Great Plains Growers Conference And Trade Show

January 8, 2016
St. Joseph, MO

Reduced-Risk Insecticides And Biopesticides

Raymond A. Cloyd

Professor, Extension Specialist in Horticultural Entomology/Plant Protection

Kansas State University, Manhattan, KS

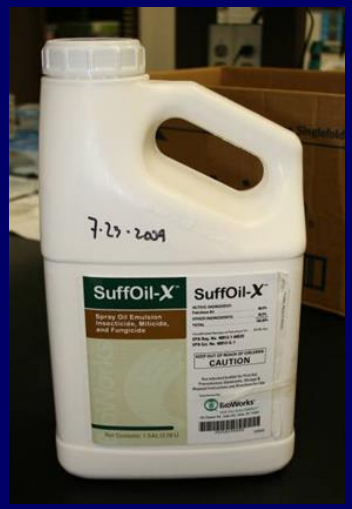
Phone: 785-532-4750 **Email: rcloyd@ksu.edu**

Overview: What To Expect

- Introduction
- Types of insecticides
- What are reduced-risk insecticides and biopesticides?
- Benefits and limitations of reduced-risk insecticides and biopesticides
- Questions and discussion

Types of Pesticides

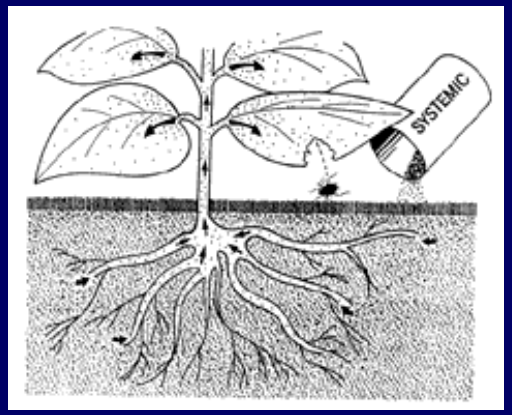
* Conventional
* Alternative
* Botanical
* Biorational
* Reduced-risk
* Biopesticide (selective)



Activity Of Insecticides

- Contact

- Stomach poison



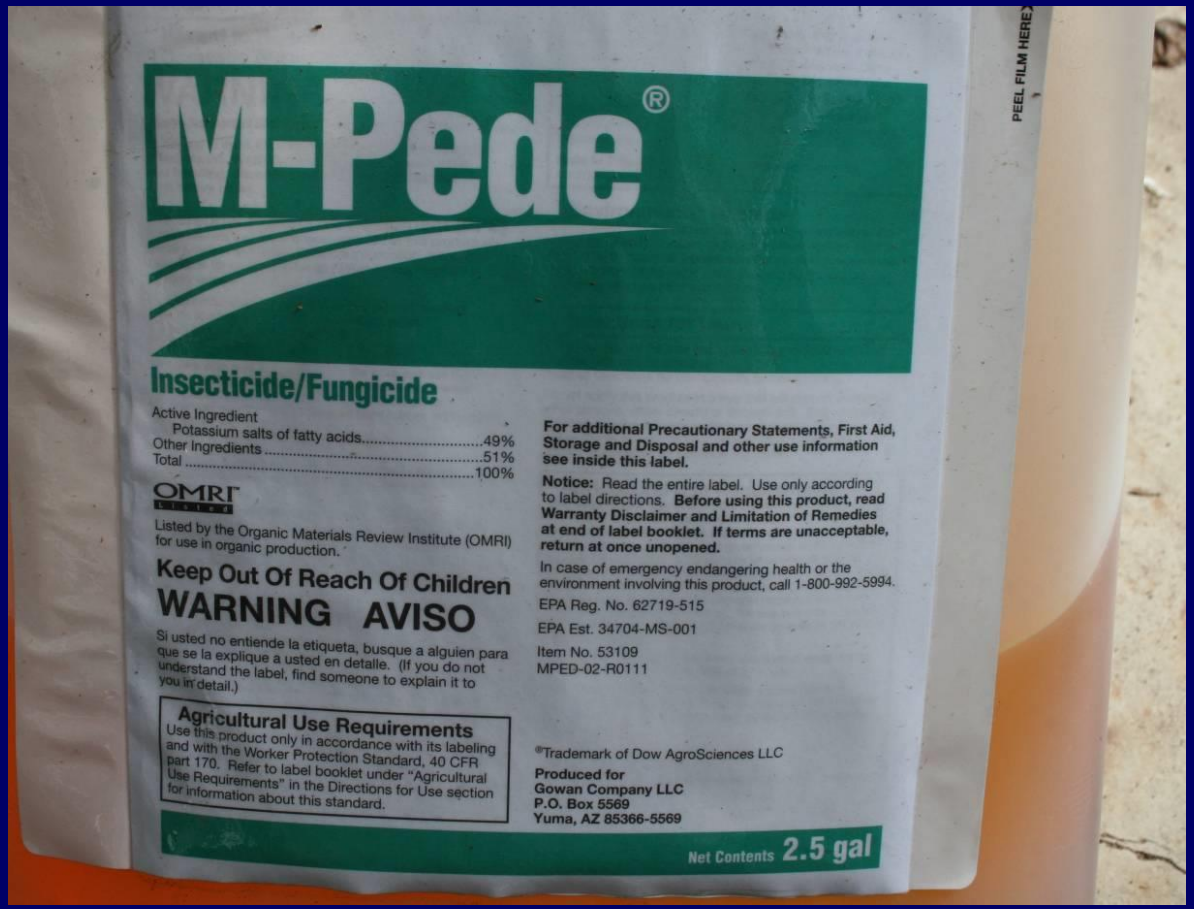
- Systemic

- Translaminar

Contact Insecticide: kill an insect (and/or mite) by direct contact or when an insect (or mite) walks or crawls over a treated surface. Insect (or mite) walks across treated surfaces and active ingredient enters the feet and moves to the site of action.

Malathion Insecticide

Insecticidal Soap Product: M-Pede



Stomach Poison: insect pest feeds on treated surface and ingests the insecticide, which is then absorbed through the stomach lining. Ingestion is usually more toxic to insect than direct contact.

Bacillus thuringiensis subsp. *kurstaki* (Btk) Product

How Btk Kills Caterpillars

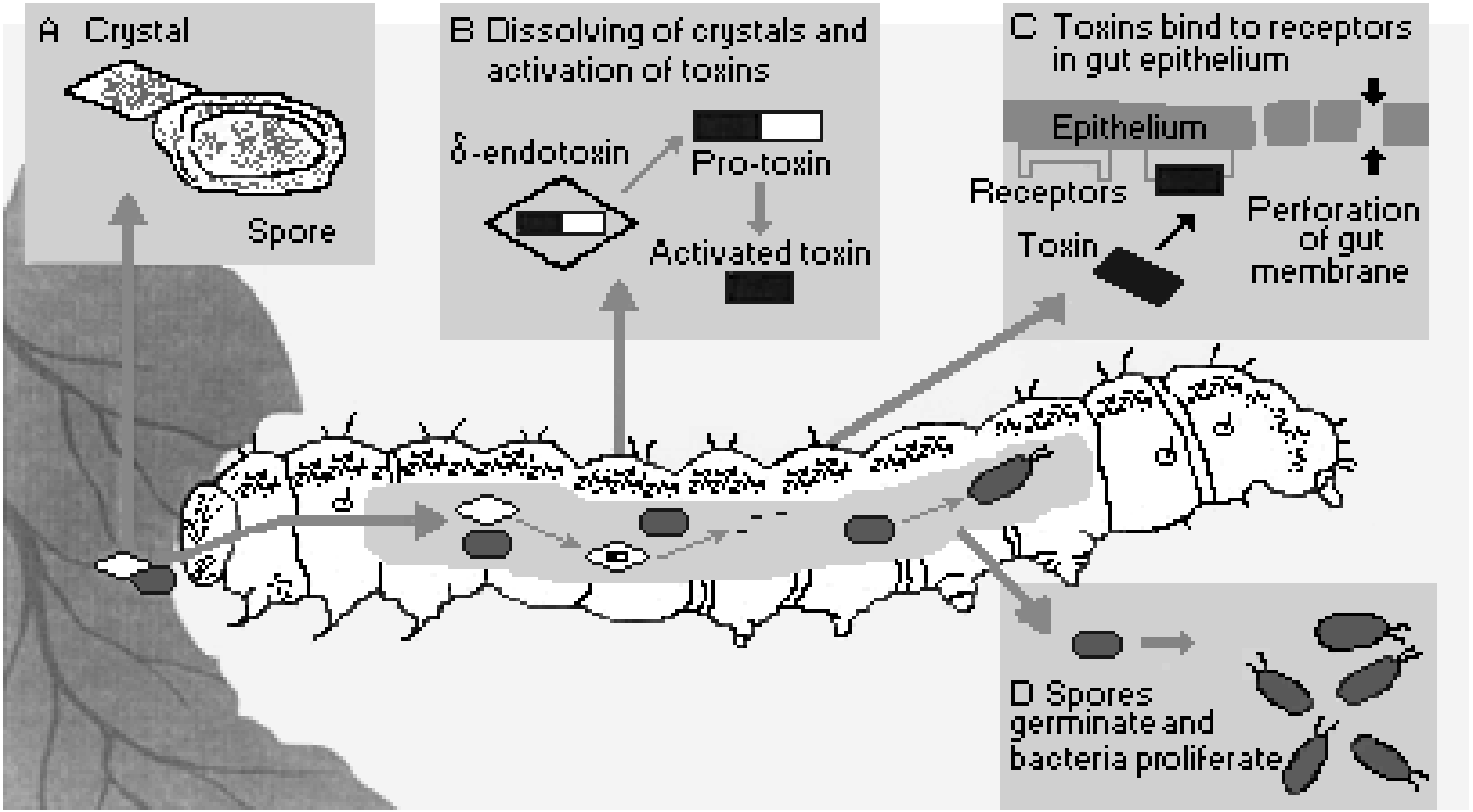
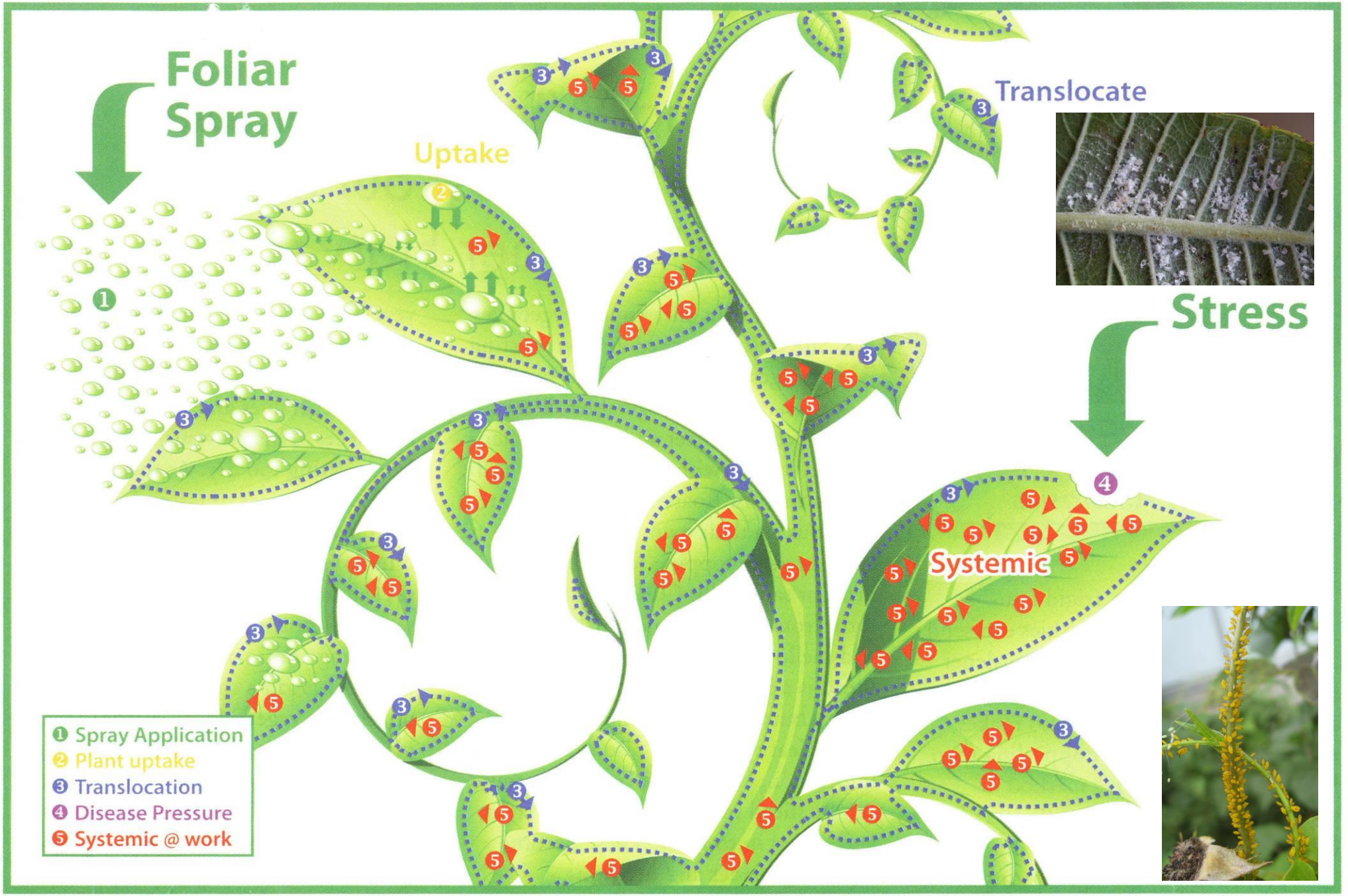


Fig. 1. Mechanism of toxicity of Bt

Systemic Insecticide: active ingredient is taken up and translocated/distributed throughout the plant. Primarily used to control phloem-feeding insects such as aphids, whiteflies, mealybugs, and soft scales.


Foliar Spray
Uptake
Translocate
Stress
Systemic
1 Spray Application
2 Plant uptake
3 Translocation
4 Disease Pressure
5 Systemic @ work

Active Ingredient=Imidacloprid

Active Ingredient=Dinotefuran

Translaminar Insecticide

(Local Systemic): material penetrates leaf tissue and forms a reservoir of active ingredient within the leaf. This provides residual activity against foliar-feeding insects (and mites).

Translaminar Activity

Conserve Insecticide: Active Ingredient= Spinosad

Organophosphates And Carbamates

Organophosphates:

* Acephate (Orthene), chlorpyrifos (Dursban/Lorsban), malathion, and dimethoate (Cygon).

Carbamates:

* Methiocarb (Mesurol) and carbaryl (Sevin).

U.S. Environmental Protection Agency (EPA) Conventional Reduced Risk Pesticide Program

*** Purpose: expedite the review and registration process of "conventional pesticides" (insecticides) that pose less of a risk to human health and the environment than existing conventional alternatives (organophosphates and carbamates).**

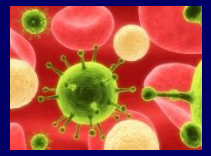
*** Reduced-risk insecticides are often referred to as organophosphate and carbamate alternatives or replacements.**

Reduced-Risk Pesticides

- Class of compounds that pose a low health risk to humans and the environment. Considered to be "alternative" to organophosphate-based insecticides.

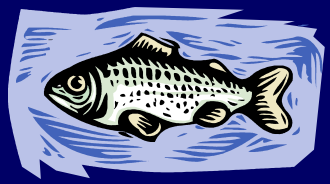
- Reduced-risk pesticides are designed to accomplish the following: 1) reduce pesticide risks to human health, 2) reduce pesticide risks to non-target organisms, 3) reduce potential contamination of valued, environmental resources, and 4) broaden adoption of integrated pest management (IPM) or increase effectiveness.

Advantages Of Reduced-Risk Pesticides Over Conventional Pesticides



- Low impact on human health.
- Lower toxicity to non-target organisms (e.g. birds, fish, and plants).

- Less potential for groundwater contamination.



- Low use rates.
- Minimal potential for pesticide resistance.
- May be used with IPM practices including cultural, physical, and/or biological.

1) Low Impact On Human Health

* Very low mammalian toxicity (high LD_{50}).

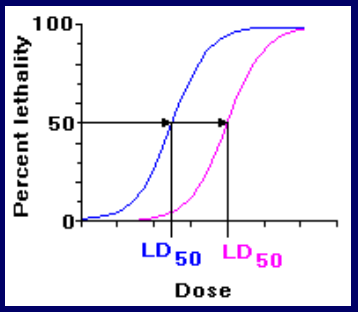
* Toxicity is lower, in general, than currently registered "high risk" conventional insecticides.

* Replace insecticides that may have more human health concerns.

* Reduced exposure to handlers, applicators, and workers.

LD_{50}

- **The lethal dose of a pesticide that will kill half of the test population of animals. LD_{50} values are given in milligrams of toxicant per kilogram of test animal body weight (mg/kg). This is a measure of the toxicity of the pesticide. The lower the number, the more toxic the pesticide may be to humans.**



LD_{50} Or Toxicity Of Botanical Pesticides

Nicotine	LD_{50}=50-60 mg/kg	Danger
Rotenone	LD_{50}=60-1,500 mg/kg	Caution
Sevin*	LD_{50}=850 mg/kg	Warning/Caution
Malathion*	LD_{50}=885-2,800 mg/kg	Caution
Ryania	LD_{50}=750-1,200 mg/kg	Caution
Pyrethrins	LD_{50}=1,200-1,500 mg/kg	Caution
Linalool	LD_{50}=2,440-3,180 mg/kg	Caution
Sabadilla	LD_{50}=4,000-5,000 mg/kg	Caution
Limonene	LD_{50}=>5,000 mg/kg	Caution
Neem	LD_{50}=13,000 mg/kg	Caution

2) Low Toxicity To Non-Target Organisms

* “Very” low toxicity to birds, pollinators, natural enemies (parasitoids and predators), and fish.

* Toxicity/risk issues.

3) Low Potential For Water Contamination

*** Minimal contamination associated with ground water, surface water, drift, and runoff.**

4) Low Exposure: Minimal Impact On Integrated Pest Management (IPM) Practices

* Lower use rates (compared to conventional insecticides).

* Fewer applications needed (compared to conventional insecticides).

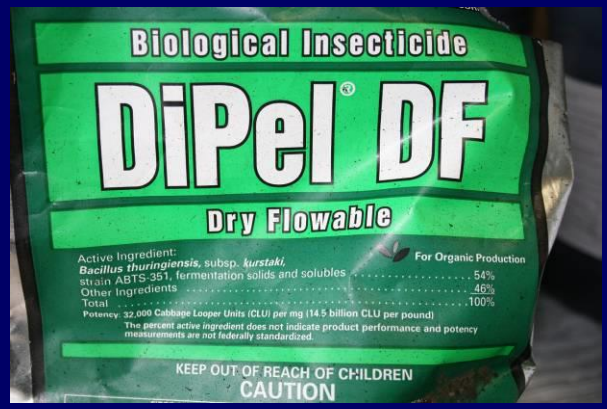
* Less potential for resistance development (based on mode of action).

* Enhanced plant protection.

* Must be effective.

Disadvantages Of Reduced-Risk Pesticides

- Inconsistent field results.
- Limited shelf-life.
- Formulation issues.



- Economics (compared with conventional).

- Narrow range of target insect and mite pests.

Plant Protection (IPM)

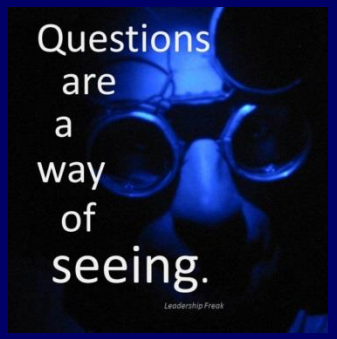
* Prevention is the key: avoid outbreaks.

* Insecticides: used as the “last resort.”

Mind-Sets Associated With Plant Protection

*Pests→Beneficials

*Beneficials→Pests



Characteristics Of A Reduced-Risk Insecticide

* “Selective”: toxic to pest, but not directly or indirectly harmful to natural enemies (parasitoids and predators).
* Environmental safety to humans and non-target organisms.
* Low persistence or short-residual activity.
* Less impact on plants (no phytotoxicity).

How Can An Insecticide Be "Selective?"

*** Biochemical Mechanisms of Selectivity:**

a. Non-target organisms (e.g. vertebrates) do not possess biochemical receptor or enzyme target site.

b. Insecticide does not bind to biochemical target site.

c. Non-target organisms are able to detoxify the insecticide; however, the insecticide persists in the pest.

*** Operational Mechanisms of Selectivity:**

a. Insecticide is applied such that there is a "lower" risk of harming non-target organisms.

b. Time applications to avoid impacting pollinators.

Pollinators

* Bees (Honey Bee and Bumble Bee)

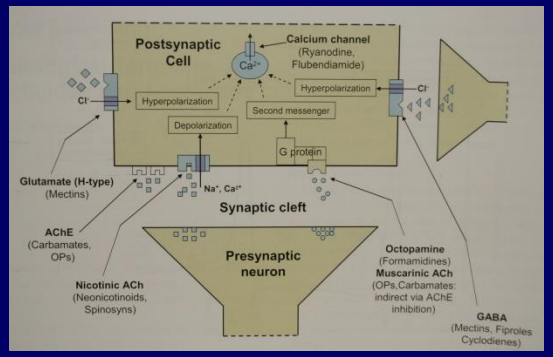
* Butterflies and Moths

* Native Bees (Wild Bees)

Selectivity Of Reduced-Risk Insecticides

Common Name (AI)	Trade Name	Oral LD_{50} (mg/kg)	Dermal LD_{50}
Azinophos-Methyl	Guthion	4.4	155
Chlorpyrifos	Lorsban/Dursban	223	222
Acetamiprid	TriStar	1064	>2000
Indoxacarb	Avaunt	1277	>5000
Pyriproxyfen	Distance	4253	>2000
Methoxyfenozide	Intrepid	>5000	>2000
Novaluron	Pedestal	>5000	>2000
Pymetrozine	Endeavor	>5000	>2000
Spinosad	Conserve	>5000	>2000

Insecticide Groups Considered Reduced-Risk (Based On Mode Of Action)



Nervous system targets:

* Acetylcholine receptor agonists
* Chloride channel blockers
* Ryanodine receptor activators

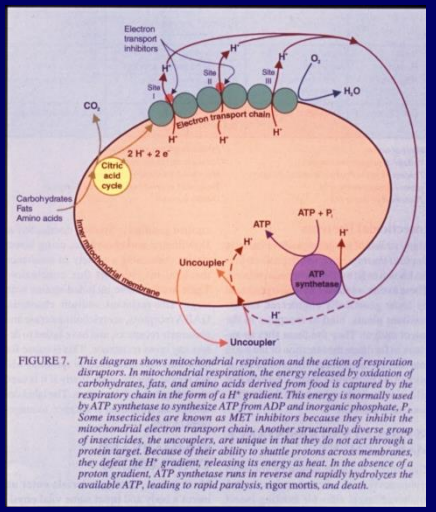


FIGURE 7. *This diagram shows mitochondrial respiration and the action of respiration disruptors. In mitochondrial respiration, the energy released by oxidation of carbohydrates, fats, and amino acids derived from food is captured by the respiratory chain in the form of a H^+ gradient. This energy is normally used by ATP synthetase to synthesize ATP from ADP and inorganic phosphate, P_i. Some insecticides are known as MET inhibitors because they inhibit the mitochondrial electron transport chain. Another structurally diverse group of insecticides, the uncouplers, are unique in that they do not act through a protein target. Because of their ability to shuttle protons across membranes, they defeat the H^+ gradient, releasing its energy as heat. In the absence of a proton gradient, ATP synthetase runs in reverse and rapidly hydrolyzes the available ATP, leading to rapid paralysis, rigor mortis, and death.*

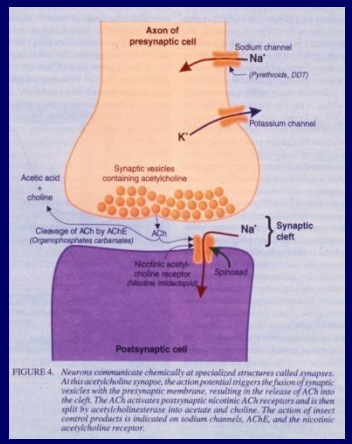
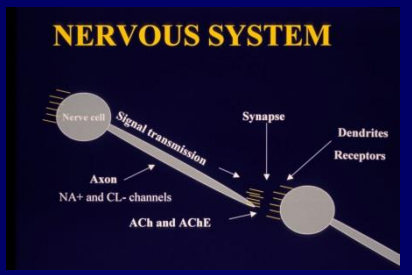


FIGURE 4. *Neurons communicate chemically at specialized structures called synapses. At this acetylcholine synapse, the action potential triggers the fusion of synaptic vesicles with the presynaptic membrane, resulting in the release of ACh into the cleft. The ACh activates postsynaptic nicotinic ACh receptors and is then split by acetylcholinesterase into acetate and choline. The action of insect control products is indicated on sodium channels, AChE, and the nicotinic acetylcholine receptor.*

Insect growth regulators (IGRs):

* Mimic molting hormone (ecdysone): agonist
* Chitin synthesis inhibitors (antagonists)
* Juvenile hormone mimics (agonists)



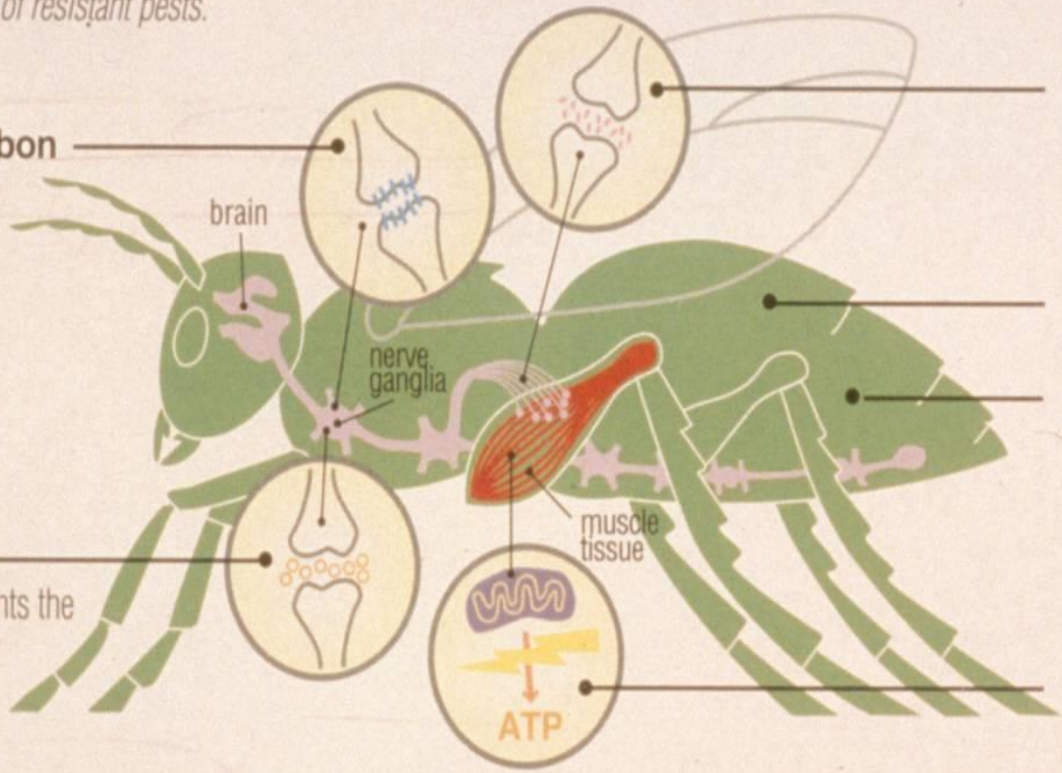
Respiratory inhibitors:

* Inhibit electron transport and consequently the synthesis of energy via adenosine triphosphate (ATP)

Insecticide And Miticide Mode Of Action Makes A Difference

Insecticide Mode of Action Makes a Difference

Rotation of products having different modes of action can prevent the development of resistant pests.



Pyrethroid
Chlorinated hydrocarbon
Destabilizes nerve cell membranes.

Organophosphate
Carbamate
Inhibits cholinesterase, prevents the termination of nerve impulse transmission.

Abamectin
Affects GABA-dependent chloride ion channel, inhibiting nerve transmission.

Growth Regulators
(Chitin synthesis inhibitors and juvenoids)

Soap and oil
Damages the waxy layer of the exoskeleton of soft bodied insects, resulting in suffocation.

Pyridazinone (SANMITE)
Mitochondrial electron transport inhibitor (METI) blocks respiration within the insect cell.

What Is The Difference Between An "Agonist" And An "Antagonist?"

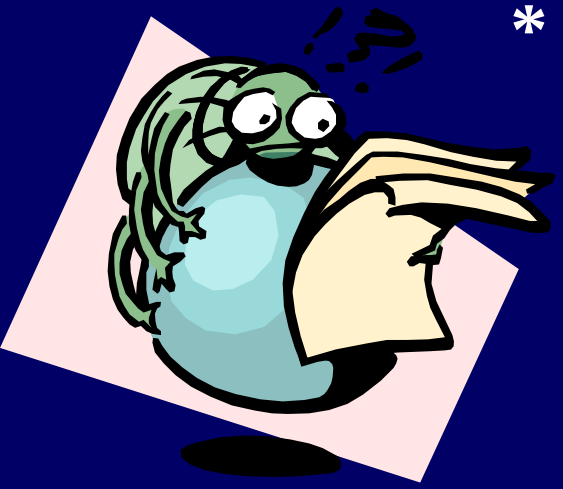
* Agonist=any substance that acts like another substance thus stimulating an action.

* Antagonist=any substance that acts against or blocks an action.

Mode of Action of Insect Growth Regulators

Juvenille Hormone Mimics

* Fenoxycarb (Preclude)
* Kinoprene (Enstar)
* Pyriproxyfen (Distance/Fulcrum)



Chitin Synthesis Inhibitors

* Buprofezin (Talus)
* Cyromazine (Citation)
* Diflubenzuron (Adept)
* Etoxazole (TetraSan)
* Novaluron (Pedestal)

Ecdysone Antagonists

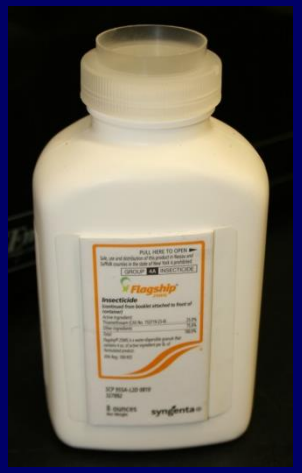
* Azadirachtin (Azatin/Ornazin/Molt-X)

Reduced-Risk/Organophosphate Alternative Insecticides

1. Hexaflumuron (termites)
2. Tebufenozide (IGR)
3. Spinosad (micro-organism)
4. Diflubenzuron (IGR)
5. Pyriproxyfen (IGR)
6. Bifenazate (miticide)
7. Fipronil (termites)
8. Pymetrozine (selective feeding blocker)

Reduced-Risk/Organophosphate Alternative Insecticides

9. Methoxyfenozide (IGR)
10. Buprofezin (IGR)
11. Fenpyroximate (miticide)
12. Indoxacarb (acts similar to pyrethroids)
13. Thiamethoxam (neonicotinoid)*
14. Imidacloprid (neonicotinoid)*
15. Cypermethrin (pyrethroid)
16. Novaluron (IGR)



Reduced-Risk/Organophosphate Alternative Insecticide

17. Chlorfenapyr (termites)
18. Acetamiprid (neonicotinoid)*
19. Lambda-cyhalothrin (pyrethroid)
20. Noviflumuron (termites)
21. Clothianidin (neonicotinoid)*
22. Emamectin benzoate (similar to abamectin)
23. Flonicamid (selective feeding blocker)
24. Acequinocyl (miticide)

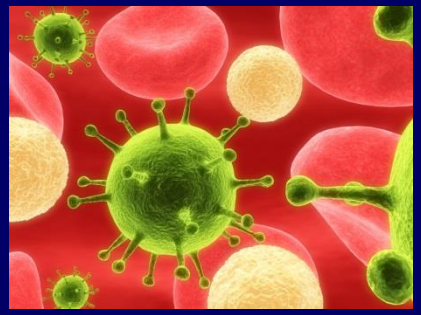
Reduced-Risk/Organophosphate Alternative Insecticides

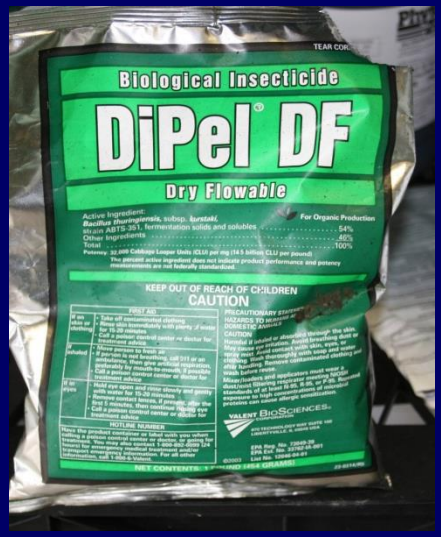
25. Etoxazole (mite growth regulator)
26. Gamma-cyhalothrin (pyrethroid)
27. Dinotefuran (neonicotinoid)*
28. Deltamethrin (pyrethroid)
29. Clofentezine (miticide)
30. Spiromesifen (insecticide and miticide)
31. Spinetoram (same mode of action as spinosad)
32. Chlorantraniliprole (active on ryanodine receptors)
33. Spirotetramat (moves both up and down the plant)
34. Tolfenpyrad (insecticide)

Biopesticide

- Biopesticides are types of pesticides that are derived from natural materials such as animals, plants, bacteria, and certain minerals.

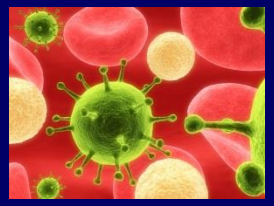
- Biopesticides are placed into three major classes:
  - Microbial pesticides
  - Plant-incorporated protectants
  - Biochemical pesticides





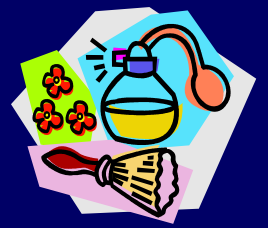
Biopesticide Classes

- Microbial pesticides (or mycoinsecticides): consist of a micro-organism as the active ingredient (e.g. bacterium, fungus, virus, or protozoa). Highly selective in activity against specific target insect pests.



- Plant-incorporated protectants: substances that plants produce based on genetic material that is incorporated into plants.

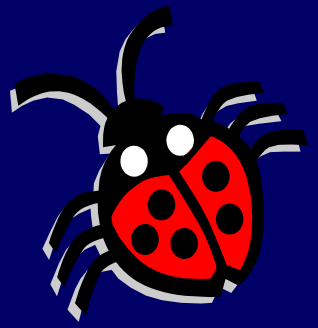
- Biochemical pesticides: naturally occurring substances that control insect pests by non-toxic mechanisms (e.g. sex pheromones).



General Characteristics Of Biopesticides

- Short-residual activity.
- Sensitive to ultra-violet (sunlight) degradation and rainfall.

- Primarily active on the young (immature) stages of insect and mite pests.

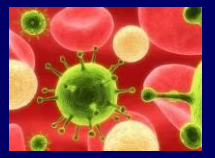


- Less harmful to natural enemies (e. g. parasitoids and predators) compared to conventional pesticides.

- In general, low mammalian toxicity.
- May take longer to kill insect and/or mite pests.

Microbial Insecticides

***Bacillus thuringiensis* (Bt):**

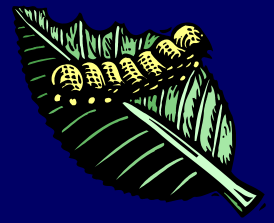


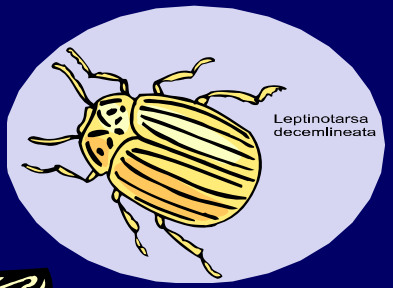
- ***Bacillus thuringiensis* subsp. *kurstaki* (Dipel)**
- ***Bacillus thuringiensis* subsp. *aizawai* (XenTari)**

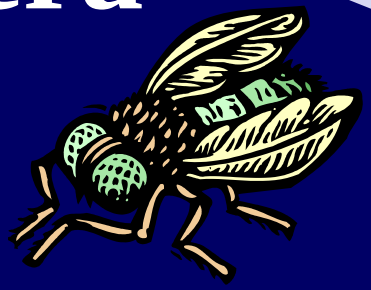
- ***Bacillus thuringiensis* subsp. *tenebrionis* (Novodor)**
- ***Bacillus thuringiensis* subsp. *israelensis* (Gnatrol)**

Microbial Insecticides

Subspecies	Endotoxin Specificity
• kurstaki	• Lepidoptera
• aizawai	• Lepidoptera
• tenebrionis	• Coleoptera
• israelensis	• Diptera







Understanding Microbials

- Larvae must be actively feeding on treated plant surface: stomach poison. Has to be consumed to be effective.
- Thorough coverage of all plant parts is required in order to provide uniform residues where larvae are feeding.
- Apply before economic thresholds for damage have been exceeded.
- Avoid applications during periods of cold or excessively hot temperatures.

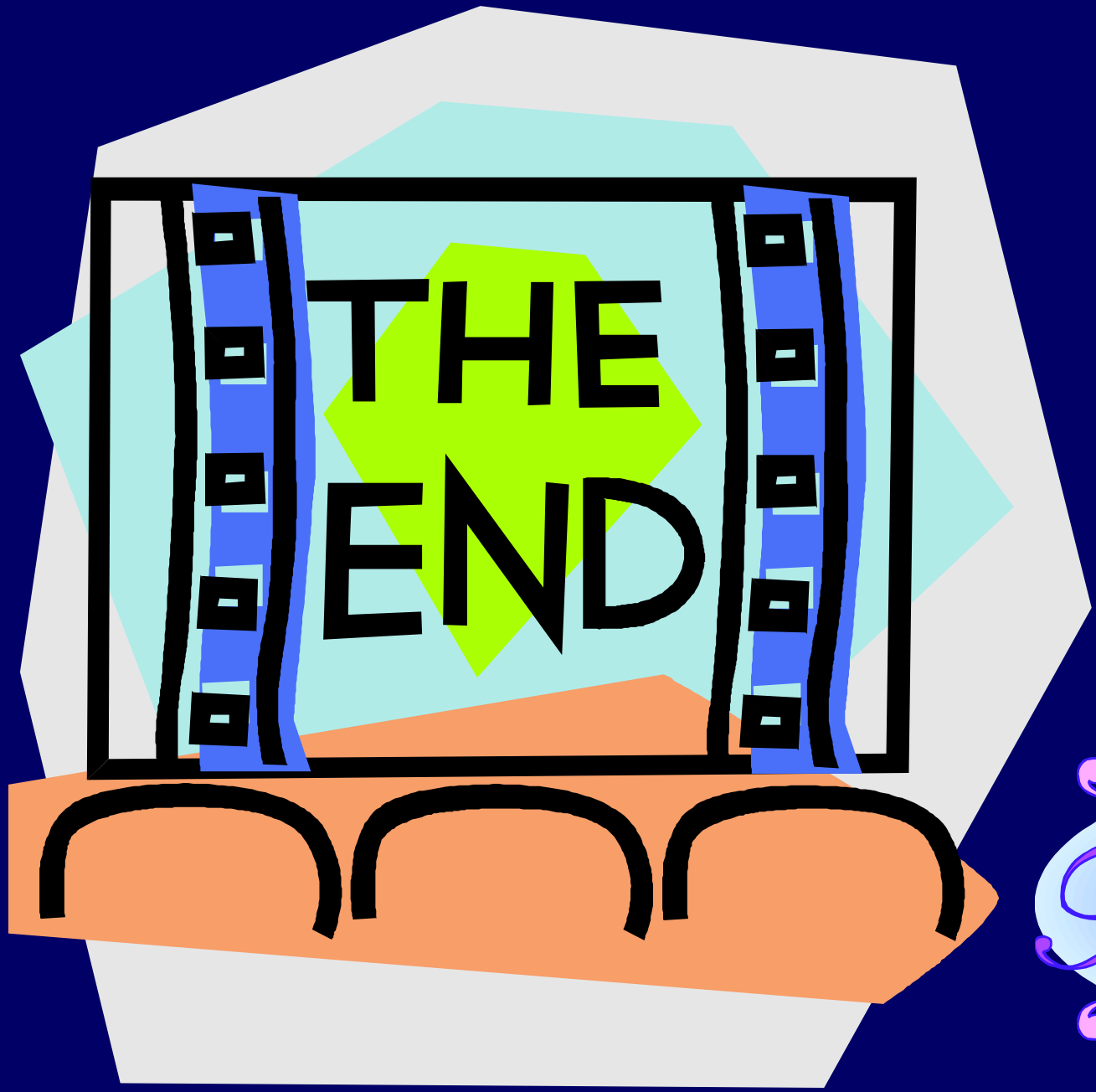
- Susceptible to ultra-violet light degradation and rain-fast. As such, multiple applications will be required.

Summary/Highlights

1. There are many different types of pesticides including: conventional, alternative, botanical, biorational, reduced-risk, and biopesticide.

2. Reduced-risk pesticides pose a low health risk to humans and the environment. They are considered "alternatives" to organophosphate-based insecticides.

3. Biopesticides are pesticides derived from natural materials such as animals, plants, bacteria, and certain minerals. There are three major classes: microbial pesticides, plant-incorporated protectants, and biochemical pesticides.



DONE!

Thank You For Your Attention!

I Hope You All Learned Something!

It's QUESTION TIME!!