Insecticide Mode of Resistance

Utah Pests In-Service Training

Ryan Davis

Outline

1) Insect resistance

2) Insecticide Mode of Action (MoA)

3) Cover 9 common MoA's

Insect Resistance

Insect resistance:

occurs when a population of insects builds up a tolerance to a specific chemical, or group of chemicals with the same Mode of Action (MoA).

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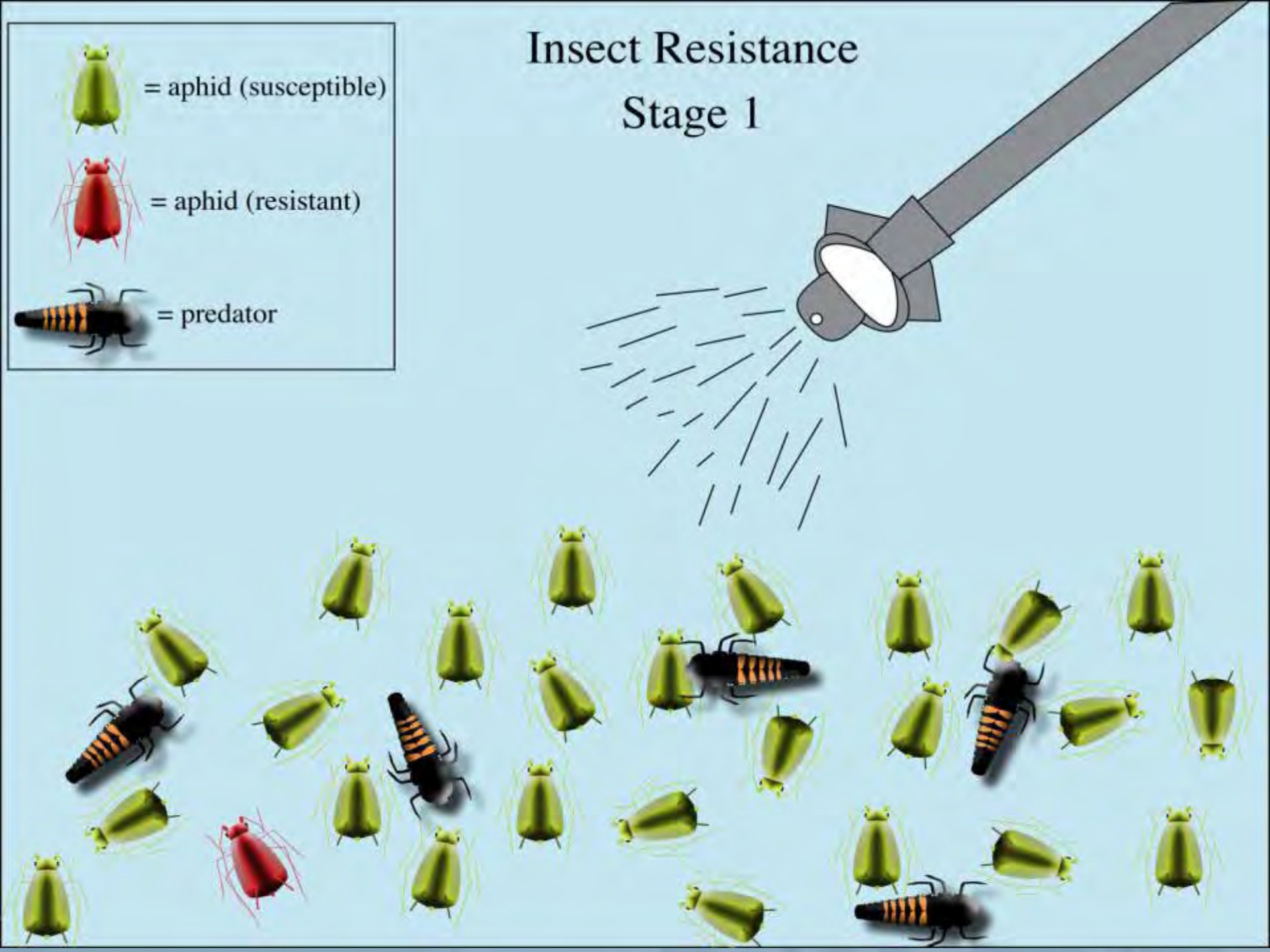
Insect Resistance

Stage 1

= aphid (susceptible)

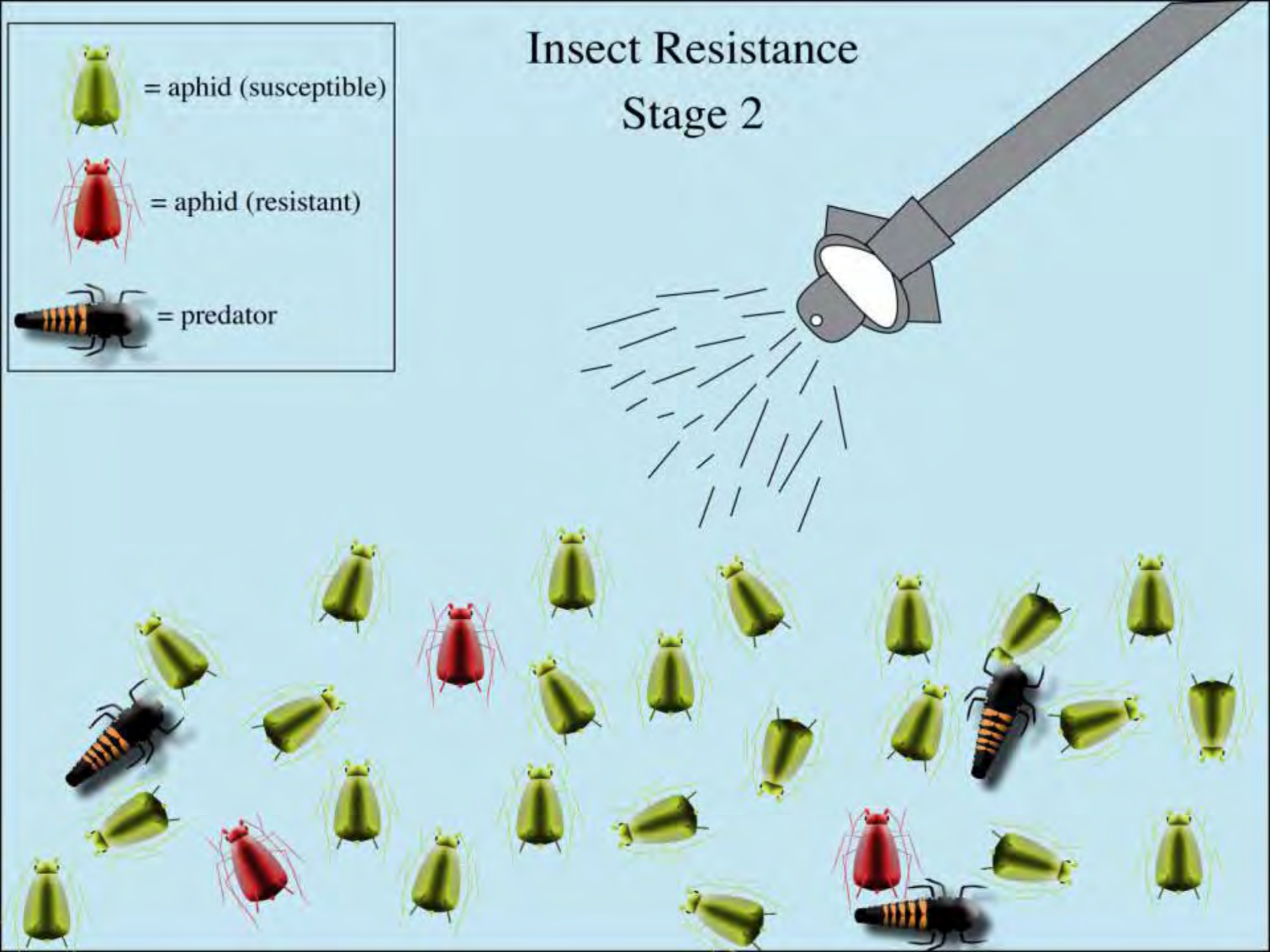
= aphid (resistant)

= predator



Insect Resistance

Stage 2



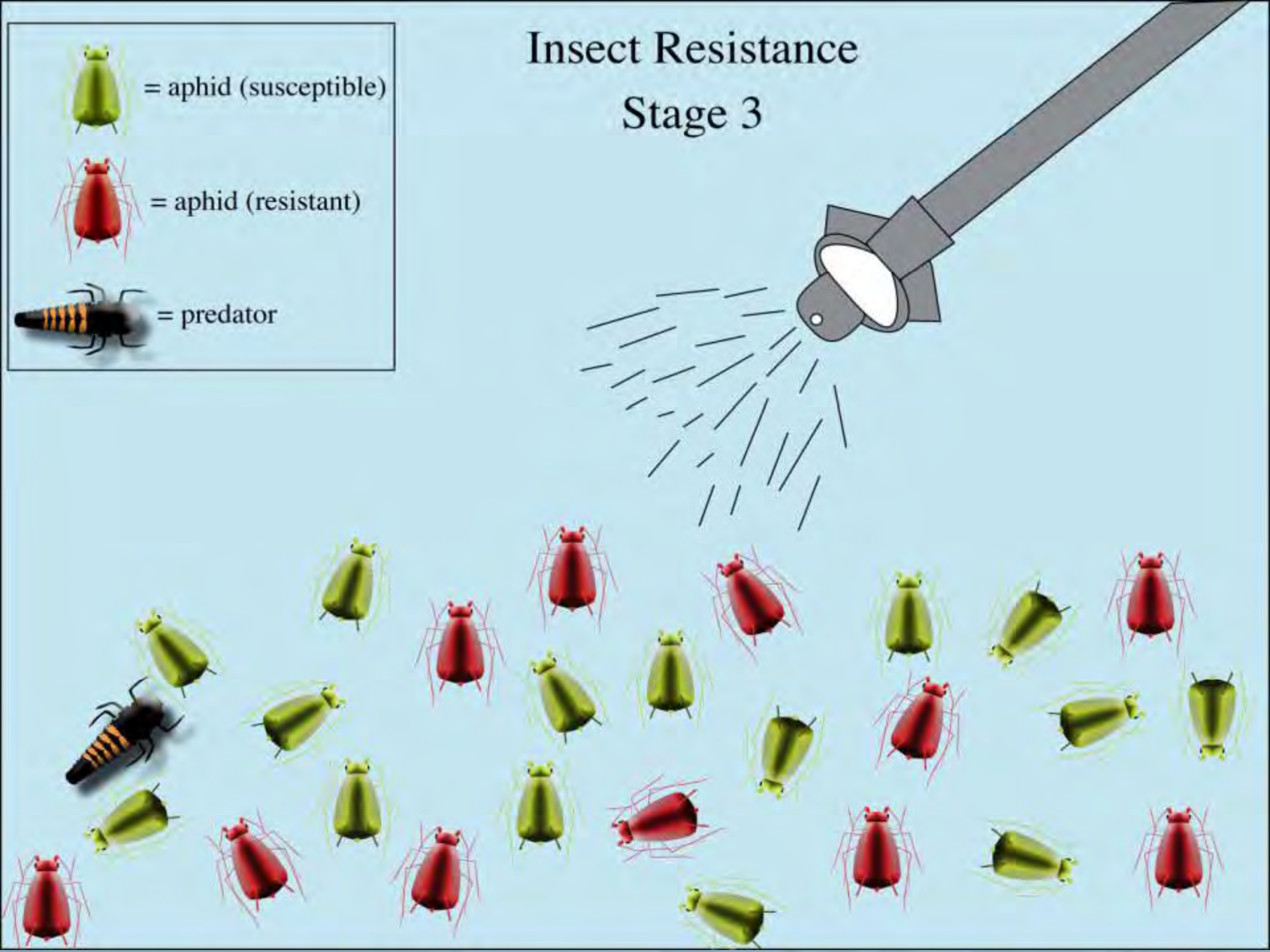
Insect Resistance

Stage 3

= aphid (susceptible)

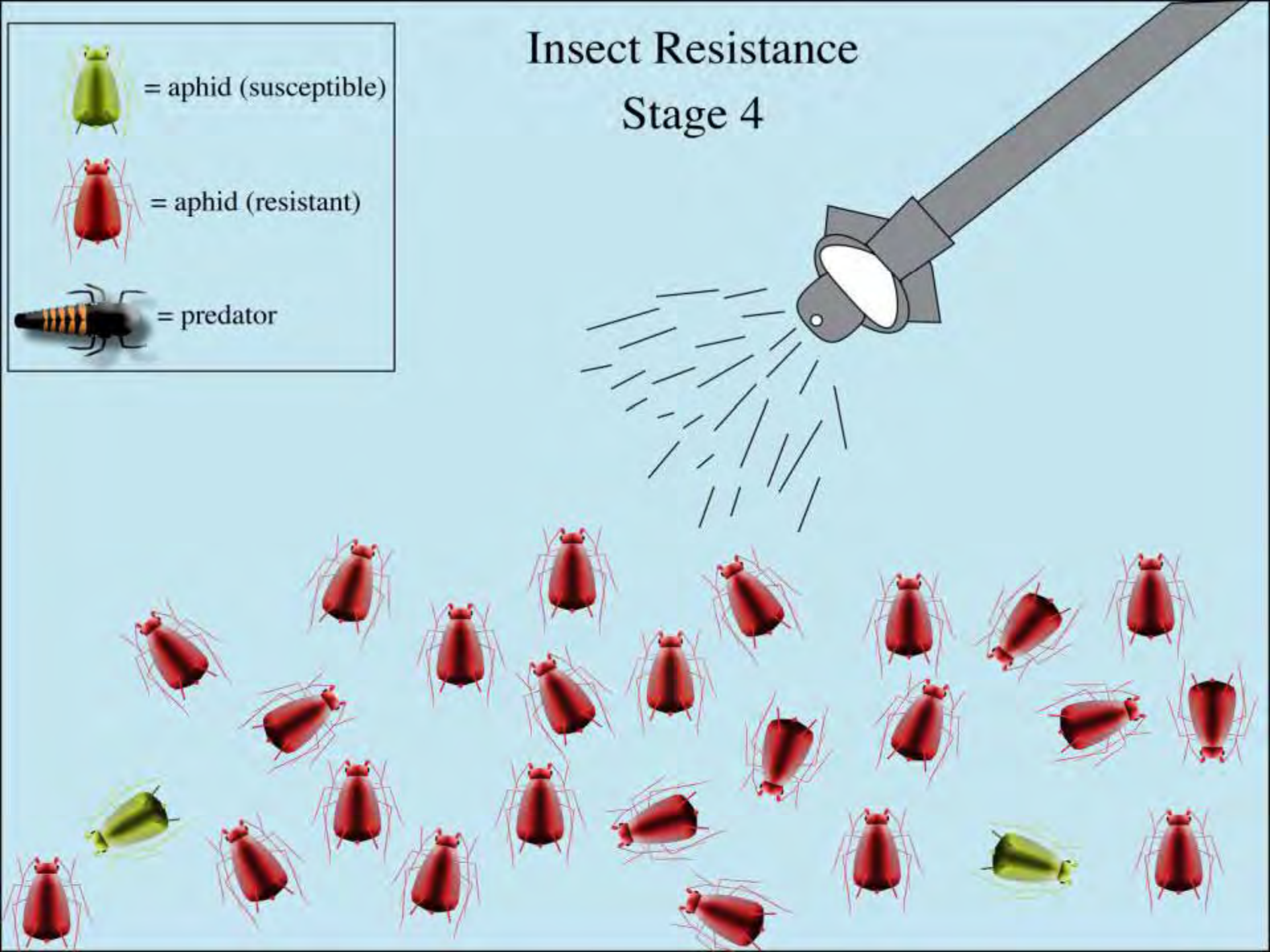
= aphid (resistant)

= predator



Insect Resistance

Stage 4



How Can You Help Reduce Insect Resistance to Insecticides?

1) consult extension agent for spray recommendations

2) minimize insecticide use by using early-maturing or pest-tolerant crops

3) use non-chemical techniques first (eg. Biological sprays, crop rotation, etc.)

4) select insecticides and management tools which preserve natural enemies

5) use products at their full, recommended doses

6) use well-maintained equipment to achieve full and proper coverage

7) target younger, more susceptible insect stages

How Can You Help Reduce Insect Resistance to Insecticides?

8) use appropriate local economic thresholds and spray intervals

9) Follow label or extension recommendations on rotating different classes (MoA's) of insecticides

10) When multiple applications per year are needed rotate different MoA's

11) If control is not achieved do NOT spray the same insecticide, switch to one with a different MoA

12) Do NOT mix chemicals for use against one target pest

13) Withhold a chemical from use until the population once again becomes susceptible. Treat with a different MoA insecticide in the mean time.

14) Use insecticides that are specific to your target pest

(eg. narrow spectrum)

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MODE of ACTION (MoA)

What is Mode of Action?

-is the sum of anatomical, physiological and biochemical interactions and responses that result in toxic action of a chemical, as well as the physical (location) and molecular (degradation) fate of the chemical in the organism.

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What?

MoA = how an insecticide kills!

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MoA Organization

Levels of Classification

Main Group

⬇

Chemical Sub-group

⬇

Active Ingredients

⬇

Product Name

Example

1. Acetylcholinesterase inhibitors

1A. Carbamates	1B. Organophosphates
Carbaryl	Diazinon
SEVIN BONIDE ROSE RX ECO BRAN 2% HI-YIELD 5% GARDEN & PET DUST 58 products	DIAZINON 50W DIAZINON AG 500W TERMINATOR II INSECTICIDE CATTLE EAR TAG 9 products

- 28 MoA's

-7 MoA's are unknown

*Physical toxicants are not listed: oils, soaps, dusts, etc.

Common Insecticides for Ornamental and Turfgrass Use*			
Active Ingredient	Insecticide Class	O = Onram. T = Turf	
Bt	biological	O	T
nematodes	" "	O	T
azadirachtin	botanical*	O	-
carbaryl	carbamate	O	T
halofenozide	diacylhydrazines	-	T
insecticidal soap	fatty acid	O	
hydramethylnon	hydramethylnon	-	T
imidacloprid	neonicitinoid	O	T
acephate	organophosphate	O	T
disulfton	" "	O	-
malathion	" "	O	-
chlorpyrifos	" "	-	T
fenbutatin-oxide	organotin	O	
horticultural oil	petroleum distillate	O	-
pyrethrins/pyrethrum	pyrethrin	O	-
bifenthrin	pyrethroid	O	T
esvenvalerate	" "	O	-
permethrin	" "	O	-
cyfluthrin	" "	-	T
lambda-cyhalothrin	" "	-	T
spinosad	spinosyn	O	T

What to talk about?

*Surveyed 2008 PNW Insect Management Handbook

- Selected commonly recommended insecticides for ornamental and turf

- chose insecticides based on use frequency and “coolness factor”

- http://pnwpest.org/pnw/insects

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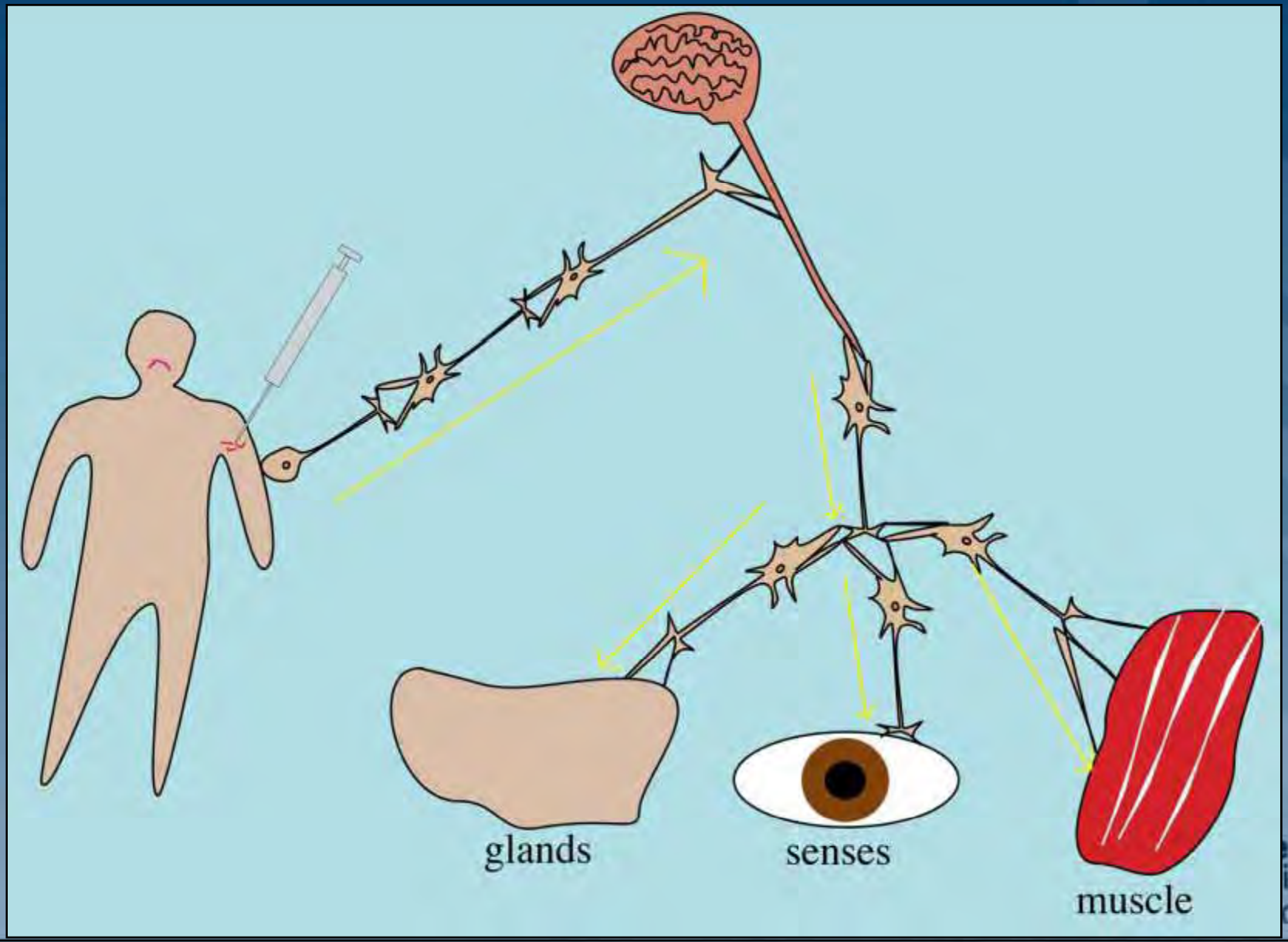
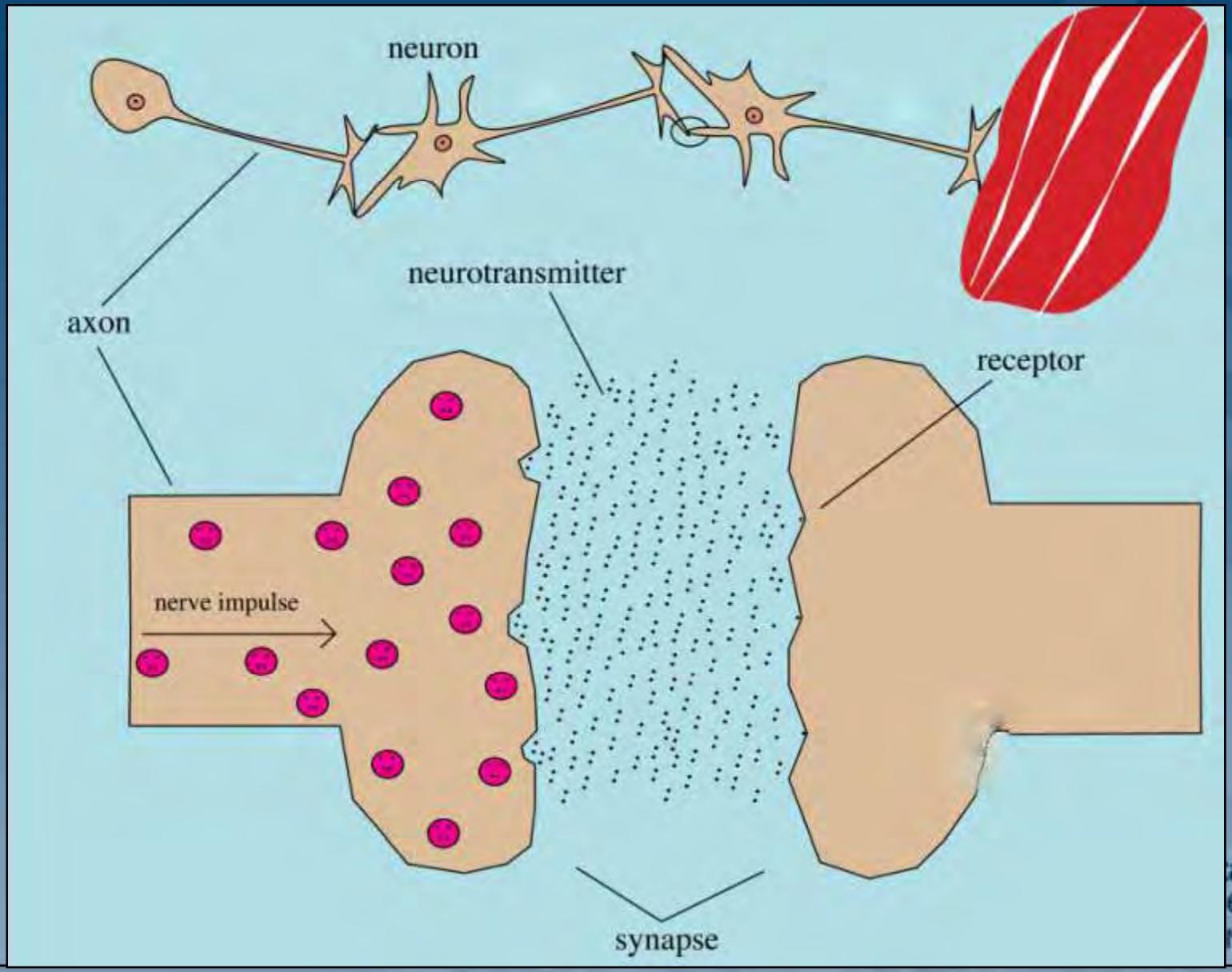
Mode of Action (MoA) Outline

1. Carbamates and Organophosphates
2. Pyrethroids, Pyrethrins
3. Neonicitinoids
4. Spinosyns
5. Insect Growth Regulators (IGR): Juvenile Hormone
6. Oils
7. Entomopathogenic nematodes
8. Dusts
9. *Bacillus thuringiensis* (Bt)

General Nerve Overview



General Nerve Overview



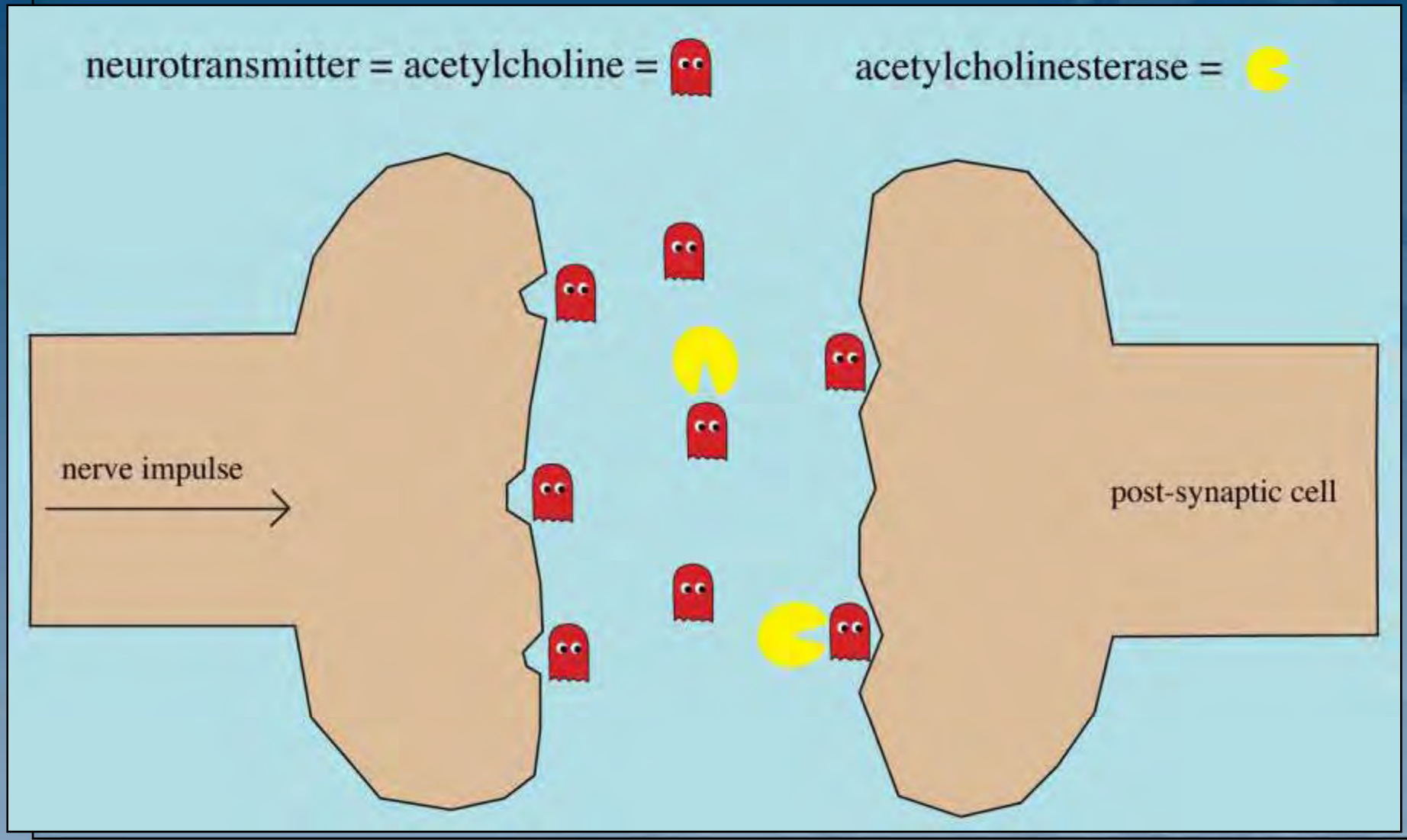
MoA Group 1. Acetylcholinesterase Inhibitors: Carbamates, Organophosphates

MoA Group 1A and 1B Examples:

- 1A: SEVIN, FURADAN, MESUROL

- 1B: ACEPHATE, DURSBAN, DIAZINON, MALATHION

MoA Group 1. Acetylcholinesterase Inhibitors: Carbamates, Organophosphates



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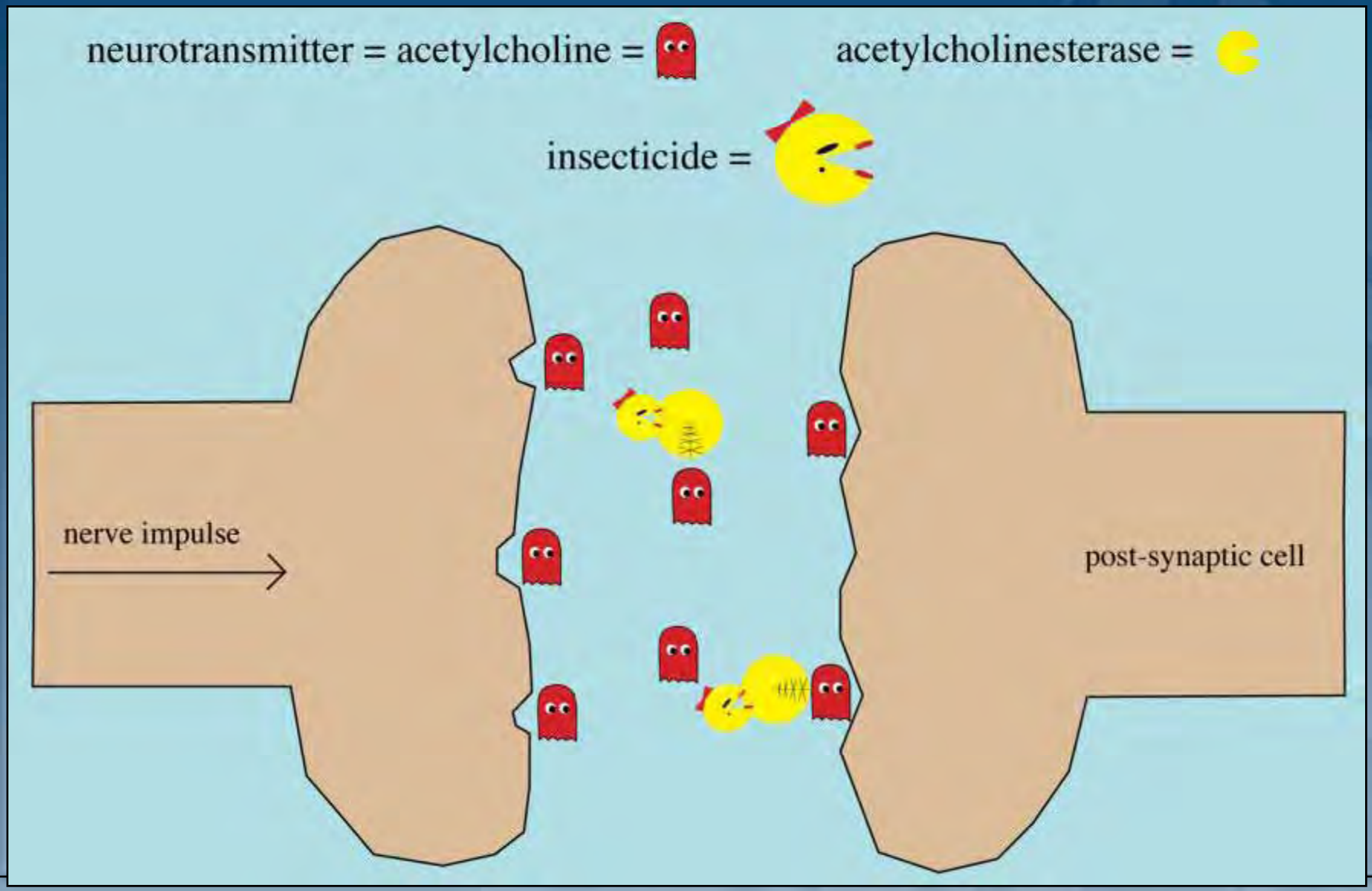
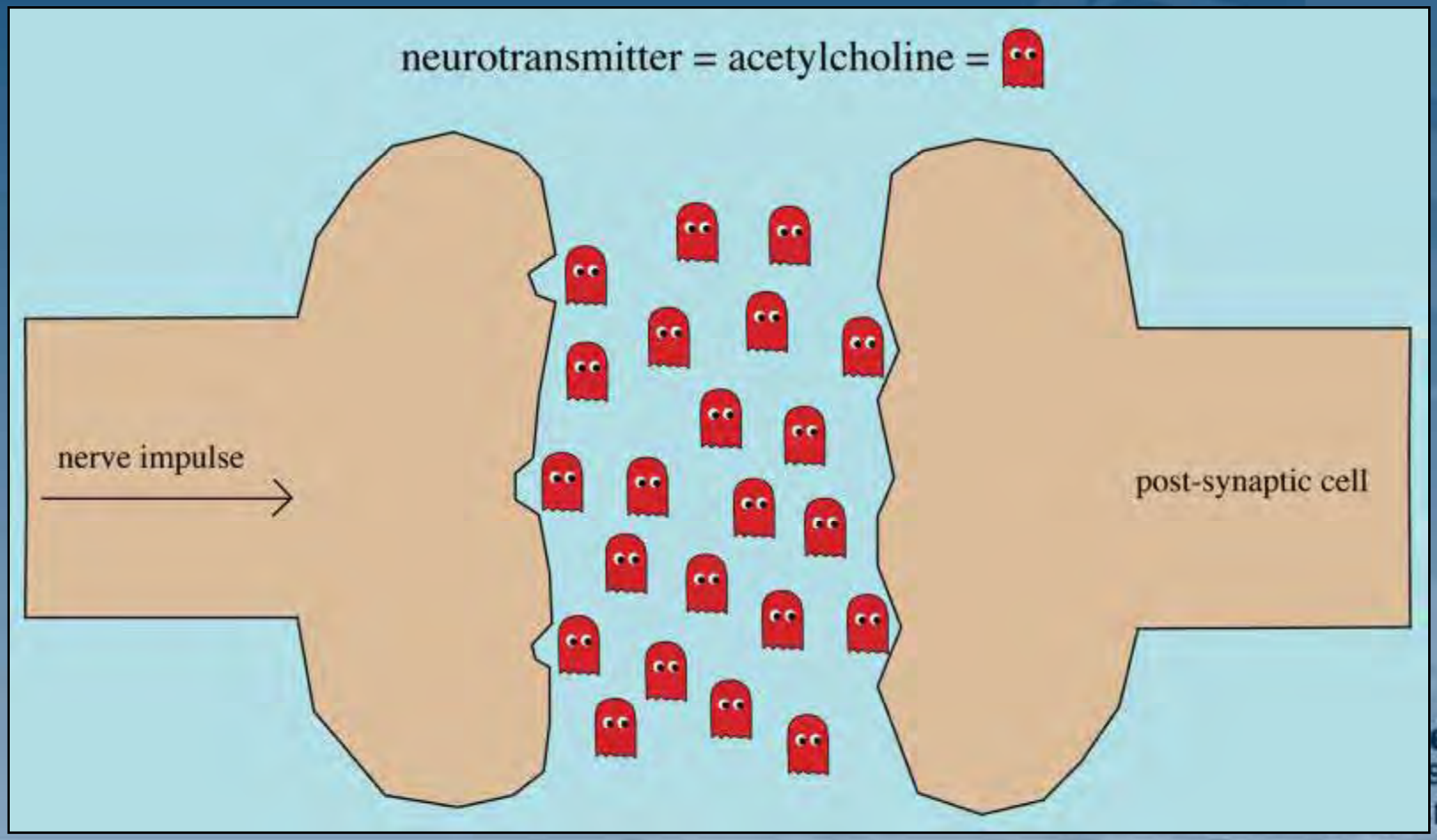


MoA Group 1. Acetylcholinesterase Inhibitors: Carbamates, Organophosphates

Rapid firing of nerve impulses: convulsion, paralysis, death (respiratory failure)



MoA Group 3: Sodium Channel Modulators Pyrethroids, Pyrethrins, DDT, Methoxychlor

Group 3 Examples:

- 3A: TALSTAR, ALOFT, Bifenthrin, WARRIOR, ADJOURN, Permethrin, Pyrethroids, Pyrethrins

- 3B: DDT, Methoxychlor

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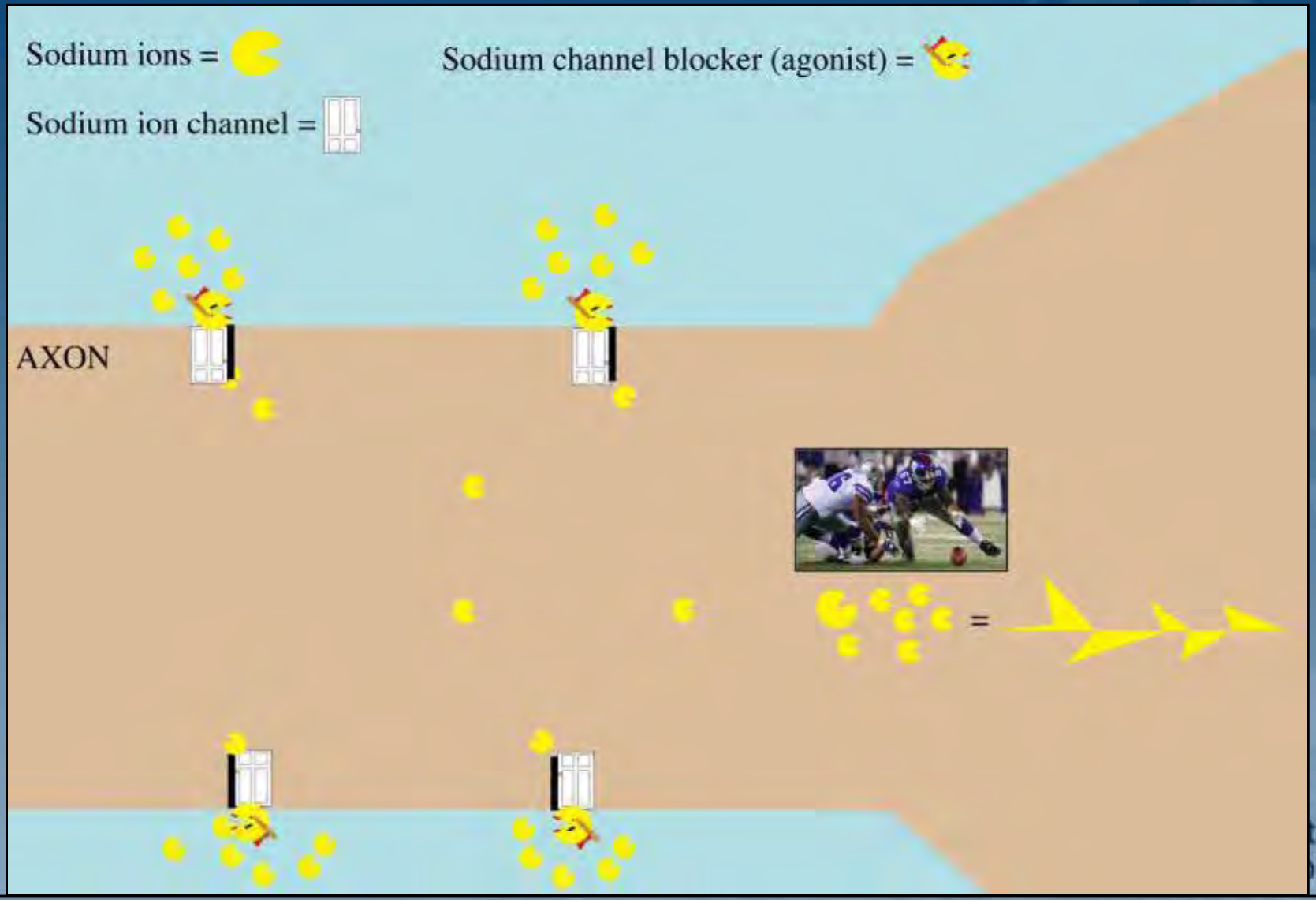
MoA Group 3: Sodium Channel Modulators Pyrethroids, Pyrethrins, DDT, Methoxychlor



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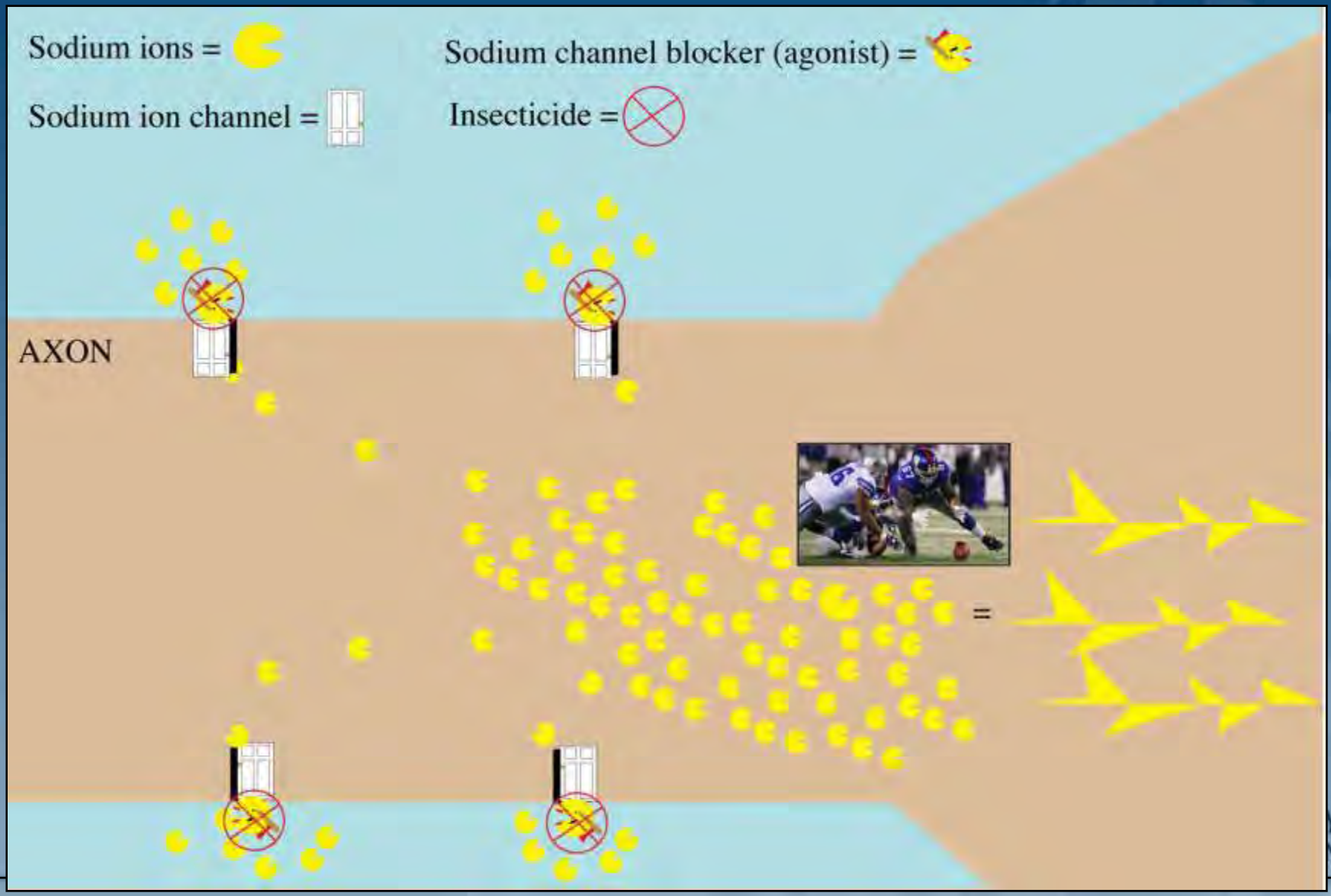

MoA Group 3: Sodium Channel Modulators Pyrethroids, Pyrethrins, DDT, Methoxychlor

Side Effects: stimulate repetitive nerve discharges (twitching=“DDT Jitters”), leading to paralysis, and death.

Both Group 3A and 3B are more effective at colder temperatures

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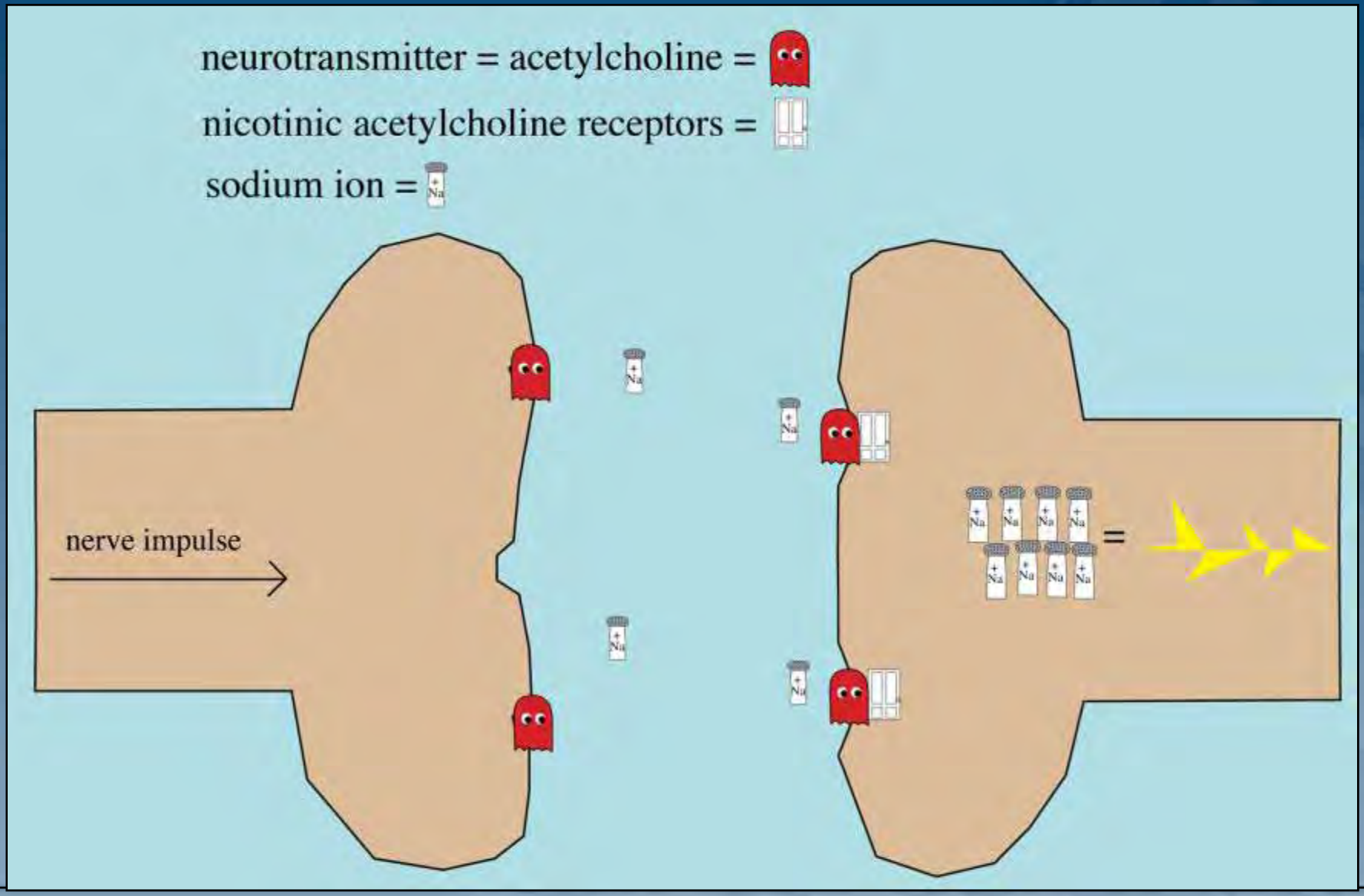
MoA Group 4: Nicotinic Acetylcholine Receptor Agonists Neo-nicotinoids (merit), and Nicotine

Group 4 Examples:

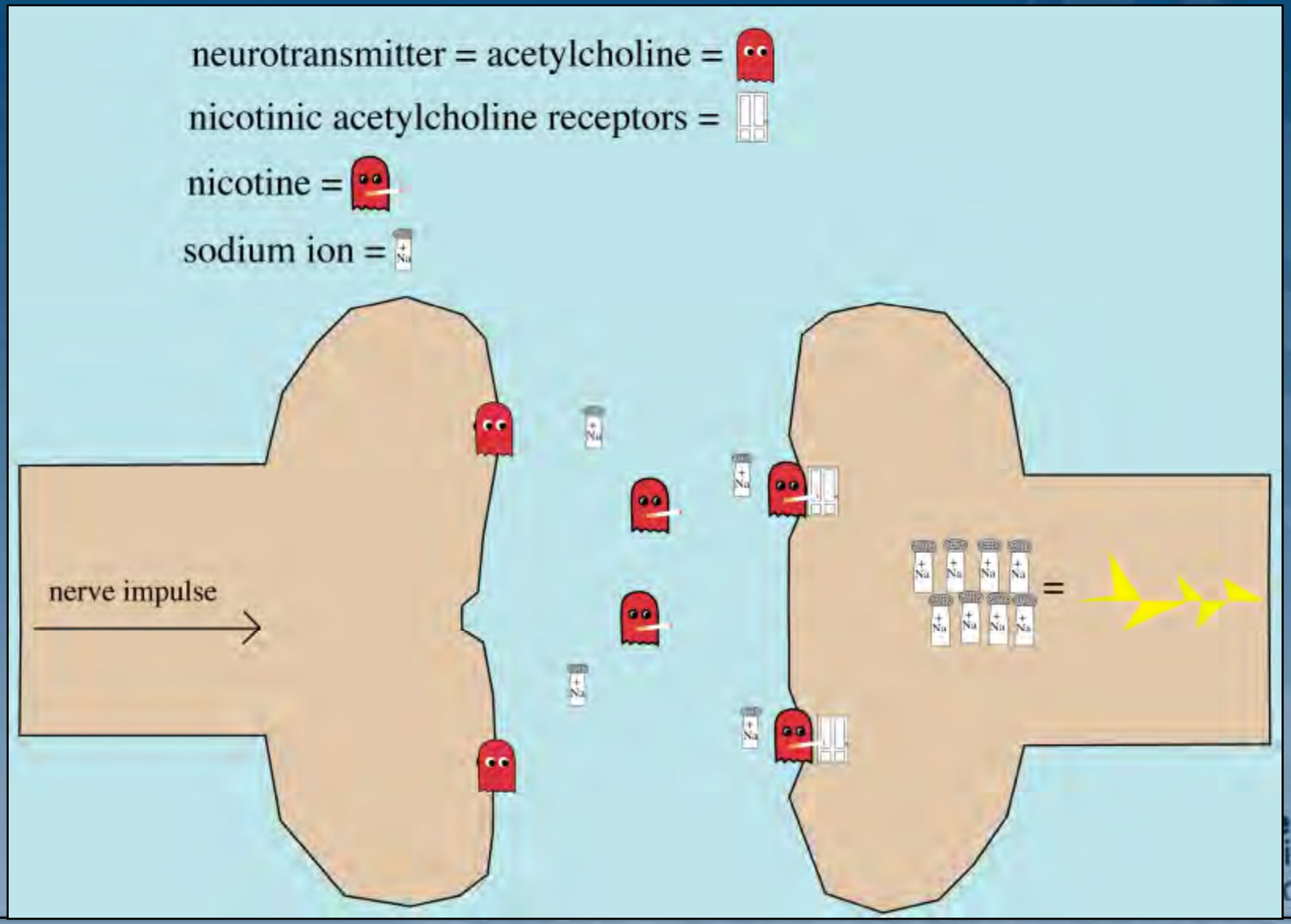
- 4A: MERIT, SAFARI, BAYER ADVANCED 12-MONTH…

- 4B: FERTI-LOME DOG AND RABBIT RIDDER, FULEX NICOTINE FUMIGATOR

MoA Group 4: Nicotinic Acetylcholine Receptor Agonists Neo-nicotinoids (merit), and Nicotine



MoA Group 4: Nicotinic Acetylcholine Receptor Agonists Neo-nicotinoids (merit), and Nicotine



MoA Group 4: Nicotinic Acetylcholine Receptor Agonists
Neo-nicotinoids (merit), and Nicotine

Side Effects (neo-nicotinoids target insects, not mammals): increased or decreased heart rate, excitation, convulsions, paralysis, and death

MoA Group 5: Nicotinic Acetylcholine Receptor Allosteric Activators

Spinosyns

Group 5 Examples:

5: Spinosad, CONSERVE, ENTRUST, SUCCESS

MoA Group 5: Nicotinic Acetylcholine Receptor Allosteric Activators

Spinosyns

Where does Spinosad come from?

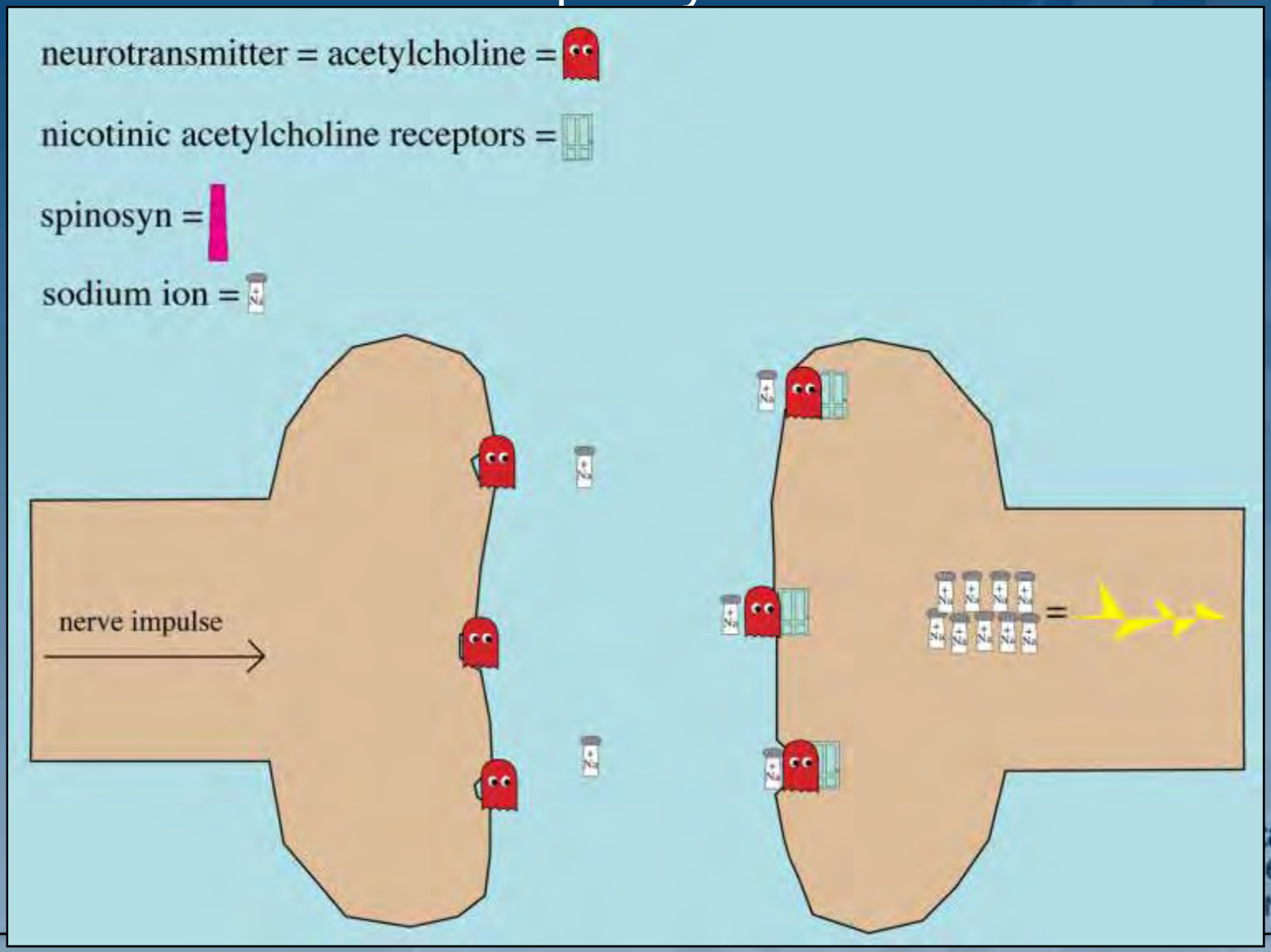
- Soil in an abandoned rum distillery on a Caribbean Island

- By-product of a bacterial fermentation of corn, cottonseed flour, soybean flour, glucose, methyl oleate, and calcium carbonate.

- Compatible with organic farming/gardening practices

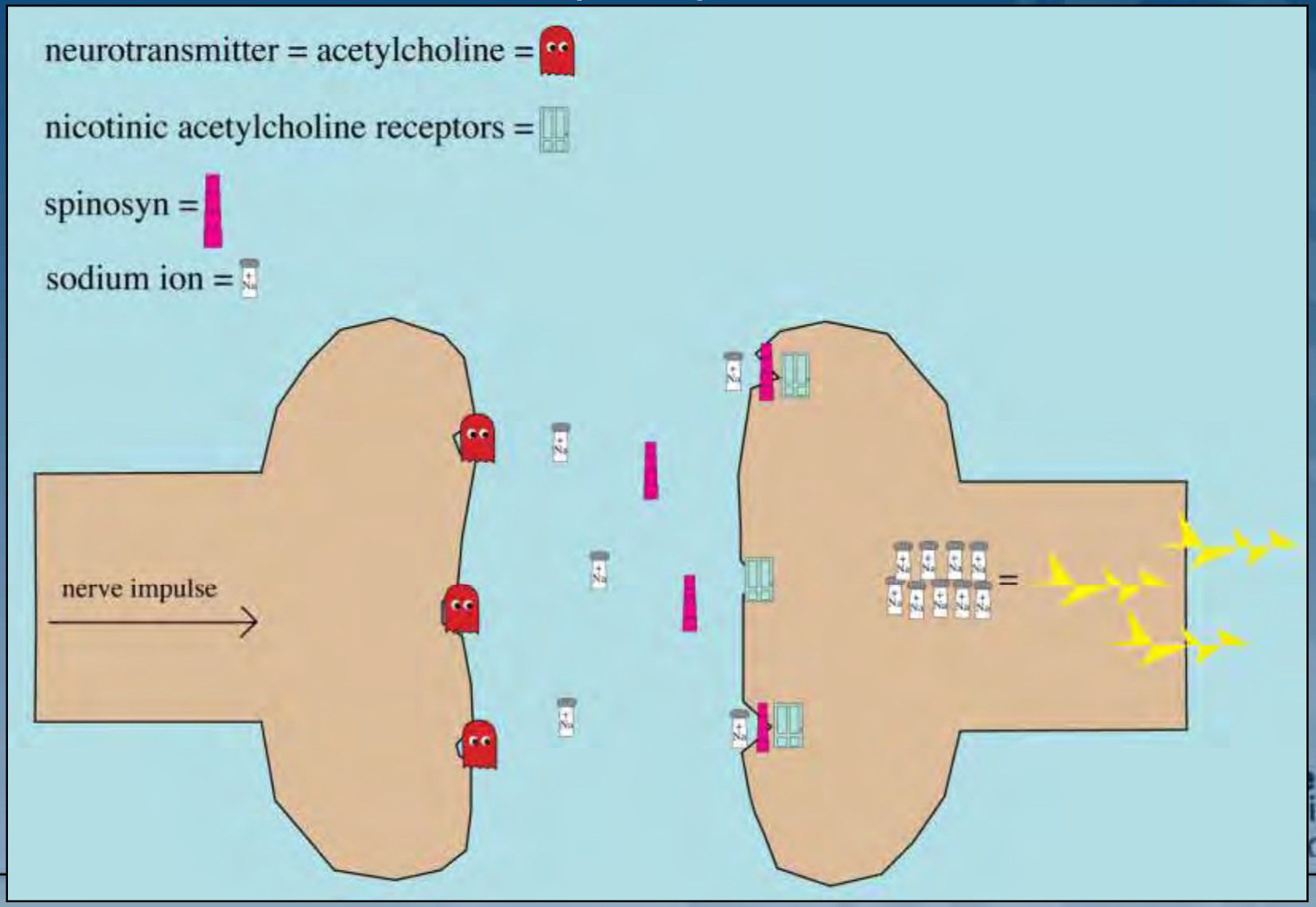
MoA Group 5: Nicotinic Acetylcholine Receptor Allosteric Activators

Spinosyns



MoA Group 5: Nicotinic Acetylcholine Receptor Allosteric Activators

Spinosyns



MoA Group 5: Nicotinic Acetylcholine Receptor Allosteric Activators

Spinosyns

Side Effects: increased or decreased heart rate, excitation, convulsions, paralysis, and death

MoA Group 7: Juvenile Hormone Mimics (IGR)

Group 7 Examples:

7A: GENTROL, ENSTAR II INSECT GROWTH REGULATOR,

7B: AWARD

7C: SENTRY, SERGEANTS GOLD (pet flea and tick products)

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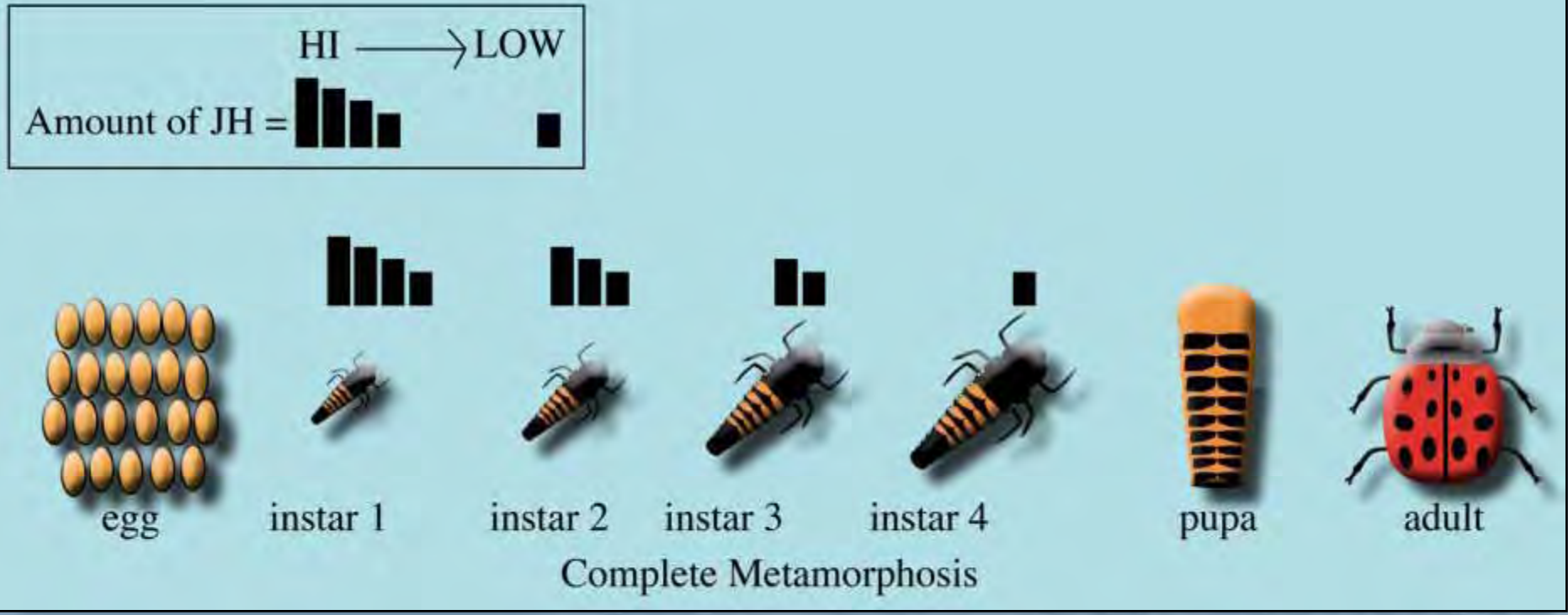
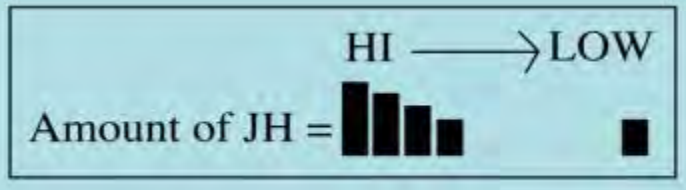
MoA Group 7: Juvenile Hormone Mimics (IGR)

Juvenile Hormone Analogues, Fenoxycarb, and Pyriproxyfen

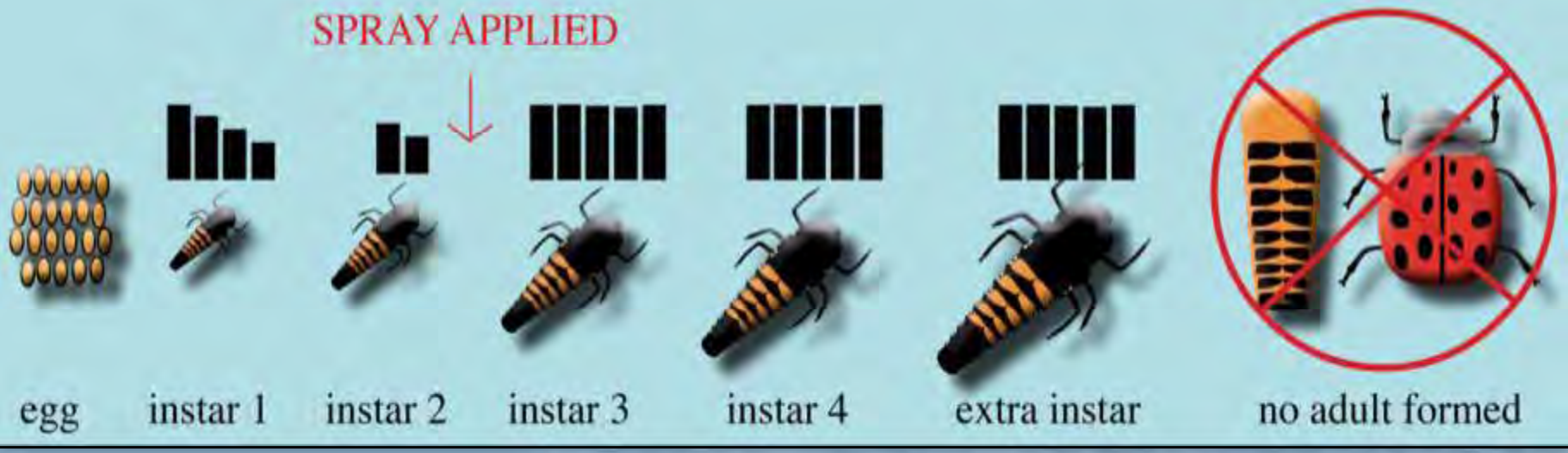
Juvenile Hormones (JH) regulate insect growth



MoA Group 7: Juvenile Hormone Mimics (IGR)



Normal



MoA Group 7: Juvenile Hormone Mimics (IGR)

Other groups that affect insect growth:

MoA Group 10: Mite growth inhibitors

MoA Group 15: Inhibitors of chitin (exoskeletal) biosynthesis, type 0, Lepidopteran

MoA Group 16: Inhibitors of chitin biosynthesis, type 1, Homopteran

MoA Group 17: Molting disruption, Dipteran

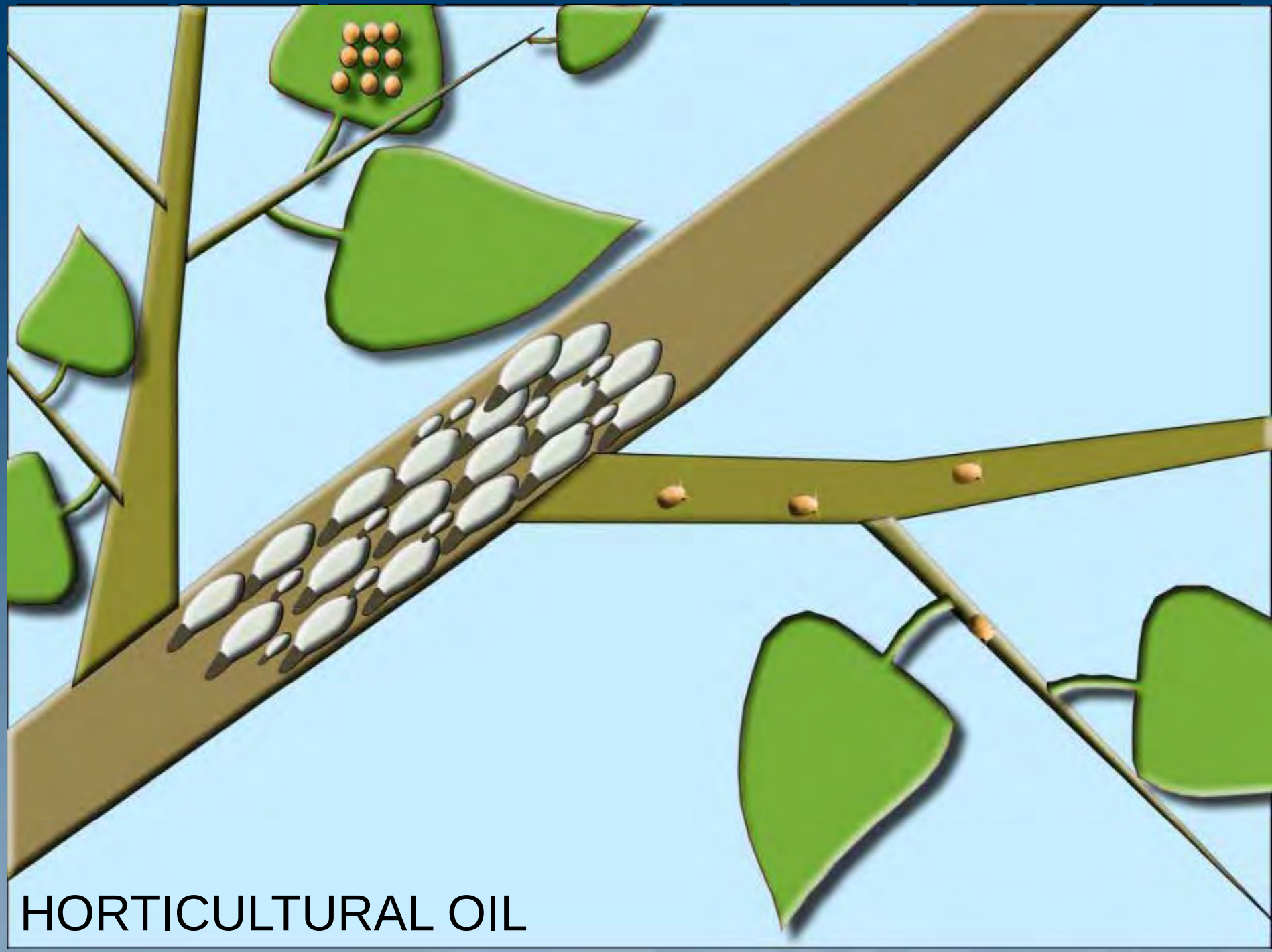
MoA Group 18: Ecdysone receptor agonists (halofenozide)

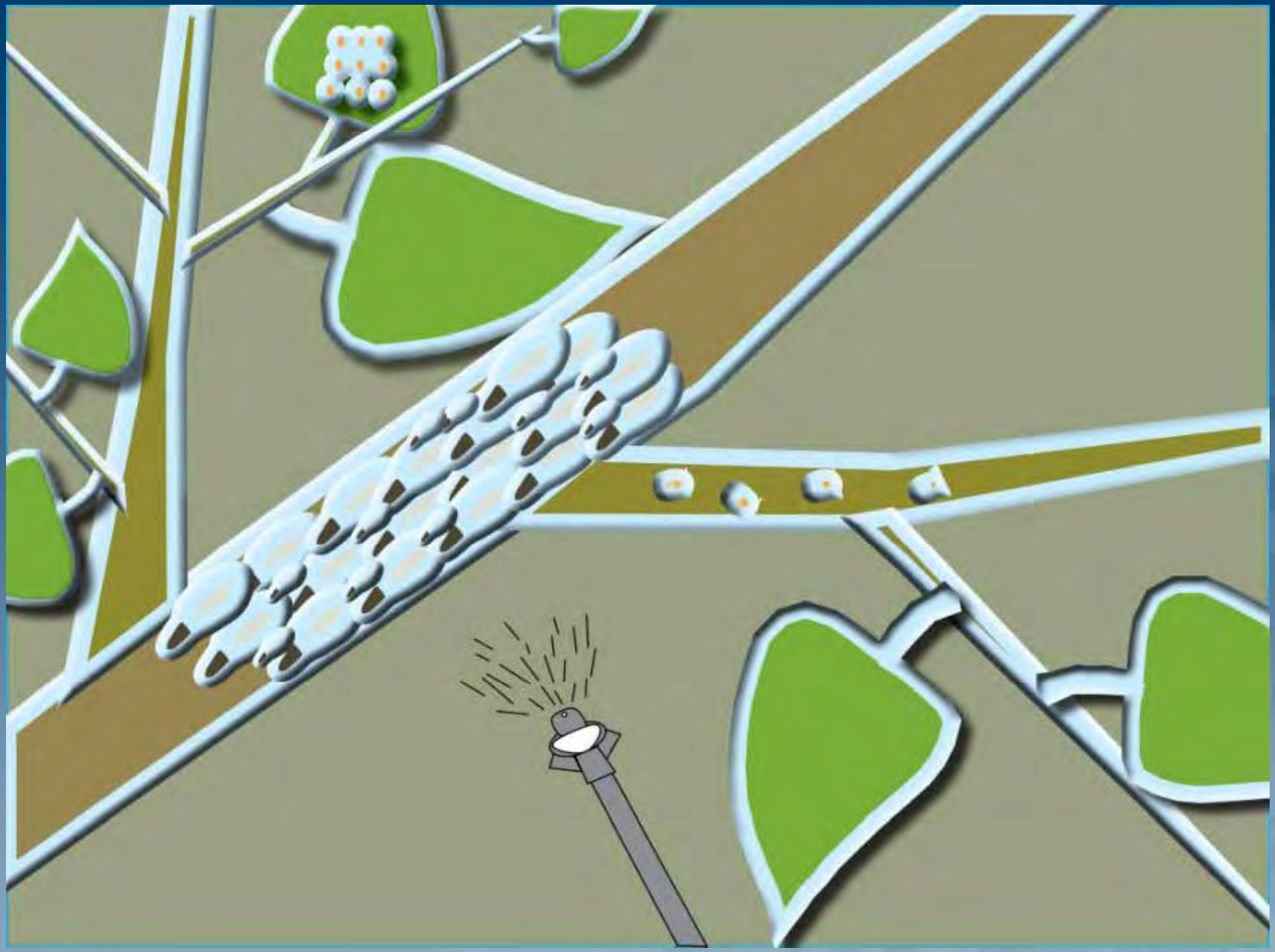
MoA (Physical toxicant): Horticultural Oil

Best for: eggs, scales (adult and crawler), blister/rust mites, spider mites, thrips, whiteflies, psyllids, etc.

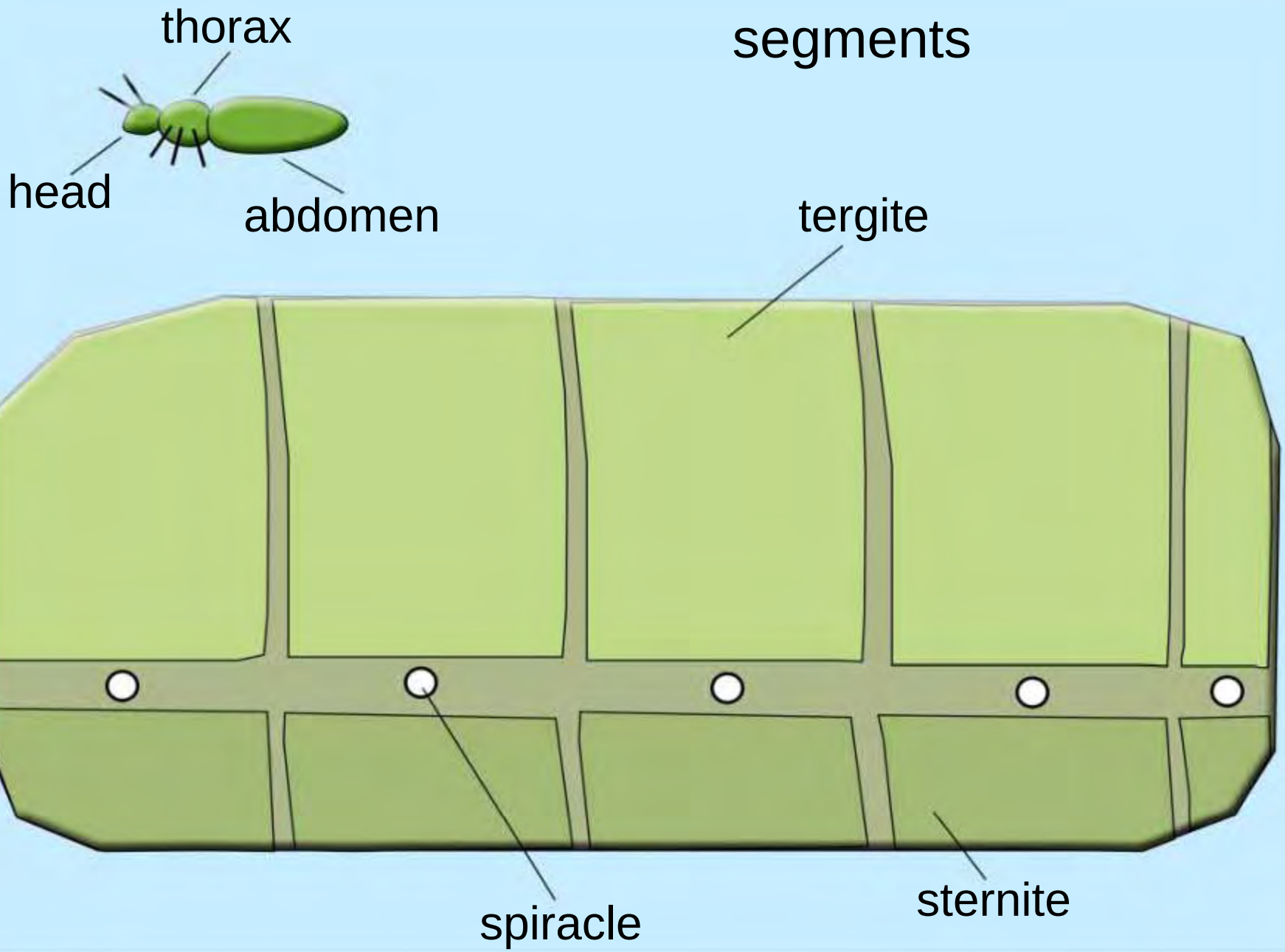
Product Names:

- Bonide
- Horticultural Oil Spray
- IFA Dormant Oil Spray
- Supreme Oil


HORTICULTURAL OIL



Lateral view of abdominal segments



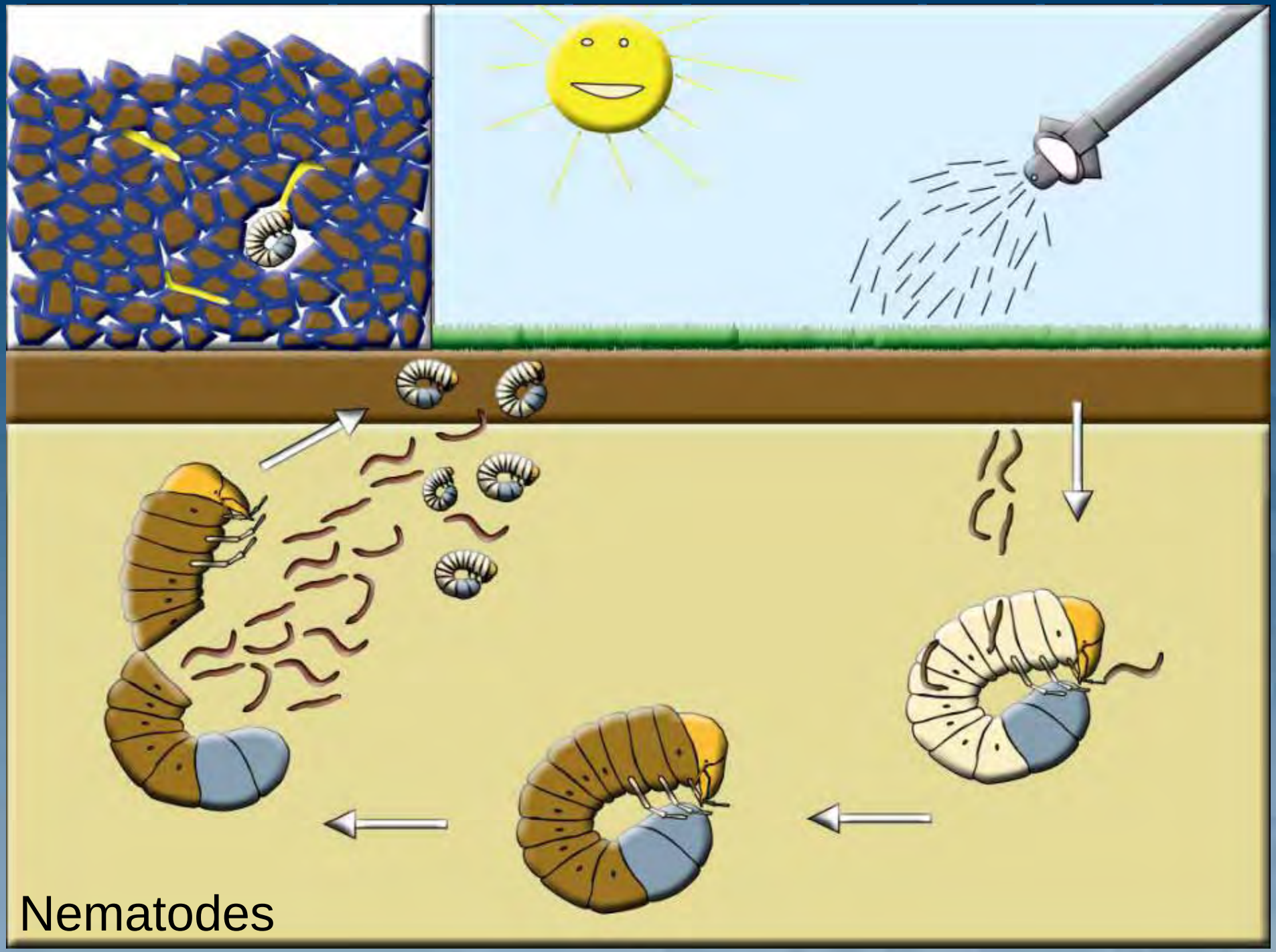
MoA (Biological: Microbial disruptors of insect midgut membranes): Entomopathogenic nematodes

Common nematode families and preferred hosts*:

Steinernematidae	Heterorhabditidae
Annual bluegrass weevil	Black turfgrass ataenius
Bluegrass billbug	European chafer
Hunting billbug	Green June beetle
Black cutworm	Japanese beetle
Dog/cat flea larvae	May/June beetles
European crane fly	No. masked chafer
Armyworms	So. masked chafer
Sod webworms	SW. masked chafer
	West. masked chafer

Suppliers of beneficial organisms in North America:
http://www.cdpr.ca.gov/docs/pestmgt/ipminov/ben_supp/contents.htm

*Dr. Parwinder Grewal, The Ohio State University. http://www.oardc.ohio-state.edu/nematodes/turfgrass_pest_management.htm


Nematodes

Dawn Gouge. Texas A&M

Arnold Hara. University of Hawaii

*Nematodes are not compatible with the following chemicals:

Chemical	Trade name	Chemical	Trade Name
Anilazine	Dyrene	Fipronil	Chipco Choice
Azadirachtin	Azatin	Insecticidal Soap	Various
Azinphosmethyl	Guthion	Isazophos	Triumph
Bendiocarb	Turcam	Methomyl	Lannate
Carbofuran	Furadon	Oxamyl	Vydate
Carbaryl	Sevin	2-4-D	Various
Chlorpyriphos	Dursban	Trichlorfon	Dylox
Ethoprop	Mocap	Triclorpyr	Turflon, Confront
Fenamiphos	Nemacur		

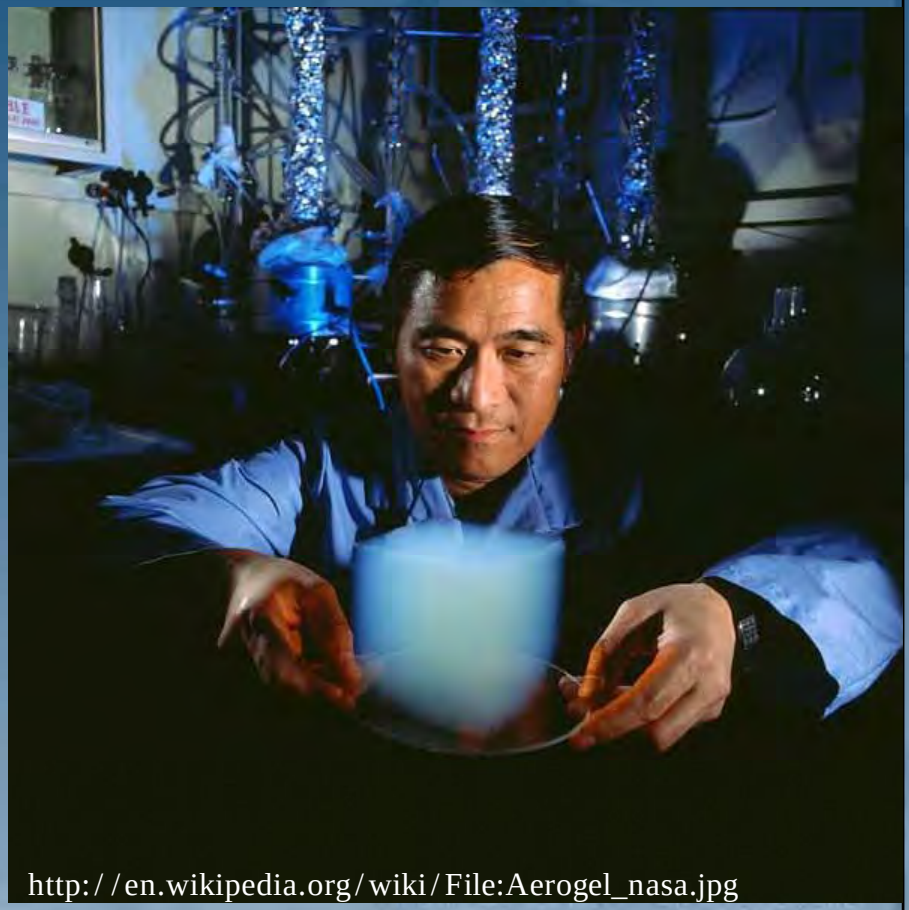
http://www.oardc.ohio-state.edu/nematodes.htm

MoA (Physical Toxicant): Insecticidal Dust

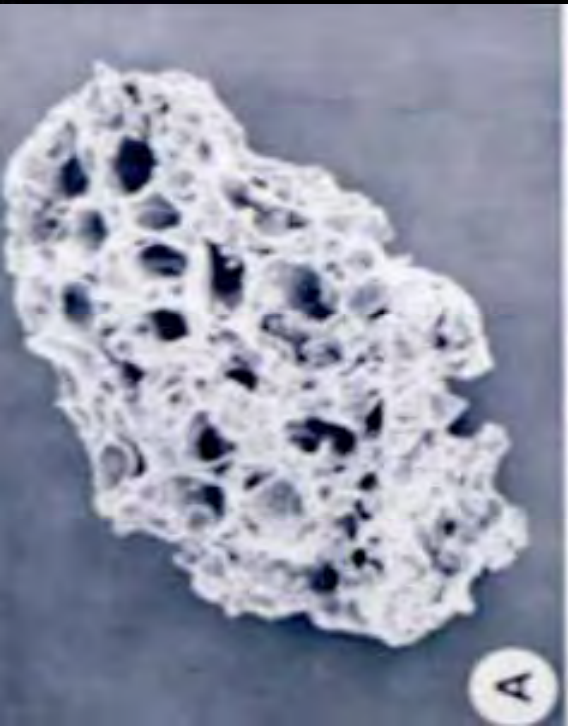
Best against soft-bodied insects such as: aphids, caterpillars,

Types of dust:

- Boric acid
- Diatomaceous earth (DE)
- Silica gel/Aerosilica

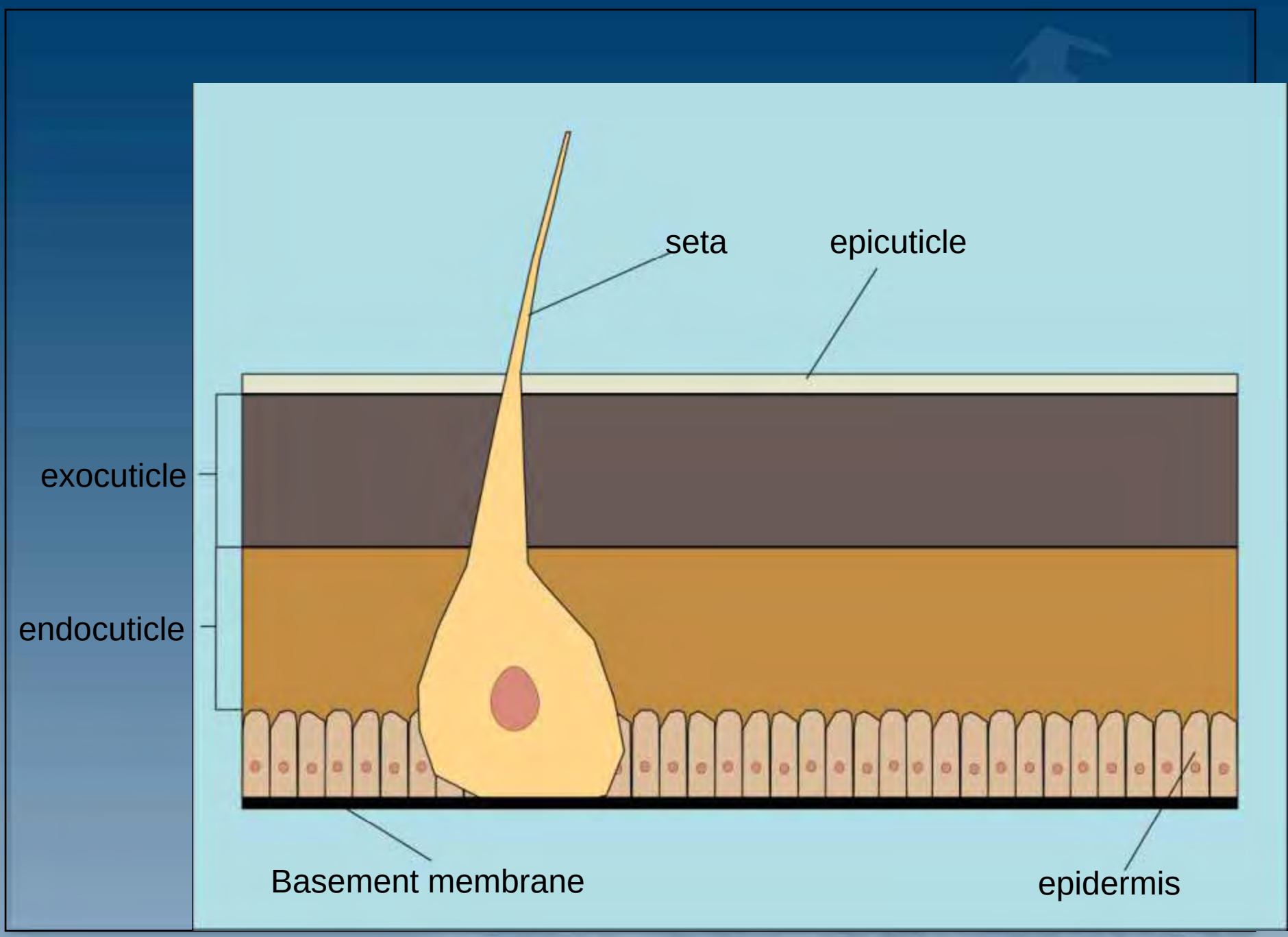


http://en.wikipedia.org/wiki/File:Aerogel_nasa.jpg


A


C


E


seta
epicuticle
exocuticle
endocuticle
Basement membrane
epidermis

*The following slide is rated R for graphic insect violence and dust.

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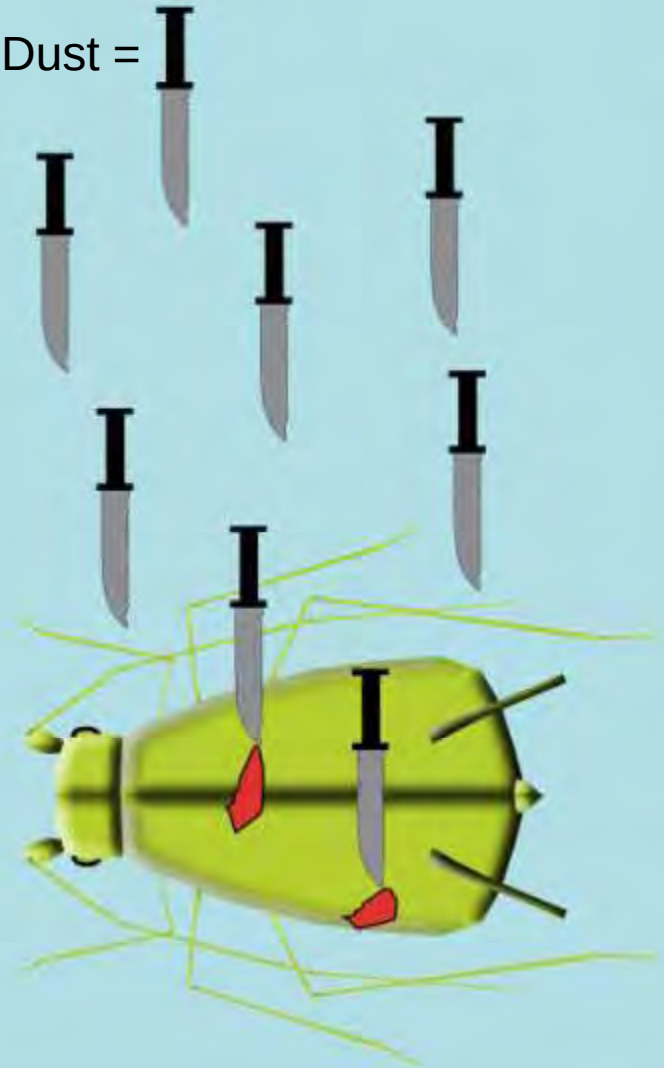
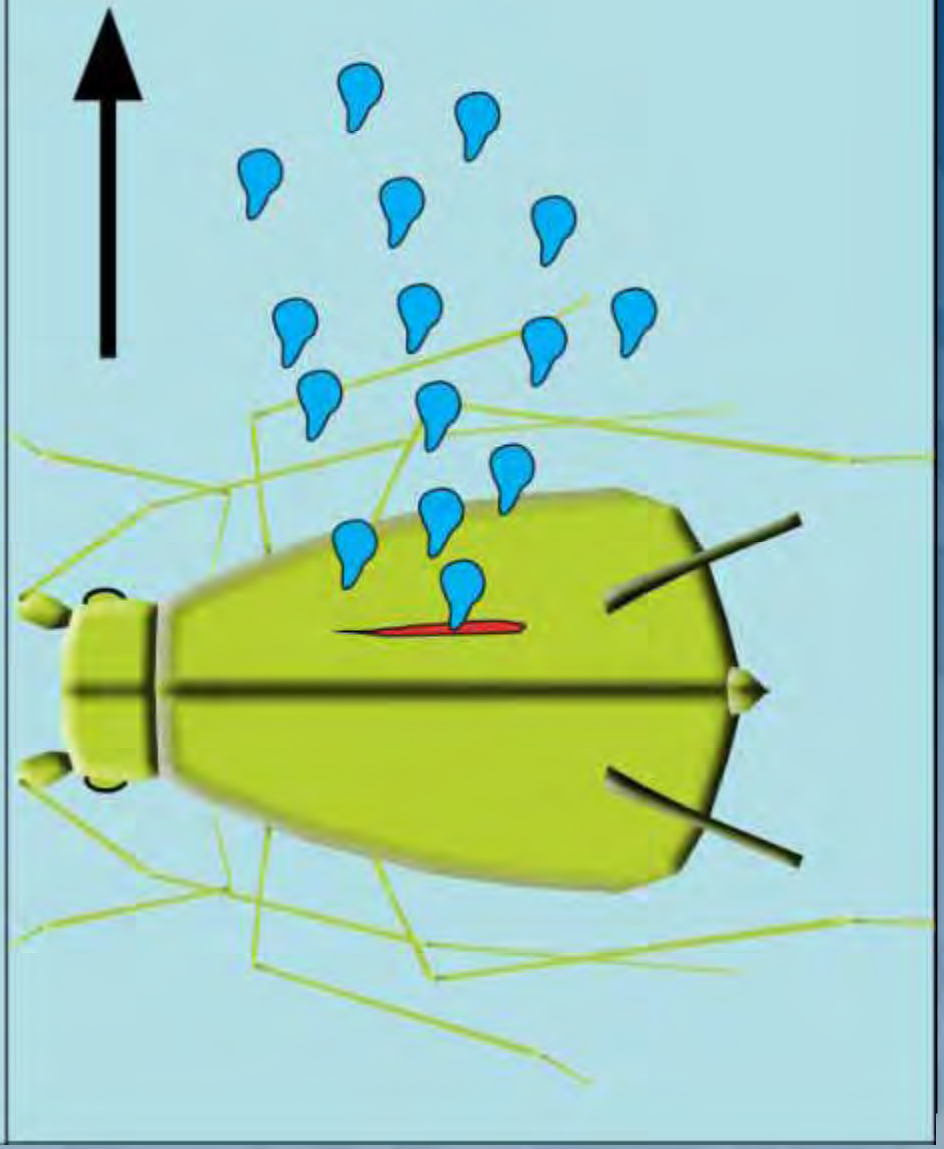
Insecticidal dust cuts through insect cuticle

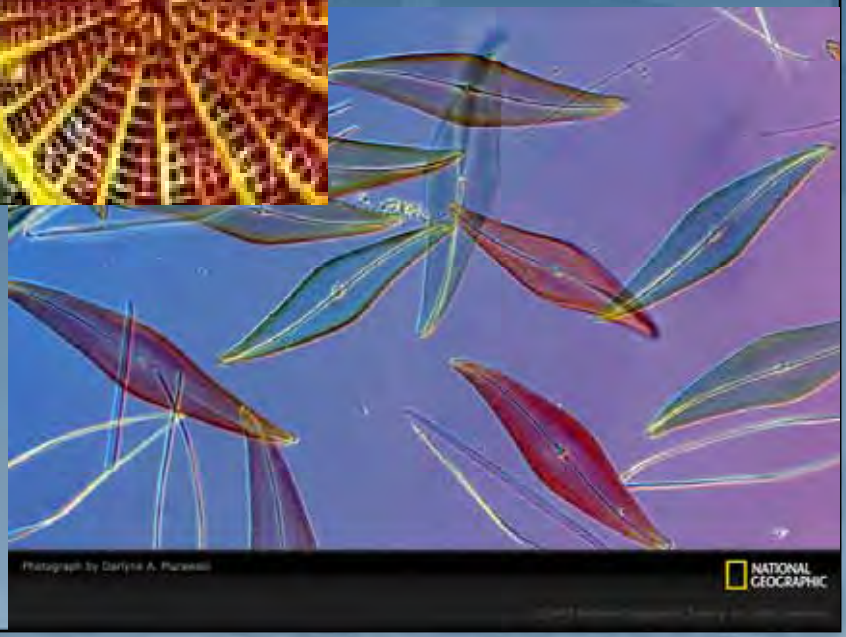
Dust =



Without cuticle insect looses water



Diatoms



MoA (Microbial disruptor of insect midgut membranes): *Bacillus Thuringiensis*

Best against : Fly, moth, and sawfly larvae (caterpillars)

Product Names: Bonide, Dipel, Thuricide (not in Kelly registry)

Species and subspecies:

- *Bacillus thuringiensis* subsp. *israelensis*
- *Bacillus sphaericus*
- *Bacillus thuringiensis* subsp. *aizawai*
- *Bacillus thuringiensis* subsp. *kurstaki*
- *Bacillus thuringiensis* subsp. *tenebrionis*

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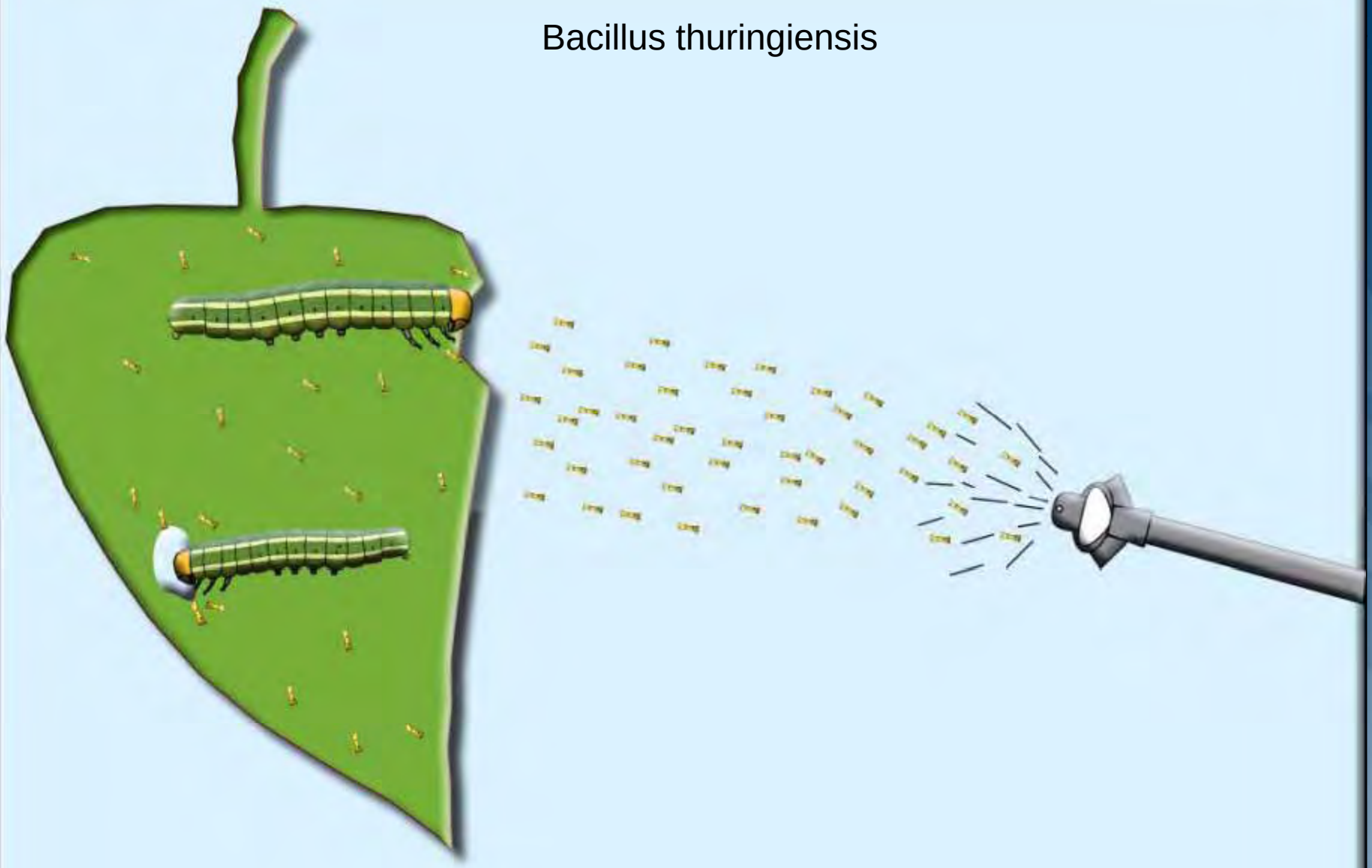
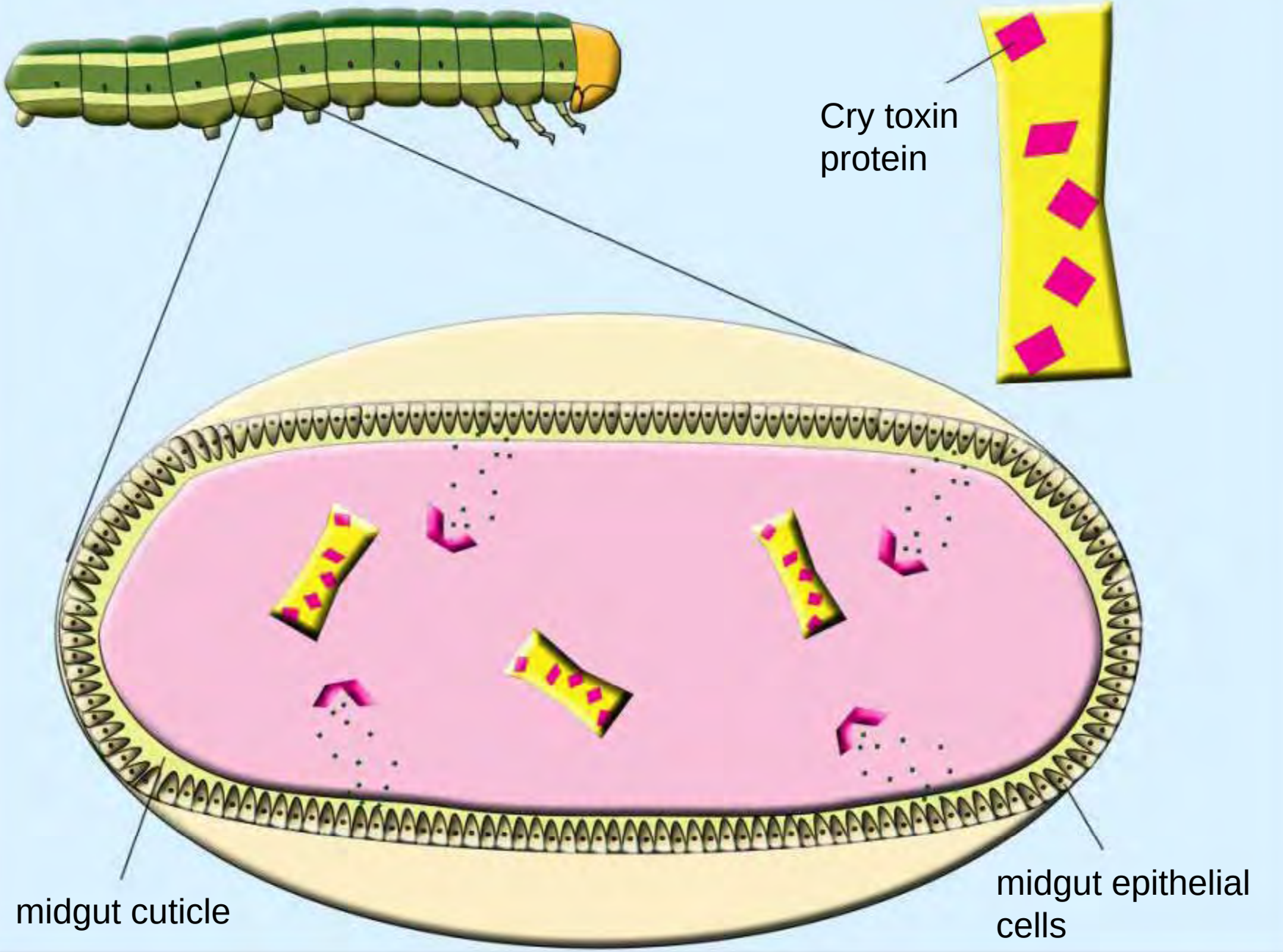
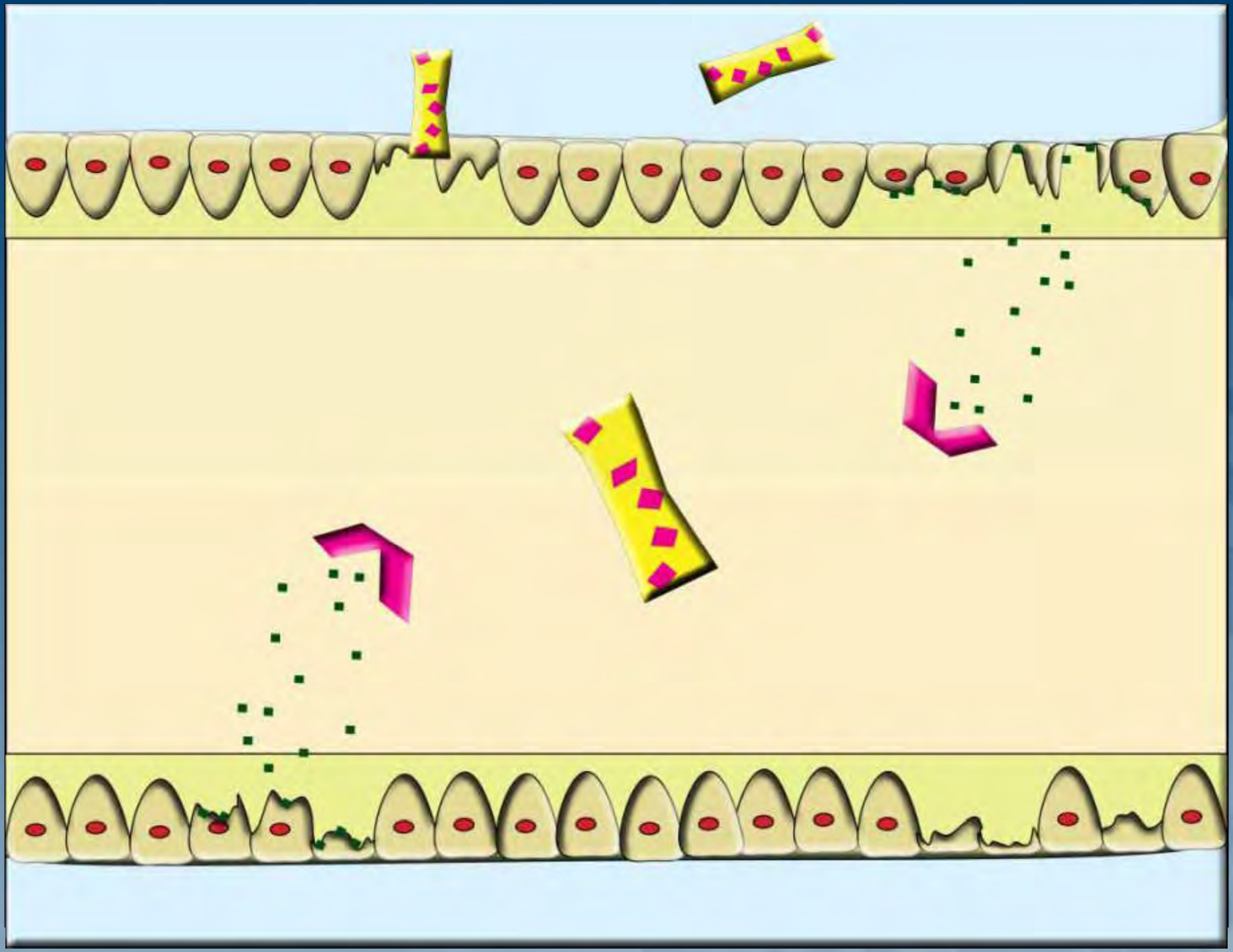
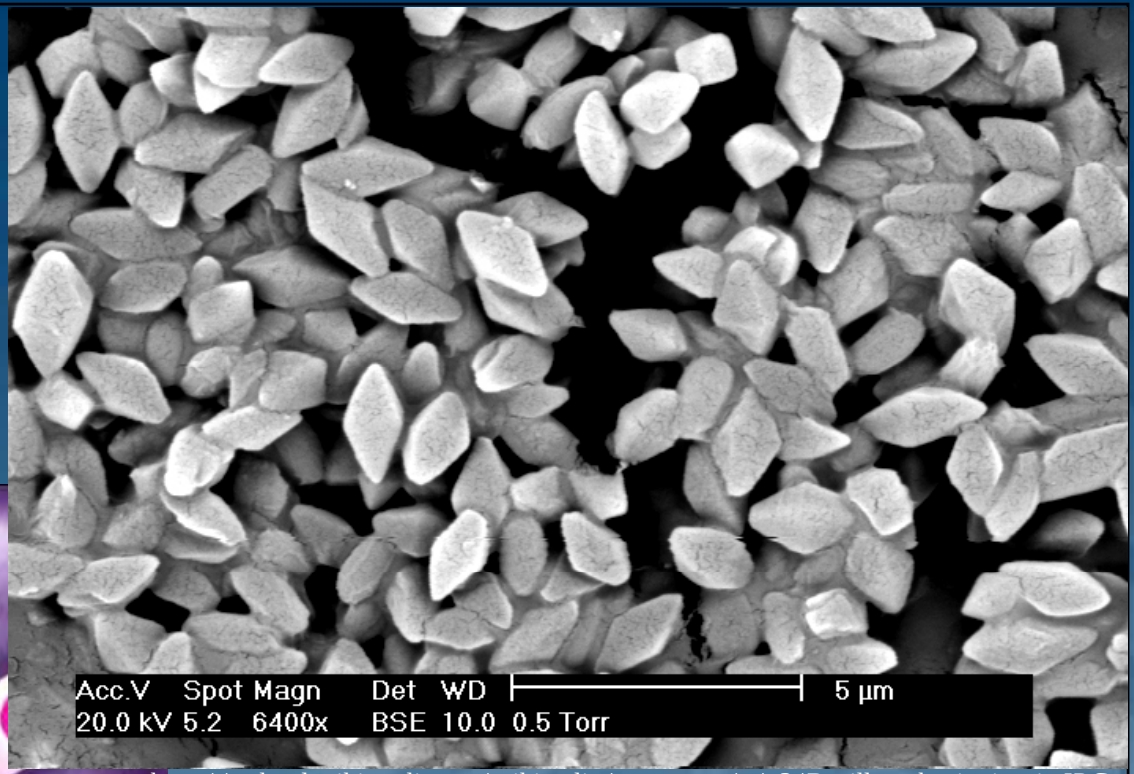
Bacillus thuringiensis




Cry toxin protein
midgut cuticle
midgut epithelial cells





http://upload.wikimedia.org/wikipedia/commons/e/e3/Bacillus_thuringiensis.JPG

http://images.google.com/biosci.sierracollege.edu

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Things to remember

1. Insect resistance is caused by using insecticides within the same group, sub-group, active ingredient, or product.
2. Rotate insecticides from different MoA main groups as part of your pest control program.
3. Tank mixing of chemicals for one target pest will result in resistance of two chemicals at once.
4. Contact county agent or UPPDL for spray recommendations.
5. Insecticides aren't just "magical liquids…" they alter arthropod, mammalian, etc., bodily functions and can cause short- and long-term health problems. Always wear proper equipment when applying pesticides.

Thank You; Questions?

Need Help?

Ryan Davis

ryan.davis@biology.usu.edu

Phone: 435-797-2435

Visit: utahpests.usu.edu

Before you spray! Please send samples.

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How Resistance Works

Genetics play the key role in resistance

S = susceptible

R = resistant

$p^2 \times p^2$	$S^A S^A S^B S^B$	=	about 100% of population
$2pq \times p^2$	$R^A S^A S^B S^B$	=	0.0002%
$p^2 \times 2pq$	$S^A S^A R^B S^B$	=	0.0002%
$4p^2q^2$	$S^A R^A S^B R^B$	=	0.00000002%

Richard Roush , The University of Melbourne, Melbourne, Victoria, Australia

Rotations, mixtures and managing cross-resistance. ESA, Nov. 2008

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Group 2: GABA-gated chloride channel antagonists: cyclodiene, organochlorines, and phenylpyrazoles

Group 2 Examples:

- 2A: ENDOSULFAN, THIONEX

- 2B: FIPRONIL, TERMIDOR, MAXFORCE BAITS

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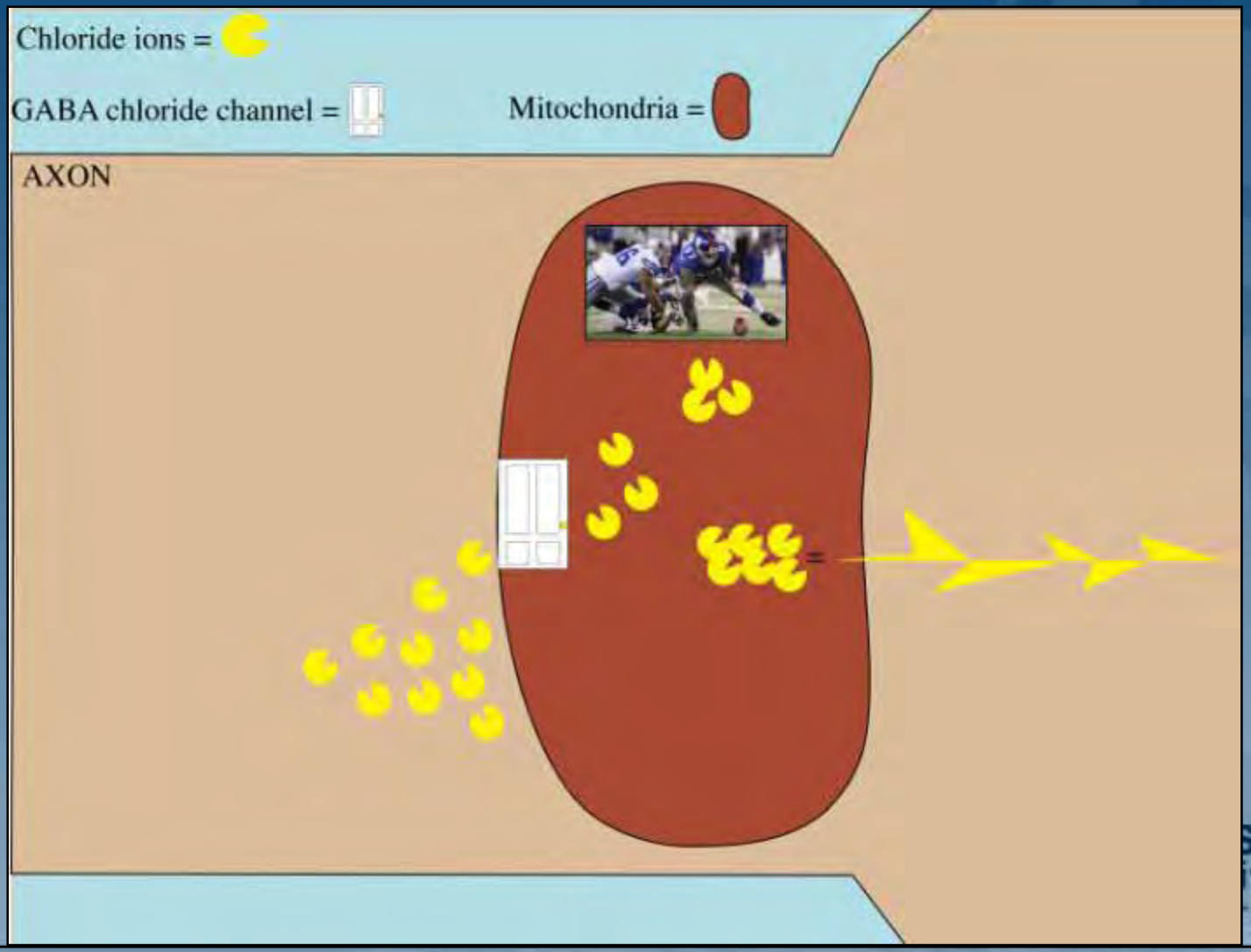

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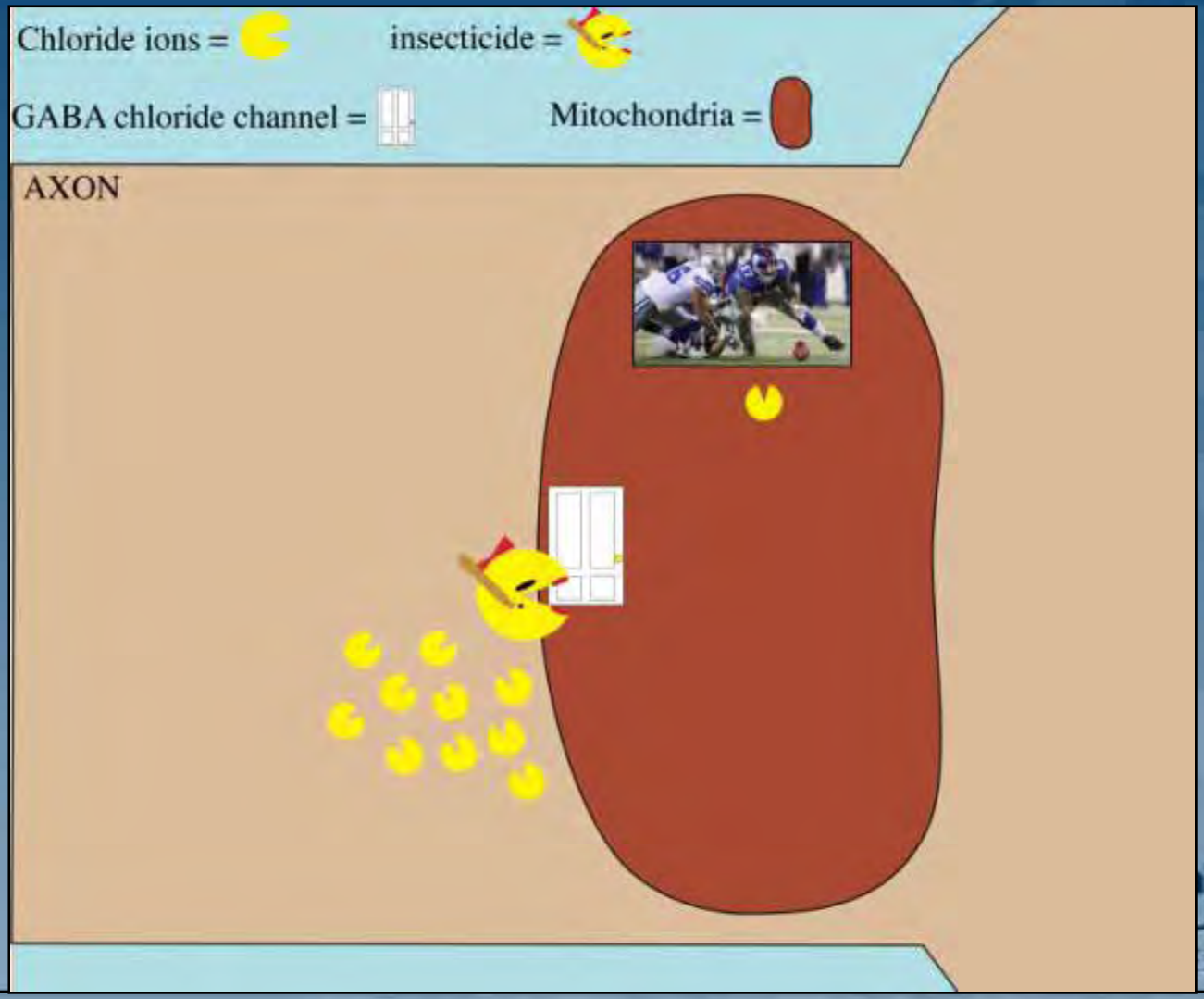

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Side Effects: Hyperactivity, tremors, convulsions, staggering, difficulty breathing, nausea, vomiting, diarrhea, lack of coordination, unconsciousness paralysis, death