# IRAC

Insecticide Resistance Action Committee

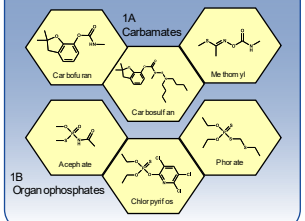
# Mode of Action Classification

**Key to Targeted Physiology**

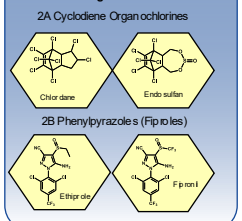
- Nerve & Muscle
- Growth & Development
- Respiration
- Midgut
- Protein Suppressor
- Unknown or Non-specific

## Group 1: Acetylcholinesterase (AChE) inhibitors

(Only representatives actives of the groups are shown)

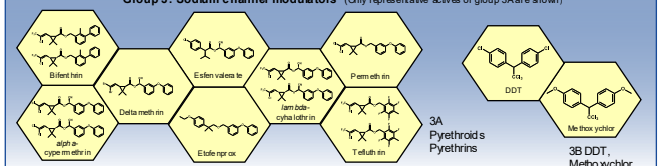



## Group 2: GABA-gated chloride channel antagonists

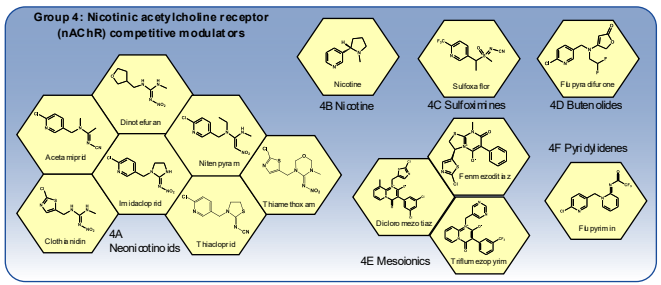



## Group 3: Sodium channel modulators

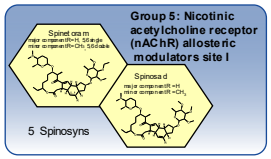
(Only representative actives of group 3A are shown)



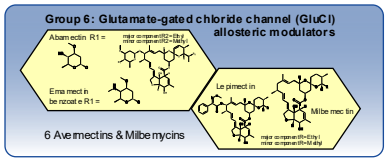

## Group 4: Nicotinic acetylcholine receptor (nAChR) competitive modulators



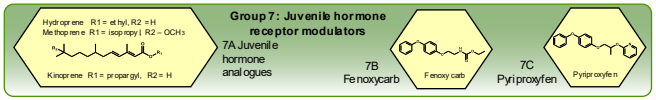

## Group 5: Nicotinic acetylcholine receptor (nAChR) allosteric modulators site I



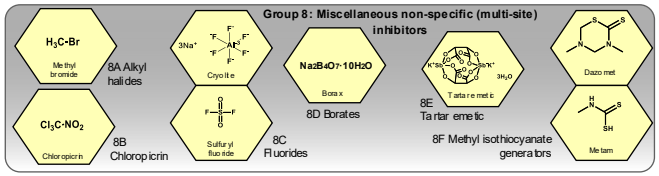

## Group 6: Glutamate-gated chloride channel (GluCl) allosteric modulators




## Group 7: Juvenile hormone receptor modulators




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



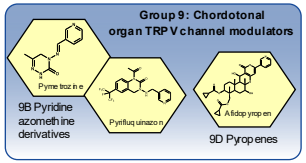

## Use of Groups:

- 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).

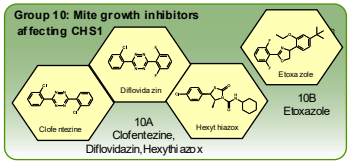
## Use of Sub-Groups:

- 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.

## Group 9: Chordotonal organ TRPV channel modulators




## Group 10: Mite growth inhibitors affecting CHS1




## Group 11: Microbial disruptors of insect midgut membranes

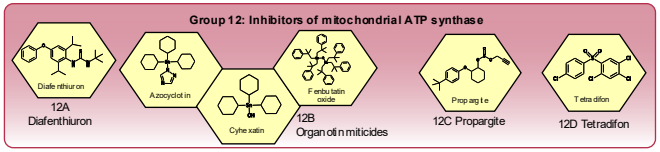
Includes transgenic crops expressing *Bacillus thuringiensis* toxins (however, specific guidance for resistance management of transgenic crops is not based on rotation of modes of action)

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

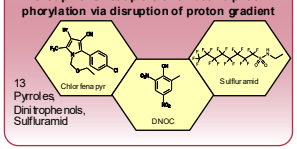
*Bacillus thuringiensis* and the insecticidal proteins produced
*B.t. aizawai, B.t. israelensis, B.t. kurstaki, B.t. tenebrionis*
11A *Bacillus thuringiensis*

*Bacillus sphaericus*
11B *Bacillus sphaericus*

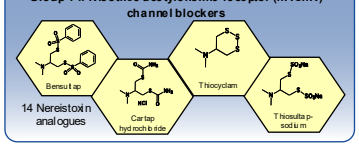
## Group 12: Inhibitors of mitochondrial ATP synthase




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

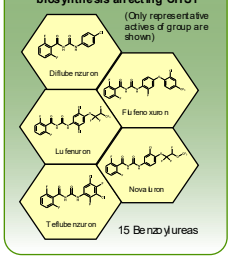



## Group 14: Nicotinic acetylcholine receptor (nAChR) channel blockers

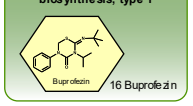



## Group 15: Inhibitors of chitin biosynthesis affecting CHS1

(Only representative actives of group are shown)

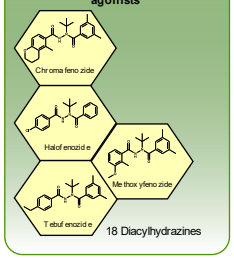



## Group 16: Inhibitors of chitin biosynthesis, type 1

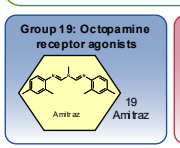



## Group 17: Moulting disruptors, Dipteran

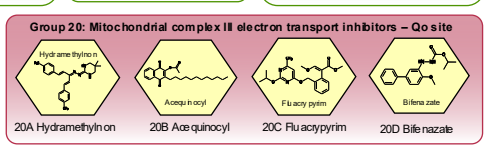

## Group 18: Ecdysone receptor agonists




## Group 19: Octopamine receptor agonists




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

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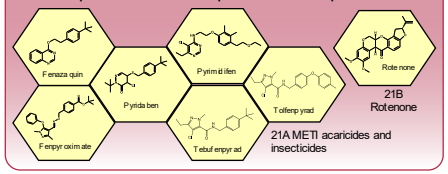
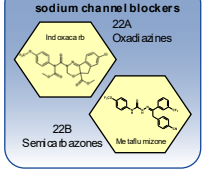
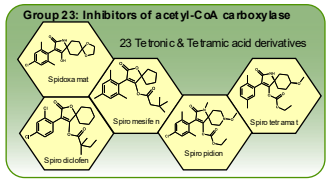
## Group 21: Mitochondrial complex I electron transport inhibitors



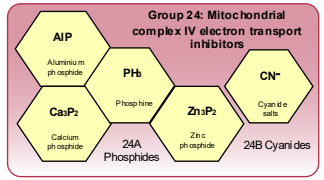

## Group 22: Voltage-dependent sodium channel blockers



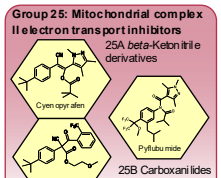

## Group 23: Inhibitors of acetyl-CoA carboxylase



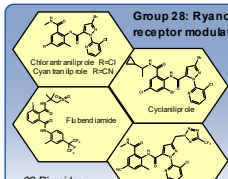

## Group 24: Mitochondrial complex IV electron transport inhibitors



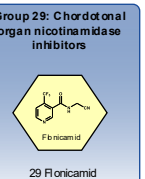

## Group 25: Mitochondrial complex II electron transport inhibitors



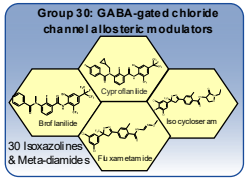

## Group 28: Ryanodine receptor modulators



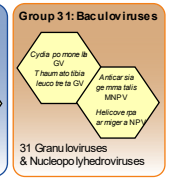

## Group 29: Chordotonal organ nicotinamidase inhibitors



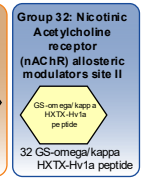

## Group 30: GABA-gated chloride channel allosteric modulators



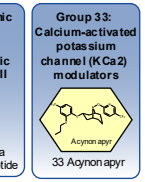

## Group 31: Baculoviruses



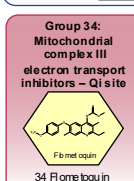

## Group 32: Nicotinic Acetylcholine receptor (nAChR) allosteric modulators site II



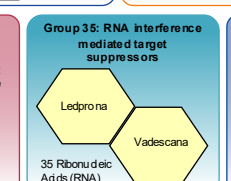

## Group 33: Calcium-activated potassium channel (KCa2) modulators



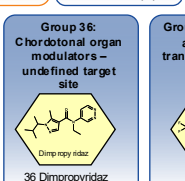

## Group 34: Mitochondrial complex III electron transport inhibitors – Qi site



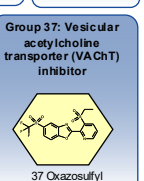

## Group 35: RNA interference mediated target suppressors



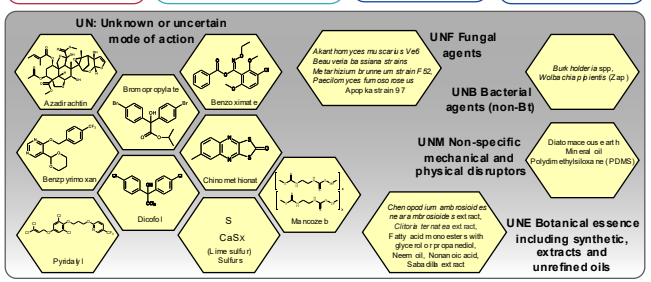

## Group 36: Chordotonal organ modulators – undefined target site




## Group 37: Vesicular acetylcholine transporter (VAChT) inhibitor




## UN: Unknown or uncertain mode of action




**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-group 10A: 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 & 27 are unassigned
- In some cases, only representative actives are shown.
- Because of documented cross-resistance between Dicofol, Bromopropylate and Abamectin, these active ingredients should not be rotated after each other in an IRM program

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