IRAC

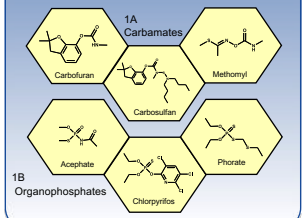
Insecticide Resistance Action Committee

Mode of Action Classification

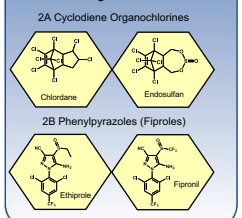
Key to Targeted Physiology

- Nerve & Muscle
- Growth & Development
- Respiration
- Midgut
- Unknown or Non-specific

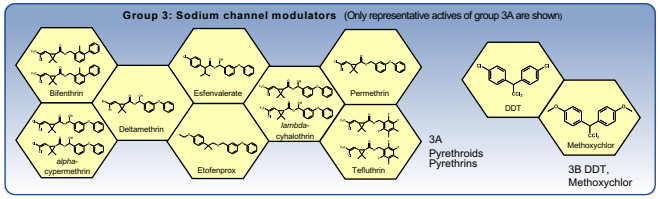
Group 1: Acetylcholinesterase (AChE) inhibitors
(Only representatives actives of the groups are shown)



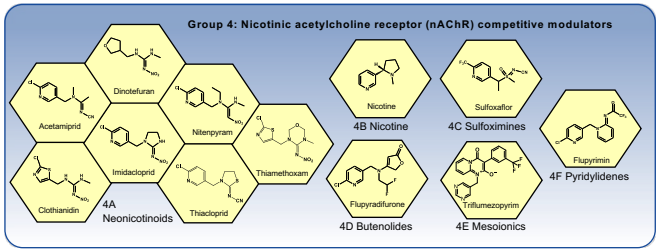
Group 2: GABA-gated chloride channel antagonists



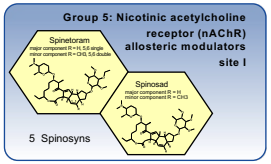
Group 3: Sodium channel modulators (Only representative actives of group 3A are shown)



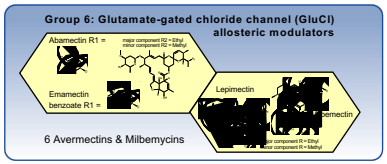
Group 4: Nicotinic acetylcholine receptor (nAChR) competitive modulators



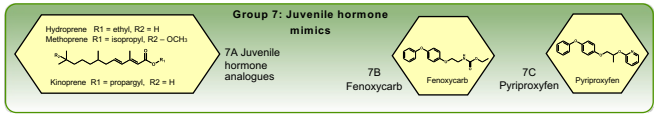
Group 5: Nicotinic acetylcholine receptor (nAChR) allosteric modulators site I



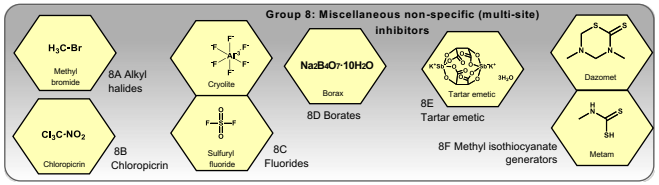
Group 6: Glutamate-gated chloride channel (GluCl) allosteric modulators



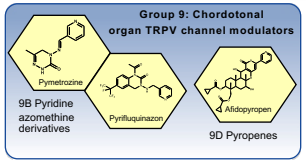
Group 7: Juvenile hormone mimics



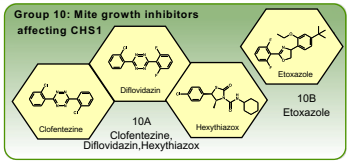
Group 8: Miscellaneous non-specific (multi-site) inhibitors



Group 9: Chordotonal organ TRPV channel modulators



Group 10: Mite growth inhibitors affecting CHS1



Group 11: Microbial disruptors of insect midgut membranes

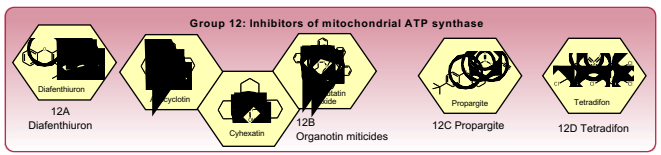
Includes transgenic crops expressing *Bacillus thuringiensis* toxins (however, specific guidance for resistance management of transgenic crops is not based on rotation of modes of action)

Rotation between certain specific *B.t.* microbial products may provide resistance management benefits for some pests. Consult product-specific recommendations.

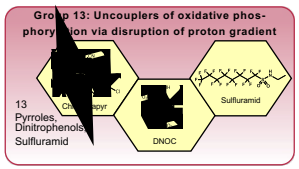
Bacillus thuringiensis and the insecticidal proteins produced *B.t. israelensis, B.t. aizawai, B.t. kurstaki, B.t. tenebrionis* — 11A *Bacillus thuringiensis*

Bacillus sphaericus — 11B *Bacillus sphaericus*

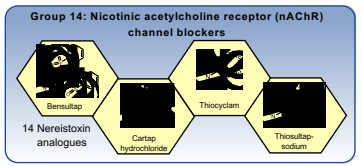
Group 12: Inhibitors of mitochondrial ATP synthase



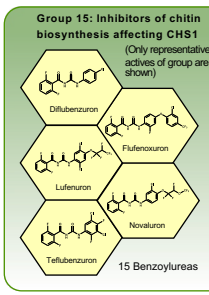
Group 13: Uncouplers of oxidative phosphorylation via disruption of proton gradient



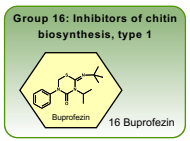
Group 14: Nicotinic acetylcholine receptor (nAChR) channel blockers



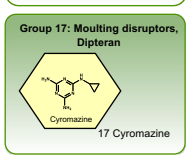
Group 15: Inhibitors of chitin biosynthesis affecting CHS1
(Only representative actives of group are shown)



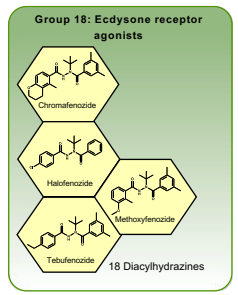
Group 16: Inhibitors of chitin biosynthesis, type 1



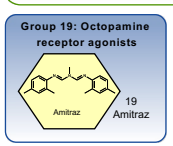
Group 17: Moulting disruptors, Dipteran



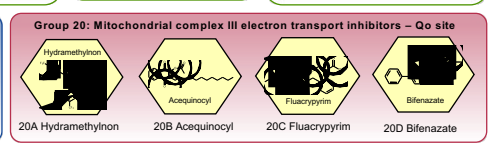
Group 18: Ecdysone receptor agonists



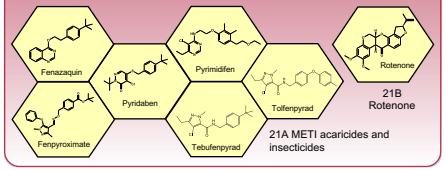
Group 19: Octopamine receptor agonists



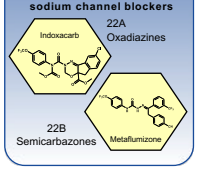
Group 20: Mitochondrial complex III electron transport inhibitors – Qo site



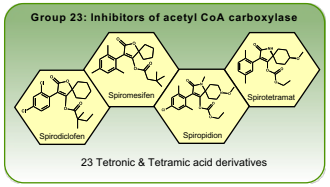
Group 21: Mitochondrial complex I electron transport inhibitors



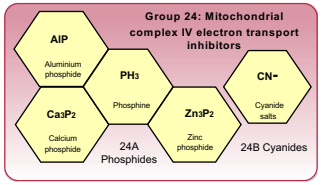
Group 22: Voltage-dependent sodium channel blockers



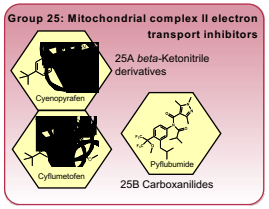
Group 23: Inhibitors of acetyl CoA carboxylase



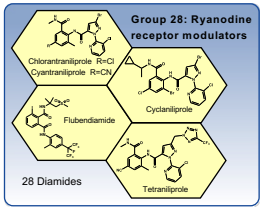
Group 24: Mitochondrial complex IV electron transport inhibitors



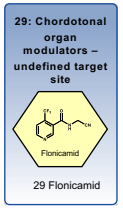
Group 25: Mitochondrial complex II electron transport inhibitors



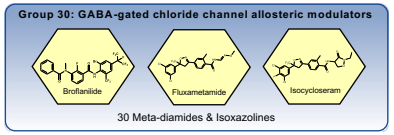
Group 28: Ryanodine receptor modulators



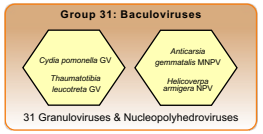
29: Chordotonal organ modulators – undefined target site



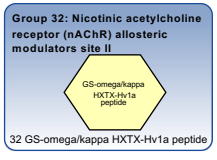
Group 30: GABA-gated chloride channel allosteric modulators



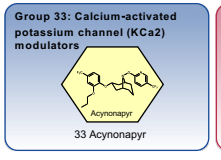
Group 31: Baculoviruses



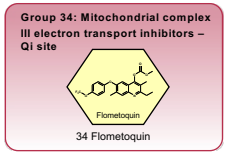
Group 32: Nicotinic acetylcholine receptor (nAChR) allosteric modulators site II



Group 33: Calcium-activated potassium channel (KCa2) modulators

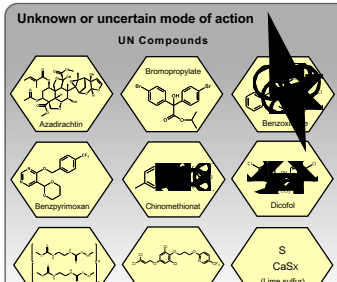


Group 34: Mitochondrial complex III electron transport inhibitors – Qi site



Unknown or uncertain mode of action

UN Compounds



UNB Bacterial agents (non-Bt)

Burkholderia spp, *Wolbachia pipientis* (Zap)

UNF Fungal agents

Beauveria bassiana strains
Metarhizium anisopliae strain F52,
Paecilomyces fumosoroseus Apopka strain 97

Chenopodium ambrosioides near ambrosioides extract
Fatty acid monoesters with glycerol or propanediol
Neem oil

UNE Botanical essence including synthetic, extracts and unrefined oils

Diatomaceous earth
Mineral oil

UNM Non-specific mechanical and physical disruptors

Use of Groups:

- Alternations, sequences or rotations of compounds between MoA groups reduce selection for target-site resistance.
- Applications are arranged into MoA spray windows defined by crop growth stage and pest biology. Several sprays of a compound may be possible within each spray window, but successive generations of a pest should not be treated with compounds from the same MoA group. Local expert advice on spray windows and timings should always be followed.
- Groups in the classification whose members do not act at a common target site are exempt from the proscription against rotation within the group (Group 8, 13 and all UN groups: UN, UNB, UNE, UNF, UNM, UNP & UNV).

Use of Sub-Groups:

- Sub-groups represent distinct structural classes which are believed to have the same mode of action.
- Sub-groups provide differentiation between compounds that may bind at the same target site but are structurally different enough that risk of metabolic cross-resistance is lower than for close chemical analogs.
- Cross-resistance potential between sub-groups is higher than between groups, so rotation between sub-groups should be considered only when there are no alternatives, and only if cross-resistance does not exist, following consultation with local expert advice. These exceptions are not sustainable, and alternative options should be sought.

Poster Notes:

- Sub-group 3B: DDT is no longer used in agriculture and therefore this is only applicable for the control of insect vectors of human disease, such as mosquitoes, because of a lack of alternatives.
- Sub-group10A: Hexythiazox is grouped with Clofentezine because they exhibit cross-resistance even though they are structurally distinct. Diflovidazin has been added to this group because it is a close analogue of Clofentezine and is expected to have the same mode of action.
- Group 20: While there is strong evidence that Bifenazate acts on the Qo site of Mitochondrial Complex III and some Bifenazate resistance mutations confer cross-resistance to Acequinocyl, the sites of action of Fluacrypyrim and Hydramethylnon have not been determined.
- Groups 26 and 27 are unassigned.
- In some cases, only representative actives are shown.
- Please visit www.irac-online.org for the complete IRAC classification.

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