contamination events

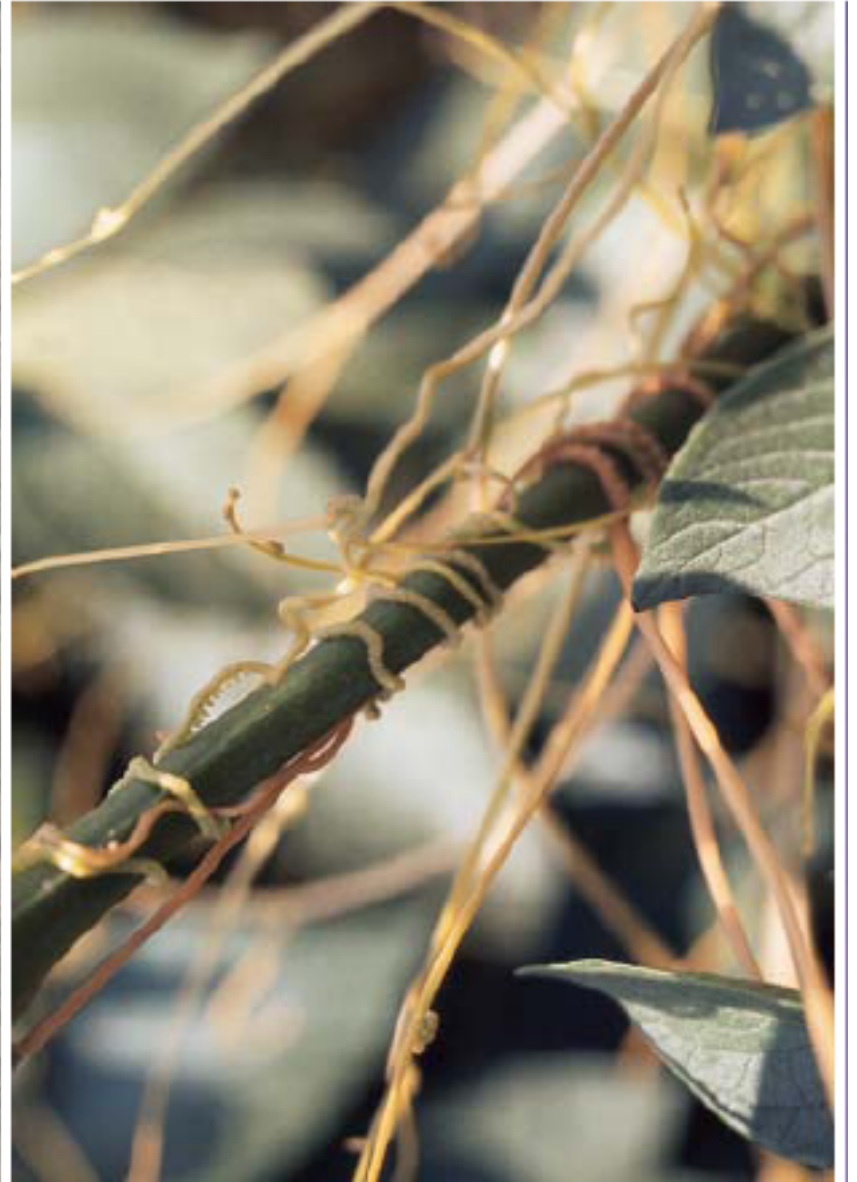


POSTHARVEST LOSSES DUE TO MYCOTOXINS

- They cause losses in that:
 1. Affect health of humans and livestock by contaminating food/feed
 2. Reduce growth rates of livestock, thereby making the ventures unprofitable
 3. Negatively affects trade, especially export of contaminated crops to sensitive markets that enforce regulations

| MYCOTOXIN | PRODUCER | EFFECTS ON HUMANS/ LIVESTOCK |
|--|---|--|
| Aflatoxins (B & G) | <i>Aspergillus flavus</i> & <i>Aspergillus parasiticus</i> | Rapid death, liver cancer, stunting, Immuno-suppression |
| Fumonisin (FB ₁ , FB ₂ , FB ₃) | <i>Fusarium verticillioides</i> | oesophageal cancer, neural tube defects |
| Deoxynivalenol | <i>Fusarium graminearum</i> | Reduced feed intake, susceptibility to bacterial infections. |
| Moniliformin | <i>Fusarium spp.</i> | Cardiotoxin |
| Ochratoxins | <i>Aspergillus spp.</i> & <i>Penicillium spp.</i> | Kidney cancer/damage |

PARASITIC HIGHER PLANTS



Common Dodder (*Cuscuta sp.*)- in sunflower & tomato



Witchweed

Striga asiatica – has red flowers

Striga hermonthica – has pink flowers

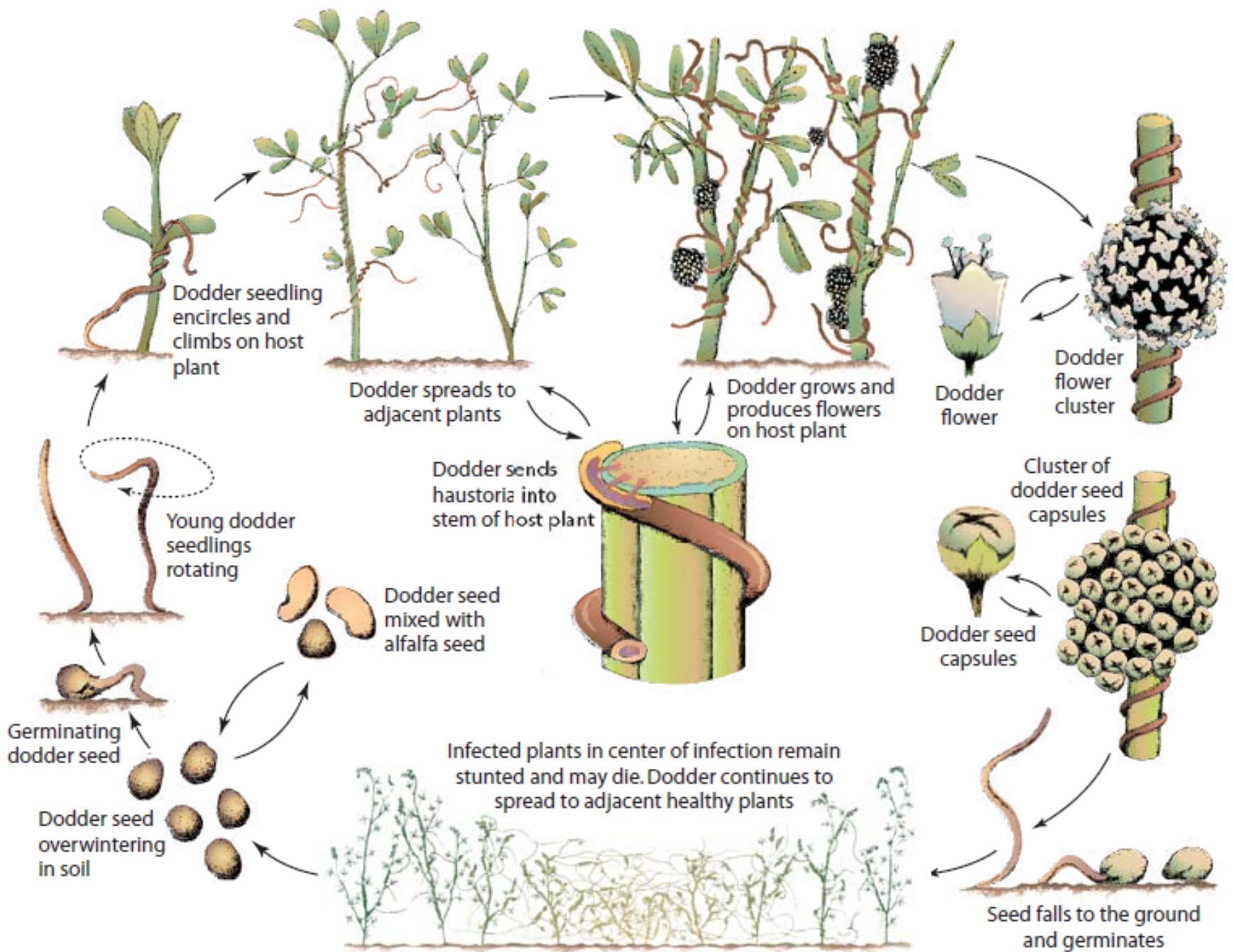


FIGURE 13-2 Disease cycle of dodder (*Cuscuta* sp.) on a plant such as alfalfa.

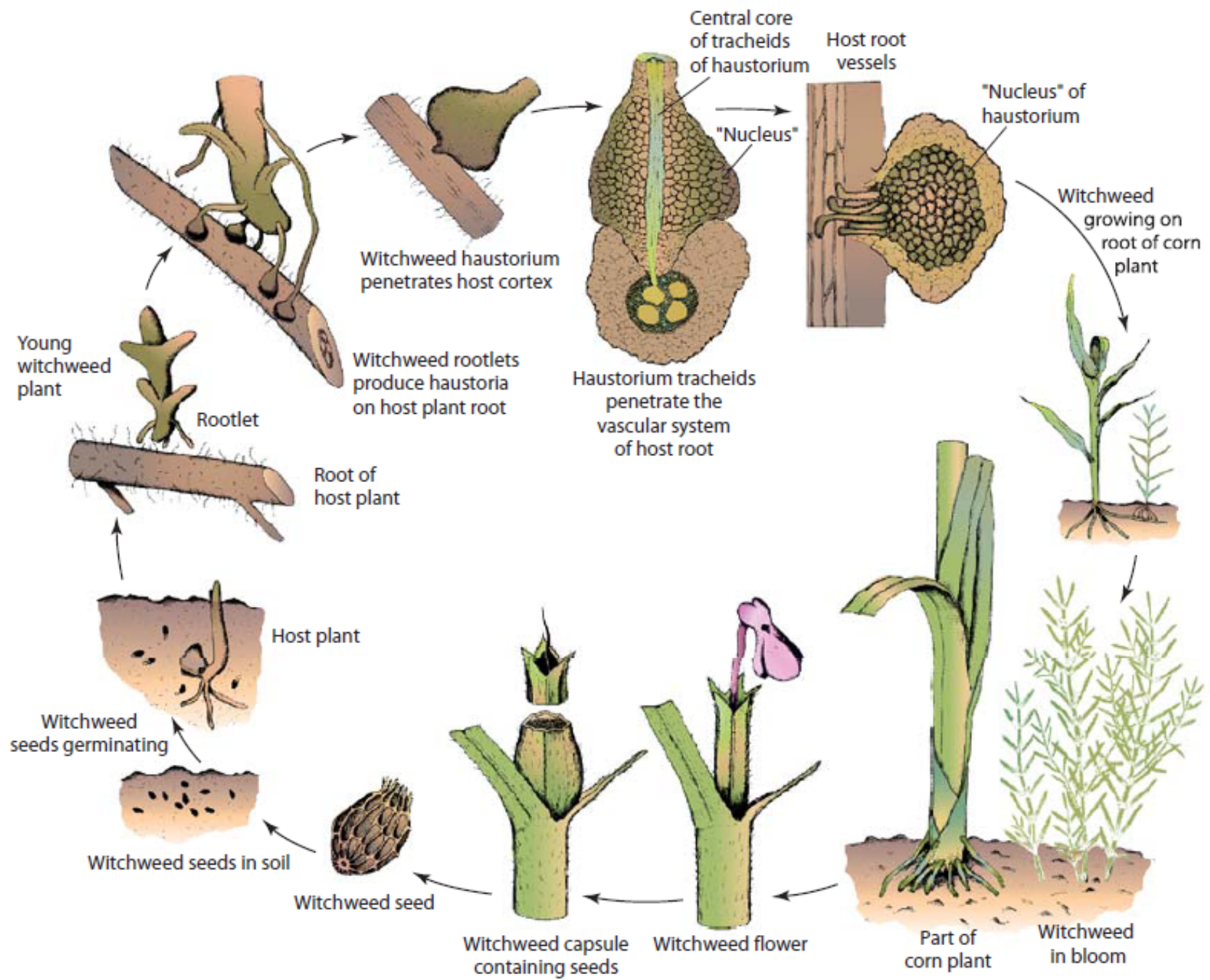


FIGURE 13-4 Disease cycle of witchweed (*Striga asiatica*) on corn.

CONTROL OF PARASITIC PLANTS

- Improved seed cleaning
- Cutting, pulling or spot spraying
- Resistant/tolerant varieties
- Biological control, if possible
- Inter-cropping with non-host plant species
- Crop rotation with nonhost species

CONTROL OF PLANT PATHOGENS AND LOSS AVOIDANCE

MAJOR SCENARIOS IN PLANT DISEASE MANAGEMENT

1. Use of synthetic pesticides
2. Integrated Disease Management (two or more from the groups Preventative, Cultural, Mechanical/Physical, Biological, Chemical)
3. Disease Management under Organic Agriculture
4. Disease Management under Agroecological Crop Production

CONTROL OF PLANT PATHOGENS AND LOSS AVOIDANCE

CHEMICAL CONTROL

EXCLUSION/LEGISLATIVE/QUARANTINE

CULTURAL MEASURES (practices done during crop production)

MULTILINES AND MIXTURES (multiple varieties mixed and planted)

PHYSICAL/MECHANICAL (e.g heat treatment)

INDUCED RESISTANCE

BIOLOGICAL CONTROL (controlling one microbe using another nonpathogenic one)

MANAGING VECTORS

HOST PLANT RESISTANCE

CULTURAL CONTROL MEASURES

- **Defn:** Measures primarily used for other reasons, but nevertheless reduce pest establishment, reproduction, dispersal and survival.
- **Examples:** clean seed; crop; rotation; plant spacing; water management; repellants/attractants; cover crops
- **Advantages:** increased plant vigour; increased yield; no harmful effects on environment or farmer; No pesticide residues
- **Disadvantages:** labour intensive; time-consuming; the practices are only effective when deployed before disease outbreak; not always easy to influence some environmental factors

BIOLOGICAL CONTROL MEASURES

- **Defn:** The use of living organisms to suppress populations of pathogens and thus reduce disease.
- **Approach:** Culture the biological control organism in the lab and release it in huge quantities into the field before the disease spreads. It is important that the biocontrol microbe chosen is well adapted to the environmental conditions in target locations.
- **Advantages:** Once established, control spills into subsequent seasons (with little or no additional treatment); no harmful effects on environment or farmer; No pesticide residues
- **Disadvantages:** Initial investment is high (research & development)

PHYSICAL/MECHANICAL CONTROL MEASURES

- **Defn:** Measures that kill the pathogen directly or prevent it from reaching the crop
- **Examples:** Roguing (removal of diseased plants/parts); Hot water treatment; disinfection of machinery or tools; soil sterilisation.
- **Advantages:** No harm to the environment; no development of resistance; one measure can control several diseases; No pesticide residues
- **Disadvantages:** labour intensive; time-consuming; works well when there is coordination among neighbouring farms; not always practical to rogue

EXCLUSION – QUARANTINE + PHYTOSANITARY MEASURES

- **Exclusion:** means keeping the pest out of a given country or area through quarantine and phytosanitary measures
- **Quarantine pest:** A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (ISPM 5, FAO). e.g The viruses causing Maize Lethal Necrosis Disease (MLN) with reference in Zambia
- **Non-quarantine regulatory pest:** one which is already present in the country but occurs in only restricted parts of the country and must be prevented from spreading to other parts of the country because of its devastating effects on a crop non-quarantine regulatory (Cassava brown streak disease)
 - ◆ e.g Cassava brown streak virus....

EXCLUSION – QUARANTINE + PHYTOSANITARY MEASURES

- **Sanitary and Phytosanitary measures:**

- ✧ Sanitary (human and animal health) and phytosanitary (plant health) measures are quarantine and biosecurity measures which are applied to protect human, animal or plant life or health from risks arising from the introduction, establishment and spread of pests and diseases and from risks arising from additives, toxins and contaminants in food and feed (WTO).

- **Phytosanitary measures:**

- ✧ quarantine and biosecurity measures which are applied to protect plant life or health from risks arising from the introduction, establishment and spread of pests and diseases



ABOUT THE DEPARTMENT OF PLANT QUARANTINE AND PHYTOSANITARY SERVICE (PQPS)

- Department under Ministry of Agriculture
- National Plant Protection Organisation (NPPO) of Zambia.
- Core mandate: providing regulatory services that seek to prevent the introduction and spread of plant pests in the country while facilitating safe movement of plants and plant products both locally and internationally.



ABOUT THE DEPARTMENT OF PLANT QUARANTINE AND PHYTOSANITARY SERVICE (PQPS)

Mandate is drawn from: Plant Pests and Diseases Act CAP 233 of the laws of Zambia:

- *“An Act to provide for the eradication and prevention of the spread of plant pests and diseases in Zambia, for the prevention of the introduction into Zambia of plant pests and diseases, and for matters incidental thereto.....”*
- Also considers: Noxious Weeds Act CAP 231; Border Management Act No. 12 of 2018....e.t.c



ABOUT THE DEPARTMENT OF PLANT QUARANTINE AND PHYTOSANITARY SERVICE (PQPS)

- Zambia is a signatory to the International Plant Protection Convention (IPPC) which is recognized by the World Trade Organisation (WTO) as the international standard setting body for plant health.
- The IPPC recognizes PQPS as the National Contact Point (NCP) for plant health in Zambia while the WTO recognizes PQPS as the National Enquiry Point (NEP) for plant health in Zambia.



Food and Agriculture
Organization of the
United Nations



International
Plant Protection
Convention

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Overview

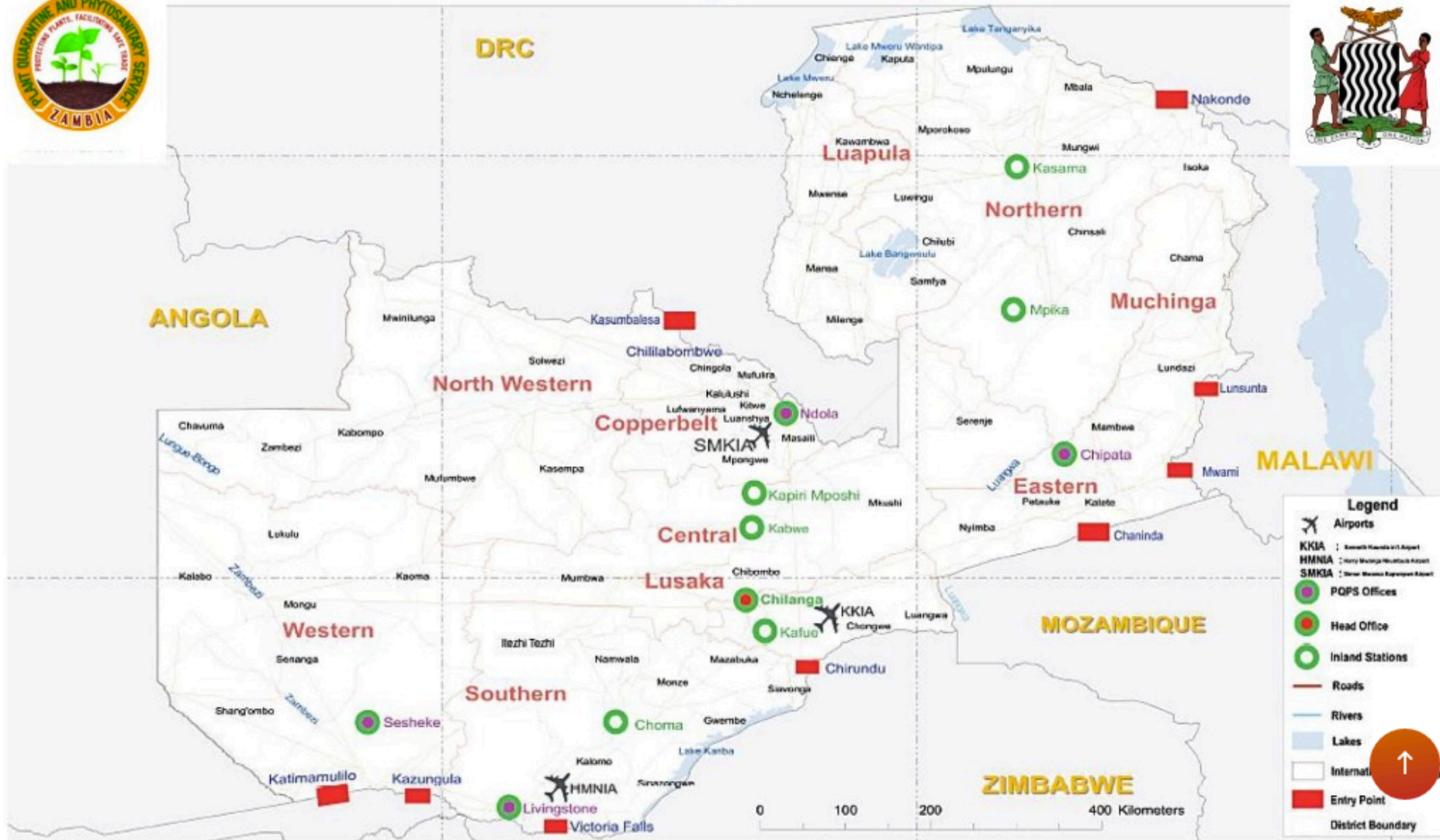
What is the International Plant Protection Convention (IPPC)?

The International Plant Protection Convention (IPPC) is an [intergovernmental treaty](#) signed by over 180 countries, aiming to protecting the world's plant resources from the spread and introduction of pests, and promoting safe trade. The Convention introduced [International Standards for Phytosanitary Measures \(ISPMs\)](#) as its main tool to achieve its goals, making it the sole global standard setting organization for plant health.

The IPPC is one of the "Three Sisters" recognized by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement, along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

MEASURES: BORDER INSPECTIONS OF AGRICULTURAL COMMODITIES AND CONTAINERS BY PQPS

The Plant Quarantine & Phytosanitary Service in Zambia



MORE MEASURES

- Provision of import permits – these are permits that require that a certain commodity being imported into Zambia is free of certain pests known to occur in the exporting country, but absent from Zambia.
- Border inspections resulting in seizure and sometimes destruction of agricultural commodities and containers that either have pests from other countries (not present in Zambia), or have been imported without proper documentation.
- Designating “pest-free zones” and prevention of movement of pests from quarantine areas
- Inland inspections to prevent spread of non-quarantine regulatory pests

MORE MEASURES

- Clean implements/machinery, tools and shoes when coming out of an infected farm
- Restrict the number of people entering an infected zone
- Prevent movement of planting materials from an infected zone
- Manage all known insect vectors of the disease in an infected area
- Enforce borders inspections to prevent contaminated plant materials
- Require disease-free certification or import permit for agricultural products

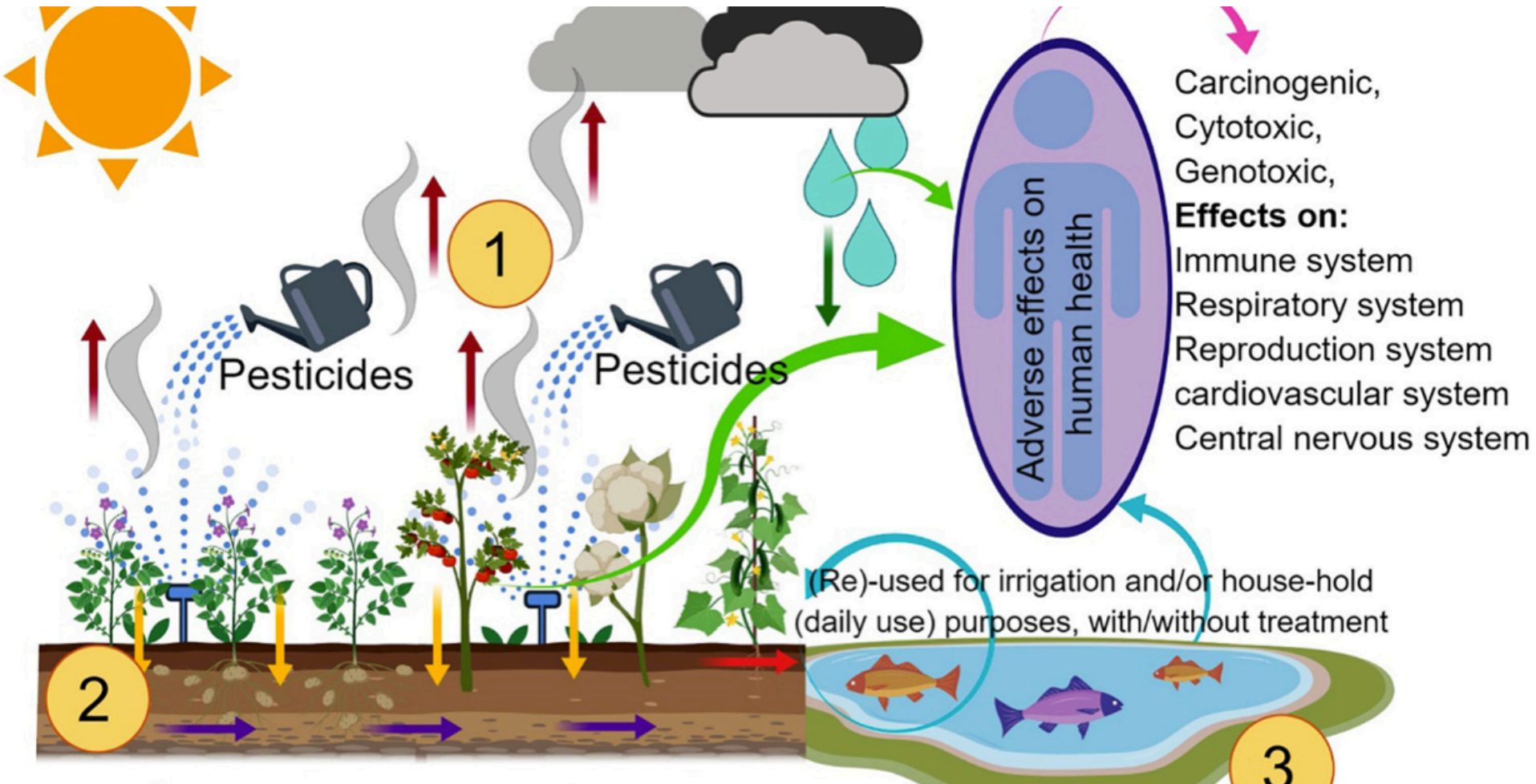
LEGISLATIVE

- **Defn:** This is the use of laws enacted by a country to prevent plant diseases from causing damage.
- **In Zambia:** This is achieved through the Plant Pests and Diseases Act CAP 233 of the laws of Zambia:
 - *“An Act to provide for the eradication and prevention of the spread of plant pests and diseases in Zambia, for the prevention of the introduction into Zambia of plant pests and diseases, and for matters incidental thereto.....”*
 - The Act empowers the Minister of Agriculture through agencies under the ministry and the government, to perform functions related to the act above
 - One such government department is PQPS (MoA)

CHEMICAL CONTROL OF PLANT PATHOGENS

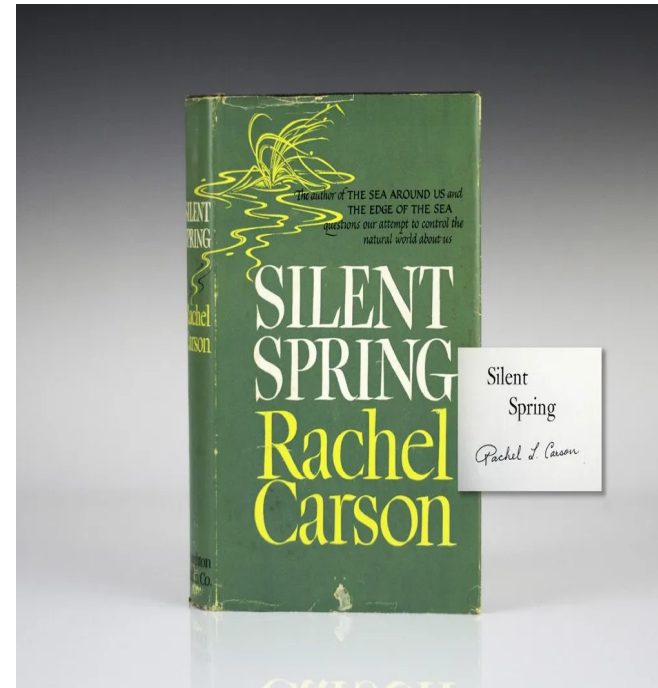
- Applicable against fungal, bacterial and nematode diseases, but not viruses (indirect via control of insects)
- Why are pesticides (fungicides, bacteriocides, nematicides) needed?
 - May be the only available control method at times
 - They may be the most economical option available
- Can be applied to the soil, seed, foliage.
- They should be used judiciously: to minimise costs, environmental damage, health hazard, and development of resistance.

CHALLENGES OF HEAVY RELIANCE ON SYNTHETIC PESTICIDES



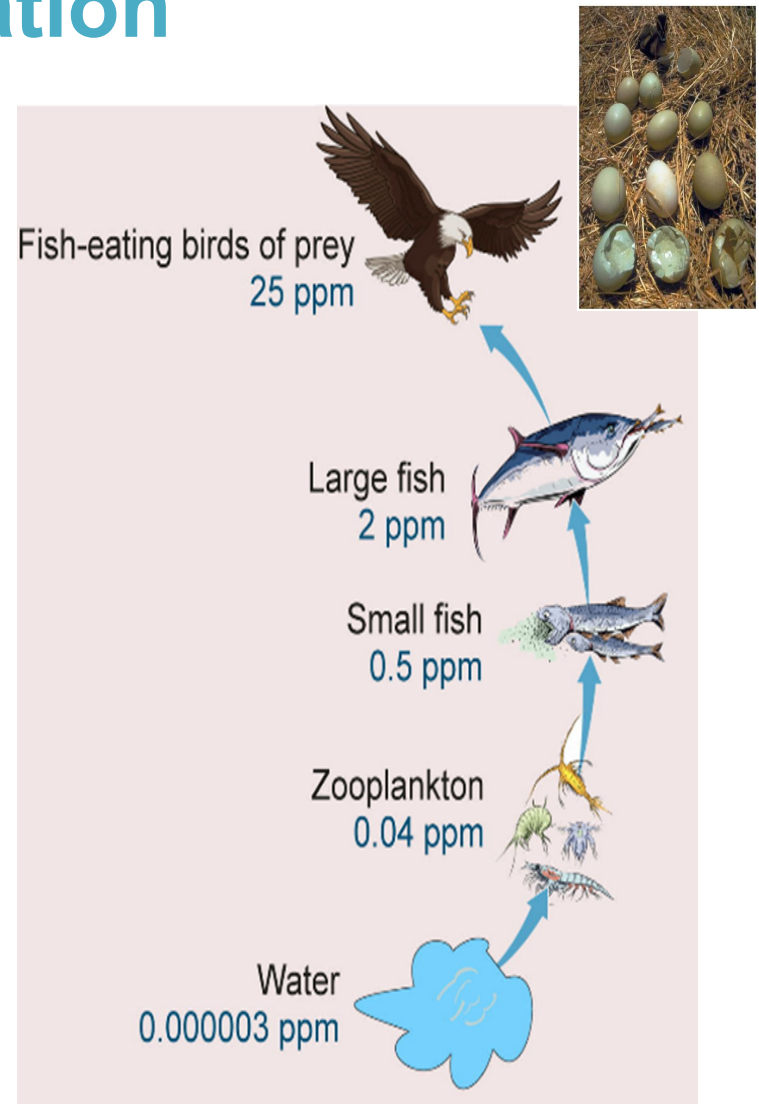
CHALLENGES OF HEAVY RELIANCE ON SYNTHETIC PESTICIDES

- Pesticides contaminate the environment (water, food...)
- Many pesticides are harmful to humans too!
- Non-target effects erode biodiversity
- Indiscriminate use has resulted in resistance in pest populations
- Increased cost of pest management



Bioaccumulation

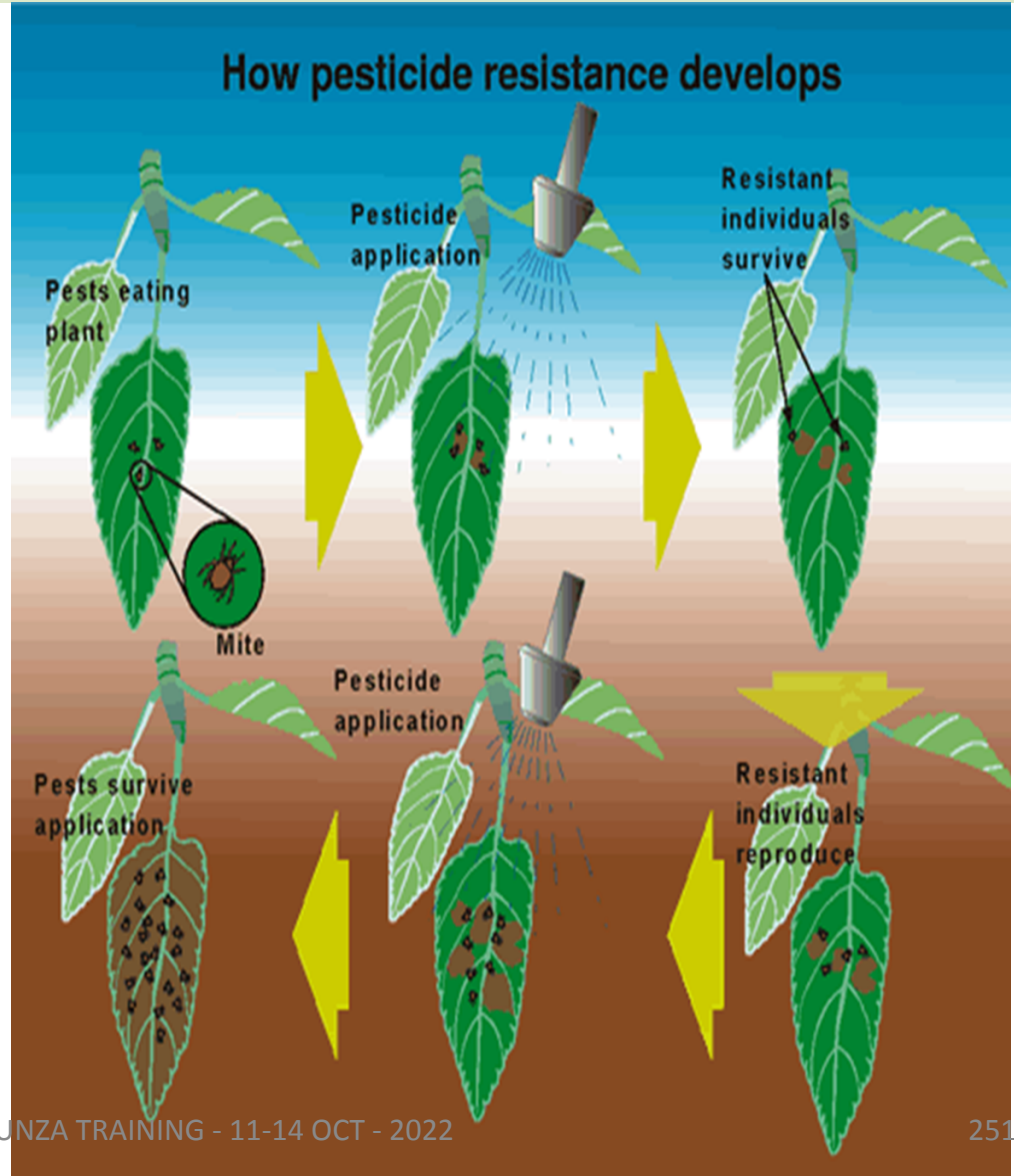
- Bioaccumulation occurred as DDT, including other organochlorines are:
 - Insoluble in water but soluble in organic solvents and fats
 - Very stable, thus with long persistence in the environment
- Accumulation of DDT in birds (i.e. *Peregrine falcons*) blocked calcium deposition during egg formation



Bioaccumulation

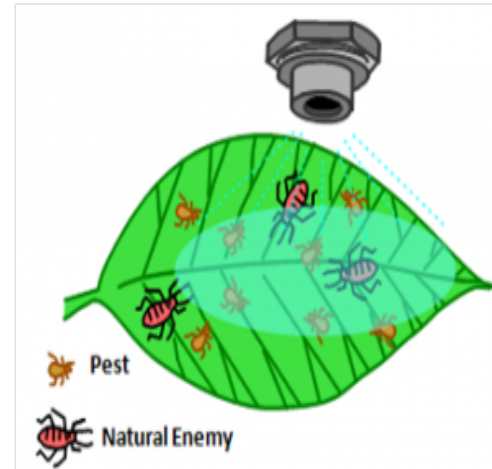
Insecticide resistance

When pathogens are no longer susceptible to a given pesticide



CHALLENGES OF HEAVY RELIANCE ON SYNTHETIC PESTICIDES

- Pest resurgence
 - Often results due to suppression of NE
 - Common in high value crops due to intensive spraying



- Toxicity
 - Health risk to spray operators
 - Pesticide residues on crops
 - Other side effects i.e. pollinators



Green revolution and heavy reliance on pesticides

Intensification: monocultures

- **Loss of rotations/Mixed cropping**

- **Loss of NE**
- **Pesticide residues**
- **Resistance**

Increased vulnerability to pests

Increased use of pesticides

CHEMICAL CONTROL OF PLANT PATHOGENS

- Applicable against fungal, bacterial and nematode diseases, but not viruses (indirect via control of insects)
- Why are pesticides (fungicides, bacteriocides, nematicides) needed?
 - May be the only available control method at times
 - They may be the most economical option available
- Can be applied to the soil, seed, foliage.
- They should be used judiciously: to minimise costs, environmental damage, health hazard, and development of resistance.
- See handout for details

PREVENTING RESISTANCE TO CHEMICALS

- Consistent use of the same chemical might speed-up build-up of resistance against the chemical in pathogen populations
- To minimise the chances of this happening, it is advisable to rotate/combine chemicals from different chemical groups.
- These groups are based on mode of action (chemicals with the same mode of action are placed into one group)
- An example is the FRAC Code (Fungicide Resistance Action Committee-FRAC Code)
- See handout for details

PREVENTING RESISTANCE TO CHEMICALS



FRAC Code List ©*2021:

Fungal control agents sorted by cross resistance pattern and mode of action

(including coding for FRAC Groups on product labels)

| MOA | TARGET SITE AND CODE | GROUP NAME | CHEMICAL OR BIOLOGICAL GROUP | COMMON NAME | COMMENTS | FRAC CODE |
|------------------------------------|---|---------------------------------------|--------------------------------|---|---|-----------|
| A: nucleic acids metabolism | A1 RNA polymerase I | PA – fungicides (PhenylAmides) | acylalanines | benalaxyl benalaxyl-M (=kiralaxyl) furalaxyl metalaxyl metalaxyl-M (=mefenoxam) | Resistance and cross resistance well known in various Oomycetes but mechanism unknown. High risk. See FRAC Phenylamide Guidelines for resistance management | 4 |
| | | | oxazolidinones | oxadixyl | | |
| | | | butyrolactones | ofurace | | |
| | A2 adenosin-deaminase | hydroxy-(2-amino-) pyrimidines | hydroxy-(2-amino-) pyrimidines | bupirimate dimethirimol ethirimol | Medium risk. Resistance and cross resistance known in powdery mildews. Resistance management required. | 8 |
| | A3 DNA/RNA synthesis (proposed) | heteroaromatics | isoxazoles | hymexazole | Resistance not known. | 32 |
| | | | isothiazolones | octhilinone | | |
| | A4 DNA topoisomerase type II (gyrase) | carboxylic acids | carboxylic acids | oxolinic acid | Bactericide. Resistance known. Risk in fungi unknown. Resistance management required. | 31 |

| MOA | TARGET SITE AND CODE | GROUP NAME | CHEMICAL OR BIOLOGICAL GROUP | COMMON NAME | COMMENTS | FRAC CODE |
|-----------------------|--|--|------------------------------|---|---|-----------|
| C. respiration | C3 complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (<i>cyt b</i> <i>gene</i>) | QoI-fungicides (Quinone outside Inhibitors) | methoxy-acrylates | azoxystrobin coumoxystrobin enoxastrobin flufenoxystrobin picoxystrobin pyraoxystrobin | Resistance known in various fungal species. Target site mutations in <i>cyt b</i> gene (G143A, F129L) and additional mechanisms. Cross resistance shown between all members of the Code 11 fungicides. High risk. See FRAC QoI Guidelines for resistance management. | 11 |
| | | | methoxy-acetamide | mandestrobin | | |
| | | | methoxy-carbamates | pyraclostrobin pyrametostrobin triclopyricarb | | |
| | | | oximino-acetates | kresoxim-methyl trifloxystrobin | | |
| | | | oximino-acetamides | dimoxystrobin fenaminstrobin metominostrobin orysastrobin | | |
| | | | oxazolidine-diones | famoxadone | | |
| | | | dihydro-dioxazines | fluoxastrobin | | |
| | | | imidazolinones | fenamidone | | |
| | | benzyl-carbamates | pyribencarb | | | |
| | | QoI-fungicides (Quinone outside | | | | |

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-**ASCOMYCETES**

- **Chlorothalonil** (M05, Foliar-Fruit/Ear/Cereal/Veg-foliar)
- **Boscalid** (C2-7, Foliar-Fruit/Veg-foliar/Cereal-foliar)
- **Carbendazim** (B1-1, Fruit/Ear/Veg-foliar)
- **Thiram** (M03, Seed dressing/Fruit-Foliar)
- **Azoxystrobin** (C3-11, Cereal-foliar/Veg-foliar/Fruit/Ear)
- **Copper** (M01, Fruit-Foliar/Veg-foliar)
- **Sulphur** (M02, Fruit/Foliar)
- **Pyraclostrobin** (C3-11, Cereal-Foliar/Veg-foliar)
- **Carboxin** (C2-7, Seed dressing)
- **Cyproconazole** (G1-3, Fruit/Ear/Cereal-foliar/Veg-foliar)
- **Captan** (M04, Fruit-Foliar)

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-**ASCOMYCETES**

- **Isoprothiolane** (F2-6, Cereal-foiar)
- **Propioconazole** (Fruit/Ear)
- **Penconazole** (G1-3, Fruit-foliar)
- **Cyprodinil** (D1-9, Fruit-foliar)
- **Bromuconazole** (G1-3, Cereal-foliar)
- **Prochloraz** (G1-3, Seed dressing)
- **Fludioxonil** (E2-12, Fruit-Foliar/Seed dressing)
- **Fluoxastrobin** (C3-11, Fruit/Ear)
- **Dithianon** (M09, Fruit-foliar)
- **Tridemorph** (G2-5, Veg-foliar/cereal-foliar)
- **Hymexazole** (A3-32, Seed dressing)

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-ASCOMYCETES

- **Silthiofam** (C7-38, Seed dressing)
- **Tebuconazole** (G1-3, Fruit/Ear/Veg-Foliar/Fruit-foliar)
- **Fenbuconazole** (G1-3, Fruit-foliar)
- **Defenoconazole** (G1-3, Veg-foliar/Cereal-foliar)
- **Thiophanate-Methyl** (B1-1, Cereal-foliar/Veg-foliar/Fruit-foliar/Fruit/Ear)
- **Myclobutanil** (G1-3, Fruit-foliar)
- **Fenpropimorph** (G2-5, Veg-foliar/Cereal-foliar)
- **Quinoxifen** (E1-13, Cereal-foliar)
- **Kresoxim-methyl** (C3-11, Fruit-foliar)
- **Iprodione** (E3-2, Veg-foliar)
- **Metconazole** (G1-3, Veg-foliar)
- **Epoxiconazole** (G1-3, Cereal-foliar)

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-OOMYCETES

- **Copper** (M01, Veg-foliar/Fruit-foliar)
- **Metiram** (M03, Veg-foliar/Fruit-foliar)
- **Metalaxyl/Metalaxyl-M** (A1-4, Fruit-foliar/Veg-foliar/Seed dressing)
- **Mancozeb** (M03, Fruit-foliar)
- **Thiram** (M03, Seed dressing/Fruit-Foliar)
- **Zineb** (M03, Fruit-foliar/Veg-foliar)
- **Propineb** (M03, Veg-foliar/Fruit-foliar)
- **Chlorothalonil** (M05, Fruit-foliar/Veg-foliar)
- **Dimethomorph** (H5-40, Veg-foliar/Fruit-foliar)
- **Fosetyl-AI** (P7-P07-33, Seed dressing/Veg-foliar)
- **Fluazinam** (C5-29, Veg-foliar)
- **Cymoxanil** (U-27, Veg-foliar)
- **Propamocarb** (F4-28, Veg-foliar)
- **Fenamidone** (C3-11, Veg-foliar)

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-BASIDIOMYCETES

- **Tebuconazole** (G1-3, Fruit/Ear/Veg-Foliar)
- **Difenoconazole** (G1-3, Veg-foliar/Cereal-foliar)
- **Chlorothalonil** (M05, Fruit/Ear/Cereal-foliar/Veg-foliar)
- **Carboxin** (C2-7, Seed dressing)
- **Fenpropimorph** (G2-5, Veg-foliar/Cereal-foliar)
- **Fludioxonil** (E2-12, Seed dressing)
- **Prochloraz** (G1-3, Seed dressing)
- **Flutriafol** (G1-3, Seed dressing/Fruit/Ear)

COMMON FUNGICIDES (ACTION GROUP, GENERAL USAGE)-BASIDIOMYCETES

- **Metconazole** (G1-3, Veg-foliar)
- **Epoxiconazole** (G1-3, Cereal-foliar/Fruit/Ear)
- **Triadimenol** (G1-3, Seed dressing)
- **Prothioconazole** (G1-3, Seed dressing/Cereal-foliar/Fruit/Ear)
- **Pyraclostrobin** (C3-11, Cereal-Foliar/Veg-foliar)
- **Azoxystrobin** (C3-11, Cereal-foliar/Veg-foliar/Fruit/Ear)
- **Cyproconazole** (G1-3, Fruit/Ear/Veg-foliar)
- **Boscalid** (C2-7, Veg-foliar)
- **Flusilazole** (G1-3, Cereal-foliar)

INTEGRATED MANAGEMENT

Integrated Disease (Pest) Management (IDM) is an effective and **environmentally sensitive** approach to disease management that relies on a **combination** of common-sense practices. IDM programs use current, comprehensive information on the **life cycles** of plant pathogens and their **interaction** with the environment. This information, in combination with available disease **control methods**, is used to manage disease by the most economical means, and with the least possible hazard to people, property, and the environment.

INTEGRATED DISEASE MANAGEMENT (IDM)

Is a disease management strategy that is:

1. Effective
2. Environmentally sensitive
3. Combination of common-sense practices
4. Uses current and comprehensive information on the life cycles of plant pathogens and their interaction with the environment.
5. Economical
6. Least possible hazard to people, property, and the environment.

PRINCIPLES OF INTEGRATED DISEASE MANAGEMENT (IDM)

1. Prevention

2. Observation/Monitoring

3. Intervention

PRINCIPLES OF INTEGRATED DISEASE MANAGEMENT (IDM)

1. Prevention

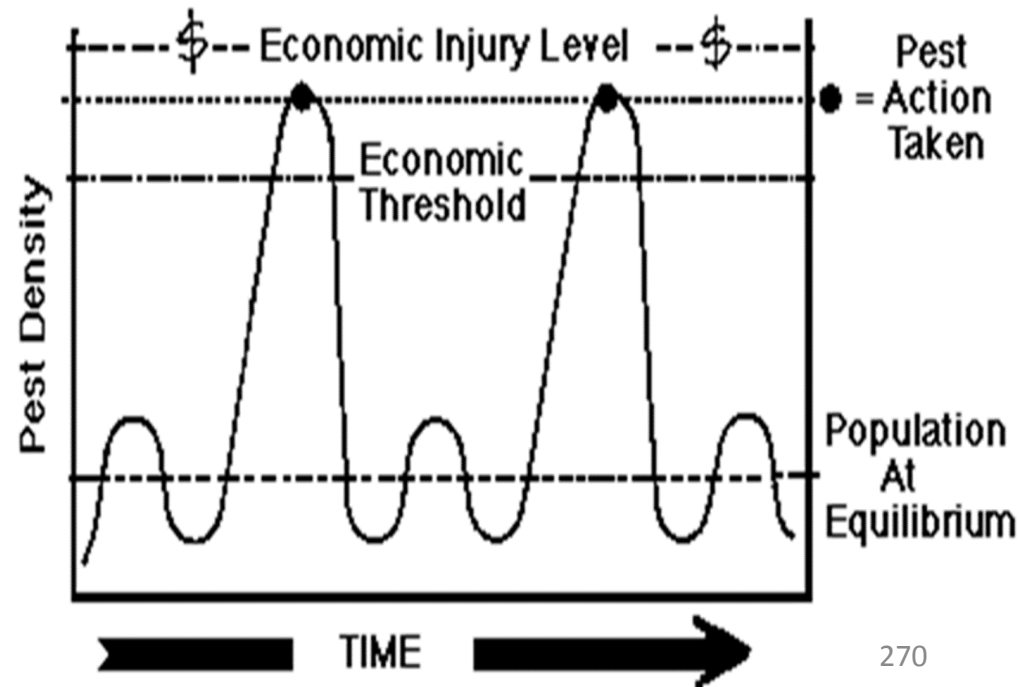
- “prevention is better than cure”. Cheaper, generally more effective.

2. Observation/Monitoring

- Monitoring disease appearance and progression. This allows you to take action, at a stage where it is still possible to make profit from your crop, but not too early...(economic threshold)

Economic threshold or action threshold

- **The time to take action!**
 - **Definition:** the disease incidence level at which control action should be initiated to prevent an increasing disease from reaching the economic injury level



PRINCIPLES OF INTEGRATED DISEASE MANAGEMENT (IDM)

3. Intervention

- Deploy the components of IDM
- Action needs to be taken when thresholds for acting have been reached
- Safer methods deployed first
- Target to have more than one control measure at a time

COMPONENTS/STEPS OF INTEGRATED DISEASE MANAGEMENT (IDM)

1. Preventive cultural practices
2. Establish Acceptable disease levels
3. Monitoring
4. Physical/Mechanical control
5. Biological control
6. Chemical control – Less toxic ones first (WHO/FAO)

IDM Component 1 – Preventive cultural practices

Cultural measures are those primarily used for other reasons, but nevertheless prevent or reduce disease establishment and spread.

1. Clean planting materials (certified seed/community seed banks, training communities)
2. Early or late planting to exploit unfavourable conditions for disease spread
3. Mulching
4. Flooding (not for water molds/chromista)
5. Trap crops/decoy crops
6. Crop rotation/intercropping
7. Plant resistant varieties

Soyabean Cyst nematode damage

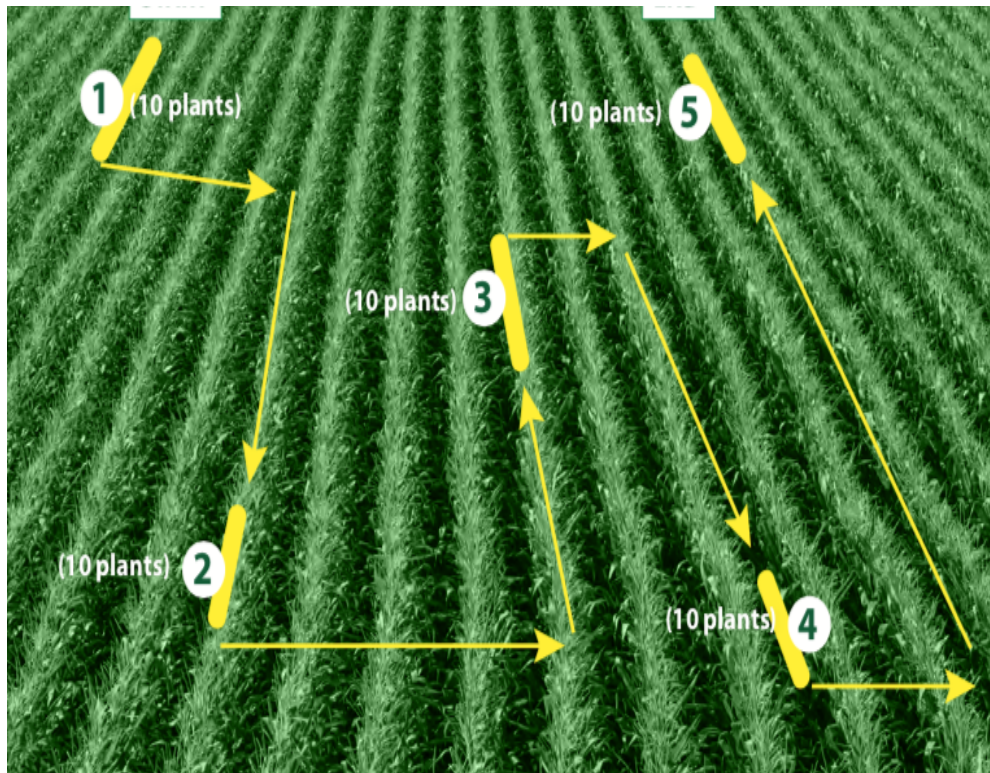


IDM Component 2– Acceptable disease levels

- In most cases, focus should be on management, not eradication, except for quarantine diseases (such as FocTR4 vs some rusts).
- Understand action thresholds. These will differ depending on disease (you will need to act sooner for diseases such as Late blight)
- Use action thresholds, apply controls only if those thresholds are crossed.

IDM Component 3 – Monitoring

- Sampling plants to determine disease prevalence



Sampling pattern

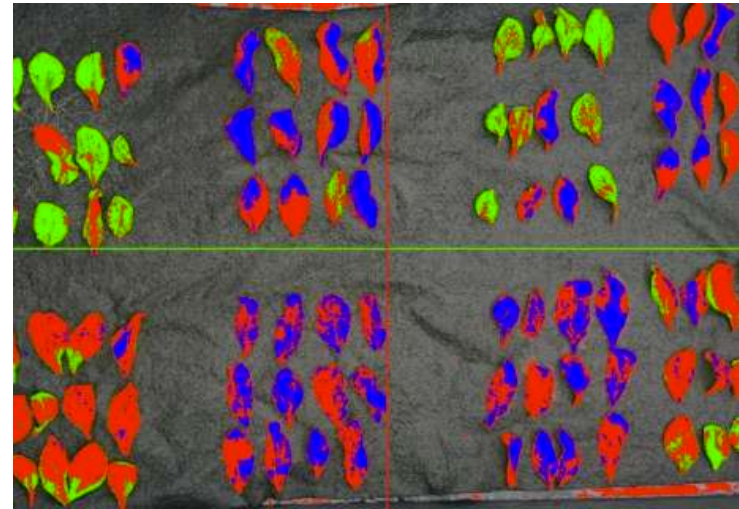
- Knowledge of symptoms is key



Grey Leaf spot disease

MONITORING AND IDENTIFICATION TOOLS/AIDS

- Molecular tools/DNA-based diagnosis (PCR)
- Geographic Information System (GIS-spatial and temporal) combined with image analysis (drone-mounted cameras e.t.c)

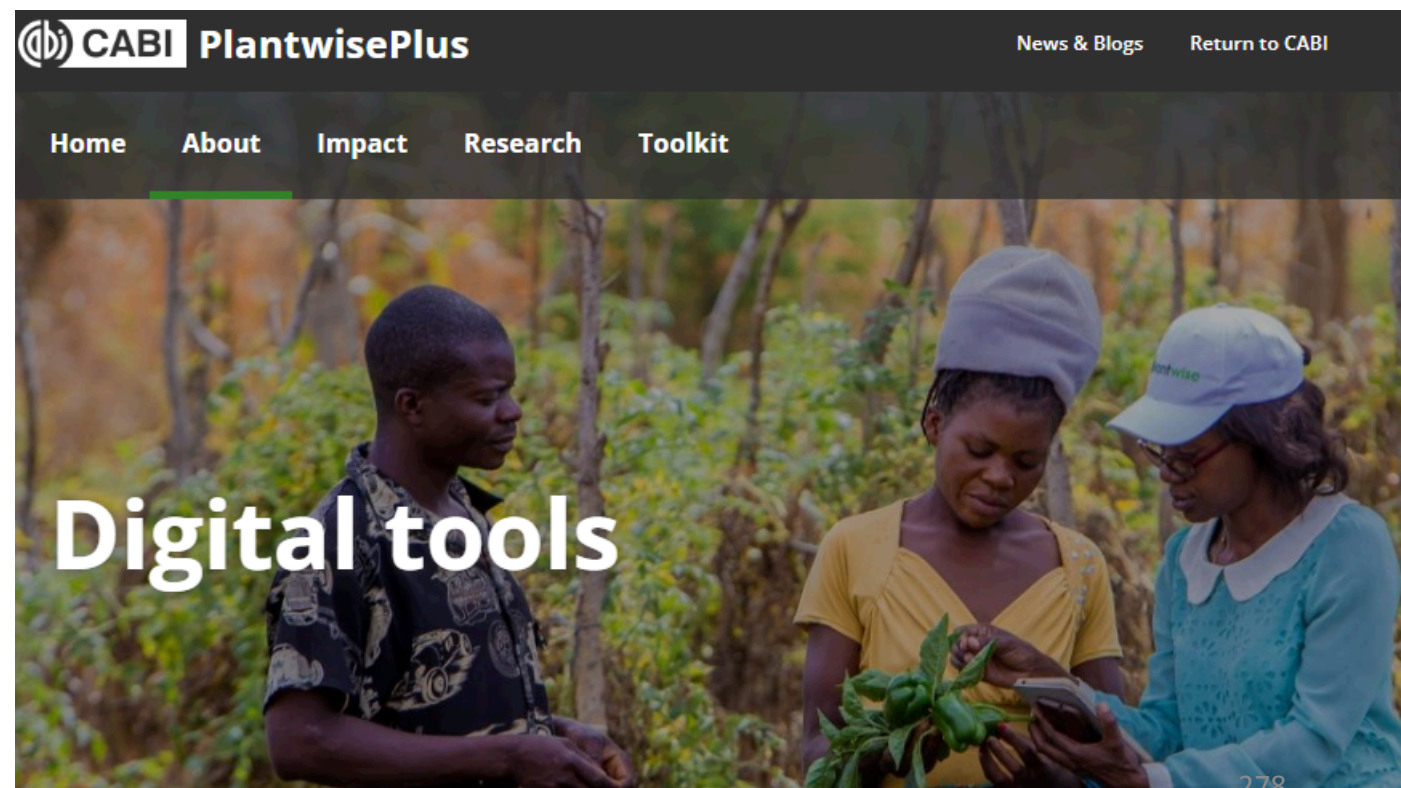


- *Prices are slowly coming down: NPPOs should consider this...*

MONITORING AND IDENTIFICATION TOOLS/AIDS

- Online repository and retrieval systems such as that by CABI/PlantWise for disease identification + factsheets with advise on control measures

- *NPPOs can access this and use it to provide advisory services to farmers*



MONITORING AND IDENTIFICATION TOOLS/AIDS

- CABI/PlantWise also has a system/module for training rural community leaders/members/farmers as Plant doctors who then run Plant Clinics



IDM Component 4 – Physical/Mechanical control

- Roguing (pulling out diseased plants/plant parts, when incidence is still very low).
- Destruction/burying crop residue from diseased fields (with guidance from extension services)
- Disinfection of machinery/tools
- Hot water-treatment of planting material (banana)
- Soil Solarisation

IDM Component 4 – Physical/Mechanical control



A

Source: Agrios 2005

281

IDM Component 5 – Biological control

- Beneficial microbes used to control pathogens.
- India is one of the AARDO countries with good examples:
- *Trichoderma viride* against the pathogens:
 - Disease-causing pathogens such as *Pythium spp.*, *Rhizoctonia solani*, *Fusarium spp.*, *Botrytis cinerea*, *Sclerotium rolfsii*, and *Sclerotinia homoeocarpa* causing root rot, root wilt, seedling rot and collar-rot diseases in crops.
- Initial capital investments might be high.

IDM Component 5 – Biological control

- India is one of the AARDO countries with good examples:
- *Ampelomyces disqualis* against the pathogens:
 - Powdery and downy mildews on courgettes and snowpeas
- *Paecilomyces lilacinus*
 - Against Root-knot nematodes in French beans, roses and tomatoes





IDM Component 5 – Biological control

- Several AARDO countries in Africa have *Aflasafe*
 - Strains of *Aspergillus flavi* that do not produce aflatoxins are being used to competitively displace aflatoxin-producers from the fields, resulting in remarked reduction in aflatoxin on maize and groundnuts
- Initial capital investments might be high.
- These biocontrol products is that they tend to establish in the field, conferring carryover effects from one season to the next

IDM Component 6 – Chemical control

- Applicable against fungal, bacterial and nematode diseases, but not viruses (indirect via control of insects)
- Why are pesticides (fungicides, bacteriocides, nematicides) needed?
 - May be the only available control method at times
 - They may be the most economical option available
- They should be used judiciously: to minimise costs, environmental damage, health hazard, and development of resistance.

IDM Component 6 – Chemical control

| Label | Name | Level of toxicity |
|--|--------------|-------------------|
|  | Red label | Extremely toxic |
|  | Yellow label | Highly toxic |
|  | Blue label | Moderately toxic |
|  | Green label | Slightly toxic |

- If a chemical must be used, choose the least toxic one for inclusion into an IDM
- These normally have color green on the label or class III/U

Class

Ia Extremely hazardous

Ib Highly hazardous

II Moderately hazardous

III Slightly hazardous

U Unlikely to present acute hazard

MAJOR SCENARIOS IN PLANT DISEASE MANAGEMENT

1. Use of synthetic pesticides
2. Integrated Disease Management (two or more from the groups Preventative, Cultural, Mechanical/Physical, Biological, Chemical)
3. Disease Management under Organic Agriculture
4. Disease Management under Agroecological Crop Production

DISEASE MANAGEMENT UNDER ORGANIC AGRICULTURE

What is organic agriculture?

- “a production system that sustains the soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions **rather than the use of inputs with adverse effects.** It combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM, 2009)”.

DISEASE MANAGEMENT UNDER ORGANIC AGRICULTURE

- No synthetic pesticides... but relies on natural methods of controlling pests and diseases...

PRINCIPLES OF ORGANIC AGRICULTURE

1. Principle of health
2. The Principle of Care
3. The Principle of Fairness
4. The Principle of Ecology

PRINCIPLES OF ORGANIC AGRICULTURE

1. Principle of health

- OA sustains and enhances health of soil, plants, animals, humans and planet/environment as one as a way of increasing productivity

2. The Principle of Care

- OA is managed with precaution and responsibility to protect health and well-being of the current and future generations as well as the environment.

3. The Principle of Fairness

- Equity, respect, justice and stewardship of the shared world both among people and with other living beings/env.

4. The Principle of Ecology

- Maintenance of ecosystems is emphasized....e.g aquatic ecosystems (for fish), soil ecosystem (for plants) e.t.c

CONVENTIONAL DISEASE MANAGEMENT TECHNIQUES VS PRINCIPLES ORGANIC AGRICU.

1. Principle of health

- Chemicals may harm health of soil, plants, animals, humans and planet/environment

2. The Principle of Care

- Chemicals may harm elements of the environment

3. The Principle of Fairness

- Hybrids/Varieties - Concerns over ownership

4. The Principle of Ecology

- Conventional methods modify ecologies (e.g eliminate some members of the soil community around plant roots)

DISEASE MANAGEMENT UNDER AGROECOLOGICAL CROP PRODUCTION

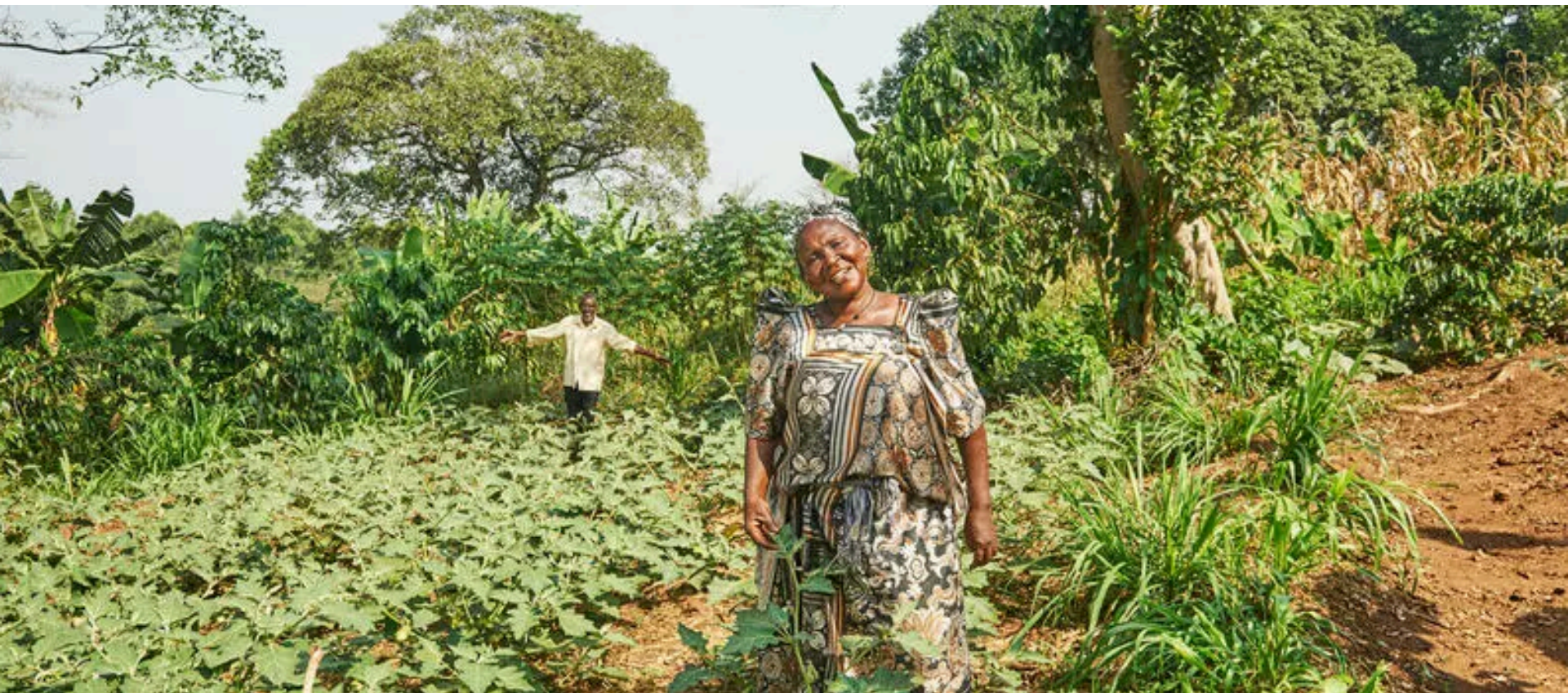
What is agroecology?

MANGO TREES INTERSPACED IN A PADDY FIELD IN NEPAL





FARMERS OUTSIDE THEIR HOME IN UGANDA



Source: agrilinks.org

Integrated Farming in India



DISEASE MANAGEMENT UNDER AGROECOLOGICAL CROP PRODUCTION

What is agroecology?

- Agroecology is a holistic systems-based approach that fashions crop production around a model similar to what we see in nature. It is an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize planned interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.

PRINCIPLES OF AGROECOLOGY

Diversity/Biodiversity (plants, microbes, animals.....)

Efficient use of resources (e.g manure from livestock goes into fishponds/gardens.....)

Resilience from agric production systems (e.g mixture of crops)

Co-creation & knowledge-sharing

Human & social values

Culture & food traditions

Synergies

Recycling

Circular & solidarity economy

Responsible governance

AGROECOLOGY VS ORGANIC AGRICULTURE

It seeks to optimize planned interactions/integration between plants, animals and human systems and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.

DISEASE MANAGEMENT UNDER ORGANIC AGRICULTURE AND AGROECOLOGY

- All the methods discussed under IDM, with the exception of (synthetic pesticides, and GMO hybrids)
- These include
 - Preventative/Cultural control
 - Resistant varieties (No GMOs)
 - Mechanical/Physical
 - Biological control – Microbes to control other microbes
 - Crop diversity: a mixture of crops naturally keeps disease levels low