How Herbicides Work

Lesson 2

Objectives

By the end of this lesson, you will:

Know the terminology associated with herbicide use, including tolerance, chemistry, efficacy, timing, and placement of applications.

Understand how herbicides are categorized according to their mechanism of action.

Above: Inflorescence of wild oat, a weed that is known to be resistant to several herbicides.

Image number 5404825 at www.invasive.org.

What is a Herbicide?

Herbicide: A chemical used to control or kill plants.

Definitions Related to Herbicides

Active Ingredient (a.i.): The chemical in a commercial product that is primarily responsible for controlling weeds.

- Specifically identified on the product label
- Also known as a herbicide's *common* name

Herbicide Chemistry: A method of classifying herbicide active ingredients into groups.

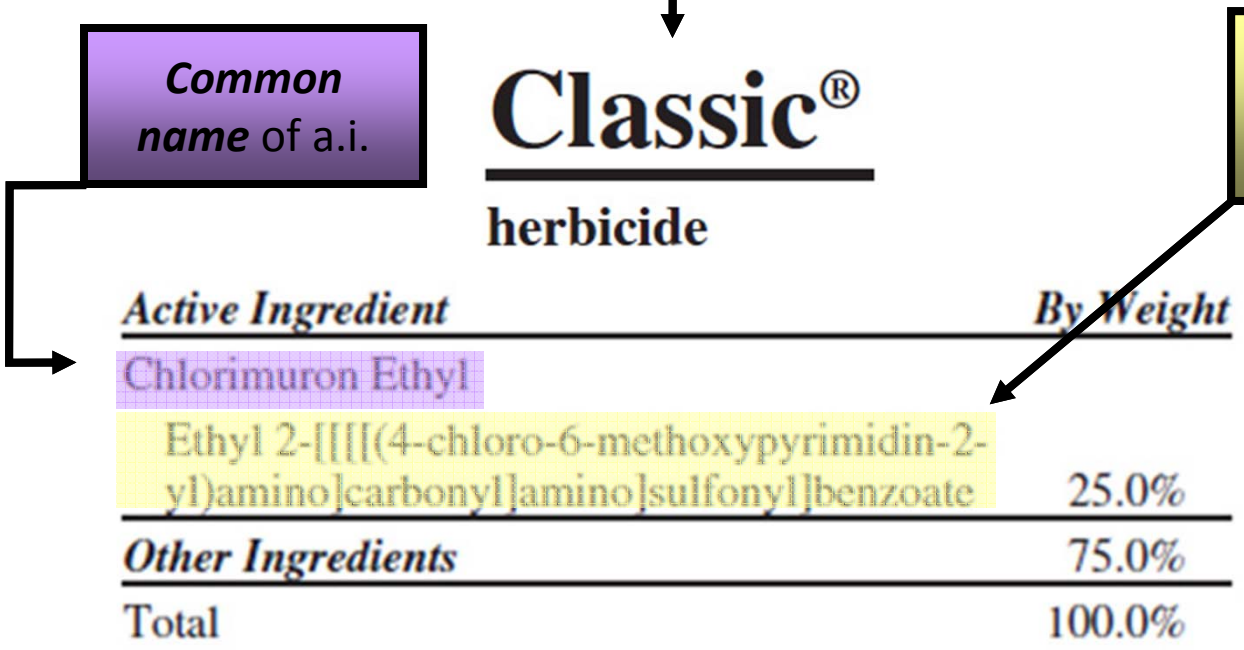
- Herbicide chemical *families* (or *classes)*
- According to their common chemical structure

Herbicide Names on a Label

The ***Trade name*** or ***Product name***, describes the formulated product and may contain more than one a.i.

Common name of a.i.

Chemical name of a.i.



Classic®

herbicide

Active Ingredient	*By Weight*
Chlorimuron Ethyl	
Ethyl 2-[[[[(4-chloro-6-methoxypyrimidin-2-yl)amino]carbonyl]amino]sulfonyl]benzoate	25.0%
Other Ingredients	75.0%
Total	100.0%

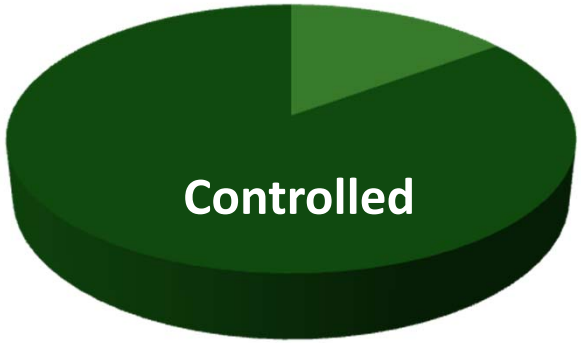
Herbicide Efficacy

Herbicide Efficacy: A measure of herbicide activity.

The ability of a herbicide to produce the desired effect.

Example:

- For many weed species, a herbicide controlling 85% or more of the target weed population has good efficacy.
- The weeds are *susceptible* to the herbicide.



Herbicide Tolerance

Herbicide tolerance is the inherent ability of a
and reproduce after herbicide treatment. This
was no selection or genetic manipulation to m
tolerant; it is naturally tolerant.

Selective herbicides are effective because the crop is tolerant to the herbicide.

Some herbicide
only on some w

Herbicide resistance can be defined as the acquired ability of a weed population to survive a herbicide previously known to be susceptible to that herbicide. Resistance is more fully explained in Lesson 3.

[Click to close.]

Herbicide tolerance is not synonymous with herbicide resistance.

- By definition, if a weed has never been controlled and there has been no change in the weed population's lack of response to a herbicide over time, the population is tolerant.

Herbicide Spectrum of Control

Narrow Spectrum: A herbicide that is more effective in controlling some plant species than others.


No activity

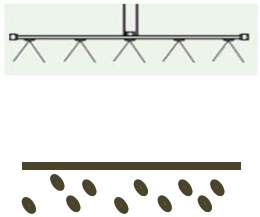

No activity


Activity

Broad Spectrum: A herbicide that controls many plant species.

Timing of Applications

Preplant

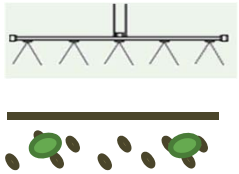


Before the crop is planted

= **Weed Seed**

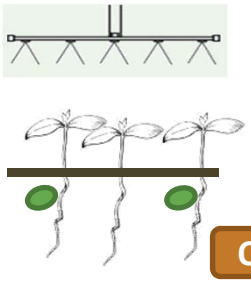
= **Crop Seed**

Preemergence



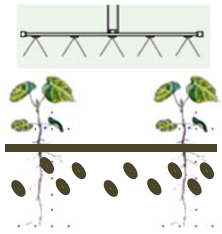
To the crop & weed
After crop is sown but before crop or weeds emerge

OR



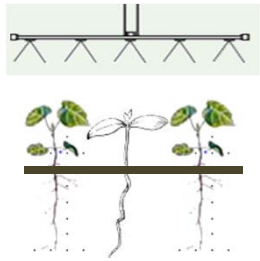
To the crop
To control emerged weeds before crop emerges

OR



To the weed
After crop emerges but before weeds emerge

Postemergence



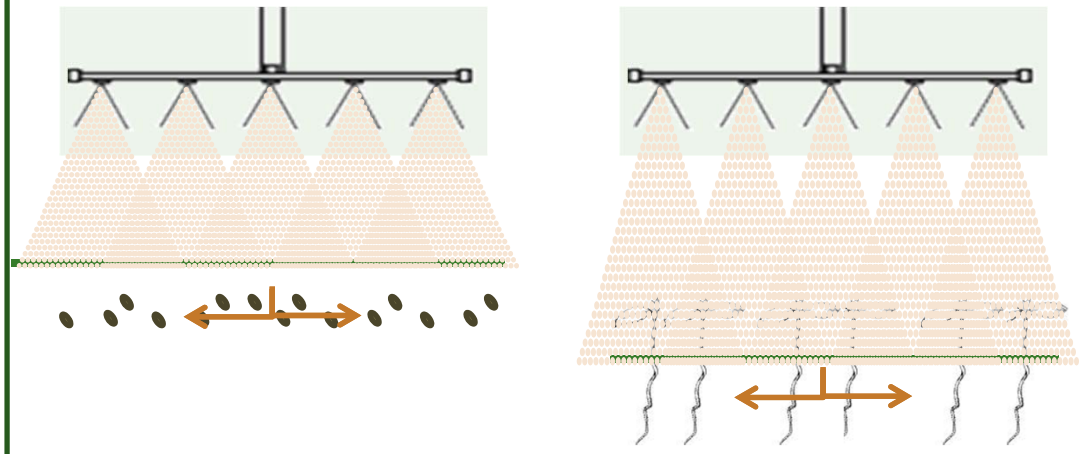
After crop and/or weeds emerge

Two primary placement options for herbicides:

- **Soil Application**
- **Foliar Application**

Placement of Applications: Soil

Soil application



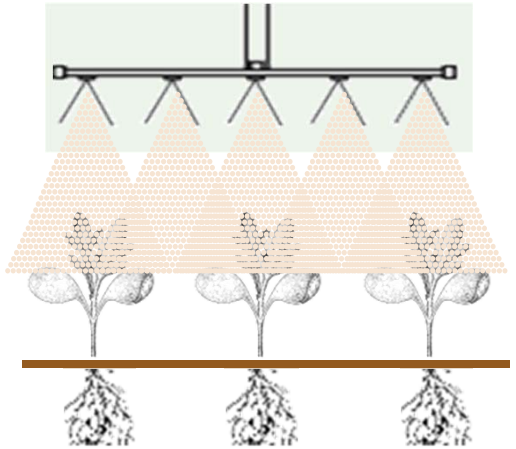
In contact with germinating or emerging weeds

In contact with roots of emerged weeds

Moisture must be present for herbicide movement into the plant.

Placement of Applications: Foliar

Foliar application



Applied directly to the leaves of plants

Herbicide Translocation in Plants

The movement, or lack thereof, of herbicides through plants after application determines how the herbicide is to be applied to obtain acceptable weed control. Herbicide translocation in plants is necessary to move the active ingredient to the location where it can inhibit plant systems. Movement of herbicides in plants can occur via:

- No translocation
- Translocation from root to shoot
- Translocation throughout the plant (systemic)
  - Shown on the right

Mode of Action and Mechanism of Action

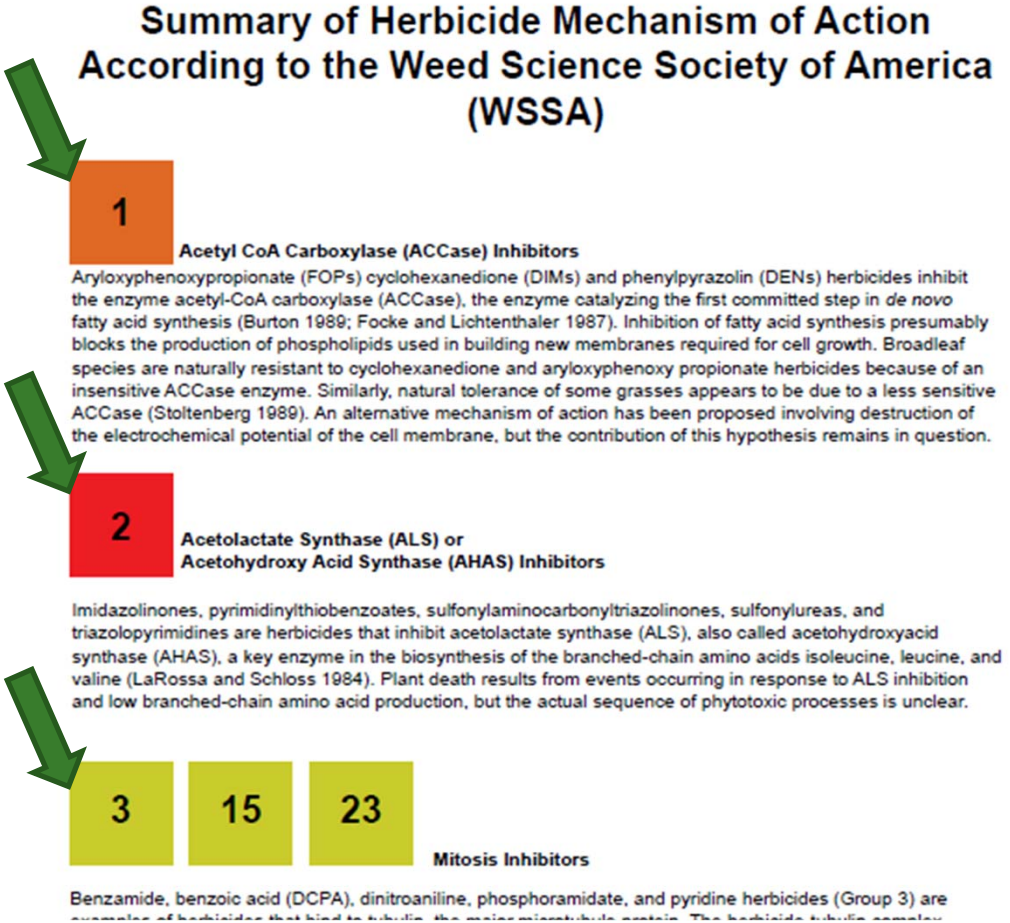
Herbicide Mode of Action: The plant processes affected by the herbicide, or the entire sequence of events that results in death of susceptible plants.

- Includes absorption, translocation, metabolism & interaction at the mechanism of action

Herbicide Mechanism of Action: The biochemical site within a plant with which a herbicide directly interacts. Site of action is sometimes used instead of mechanism of action.

The term mode of action is often incorrectly used to refer to mechanism of action.

Categorization by Mechanism of Action



Summary of Herbicide Mechanism of Action According to the Weed Science Society of America (WSSA)

1 **Acetyl CoA Carboxylase (ACCase) Inhibitors**

Aryloxyphenoxypropionate (FOPs) cyclohexanedione (DIMs) and phenylpyrazolin (DENs) herbicides inhibit the enzyme acetyl-CoA carboxylase (ACCase), the enzyme catalyzing the first committed step in *de novo* fatty acid synthesis (Burton 1989; Focke and Lichtenthaler 1987). Inhibition of fatty acid synthesis presumably blocks the production of phospholipids used in building new membranes required for cell growth. Broadleaf species are naturally resistant to cyclohexanedione and aryloxyphenoxy propionate herbicides because of an insensitive ACCase enzyme. Similarly, natural tolerance of some grasses appears to be due to a less sensitive ACCase (Stoltenberg 1989). An alternative mechanism of action has been proposed involving destruction of the electrochemical potential of the cell membrane, but the contribution of this hypothesis remains in question.

2 **Acetolactate Synthase (ALS) or Acetohydroxy Acid Synthase (AHAS) Inhibitors**

Imidazolinones, pyrimidinylthiobenzoates, sulfonylaminocarbonyltriazolinones, sulfonylureas, and triazolopyrimidines are herbicides that inhibit acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine (LaRossa and Schloss 1984). Plant death results from events occurring in response to ALS inhibition and low branched-chain amino acid production, but the actual sequence of phytotoxic processes is unclear.

3 **15** **23** **Mitosis Inhibitors**

Benzamide, benzoic acid (DCPA), dinitroaniline, phosphoramidate, and pyridine herbicides (Group 3) are

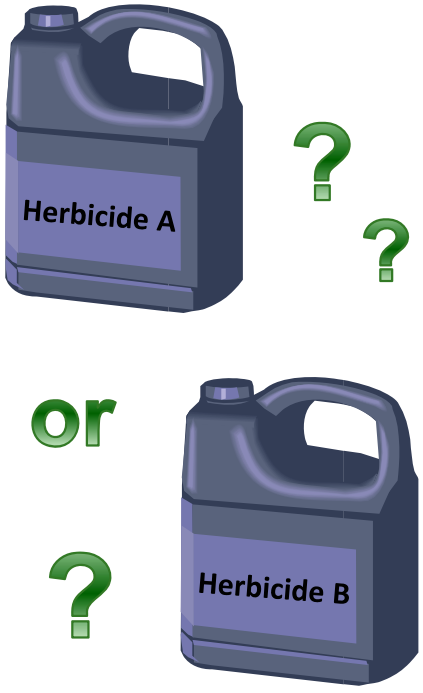
The numbering system assigns each herbicide to a mechanism of action group. Link to herbicide mechanism of action classification

The EPA recommends that labels display the group number that identifies the mechanism of action for the active ingredient(s) in a formulated product.

Goal of the Mechanism of Action Numbering System

The goal of herbicide group number classification system is to provide a tool that aids in herbicide selection.

Herbicide labels also include herbicide resistance management guidelines to direct growers and dealers to local extension experts for assistance with weed management decisions.



Examples of Mechanism of Action on Labels

GROUP	9	HERBICIDE

The product with this symbol on the label contains glyphosate, an active ingredient in Group 9; the mechanism of action is binding to the EPSP synthase enzyme resulting in inhibition of aromatic amino acid formation.

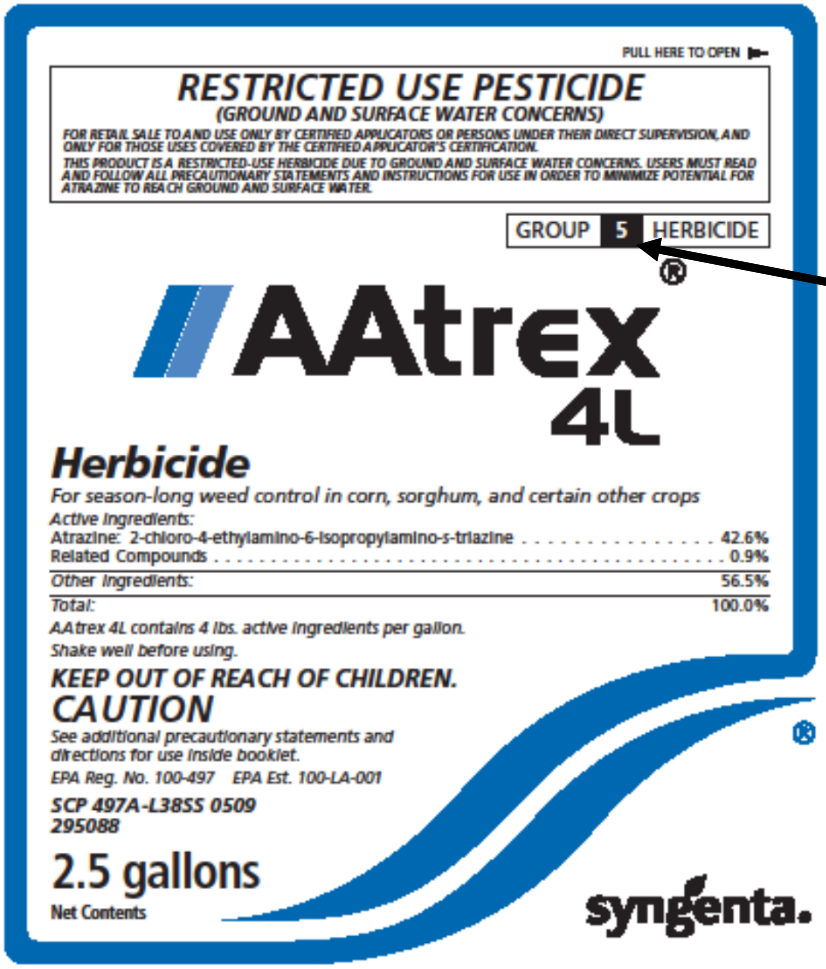
GROUP	5	HERBICIDE

The product with this symbol on the label contains atrazine, an active ingredient in Group 5; the mechanism of action is binding to the Q_8-binding niche on the D1 protein of the photosystem II complex in the chloroplast thylakoid membranes resulting in inhibition of photosynthesis.

GROUP	15 9 27	HERBICIDE

The product with this symbol contains s-metolachlor, glyphosate, and mesotrione, active ingredients with three different mechanisms of action, designated by Group 15 - inhibition of very long chain fatty acids resulting in inhibition of cell division; Group 9 - binding to the EPSP synthase enzyme and Group 27 – inhibition of 4-HPPD resulting in bleaching of the plants, respectively.

Example of a Group Number on a Label



Mechanism of Action Group Number

Conclusions

- Herbicides are important weed management tools that are described by tolerance, chemistry, efficacy, timing, and placement of applications.
- Herbicides are categorized by Mode of Action and Mechanism of Action.
- Categorization according to mechanism of action is important from a herbicide resistance management standpoint.

Credits:

This lesson was developed by a WSSA sub-committee and reviewed by the WSSA Board of Directors and other WSSA members before being released. The sub-committee was composed of the following individuals.

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- Jill Schroeder, PhD (New Mexico State University)
- David Shaw, PhD (Mississippi State University)
- John Soteres, PhD (Monsanto Company) (sub-committee chairman)
- Jeff Stachler, PhD (North Dakota State University and University of Minnesota)
- François Tardif, PhD (University of Guelph)

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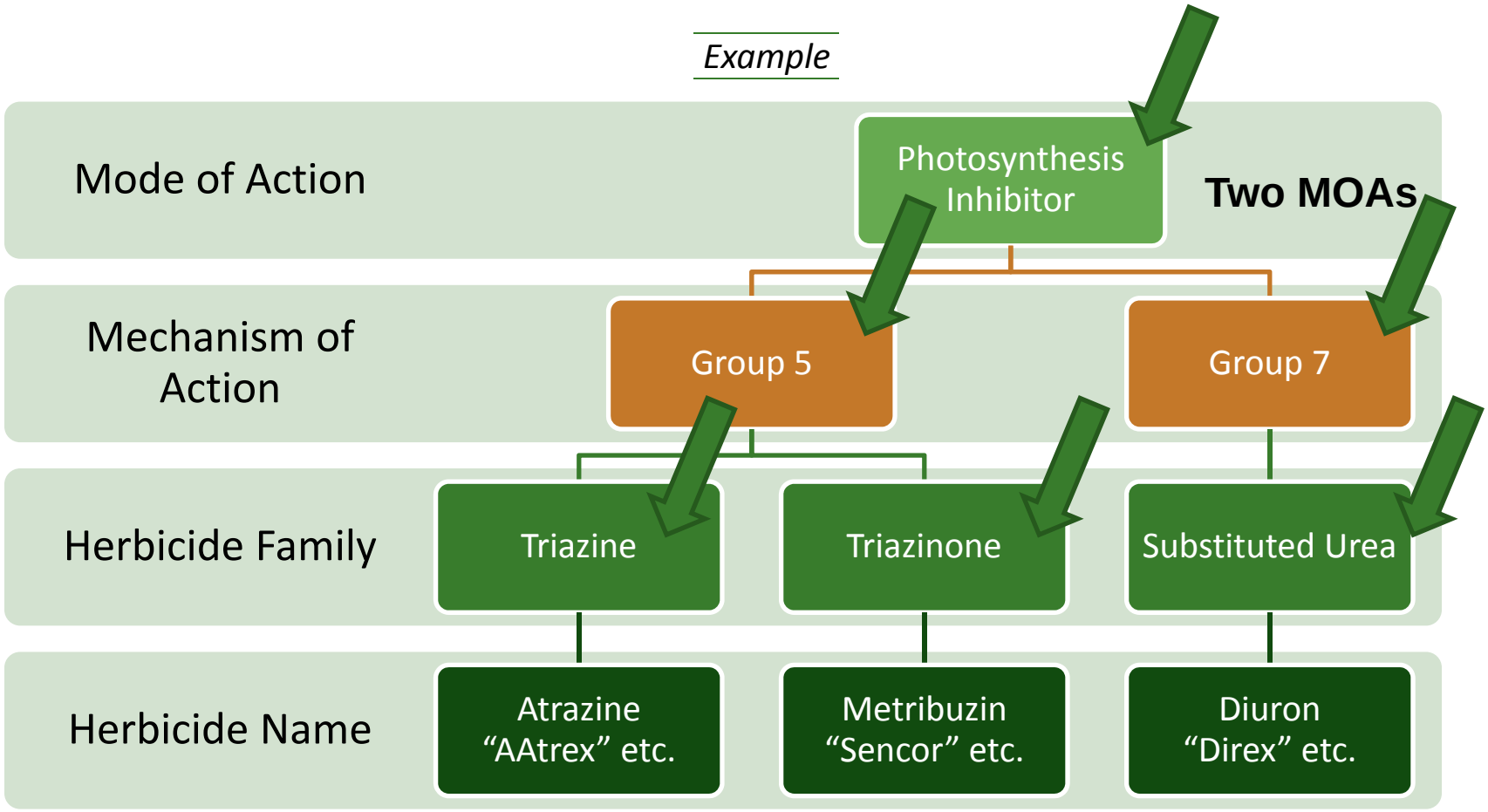
Classification Hierarchy



Classification Hierarchy