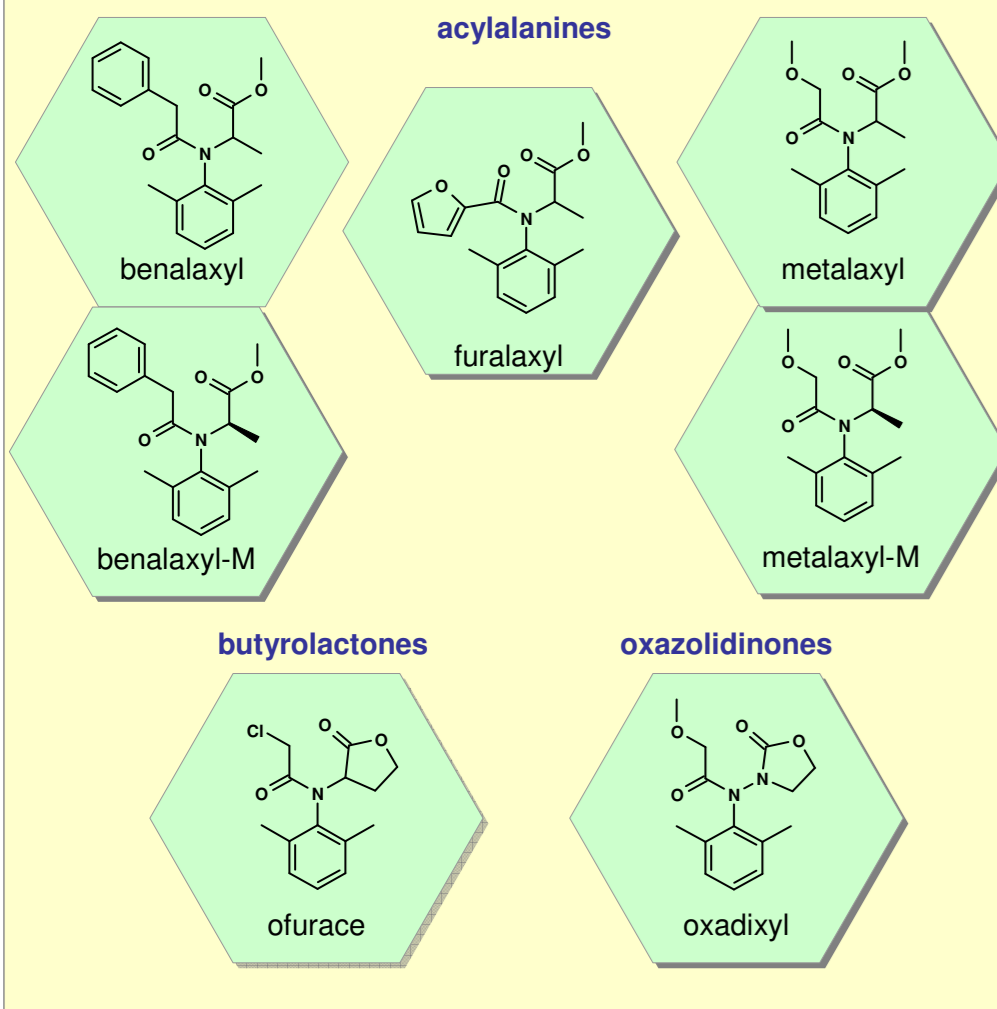


Mode of Action of Fungicides

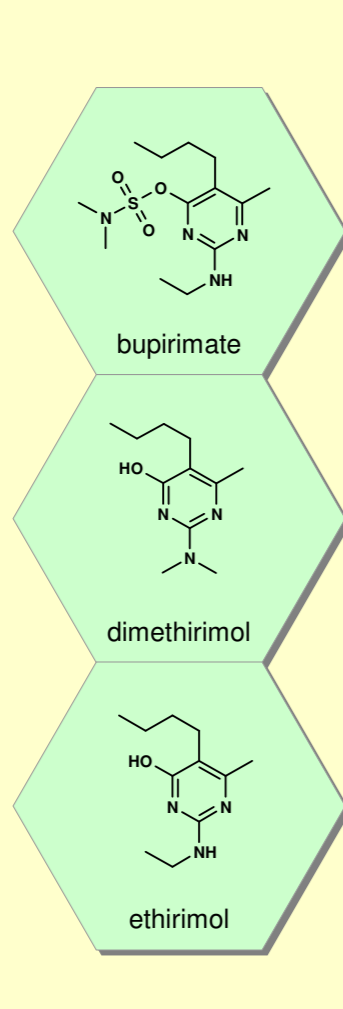
FRAC classification on mode of action 2010 (www.frac.info)

A: Nucleic Acid Synthesis

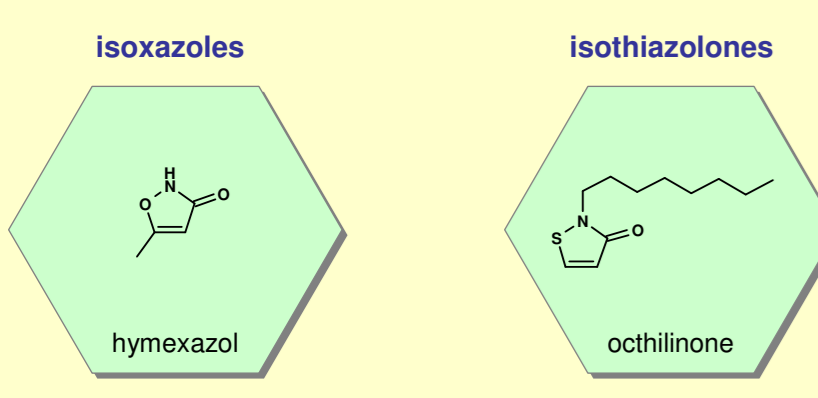
A1: RNA synthesis ▷ RNA polymerase I # 4: PA-fungicides (PhenylAmides)



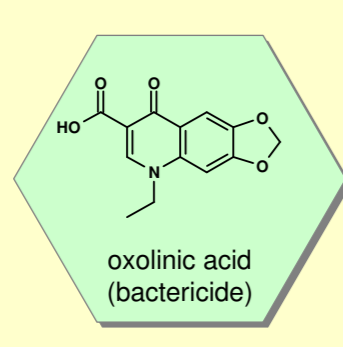
A2: purine metabolism ▷ adenosin-deaminase # 8: hydroxy (2-amino)-pyrimidines



A3: DNA / RNA synthesis (prop.) # 32: heteroaromatics

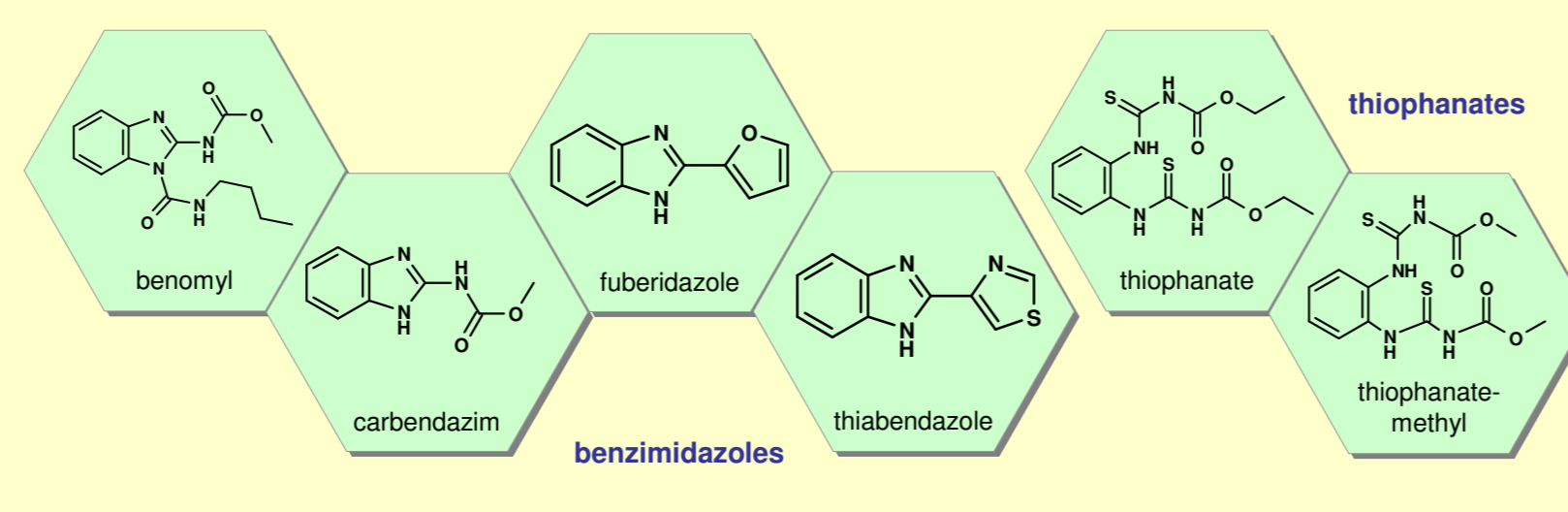


A4: DNA supercoiling ▷ DNA topoisomerase type II (gyrase) # 31: carboxylic acids

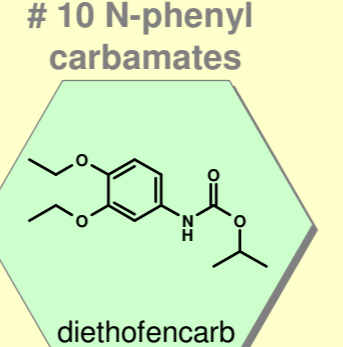


B: Mitosis and Cell Division

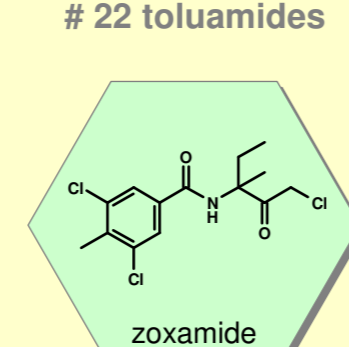
B1: ▷ β-tubulin assembly in mitosis # 1: MBC fungicides (= Methyl Benzimidazole Carbamates)



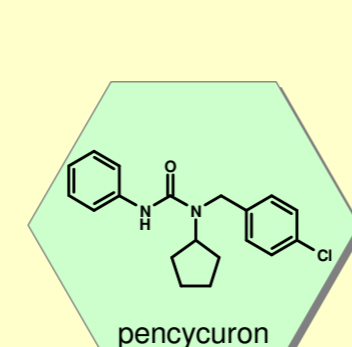
B2: ▷ β-tubulin assembly in mitosis* # 10 N-phenyl carbamates



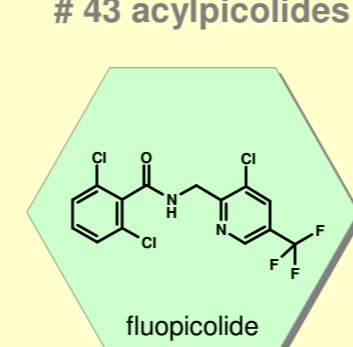
B3: ▷ β-tubulin assembly in mitosis # 22: toluamides



B4: cell division (prop.) # 20 phenylureas



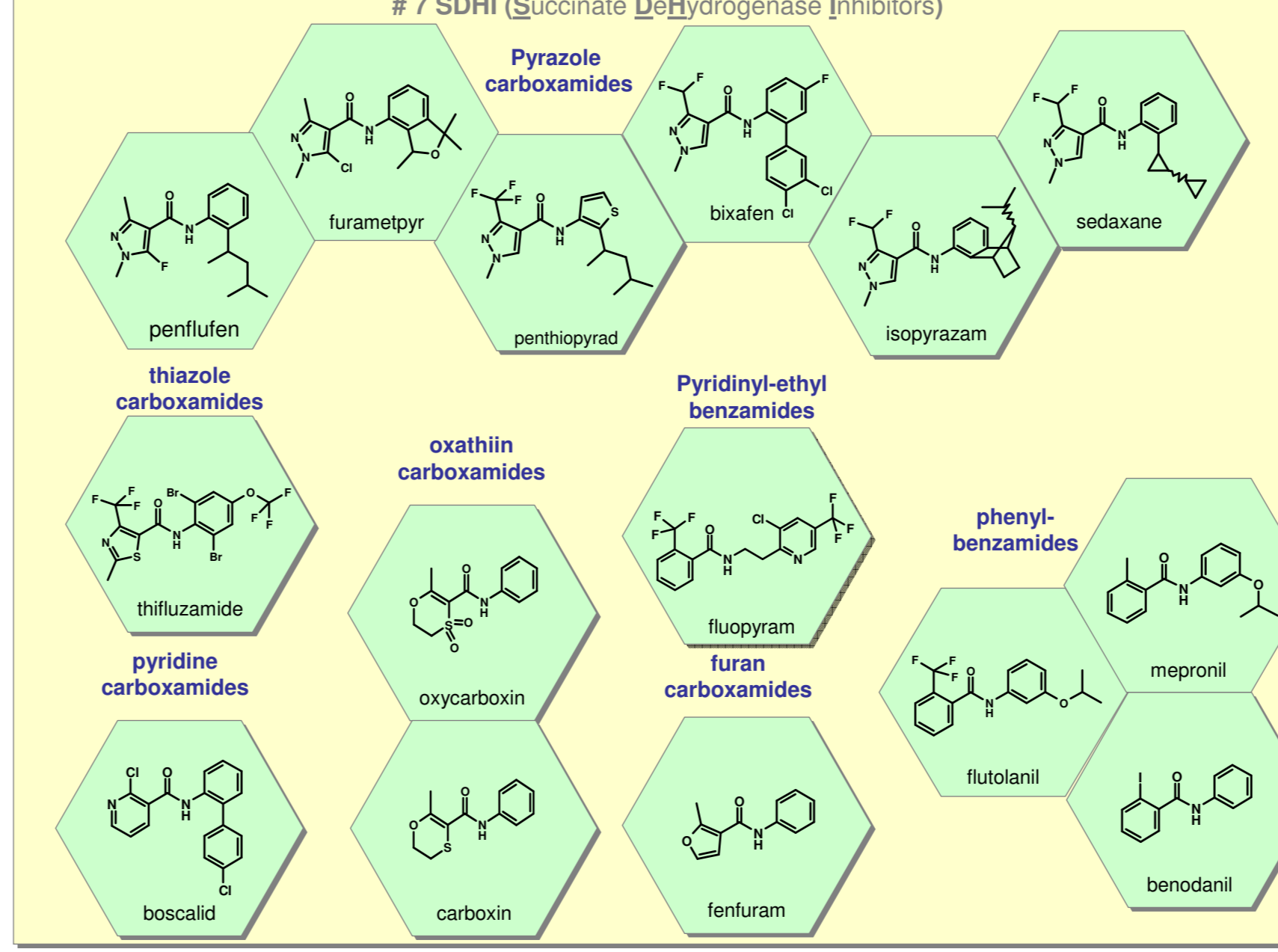
B5: delocalisation of spectrin-like proteins # 43 acylpicolides



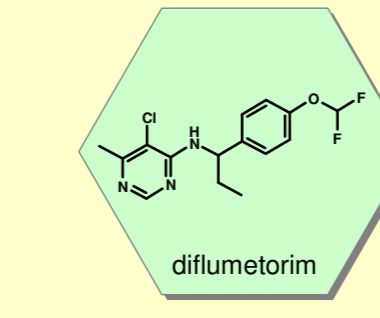
* negative cross-resistance to B1

C: Respiration

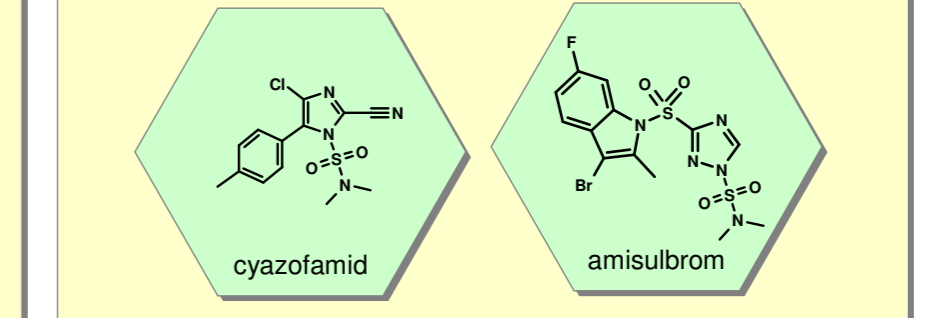
C2: inhibition of complex II: ▷ succinate-dehydrogenase # 7 SDHI (Succinate DeHydrogenase Inhibitors)



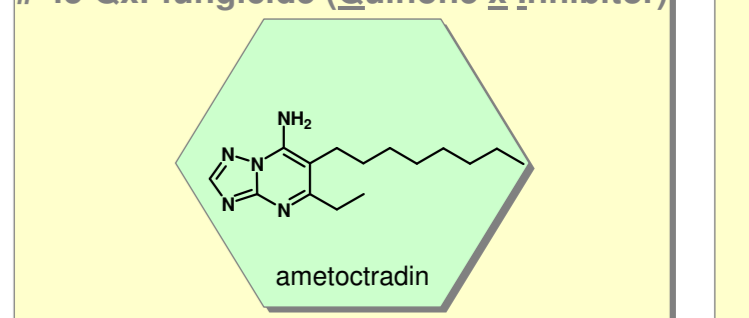
C1: inhibition of complex I NADH Oxido-reductase # 39 pyrimidinamines



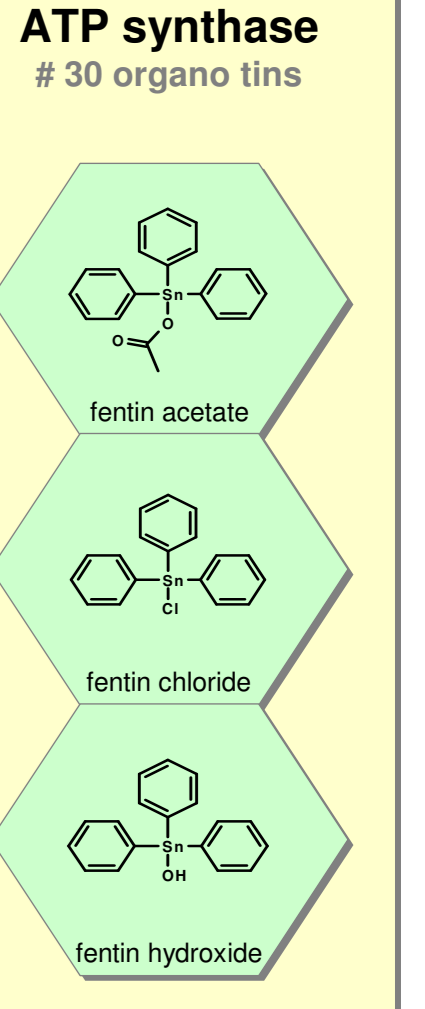
C4: inhibition of complex III ▷ cytochrome bc1(ubiquinone reductase) at Qi site # 21 Qil fungicides (Quinone Inside Inhibitors)



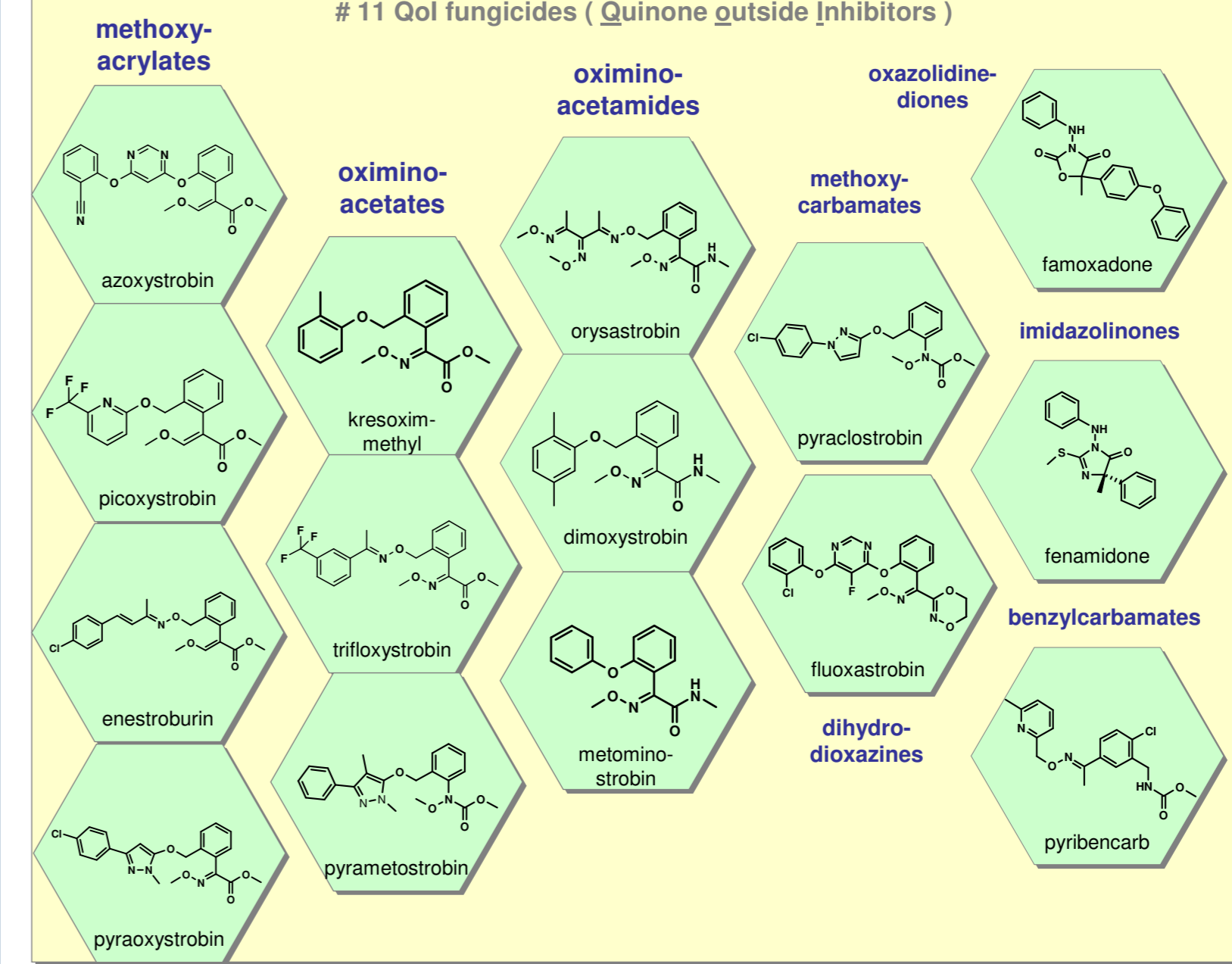
C8: inhibition of complex III ▷ cytochrome bc1(ubiquinone reductase) at Qx (unknown site) # 45 Qxl-fungicide (Quinone x Inhibitor)



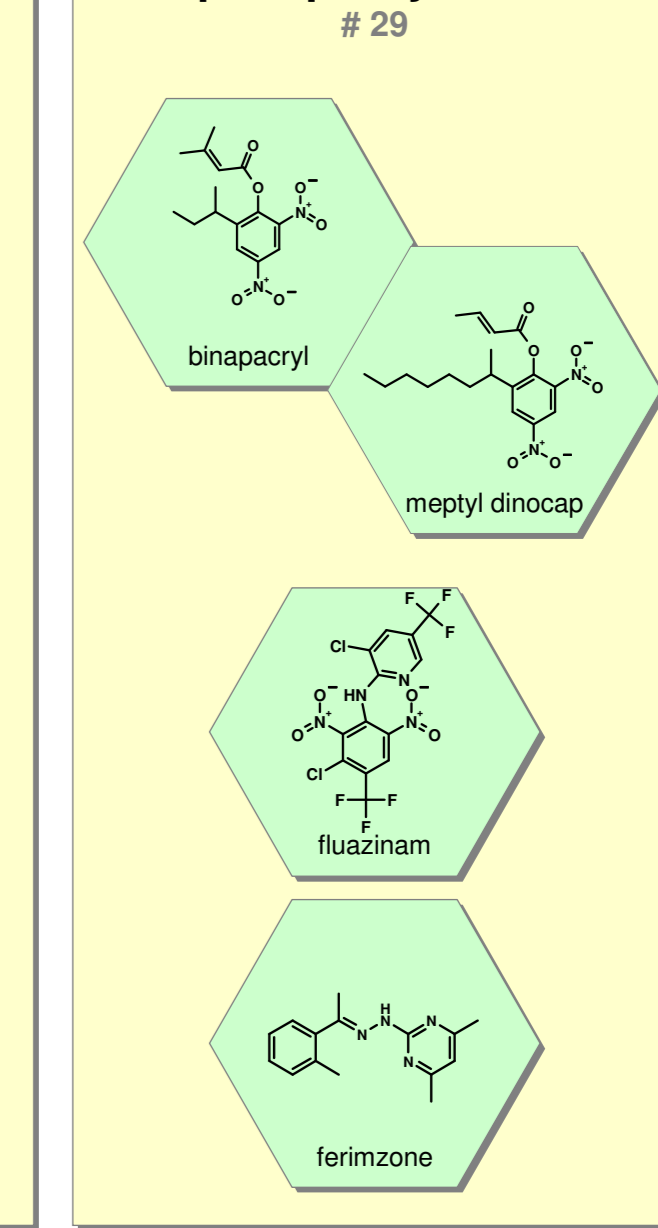
C6: inhibitors of oxidative phosphorylation, ATP synthase # 30 organo tins



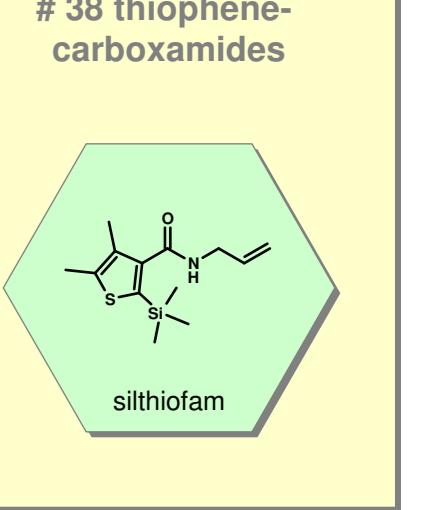
C3: inhibition of complex III cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) # 11 Qol fungicides (Quinone outside Inhibitors)



C5: uncouplers of oxidative phosphorylation # 29

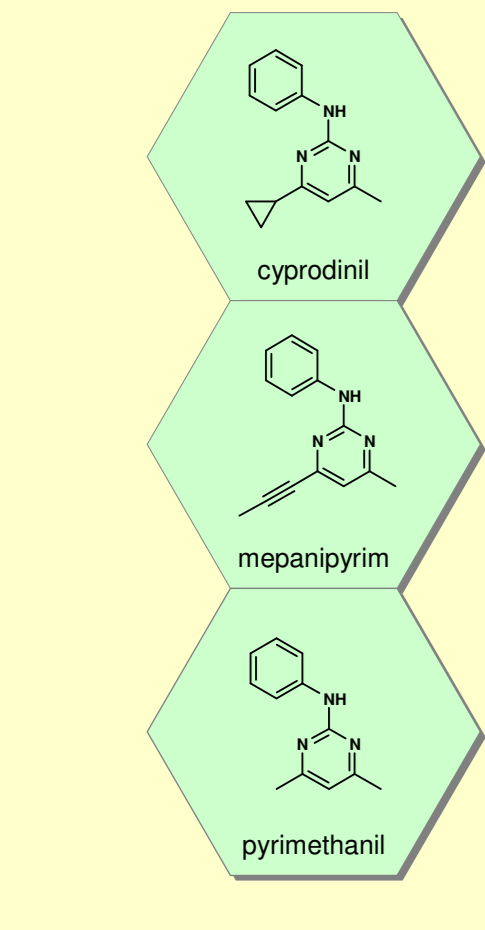


C7: ATP production (prop.) # 38 thiophene-carboxamides

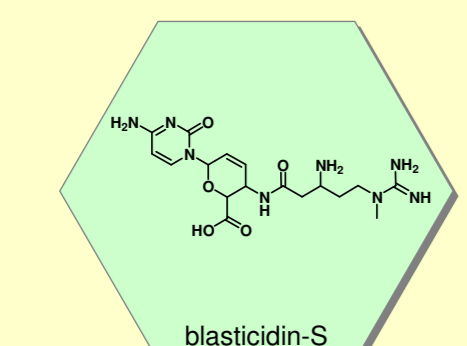


D: Amino Acid and Protein Synthesis

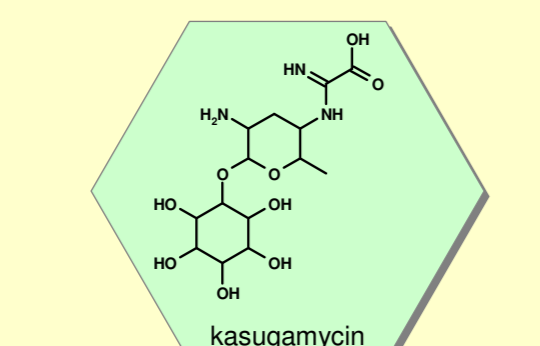
D1: methionine biosynthesis (cgs gene) (prop.) # 9 Anilino-Pyrimidines (AP fungicides)



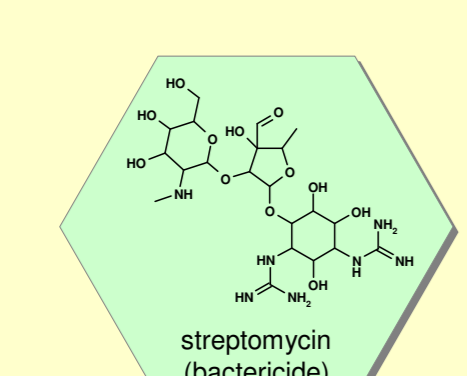
D2: protein synthesis # 24 enopyranosyl antibiotics



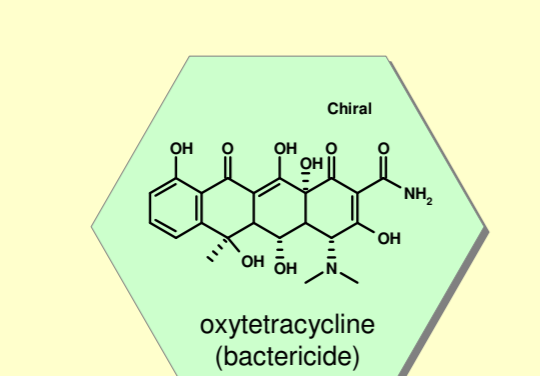
D3: protein synthesis # 24 hexopyranosyl antibiotics



D4: protein synthesis # 25 glucopyranosyl antibiotics

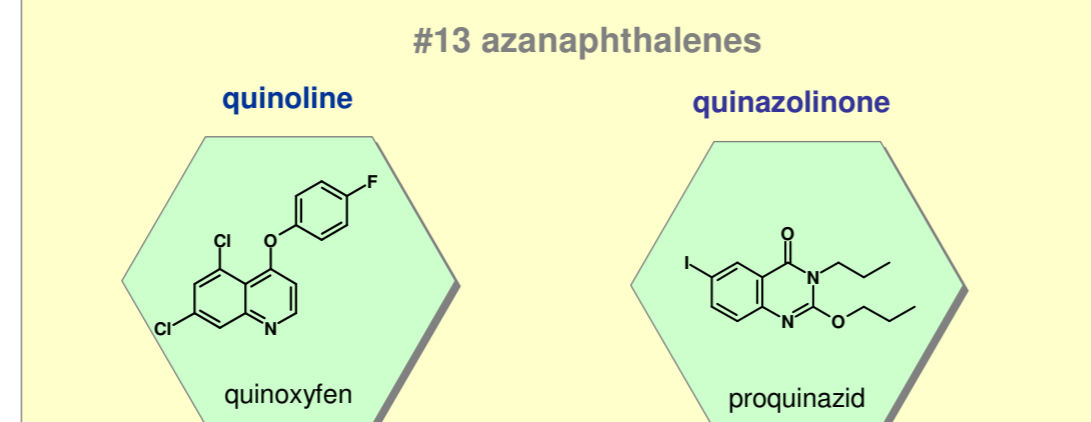


D5: protein synthesis # 41 tetracycline antibiotics

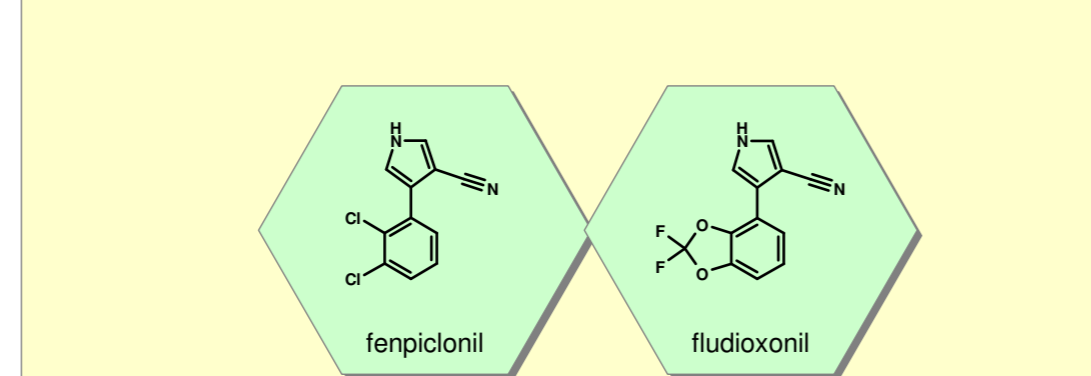


E: Signal Transduction

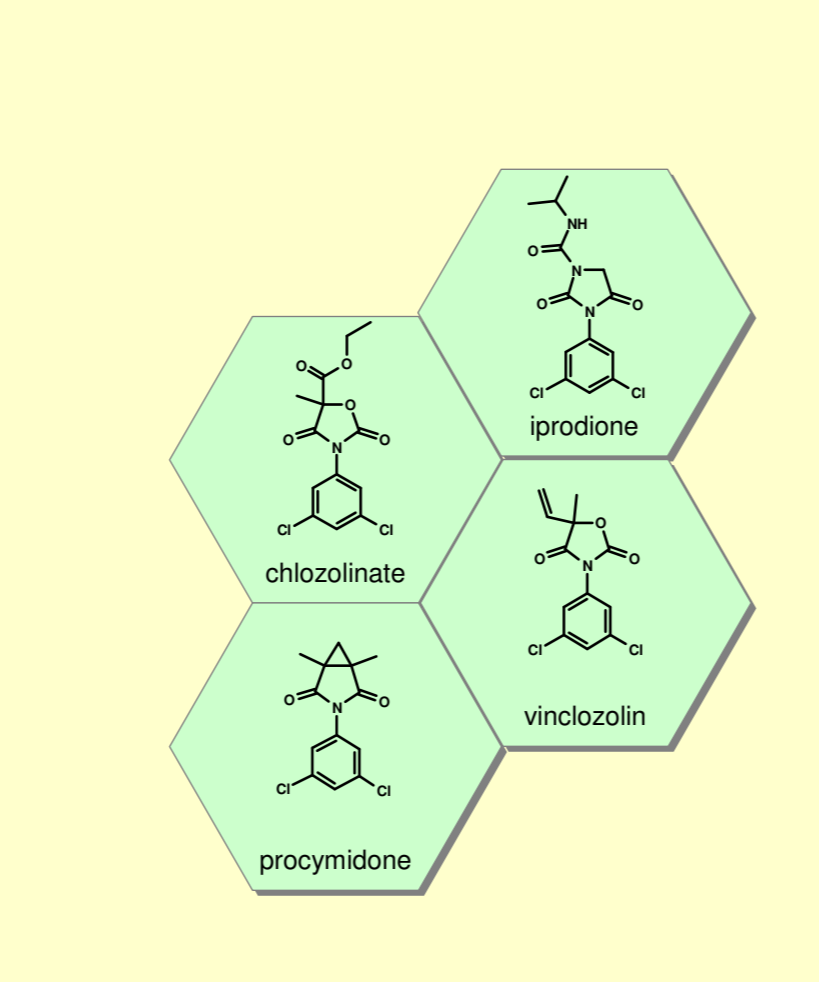
E1: Signal transduction (mechanism unknown) # 13 azanaphthalenes



E2: Osmotic signal transduction ▷ MAP / histidine-kinase (os-2, HOG1) # 12 phenylpyrroles (PP- fungicides)

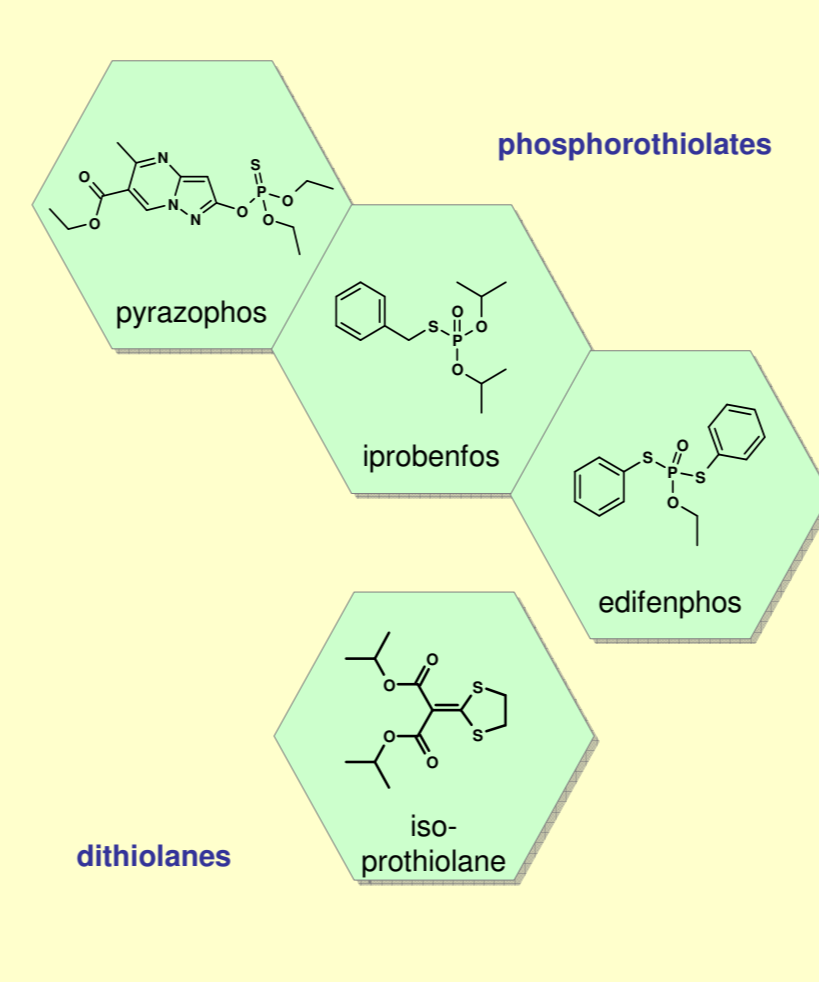


E3: Osmotic signal transduction ▷ MAP / histidine kinase (os-1, Daf1) # 2 dicarboximides

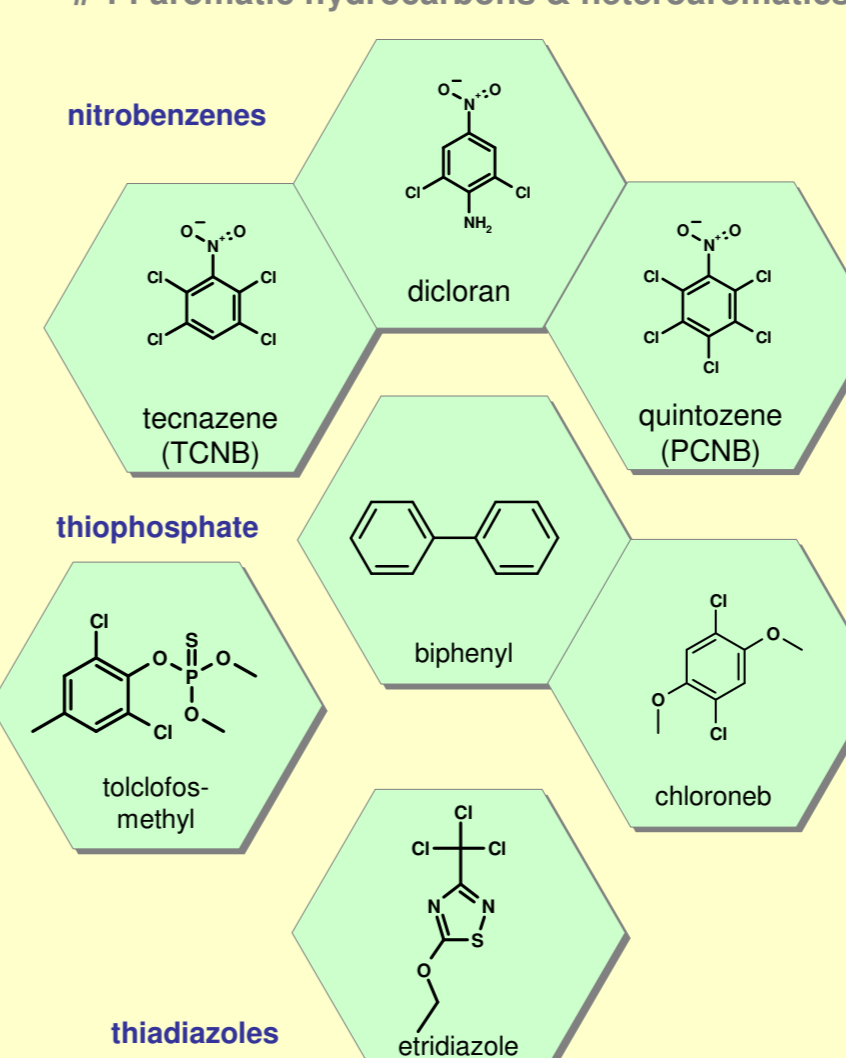


F: Lipid and Membrane Synthesis

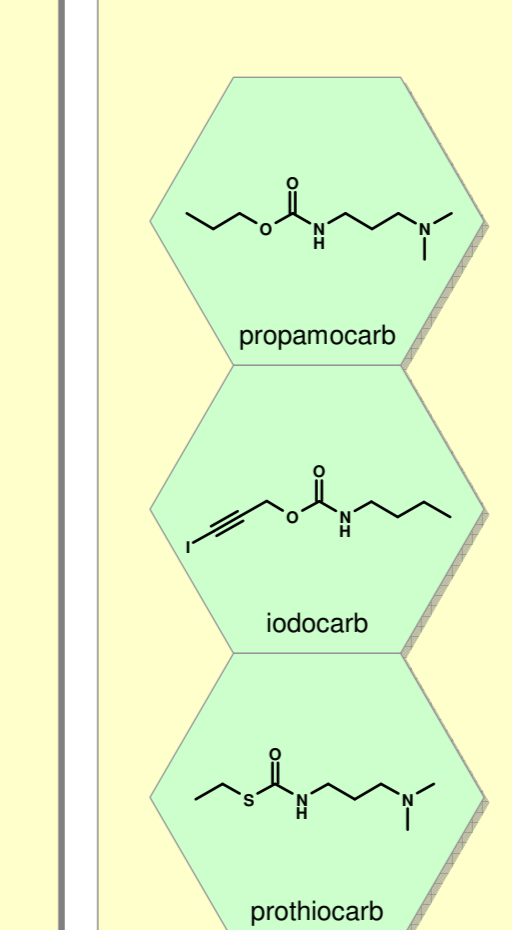
F2: phospholipid biosynthesis ▷ methyltransferase # 6 phosphorothiolates & dithiolanes



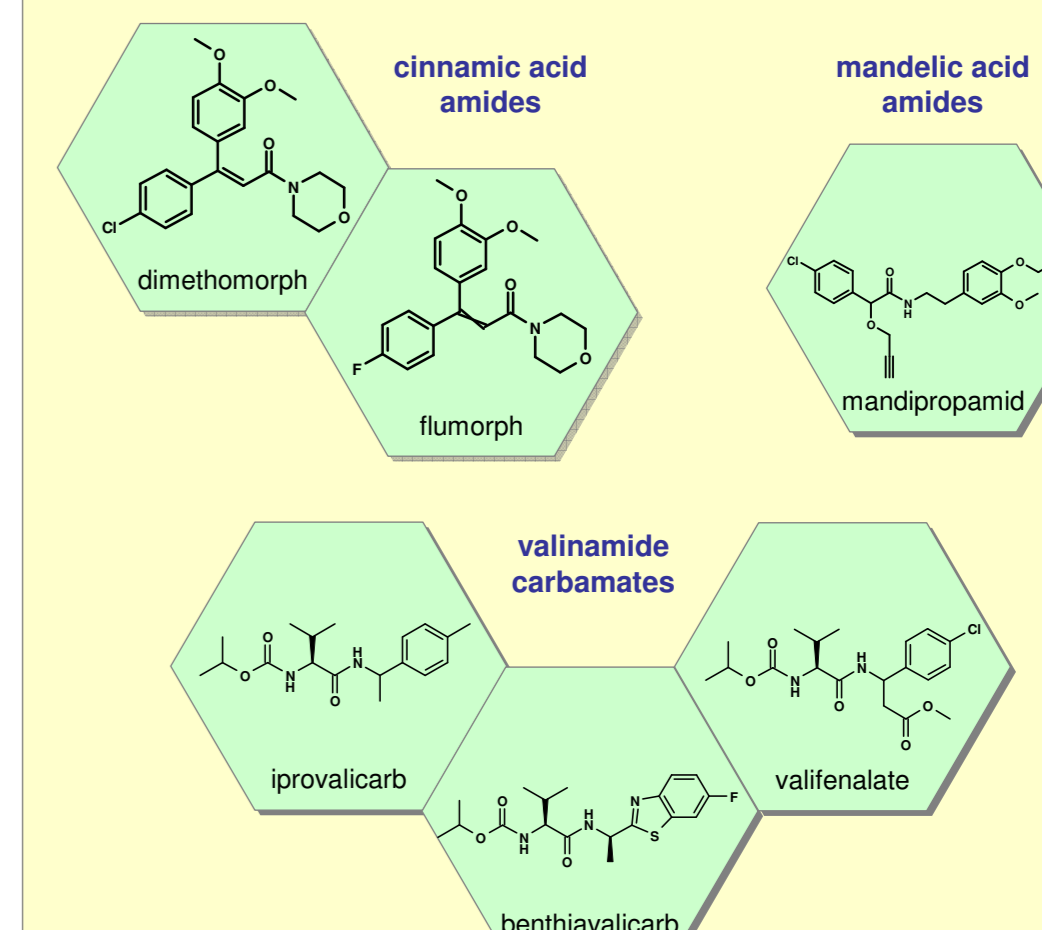
F3: lipid peroxidation (prop.) # 14 aromatic hydrocarbons & heteroaromatics



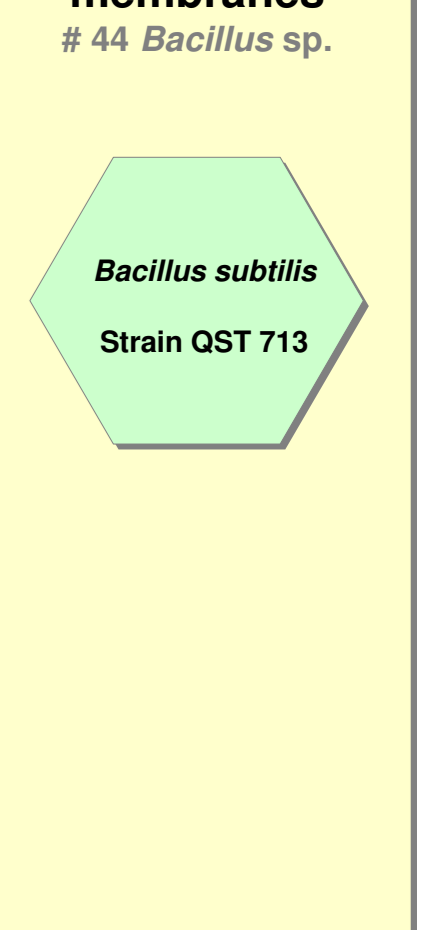
F4: cell membrane permeability, fatty acids (prop.) # 28 carbamates



F5: phospholipid biosynthesis and cell wall deposition (prop.) # 40 Carboxylic Acid Amides (CAA fungicides)

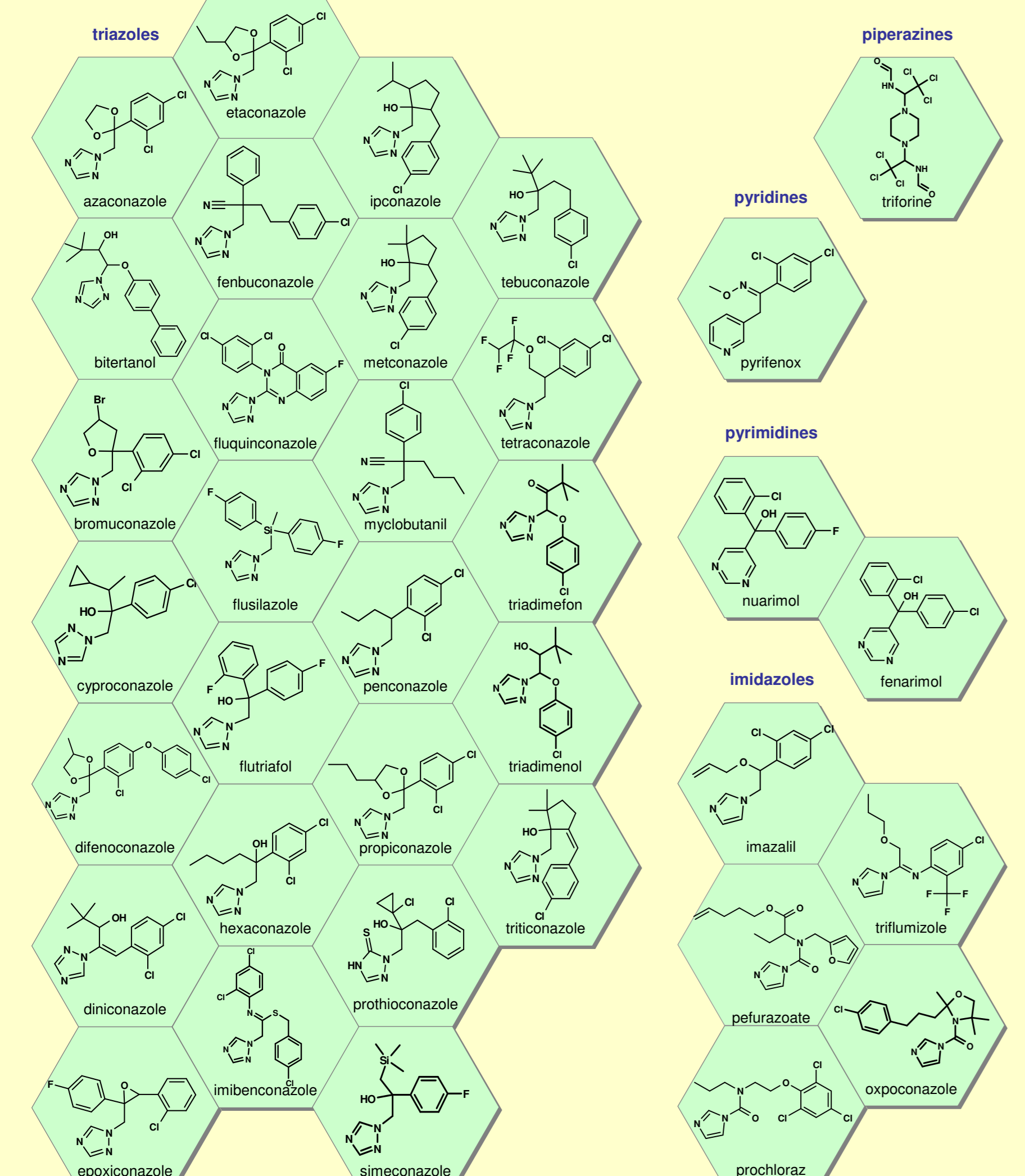


F6: microbial disrupters of pathogen cell membranes # 44 Bacillus sp.

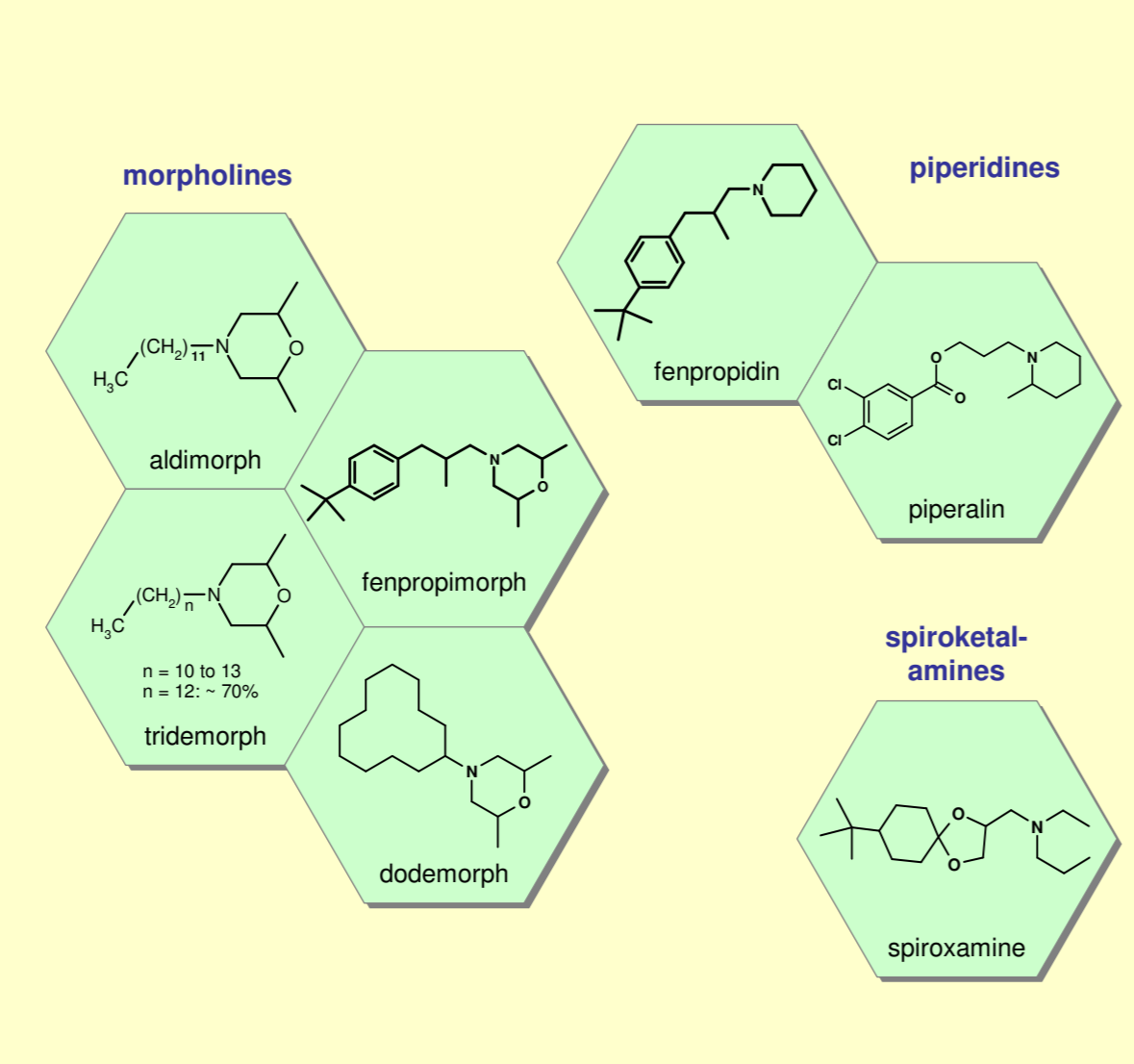


G: Sterol Biosynthesis in membranes

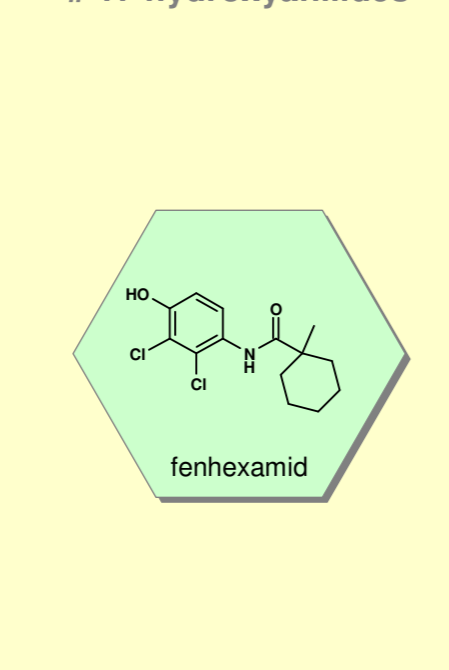
G1: Sterol Biosynthesis Inhibitor (SBI) class I: DMI fungicides ▷ C14 demethylase (erg11/cyp51) # 3 QeMethylation_inhibitors (=DMI fungicides)



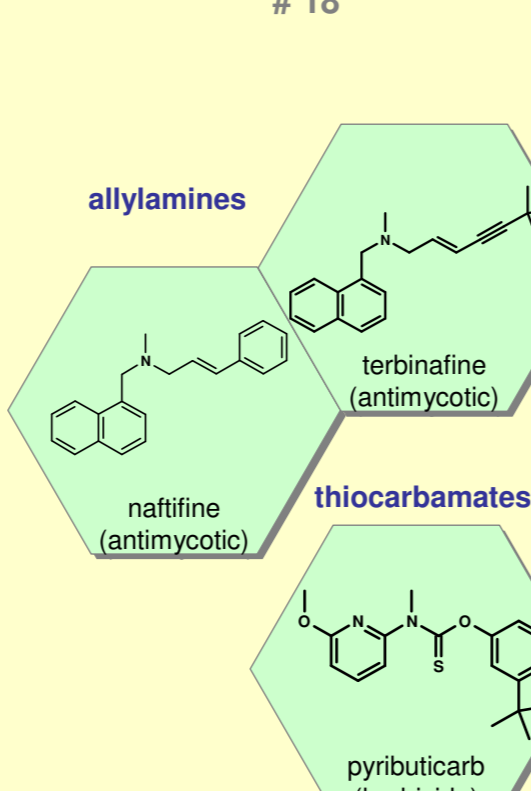
G2: SBI class II: Amines ▷ Δ¹⁴-reductase (erg24) and Δ⁹-Δ⁷-isomerase (erg2) # 5 amines



G3: SBI class III: hydroxyanilides ▷ 3-keto reductase in C4-demethylation # 17 hydroxyanilides

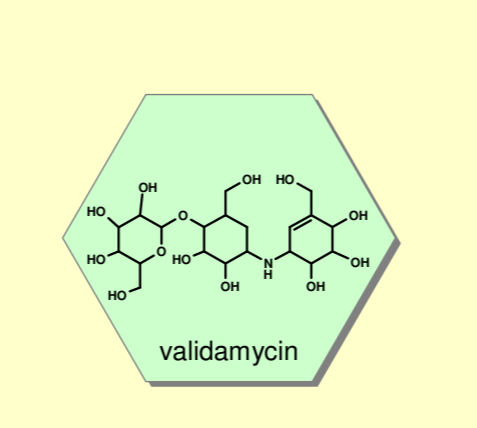


G4: SBI class IV: ▷ squalene epoxidase # 18

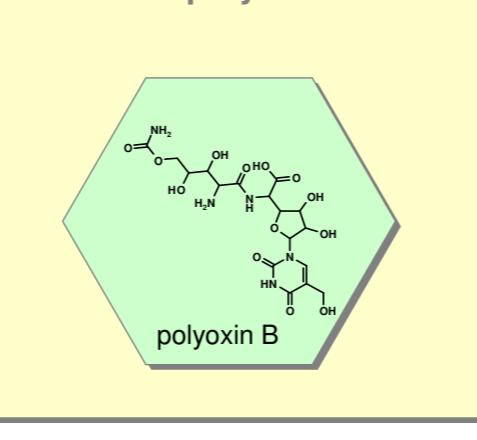


H: Glucan Synthesis

H3: trehalase and inositol biosynthesis # 26 glucopyranosyl antibiotic

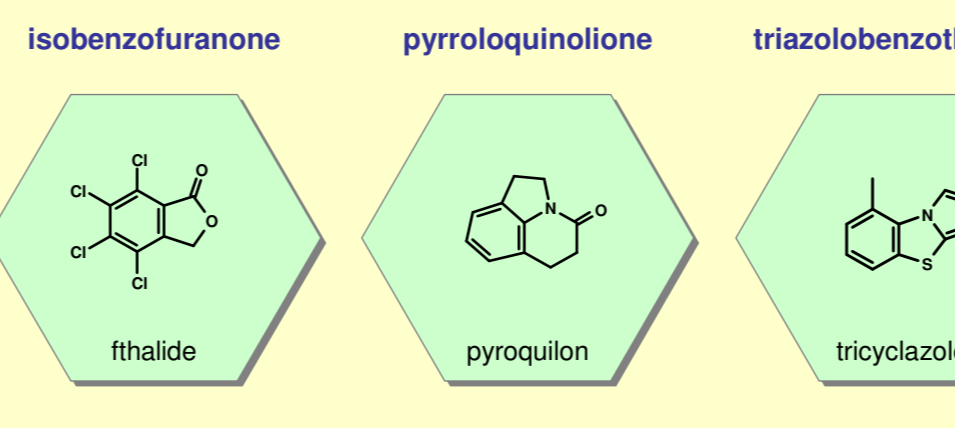


H4: chitin synthesis ▷ chitin synthase # 19 polyoxins

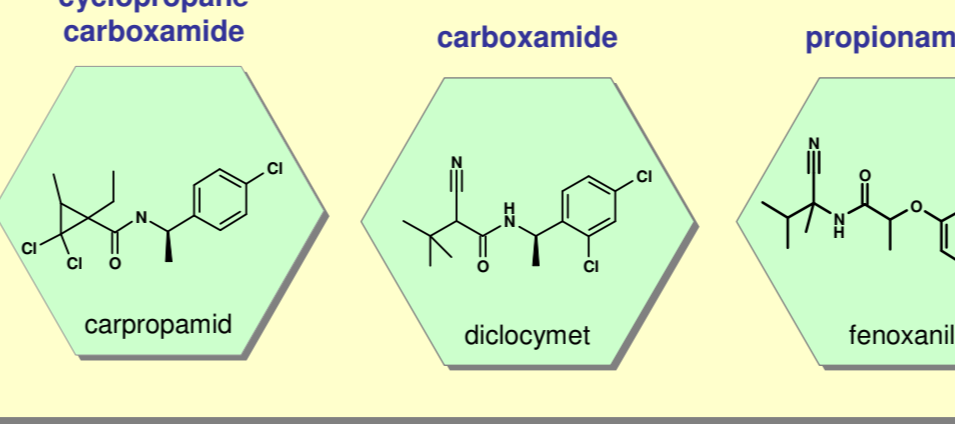


I: Melanin Synthesis in Cell Wall

I1: ▷ reductase in melanin biosynthesis # 16.1 Melanin Biosynthesis Inhibitors (MBI-R)

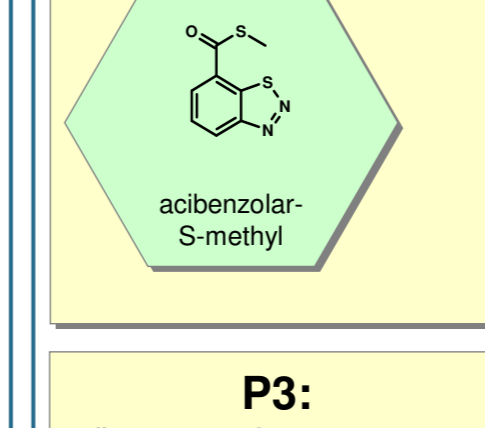


I2: ▷ dehydratase in melanin biosynthesis # 16.2 Melanin Biosynthesis Inhibitors (MBI-D)

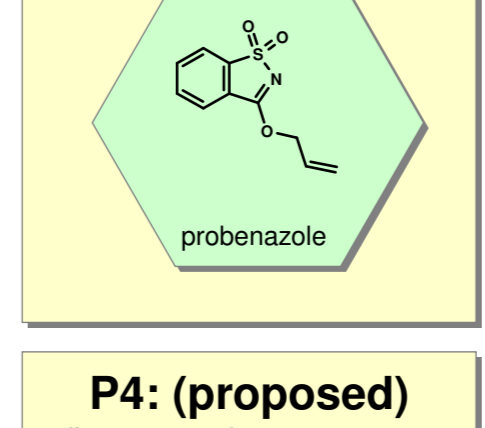


P: Host Defence Inducer

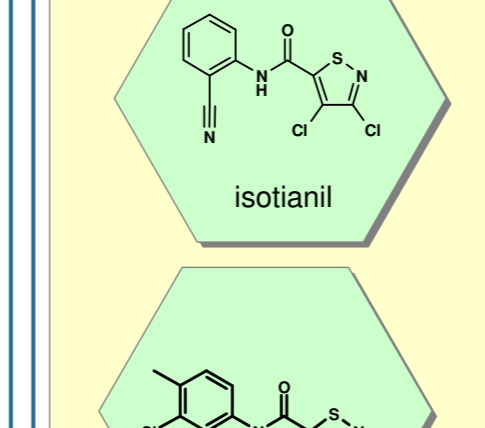
P1: salicylic pathway # P: host defence induction



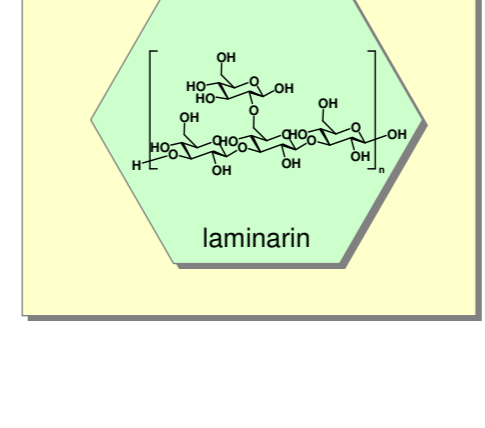
P2: # P: host defence induction



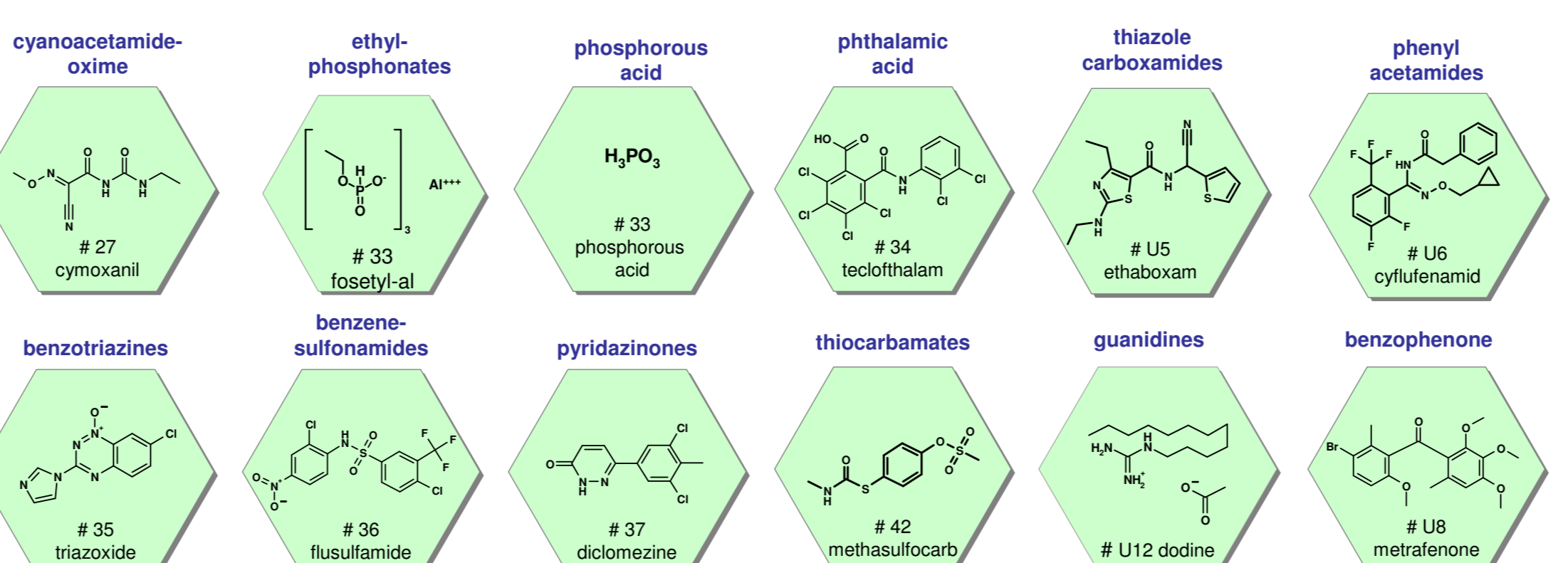
P3: # P: host defence induction



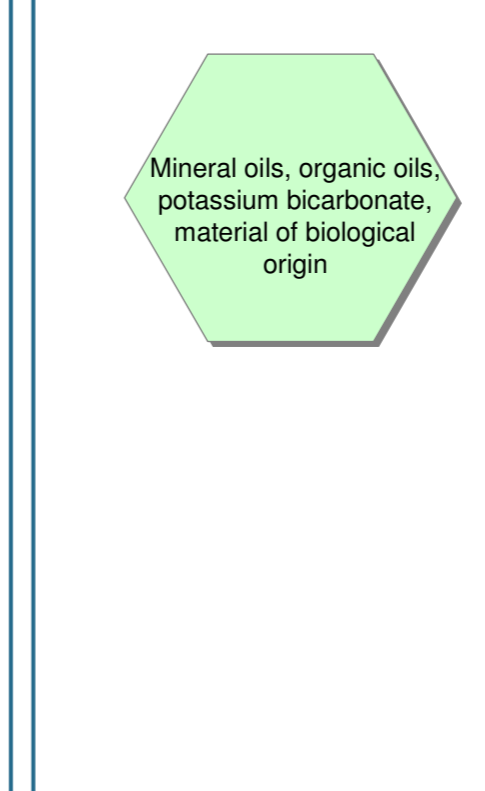
P4: (proposed) # P: host defence induction



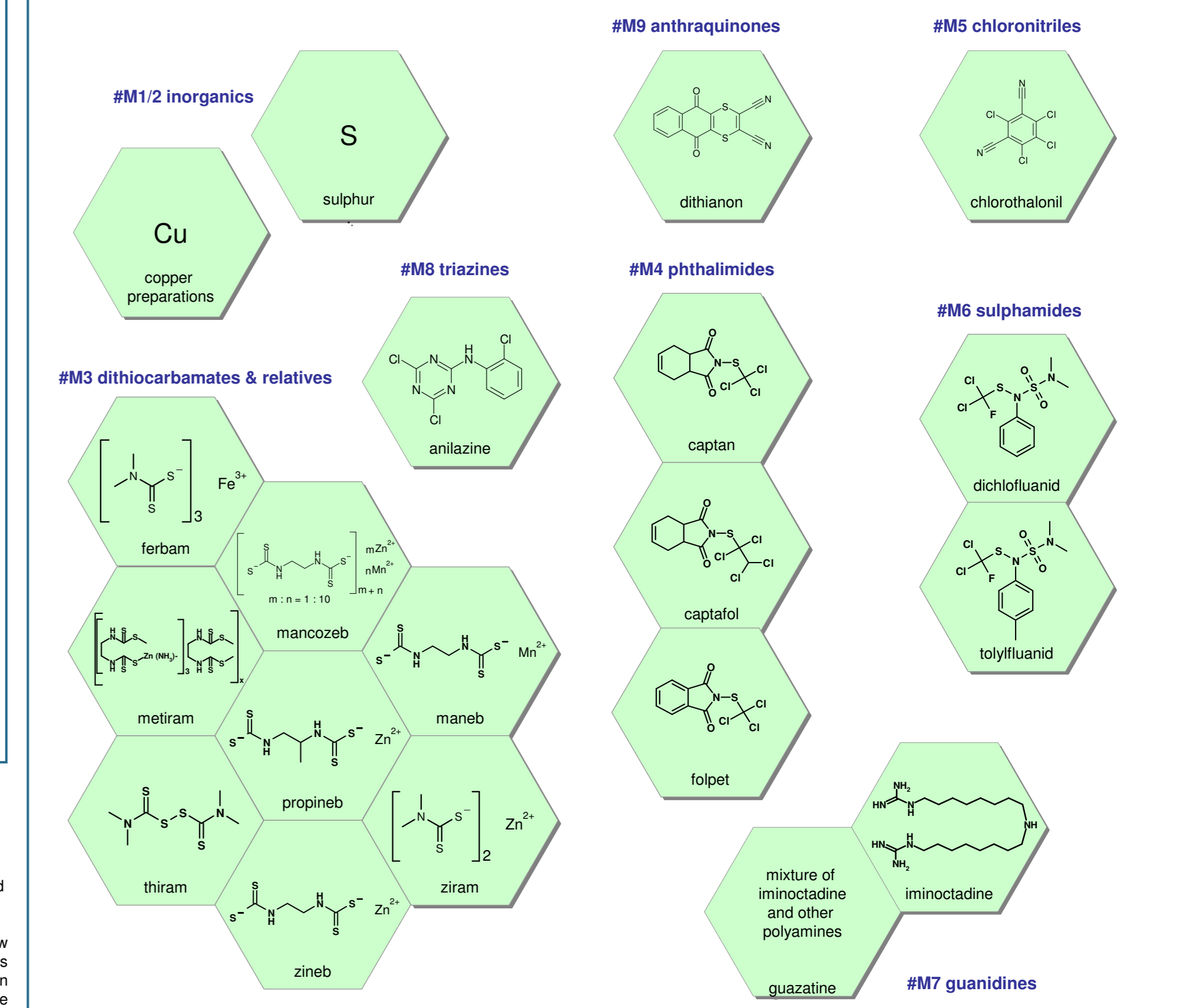
Unknown Mode of Action



NC : Not Classified



M: Multi Site Action



Legend:

- mode of action group
- sub-group
- ▷ target site of action (where known) or putative target site (prop.)
- FRAC code no. (#) and group name
- chemical (sub-) group

C: Respiration

**C2: inhibition of complex II:
▷ succinate-dehydrogenase
7 SDHI (Succinate dehydrogenase inhibitors)**

thiazole carboxamides

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE