

**Powdery mildew management
for melons:
Fungicide mode of action**

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A photograph of melon leaves showing signs of powdery mildew. The leaves are covered in a white, powdery substance, particularly on the upper surfaces. Some leaves show small, dark spots, likely from insect damage. The background is dark, making the green leaves and white mildew stand out.

**Melon powdery mildew
caused by:**

Podosphaera xanthii

formerly known as
(Sphaerotheca fuliginea)

Powdery Mildew Management Chemistries: Mode of Action

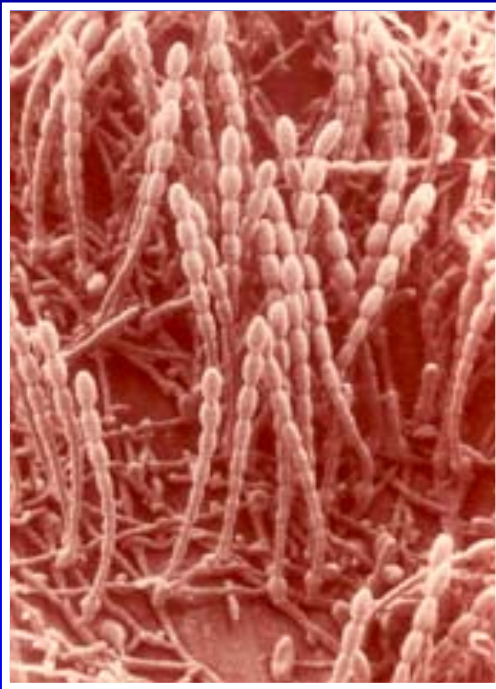


Mode of action

- Biological
- Physiological

Biological mode of action

The activity of a product on a fungus can be expressed in a physically visible manner



Effect on spore germination



Effect on fungus growth

Physiological mode of action

What happens at the cellular level to cause the visible effects on spore germination and fungal growth

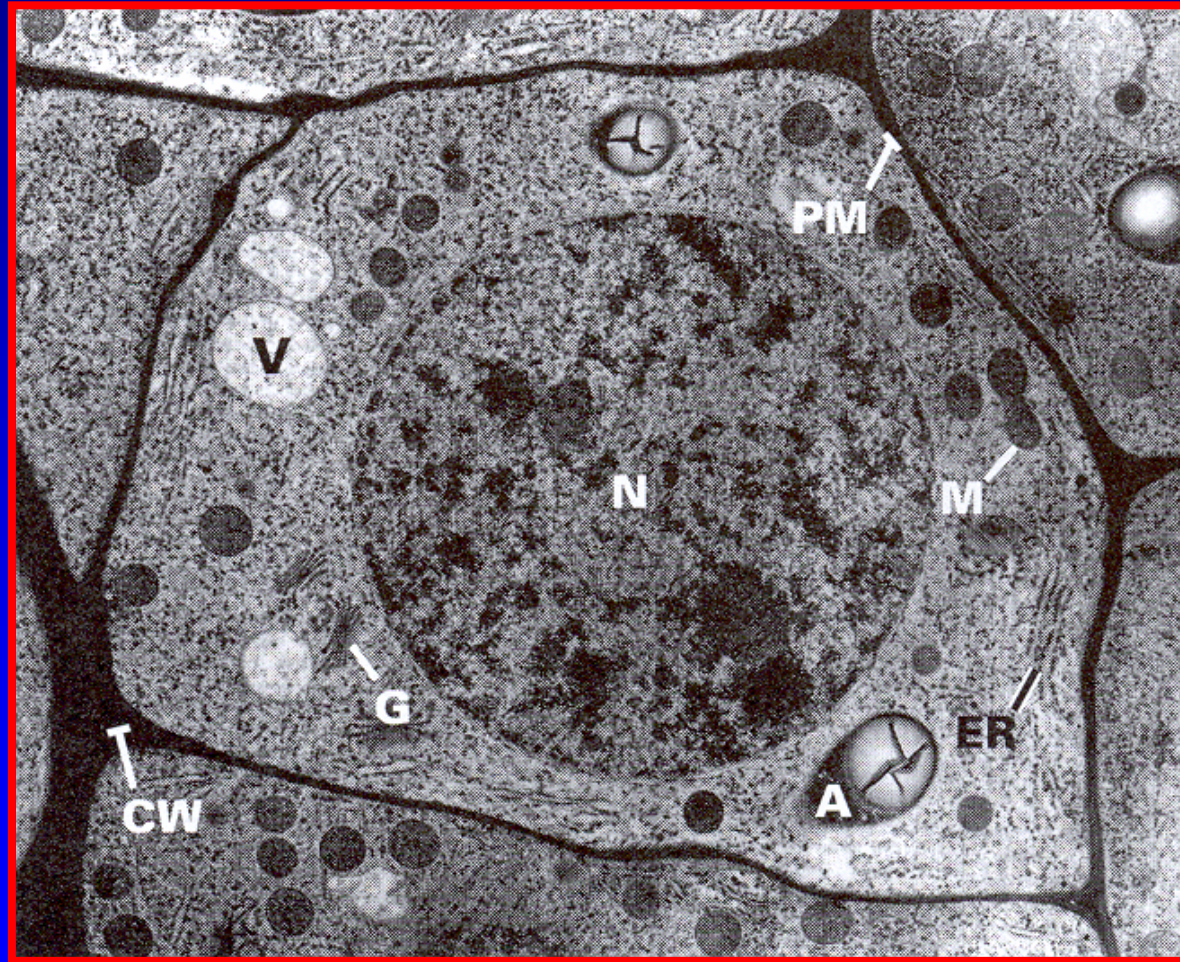
Physiological mode of action

What happens at the cellular level to cause the visible effects on spore germination and fungal growth

Awareness of the physiological mode of action is important for resistance management and preservation of fungicide effectiveness

A typical plant cell and components

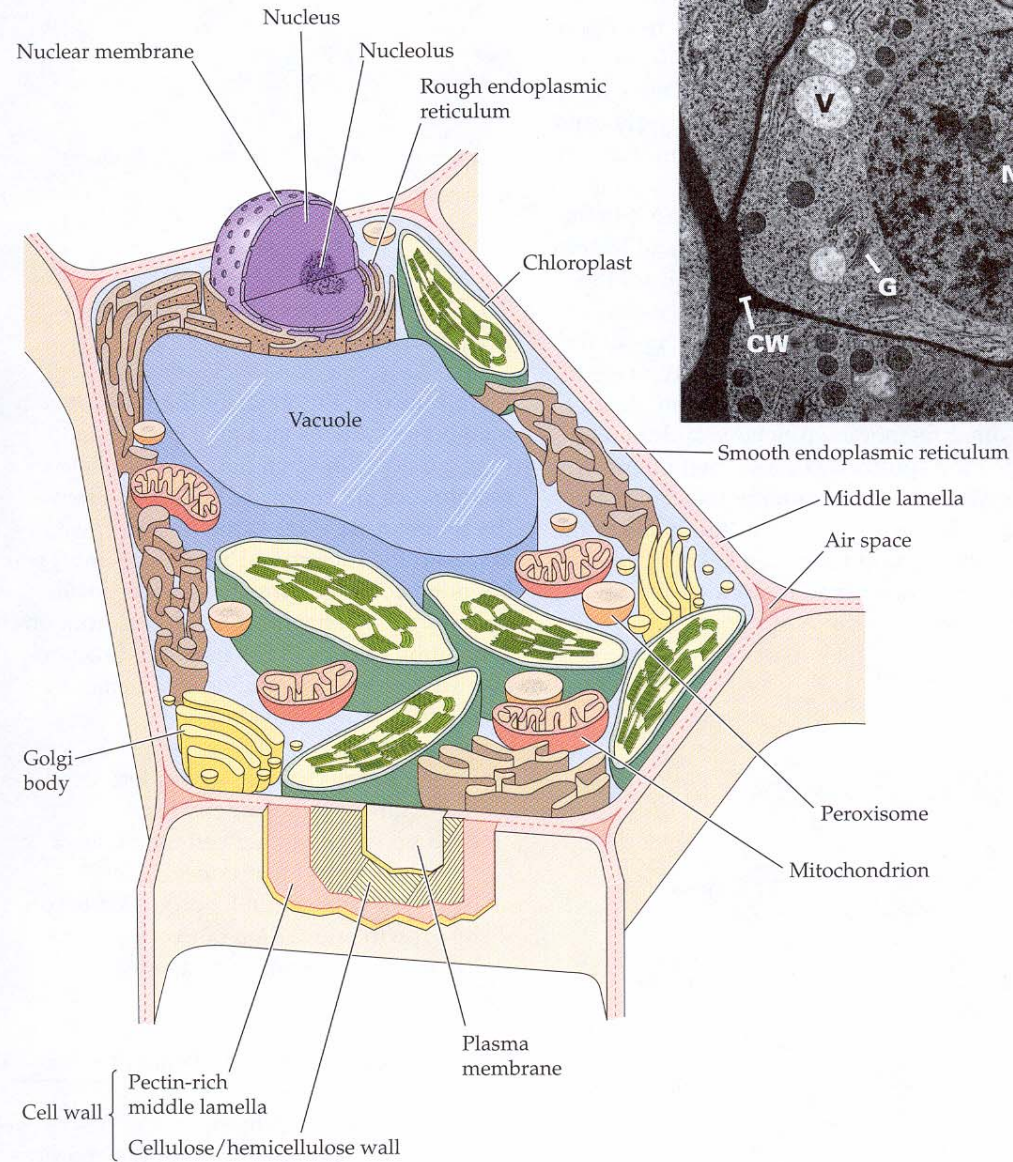
Thin-section transmission electron microscope view



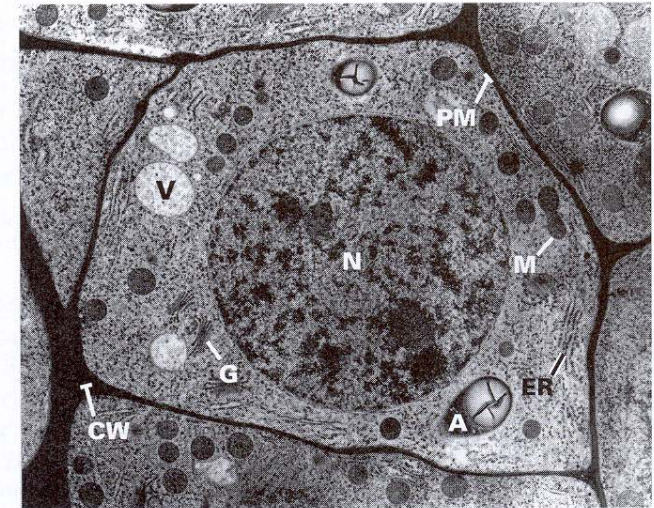
From: Biochemistry & Molecular Biology of Plants

Diagrammatic compared to thin-section view of a plant cell

(A) Mesophyll



(B)



The physiological mode of action

- Fungicides are metabolic pathway inhibitors
- Fungicides can be placed in groups with respect to their general mode of action
 - This has been done by the Fungicide Resistance Action Committee (FRAC)

Fungicide groups, based on mode of action, as created by the Fungicide Resistance Action Committee

- **Multi-site contact activity**
- **Nucleic acids synthesis**
- **Mitosis and cell division**
- **Respiration**
- **Amino acids and protein synthesis**
- **Signal transduction**
- **Lipids and membrane synthesis**
- **Sterol biosynthesis in membranes**
- **Glucan and cell wall synthesis**
- **Melanin synthesis in cell wall**
- **Host plant defense induction**

Fungicide groups containing products active against powdery mildew on melons

- **Multi-site contact activity**
- **Mitosis and cell division**
- **Respiration**
- **Signal transduction**
- **Sterol biosynthesis in membranes**
- **Host plant defense induction**

Multi-site contact activity

- Chemical group: **Inorganics**

Sulfur:

- Disrupts electron transport along the cytochromes

Resistance risk: Low

Multi-site contact activity

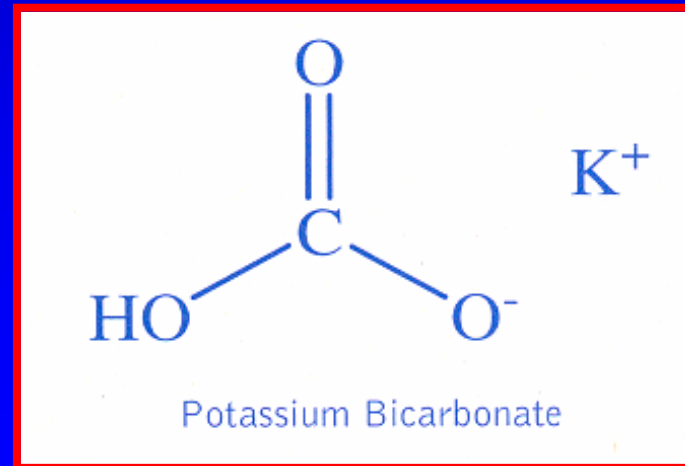
- Chemical group: **Inorganics**

Potassium bicarbonate (Armicarb, Kaligreen)

- Kills pathogen and spores by a combination of osmotic pressure, pH and specific carbonate and bicarbonate ion effects

Resistance risk:

Low



Multi-site contact activity

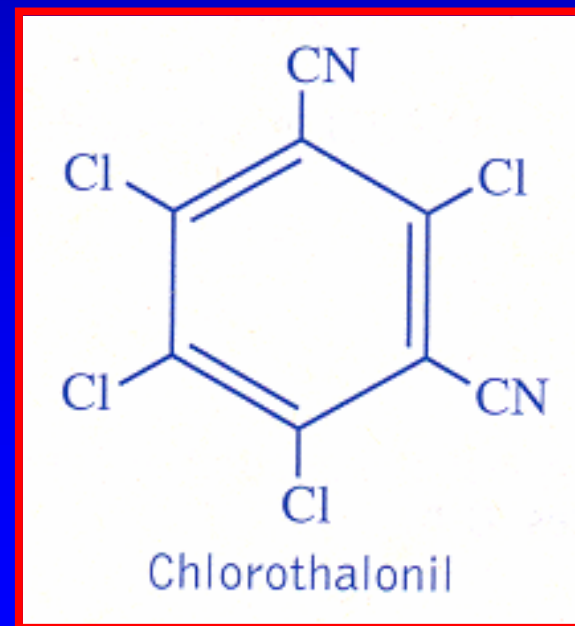
- Chemical group: **Chloronitriles**

Chlorothalonil (Bravo)

- Inactivate amino acids, proteins and enzymes by combining with amino and thiol groups

Resistance risk:

Low



Multi-site contact activity

Neem seed oil (Trilogy)

- Prevents spore germination and kills mycelium on leaf surface

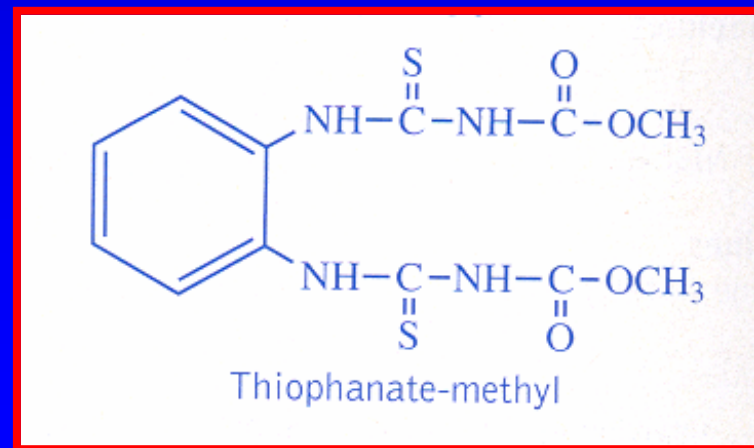
Resistance risk: Low

Inhibition of mitosis and cell division

- Group name: MBC (Methyl benzimidazole carbamates)
 - Thiophanate-methyl (Topsin)
 - Inhibit DNA synthesis (nuclear division)
 - β -tubulin assembly in mitosis

Resistance risk:

High



Inhibition of respiration (in mitochondria)

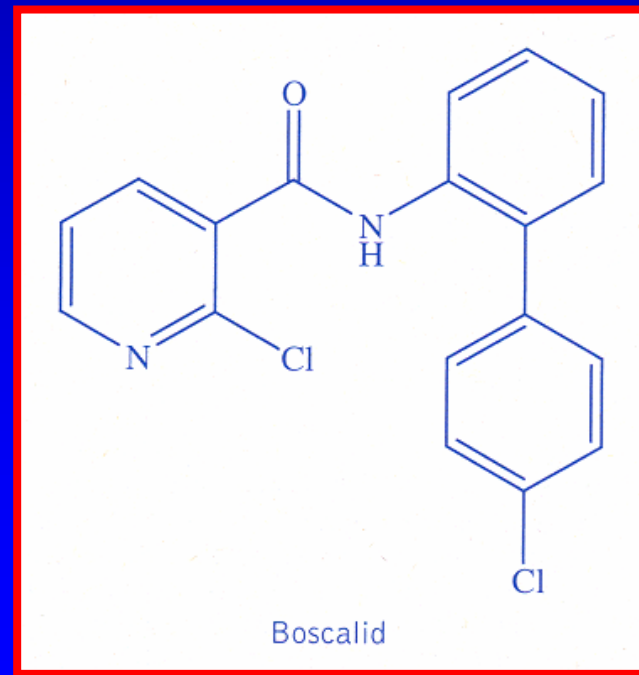
- Group name: **Carboxamides**

Boscalid (Endura)

- **Complex II: inhibits succinate dehydrogenase**

Resistance risk:

Medium

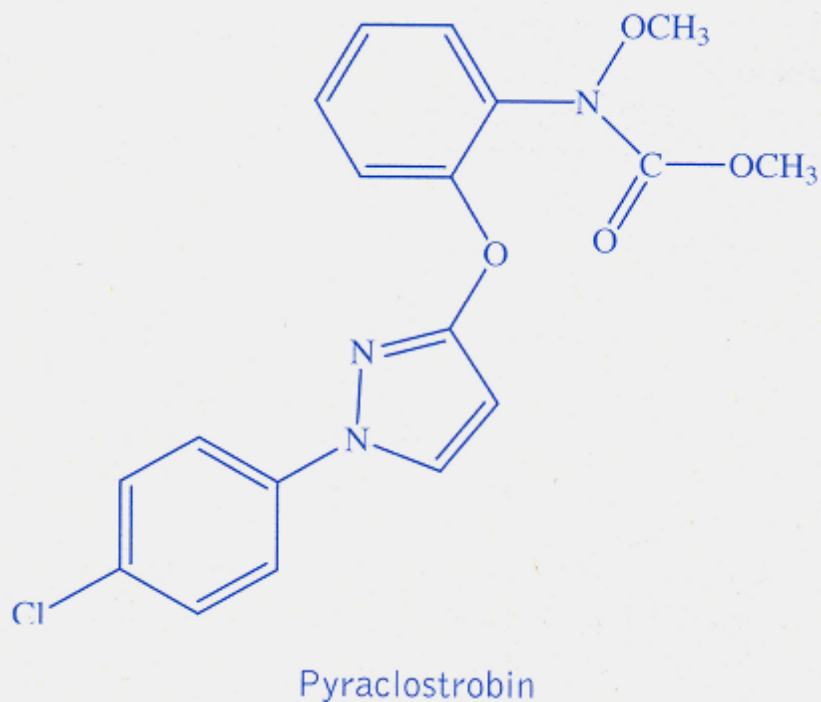
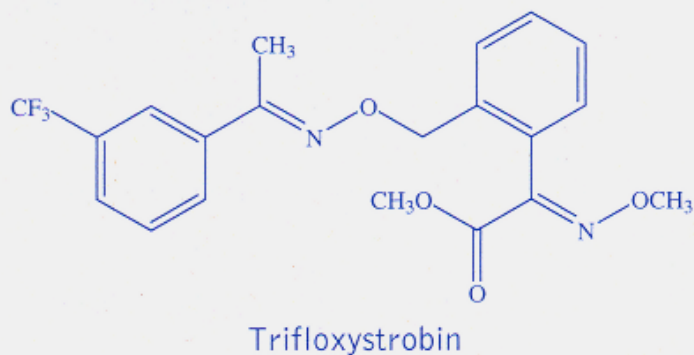


Inhibition of respiration (in mitochondria)

- Group name: **Qol-fungicides - Quinone outside inhibitors**

Strobilurins: Azoxystrobin (Quadris);

Pyraclostrobin (Cabrio); Trifloxystrobin (Flint)



Inhibition of respiration

(in mitochondria)

- Group name: **Qol-fungicides - Quinone outside inhibitors**

Strobilurins:

Azoxystrobin (Quadris)

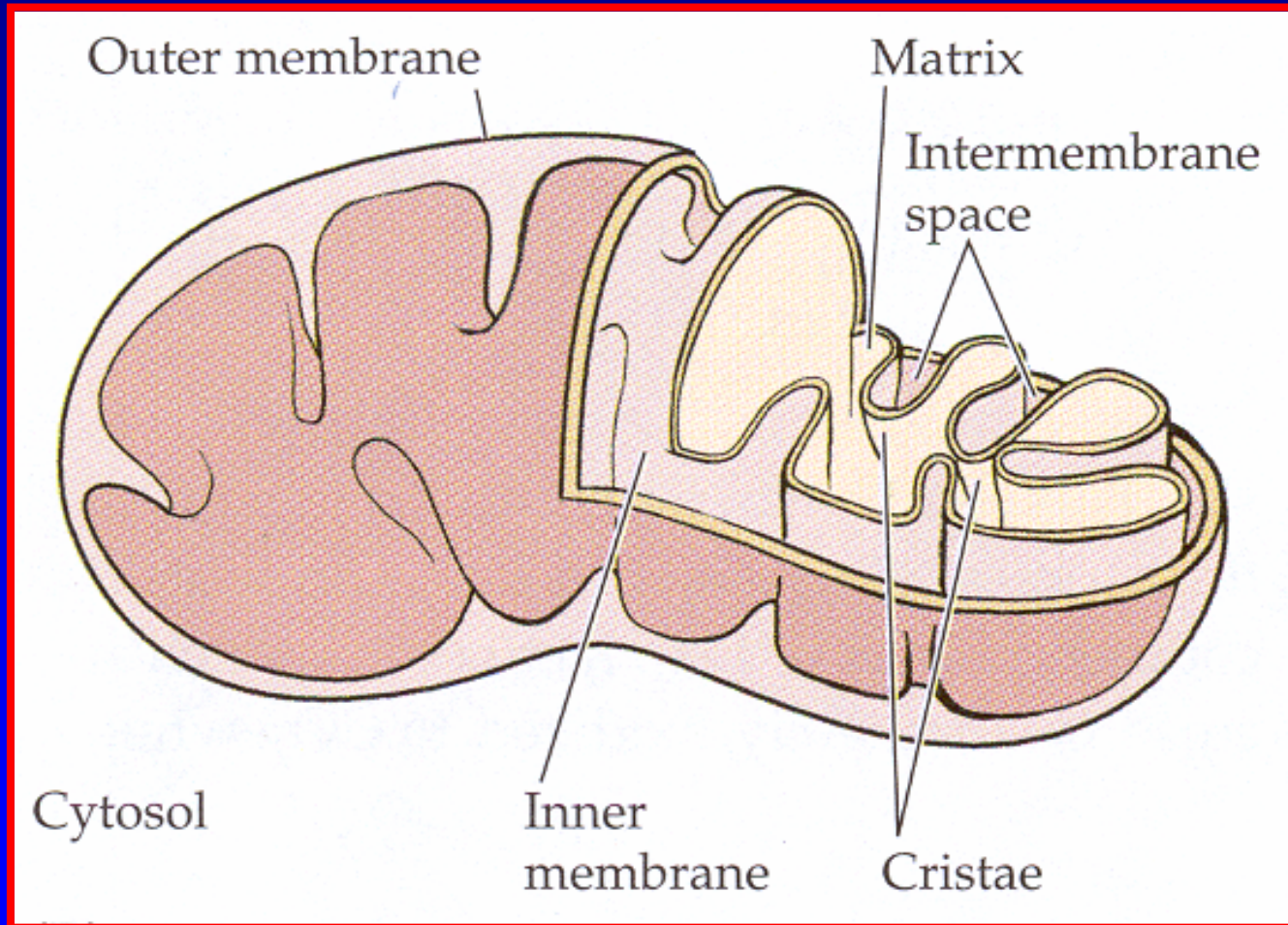
Pyraclostrobin (Cabrio)

Trifloxystrobin (Flint)

- **Complex III: blocks the cytochrome bc_1 at the Q_o site**

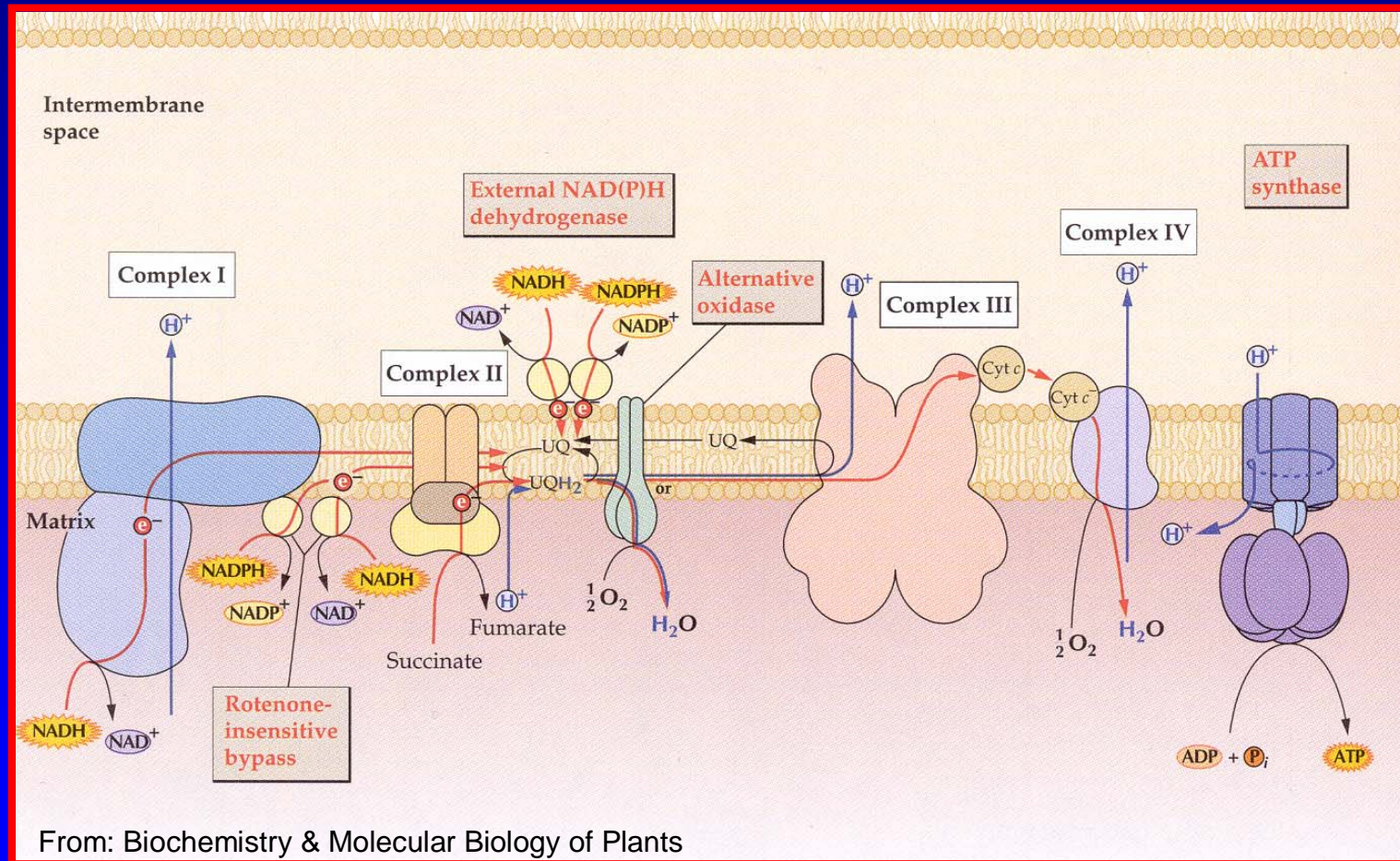
Resistance risk: High

Structural organization of a mitochondrion

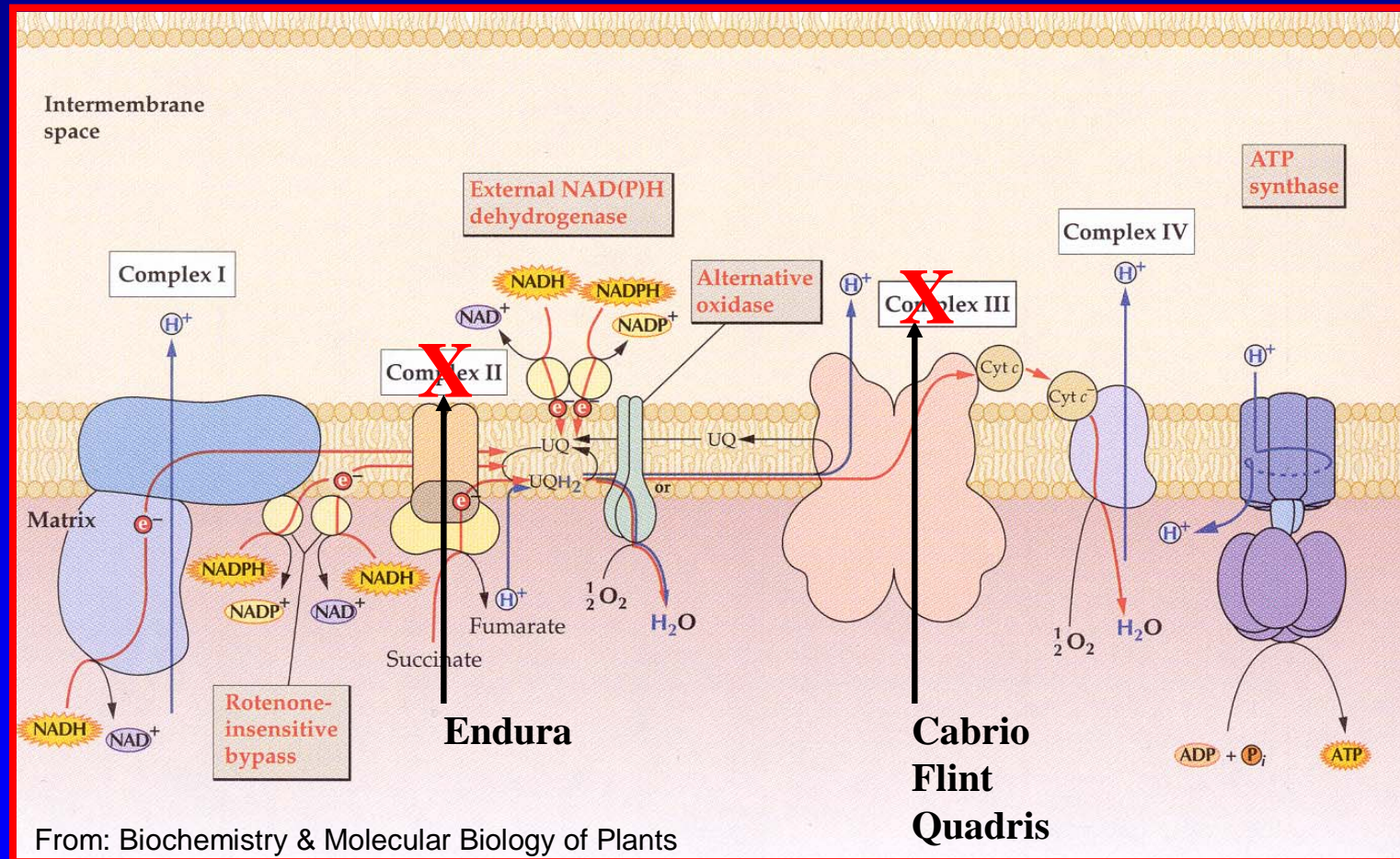


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Electron transfer chain in the inner membrane of mitochondria



Electron transfer chain in the inner membrane of mitochondria



Signal transduction disruption

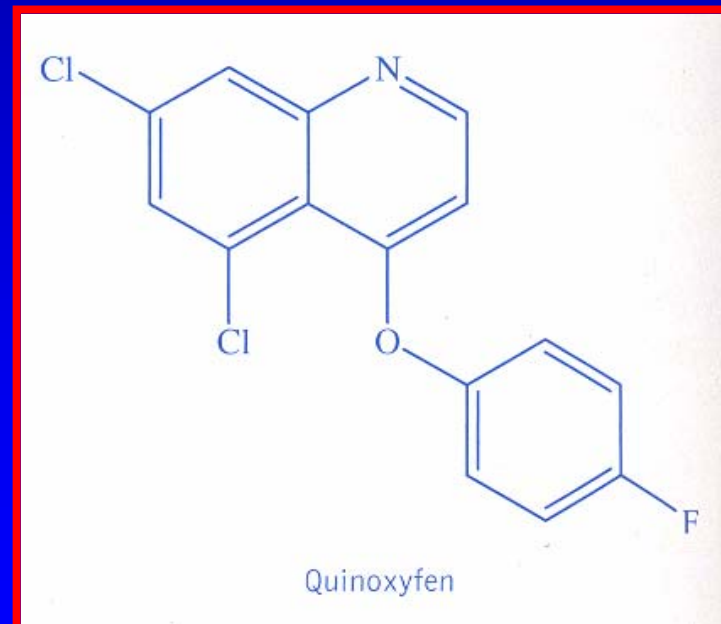
- Group name: **Quinolines**

Quinoxyfen (Quintec)

- G-proteins in early cell signalling
(proposed)

Resistance risk:

Medium



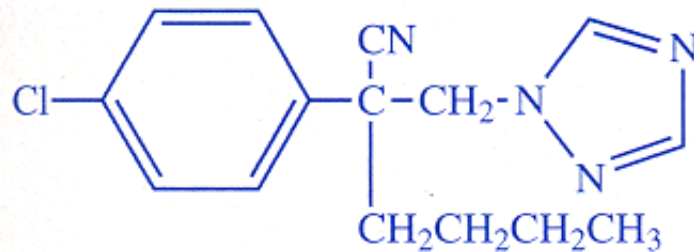
Inhibition of sterol biosynthesis in membranes

- **Ergosterol is the major sterol in most fungi**
- **It is essential for membrane structure and function**

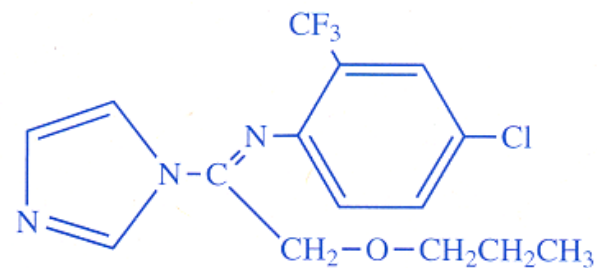
Inhibition of sterol biosynthesis in membranes

- Group name: **DMI (Demethylation inhibitors)**
 - **Myclobutanil (Rally)**
 - **Triflumazole (Procure)**
 - Inhibits C14-demethylase in sterol biosynthesis

Resistance risk: Medium



Myclobutanil



Triflumazole

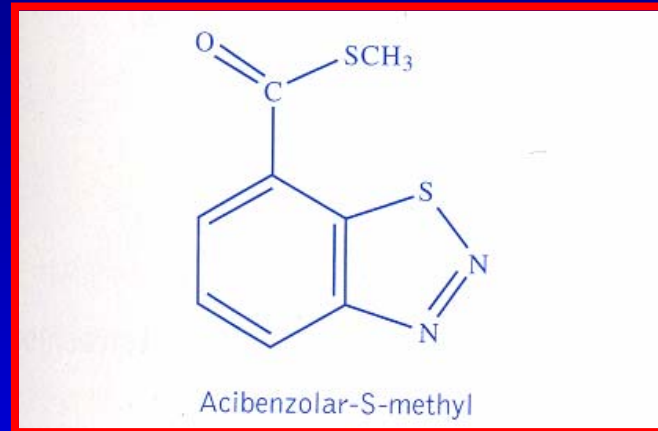
Host plant defense induction

(Plant activators)

- **In contrast to conventional fungicides, plant activators have no direct effect on pathogens**
- **Plant activators induce plants to produce natural disease-fighting compounds**

Plant activators

- **Acibenzolar-S-methyl (Actigard)**



- **Harpin (Messenger)**
- **Some biological control organisms (Serenade)**
 - **Also may control plant diseases by production of compounds directly toxic to the pathogen**

Plant activators stimulate natural plant defense mechanisms

- **Salicylic acid pathway** – Induces SAR (systemic acquired resistance), a natural biological defense response to pathogen attack
- **Jasmonic Acid Pathway** - Induces the production of disease and insect defense compounds

Salicylic Acid Pathway

- **Production of active oxygen** (hydrogen peroxide, peroxidase)
 - Peroxidases have been associated with fungal cell wall degradation and pathogen defense signaling
- **Thickening plant cell wall**
 - Increasing lignification
 - Production of phenolic esters that strengthen cross linking

Salicylic Acid Pathway

- **Systemic and local accumulation of Pathogenesis Related Proteins (PR-Proteins)**
 - **chitinases**
 - **β -1,3 Glucanase**
- **Systemic accumulation of anti-microbial compounds called phytoalexins**

Chitinases

- **Chitin is the major component of all fungal cell walls except for the Oomycetes**
- **Chitinases break down fungal cell walls**
- **Chitinases can break down insect exo-skeletons**
- **Activity is greatly enhanced by Glucanase**

β -1,3 Glucanases

- **Glucans and cellulose are the major components of Oomycete cell walls**
- **Antifungal activity is most often in combination with Chitinase**
 - **Direct defense: Degrade fungal cell walls**
 - **Indirect defense: Promoting the release of oligosaccharides that act as elicitors of defense reactions**

Jasmonic Acid Pathway

Jasmonic acid induces the production of disease and insect defense compounds

- Defense Proteins
- Phytochemicals

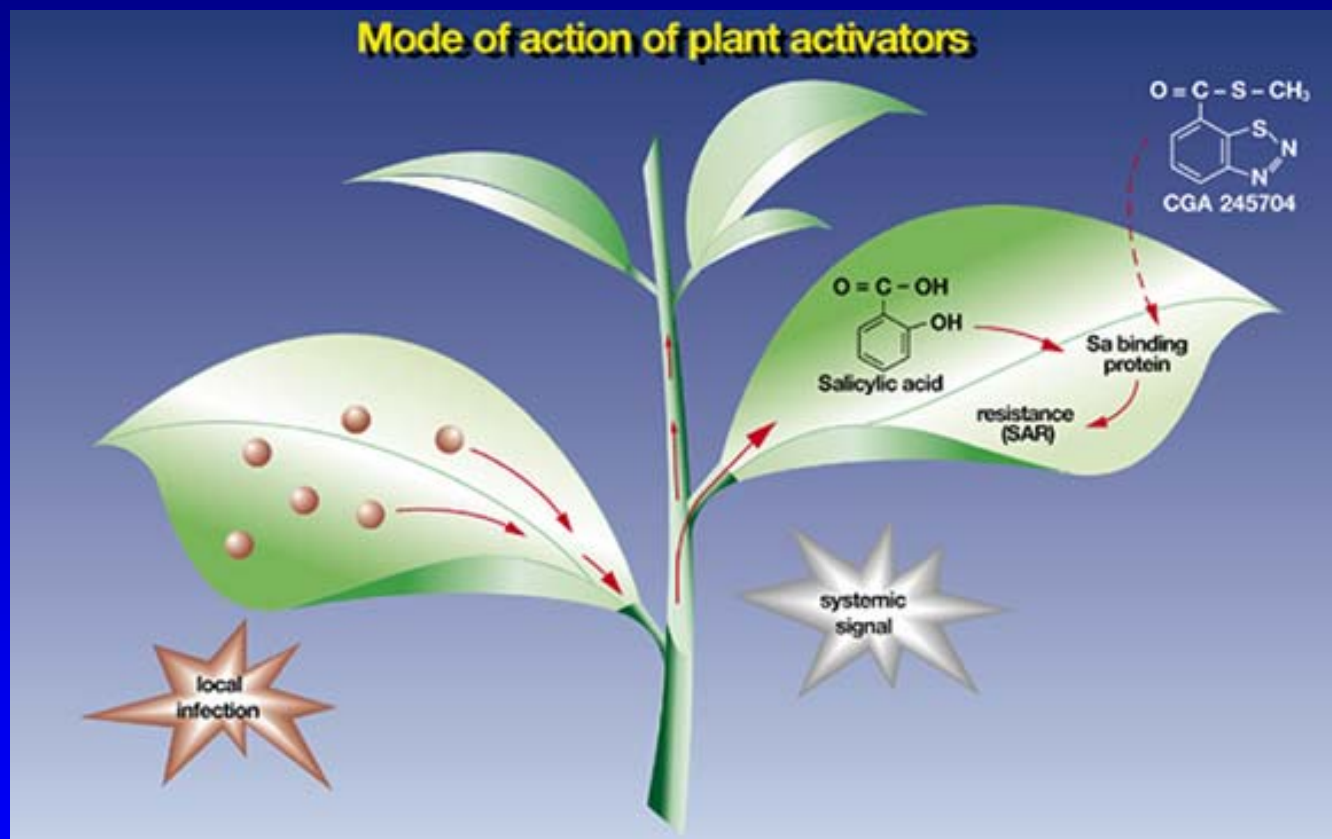
Phytochemicals

- Different from phytoalexins in that phytochemicals are induced by wounding
 - Phenolics
 - Furanocoumarins, Coumarins, Tannins, Lignin, other phenolics
 - Terpenoids
 - Alkaloids

Examples of plant activators

- **Acibenzolar-S-methyl (Actigard)**
- **Harpin (Messenger)**
- **Some biological control organisms (Serenade)**
 - **Also may control plant diseases by production of compounds directly toxic to the pathogen**

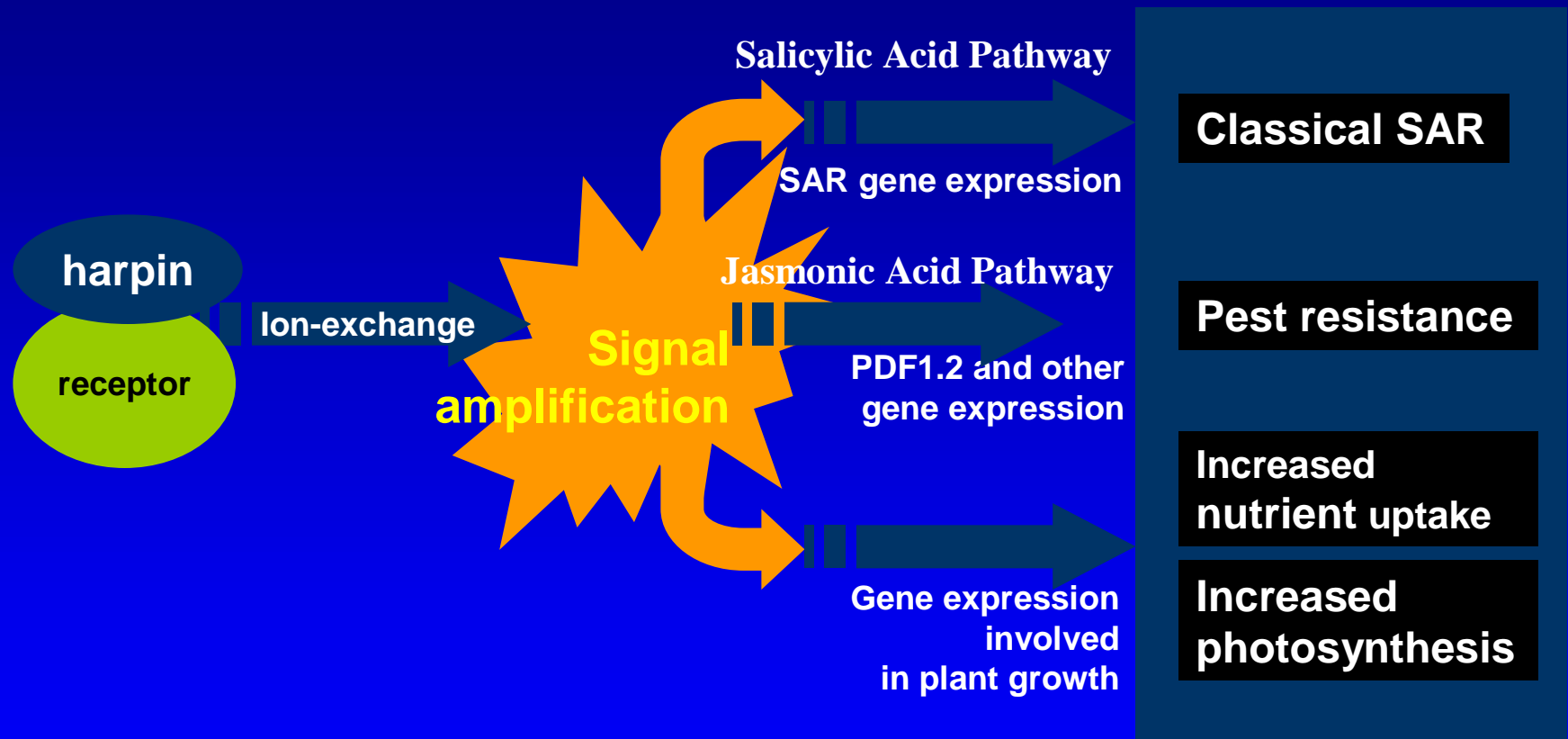
Mode of action - Actigard



Induction of Systemic Acquired Resistance

Slide courtesy of Syngenta

Mode of action - Messenger



Slide courtesy of Eden Bioscience

Concluding thought: Why is it important to know the physiological mode of action of fungicides?

- **For resistance management and preservation of fungicide effectiveness**
 - **Incorporate fungicides with different modes of action into a disease management program**
 - **In alternation or as a mixture**

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