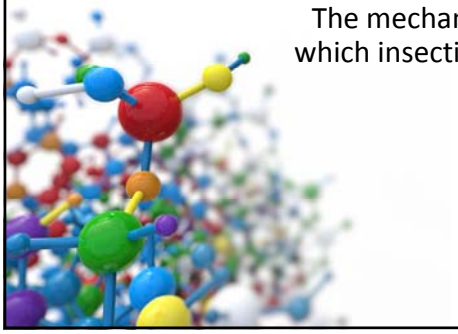
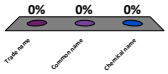
# Insecticidal Mode of Action



The mechanism by which insecticides kill

1) Fipronil is …….

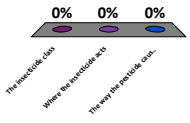
A. Trade name
B. Common name
C. Chemical name




Response Counter

1) Mode of Action is…

A. The insecticide class
B. Where the insecticide acts
C. The way the pesticide causes physiological disruption at the target site




Response Counter

Insecticides
Active ingredients + Inert ingredients

Active ingredient chemical name:
5-amino-1-(2,6 dichloro-4-(trifluoromethyl) phenyl)-4-((1,R,S)-(trifluoromethyl) sulfinyl)-1-H-pyrazole-3-carbonitrile

Common name: fipronil

Trade names: Termidor SC, TopChoice granular, MaxForce FC Professional Insect Control Ant Killer Bait Gel, etc.

Active ingredient chemicals are grouped into **insecticide classes** with similar characteristics

The **chemical structure** of the active ingredient usually defines its mode of action

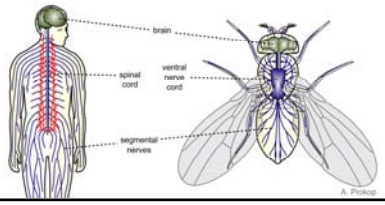
**Target site** - the physical location within an organism where the insecticide acts

**Mode of action** - the way in which it causes physiological disruption at the target site

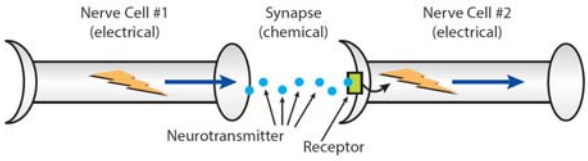
## Insecticides that Target the Insect Nervous System - neurotoxins

Multi-lobed brain, in the head and nerve cord
Chemical and physical nature of both systems is the same

Human: spinal cord located dorsally - central nervous system
Insects: nerves ventrally located - decentralized




Nervous System – interconnected cells carrying an electrical impulse driven by charged sodium, potassium, and chloride ions



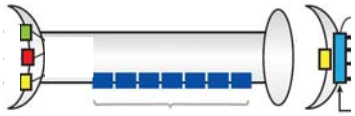

Important neurotransmitters include acetylcholine (Ach), gamma amino butyric acid (GABA), and glutamate

| Chemical Group | MOA | Target Site | Route of Entry |
|---|---|---|---|
| Insecticides that Target the Insect Nervous System | | | |
| Pyrethrins / Pyrethroids | Sodium Channel Modulation | Axon of Nerve | Contact |
| Oxadiazines | Sodium Channel Blockage | Axon of Nerve | Oral |
| Semicarbazones | Sodium Channel Blockage | Axon of Nerve | Contact & Oral |
| OPs / Carbamates | Acetyl cholinesterase Inhibition | Nerve Synapse | Contact |
| Neonicotinoids | Acetylcholine Receptor Stimulation | Nerve Post-synapse | Contact & Oral |
| Spinosyns | Acetylcholine Receptor Stimulation | Nerve Post-synapse | Oral |
| Phenylpyrazoles | GABA Receptor Blockage | Nerve Post-synapse | Contact & Oral |
| Avermectins | Glutamate Receptor Stimulation | Nerve Post-synapse | Oral |


## Pyrethrins and Pyrethroids (natural vs. synthetic)

Pyrethrins, bifenthrin, permethrin, cyfluthrin, beta-cyfluthrin, deltamethrin, cypermethrin, resmethrin, d-phenothrin, lambda-cyhalothrin

Inhibit the on/off switch of nerve cells, called sodium channels, by delaying close, causing uncontrolled, uninterrupted nerve firing



sodium channels


Permethrin

Deltamethrin

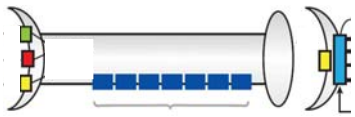

## Oxadiazines

Indoxacarb

## Semicarbazones

Metaflumizone

Indoxacarb is broken down into a metabolite (activation), both indoxacarb and metaflumizone target sodium channels completely blocking ion flow into nerve cells, insect paralysis



sodium channels

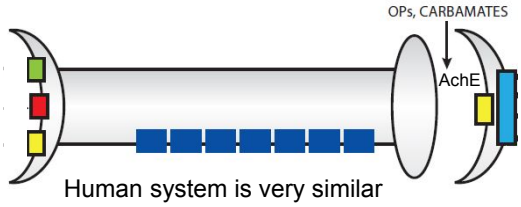

Indoxacarb


Metaflumizone

## Organophosphates (OPs) / Carbamates

Chlorpyrifos, dichlorvos (DDVP), malathion, carbaryl, propoxur

Inhibit the acetylcholinesterase (AchE) which normally removes the neurotransmitter acetylcholine from receptor sites, nerve overstimulation




Human system is very similar


Chlorpyrifos

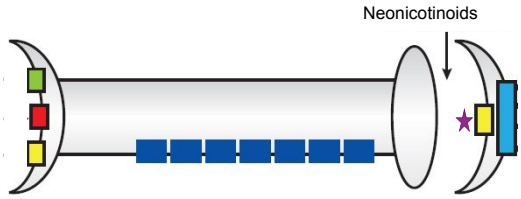
Propoxur

Dichlorvos

## Neonicotinoids

Imidacloprid, dinotefuran, thiamethoxam, clothianidin, acetamiprid

Synthetic “nicotine-like” chemical binds tightly to the acetylcholine receptor site on the post-synapse nerve cell, nerve overstimulation




Imidacloprid
Tau-luvalinate
Tebuconazole


Dinotefuran


Imidacloprid


Thiamethoxam

**Pyrethroid plus neonicotinoid – dual MOA**

Temprid: ß-cyfluthrin + imidacloprid
Transport: bifenthrin + acetamiprid
Tandem: thiamethoxam and Lambda-Cyhalothrin

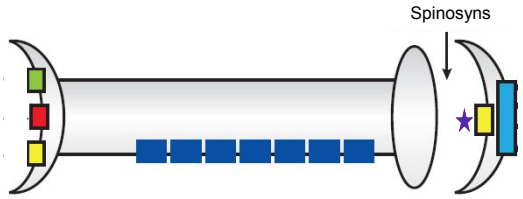

## $LD_{50}$s and Neonicotinoids

| | |
|---|---|
| Imidacloprid | 450 |
| Acetamiprid | 217 |
| Clothianidin | >5000 |
| Thiamethoxam | 1563 |
| Dinotefuran | >2000 |

## Spinosyns

Spinosad - Naturalytes

Chemicals produced by the soil bacterium *Saccharopolyspora spinosa* and bind to acetylcholine receptor site on the post-synapse nerve cell, nerve overstimulation




Spinosad

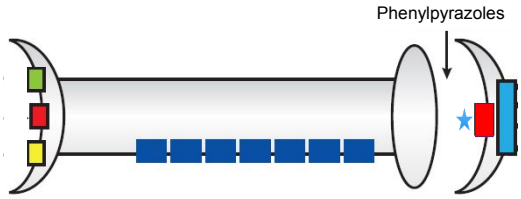

Seduce®

SPINOSAD INSECT BAIT

## Phenylpyrazoles

Fipronil

Binds to and blocks the GABA receptor on the post-synapse nerve cell, rapid, uncontrolled nerve firing





Fipronil


## $LD_{50}$s

Spinosad (synaptic stimulation nicotinic acetycholine sites)

| | |
|---|---|
| Spinosads | 3783-5000 |

Phenylpyrazoles (GABA receptor disruption)

| | |
|---|---|
| Fipronil | 97 |

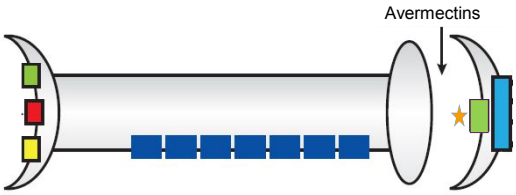
Spinosads are Category IV insecticides (practically non-toxic)

Fipronil, while quite toxic, is used at very, very low rates

## Avermectins

Abamectin, emamectin benzoate, ivermectin

Chemicals originally isolated from the soil bacterium *Streptomyces* stimulate the chloride channels that are regulated by the neurotransmitter glutamate causing paralysis





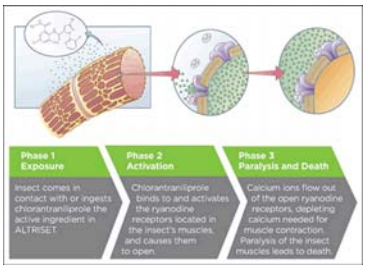

Abamectin

| Chemical Group | MOA | Target Site | Route of Entry |
|---|---|---|---|
| Insecticides that Do Not Target the Insect Nervous System | | | |
| Diamides | Muscle Stimulation | Muscular Calcium Channel | Oral |
| Juvenile Hormone Analogs | Mimic Juvenile Hormone Action | JH Degradative Enzymes / Receptor | Contact & Oral |
| Chitin Synthesis Inhibitors | Block Chitin Formation | Exoskeleton | Oral |
| Amidinohydrazones | Inhibit Energy Production | Mitochondria within Cells | Oral |
| Pyrroles | Inhibit Energy Production | Mitochondria within Cells | Contact |
| Fumigant (sulfuryl fluoride) | Inhibit Energy Production | Citric Acid / Glycolysis Cycles in Cells | Inhalation |
| Borates | Non-Specific Metabolic Disruption | Cells | Oral |
| Dehydrating Dusts | Adsorption of Cuticular Wax Layer | Exoskeleton | Contact |

## Diamides

Chlorantraniliprole

Bind to and stimulate muscular calcium channels, causing uncontrolled calcium release and resultant muscle contractions



## Insect Growth Regulators

Juvenile Hormone Analogs

Hydroprene, methoprene, pyriproxyfen, fenoxycarb

Juvenile hormones in immature insects keeps them from becoming adults – chemicals may bind to juvenile hormone-degrading enzymes, the juvenile hormone receptor itself, or a combination of both

Imidacloprid, Permethrin, Pyriproxyfen


(S)-Hydroprene


## Insect Growth Regulators

Chitin Synthesis Inhibitors

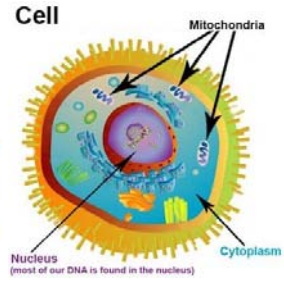
Diflubenzuron, hexaflumuron, noviflumuron, lufenuron

During molting, chitin is synthesized and incorporated into the insect's exoskeleton - chitin synthesis inhibitors block chitin synthase

## Amidinohydrazone

Hydramethylnon

Cellular poison disrupting energy production by mitochondria

## Pyrrole

Chlorfenapyr

Must be converted by enzymes within the insect to an active form (activation)

The metabolite form is insecticidal and toxic to mammals, but, mammals lack the activation enzymes

It disrupts energy production by mitochondria

## Fumigant

Sulfuryl fluoride

Inhibits energy production in cells – non-specific metabolic inhibitor

Warning agent chloropicrin (tear gas)

## Borates

Borax, boric acid, disodium octaborate tetrahydrate

Boron is an essential micronutrient for plants and animals - at higher concentrations can be toxic

Evidence suggests that high levels of boron acts as a general cellular toxin or non-specific metabolic disruptor


## Dehydrating Dusts

Silica gels, diatomaceous earth

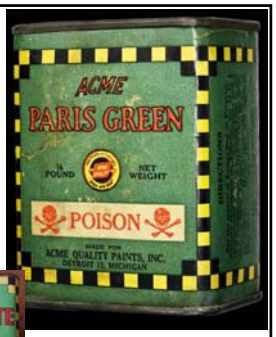
Silica gels are synthetically produced, diatomaceous earth is the fossilized remains of diatoms

Adsorb the thin wax layer on the insect exoskeleton that prevents insects from losing water and desiccating


Amorphous silica gel

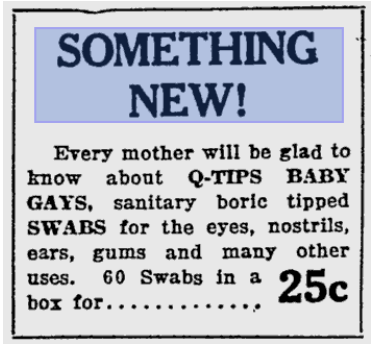

DDT

Cyanide


copper acetoarsenite

1927 newspaper ad

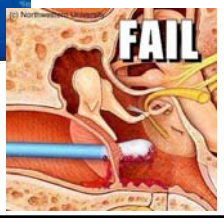


SOMETHING NEW!

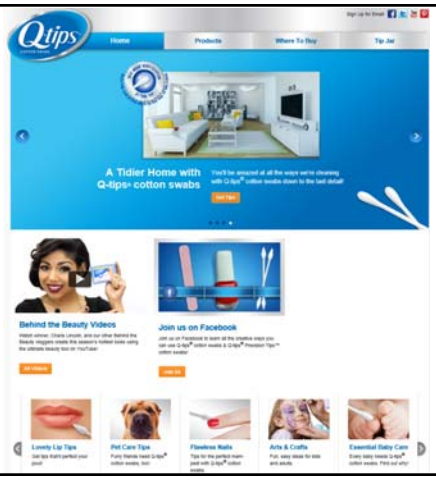
Every mother will be glad to know about Q-TIPS BABY GAYS, sanitary boric tipped SWABS for the eyes, nostrils, ears, gums and many other uses. 60 Swabs in a box for..... 25c


1970's






BENIGN
PAROXYSMAL
POSITIONAL VERTIGO



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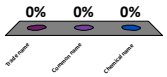
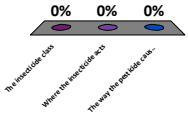



Response Counter

1) Mode of Action is…

A. The insecticide class
B. Where the insecticide acts
C. The way the pesticide causes physiological disruption at the target site




Response Counter

## Resources


- Suiter, D. R. and Scharf, M. E. 2015 Insecticide Basics for the Pest Management Professional. UGA Bulletin 1352.
- Insecticide Resistance Action Committee http://www.irac-online.org/modes-of-action/