

Arthropods

- Bilateral symmetry
- A segmented (jointed) body with many segments grouped into two or more regions
- Paired, segmented appendages such as legs and antennae
- An external skeleton that is made up of chitin and that is shed periodically as the arthropod grows
- Cold blooded animals

Hexapoda (Insecta) - insects

- 3 pairs of legs (one pair of legs on each segment of the thorax)
- 3 body regions (head, thorax, abdomen)
- Most have antennae and wings



Arachnida – spiders, mites, ticks, scorpions

- 4 pairs of legs
- 2 body regions (cephalothorax and abdomen)
- No antennae or wings



Chilopoda – centipedes

- Long, jointed antennae
- Many body segments
- 1 pair of legs per body segment, attached close to the underside of the body
- Front legs connected to a poison gland, can inflict a painful bite
- Predators of insects and other arthropods



Diplopoda – millipedes



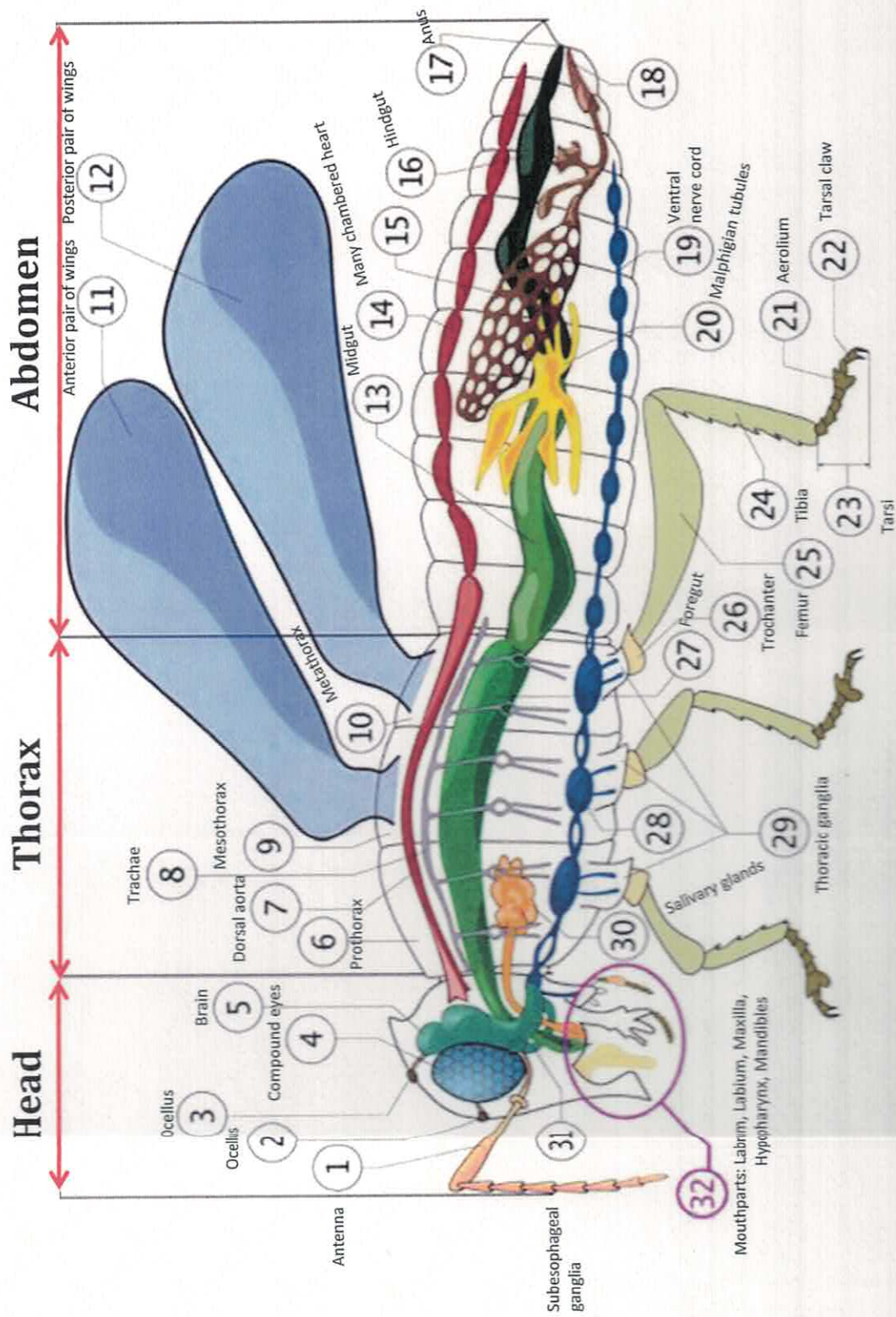
- Short antennae
- Many body segments
- 2 pairs of legs per body segment, attached to the middle of each body segment
- Feed on decaying plants and animals

Crustacea – pillbugs, sowbugs, shrimp, crab, etc.

- At least 5 pairs of legs
- 2 pairs of antennae
- Breathe by means of gills



Insect Systems and Body Parts



Type of Mouthparts

Chewing mouthparts

- Silverfish and bristletails
- Springtails
- Dragonflies, damselflies, mayflies
- Cockroaches
- Grasshoppers, crickets, katydids
- Praying mantis, walking sticks
- Termites
- Earwigs
- Psocids (booklice and barklice)
- Chewing lice
- Beetles
- Ants, some bees and wasps

Chewing-lapping mouthparts

- Some bees and wasps

Rasping mouthparts

- Thrips

Piercing-Sucking mouthparts

- Sucking lice (head & body lice, pubic lice)
- True bugs (bedbugs, boxelder bugs, stink bugs, assassin bugs, seed bugs, etc.)
- Cicadas, aphids, scale insects, leafhoppers, treehoppers, spittlebugs, etc.
- Biting flies (black fly, stable fly, horse fly, deer fly) and mosquitoes
- Fleas

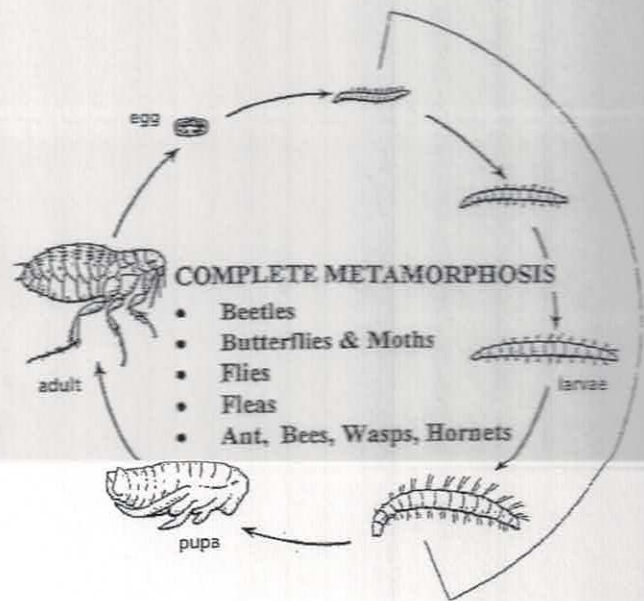
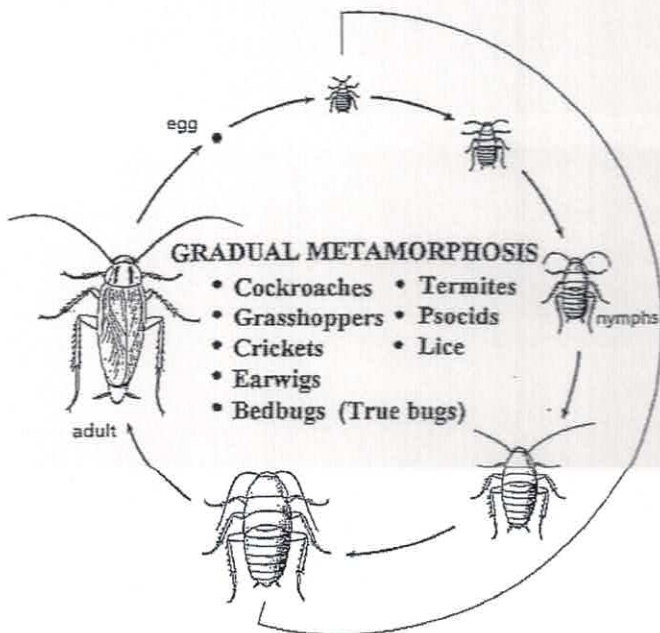
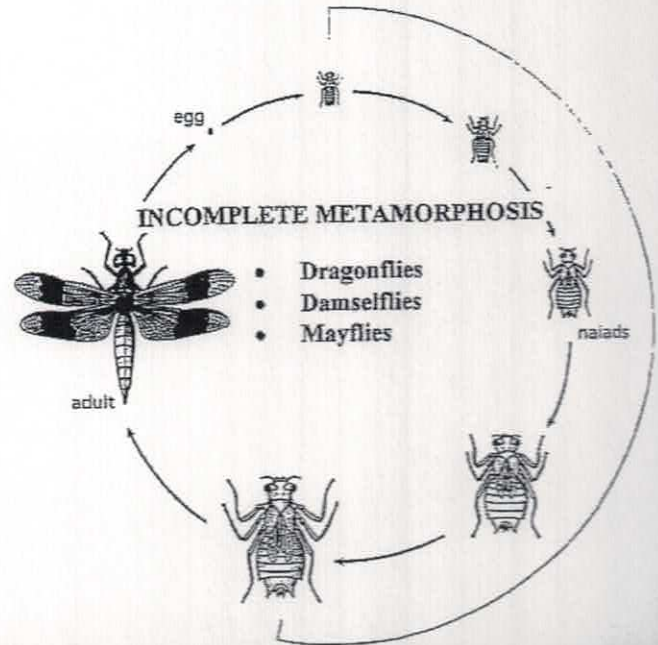
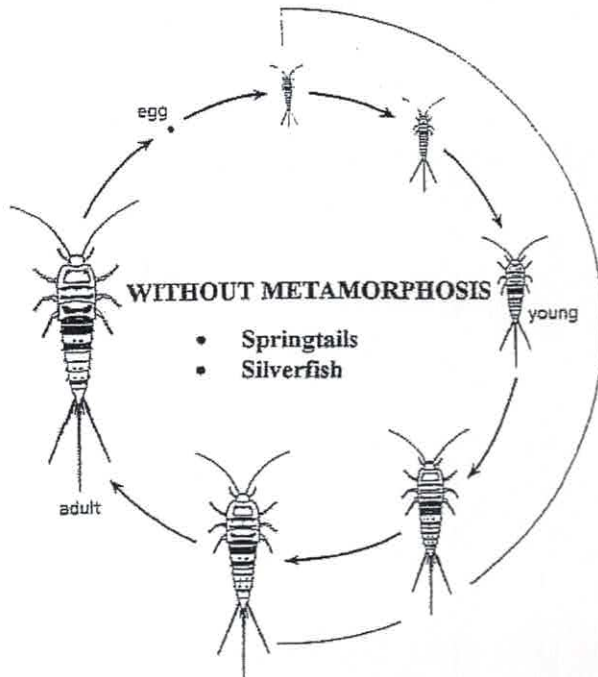
Siphoning mouthparts

- Moths, skippers & butterflies

Sponging mouthparts

- Certain flies (blow flies, fruit flies, house flies)

Types of Metamorphosis



Class Hexapoda (Insects)

All insects have the following characteristics:

- **3 body regions (head, thorax, abdomen)**
- **3 pairs of legs**

- **Order Thysanura – Silverfish, Firebrats, Bristletails**
- **Order Colembola – Springtails**
- **Order Blattodea – Cockroaches, Praying Mantis, Walking Sticks & now Termites**
- **Order Orthoptera – Grasshoppers & Crickets**
- **Order Isoptera (the old Order) - Termites now belong to Order Blattodea)**
- **Order Dermaptera – Earwigs**
- **Order Hemiptera – True Bugs, Bed bugs**
- **Order Psocoptera – Psocids (Booklice)**
- **Order Diptera – Flies & Mosquitoes**
- **Order Siphonaptera – Fleas**
- **Order Hymenoptera – Ants, Bees, Wasps, Hornets, Yellow Jackets, Horntails (Wood Wasps)**
- **Order Coleoptera – Beetles**
- **Order Lepidoptera – Moths & Butterflies**

Some Important Orders of Class Insecta (Hexapoda)

All insects have the following characteristics:

- 3 distinct body regions (head, thorax, and abdomen)
- 3 pairs of legs (one pair on each thoracic segment)
- Order Thysanura – Silverfish, Firebrats, Bristletails
(Greek word “thysanos” for fringe, tassel, or tag and “ura” for tail referring to appendages at end of abdomen)
- Order Collembola – Springtails (not considered insects by some entomologists)
(Greek word “colle” for glue and “embolon” for wedge referring to the collophore on the underside of the first abdominal segment)
- Order Blattodea (Cockroaches, Praying Mantis, Walking Sticks & now Termites)
(Latinized Greek word “blatta” for cockroach)
- Order Orthoptera – Grasshoppers & Crickets
(Greek word “ortho” for straight and “ptera” for wings referring to its parallel-sided structure of its front wings “tegmina”)
- Order Isoptera (now belong to Order Blattodea)– Termites
(Greek word “iso” for equal and “ptera” for wings referring to its two pairs of wings with similar size, shape and venation)
- Order Dermaptera – Earwigs
(Greek word “derma” for skin and “ptera” for wings referring to its thickened front wings which cover its folded membranous rear wings)
- Order Hemiptera – True Bugs, Bed bugs
(Greek word “hemi” for half and “ptera” for wings referring to its front wings which are hardened near their base and membranous at their ends)
- Order Pscocoptera – Psocids (Booklice)
(Greek word “psokos” for rubbed or gnawed and “ptera” for wings referring to winged insects that gnaw or rub as they eat)
- Order Diptera – Flies & Mosquitoes
(Greek word “di” for two and “ptera” for wings referring to the one pair of wings that all members of this order have)
- Order Siphonaptera – Fleas
(Greek word “siphon” for tube or pipe and “aptera” for wingless referring to piercing sucking mouthparts and being a wingless insect)
- Order Hymenoptera – Ants, Bees, Wasps, Hornets, Yellow Jackets, Horntails
(Greek word “hymen” for membrane and “ptera” for wings)
- Order Coleoptera – Beetles
(Greek word “koleos” for sheath and “ptera” for wings referring to its hardened, sheath-like front wings which cover the abdomen and meet down the middle of its back in a straight line)
- Order Lepidoptera – Moths & Butterflies
(Greek word “lepidos” for scale and “ptera” for wings)

Class Hexapoda (Insects)

All insects have the following characteristics:

- 3 body regions (head, thorax, abdomen)
- 3 pairs of legs

Order Thysanura - Silverfish, Firebrats, Bristletails



Order Colembola - Springtails



Order Blattodea - Cockroaches, Praying Mantis, Walking sticks and now including Termites



Order Orthoptera - Grasshoppers and Crickets



Order Isoptera (the old Order of Termites) - the new Order of Termites is Order Blattodea



Order Dermaptera - Earwigs



Class Hexapoda (Insecta) - Insects

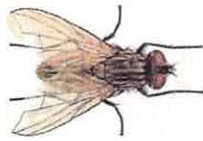
Order Hemiptera - True Bugs, Bed Bugs



Order Psocoptera - Psocids (Booklice and Barklice)



Order Diptera - Flies and Mosquitoes



Order Siphonaptera - Fleas



Order Hymenoptera - Ants, Bees, Wasps, Hornets, Yellow Jackets, Horntails (Wood Wasps)



Order Coleoptera - Beetles



Order Lepidoptera - Moths and Butterflies



PESTICIDES

Naturally Occurring Pesticides

Botanicals – made from plant parts

- Pyrethrum (PT565 Plus XLO)
- Peppermint oil
- Clove oil
- Citrus oils
- Lavender oil
- Thyme oil
- Rosemary oil

Inorganic (Minerals) – made from earth

- Silica aerogel (Drione, TriDie)
- Diatomaceous earth
- Limestone
- Boric acid (Terro, Intice)
- Borates (BoraCare, Timbor)

Glycoside Insecticide

- Abamectin (Avert)

Man-Made Pesticides

Chlorinated Hydrocarbons

- Chlordane
- Heptachlor
- Aldrin
- Lindane
- DDT

Organophosphates (OPS)

- Dursban
- Diazinon
- DDVP (Vapona)
- Orthene
- Malathion
- Propetamphos
- Pryfon

Carbamates

- Ficam
- Sevin
- Baygon

Synthetic Pyrethroids (Pyrethroids)

- Allethrin
- Phenothrin
- Resmethrin
- Permethrin
- Cypermethrin
- Cyfluthrin
- Lambda cyhalothrin
- Bifenthrin
- Prallethrin
- Tetramethrin
- Tralomethrin
- Esfenvalerate

IGRs

- Hydroprene (Gentrol)
- Methoprene (Precor)
- Pyriproxyfen (Nylar)
- Hexaflumuron (Recruit I)
- Noviflumuron (Recruit III or HD)
- Diflubenzuron (Advance)
- Novaluron (Trelona)

Amidinohydrazones

- Hydramethylon (MaxForce, Siege)

Fluoroaliphatic sulfonamides

- Sulfuramid (Dual Choice PC)

Phenyl pyrazoles

- Fipronil (Termidor)

Neonicotinoids

- Imidachloprid (Premise)
- Dinotefuran (Alpine)

Pyrrol or pyrazole analog

- Chlorfenapur (Phantom)

Oxadiazine

- Indoxacarb (Advion, Arilon)

Fumigants (gasses or vapors)

- Sulfuryl fluoride (Vikane, Pro Fume)
- Methyl bromide (Meth-O-Gas)
- Hydrogen phosphide (Phostoxin)
- Chloropicrin (Tear gas)

Acute Rodenticides (Non-anticoagulant)

- Zinc Phosphide
- Bromethalin (Vengeance)
- Cholecalciferol (Quintox)

Multiple dose (1st Gen.) Anticoagulants

- Warfarin
- Diphacinone (Liquatox, Ramik)
- Pival/Pivalyn
- Chlorophacinone (Eatin's AC Formula 50)

Single dose (2nd Gen.) Anticoagulants

- Bromadiolone (Maki)
- Brodifacoum (Talon)
- Difethiolone (Generation, First Strike)
- Difenacoum (Di-Kill, Multi-Kill)

FORMULATIONS

Emulsifiable Concentrates (E or EC)

A.I. (active ingredient) + Oil (petroleum-based solvent) + Emulsifier (soap) = Emulsifiable Concentrate (EC)
EC + Water (shake lightly) = Emulsion (milky in appearance)

Advantages:

- Relatively easy to handle, transport, and store
- Little agitation needed – will not settle out or separate when equipment is running
- Not abrasive
- Will not plug screens or nozzles
- Works well on stainless steel surfaces

Disadvantages:

- High A.I. concentration makes it easy to overdose or underdose through mixing or calibration errors
- Easily absorbed through skin of humans and animals
- Solvents may cause rubber or plastic hoses, gaskets and pump parts and surfaces to deteriorate
- May cause damage to desirable plants (phytotoxicity)
- May cause pitting or discoloration of painted finishes
- Flammable – should be used and stored away from heat or open flame
- May be corrosive

Wettable Powder (W or WP)

A.I. + Inert Ingredient (talc or clay) + Wetting Agent = Wettable Powder (WP)
WP + Water (shake vigorously) = Suspension

Advantages:

- Easy to store, transport and handle
- Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals and surfaces
- Easily measured and mixed
- Less skin and eye absorption than ECs and other liquid formulations
- Good to use outside/sits on top of porous surfaces where it can easily be picked up by pests

Disadvantages:

- Inhalation hazard to applicator while measuring and mixing the concentrated powder
- Requires good and constant agitation in the spray tank and quickly settles out if the agitator is off
- Abrasive to many types of pumps and nozzles, causing them to wear out quickly
- Difficult to mix in very hard, alkaline water
- Often clogs nozzles and screens
- Residues may be visible on some treated surfaces

Soluble Powders (SP) or Water Soluble Powders (WSP)

Soluble powders look like wettable powders, but when mixed with water, soluble powders dissolve readily and form a true solution. After they are mixed thoroughly, no additional agitation is necessary.

Advantages:

- Easy to store, transport and handle
- Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals and surfaces
- Easily measured and mixed
- Less skin and eye absorption than ECs and other liquid formulations

Disadvantages:

- Inhalation hazard to applicator while measuring and mixing the concentrated powder

Flowable Microencapsulations (ME, FM, CS)

A.I. inside polyvinyl plastic balls (6 to 30 microns in diameter) + Wetting Agent = Microencapsulated Conc.
ME, FM or CS Conc. + Water (shake vigorously) = Microencapsulated suspension

*Low toxicity to people/pets & good to use outside/Sits on top of porous surfaces where it can easily be picked up by pests

Advantages:

- Highly toxic concentrates are safer for applicators to mix and apply
- Delayed slow release of the A.I. prolongs its effectiveness (excellent residual activity), allowing for fewer and less precisely timed applications
- Does not break down readily in water
- The pesticide volatilizes slowly; less is lost from the application site, allowing for greater effectiveness
- These formulations often reduce injury to plants
- Sits on top of porous surfaces where it can easily be picked up by pests
- Low toxicity to people and pets

Disadvantages:

- Constant or frequent agitation may be required (see label directions)
- Residues may be visible on some treated surfaces

Suspension Concentrates (SC)

Fine particles of A.I. suspended in other formula ingredients usually mixed with water to form a suspension

Advantages:

- Good residual activity
- Little or no residue left on treated surfaces

Disadvantages:

- Agitation of the spray mixture may be required (see label directions)

Ready-To-Use (RTU) Sprays

A.I. is diluted to a finished spray concentration and packaged as a pressurized aerosol or in a trigger sprayer

Advantages:

- No dilution or other preparation are required for use in field
- Diluted forms are generally less toxic than concentrates (in case of spill or accident)
- Specialized applications like crack and crevice and total release are available

Disadvantages:

- May be more expensive to purchase than concentrates
- Bulky to transport

Dusts (D or Dust)

A.I. + Inert ingredient (sine particles of talc, chalk, nut hulls, volcanic ash or clay) = Dust

Advantages:

- Most are ready to use, with no mixing
- Requires simple, inexpensive equipment
- Effective in dry, cracks & crevices and voids
- Exceptional residual when kept dry

Disadvantages:

- Takes experience to apply correctly
- Residues may be visible on some treated surfaces
- Difficult to control dispersal of dust particles to non-target areas (drift)
- Dust residue is easily moved off-target by air movement or water
- Dampness can cause clogging of equipment and lumping
- May cause irritation of eyes, nose, throat and skin
- Will not stick to surfaces as well as liquids
- Difficult to get even distribution of particles

Granules (G or Granule)

A.I. + Inert ingredient (larger particle of corn cob, vermiculite, walnut shells, clay) = Granule

A.I. either coats the outside of the particles or is absorbed into them

Advantages:

- Ready to use, no mixing required
- Longer residual activity than WPs and ECs
- Drift hazard is low and particles settle quickly
- Little hazard to the applicator, no spray and little dust
- Its weight carries the formulation through foliage to soil or wet target area
- Simple application equipment is needed, such as spreaders
- It may break down more slowly than WPs or ECs because of a slow-release coating

Disadvantages:

- Often difficult to calibrate equipment and apply uniformly
- Will not stick to foliage or other uneven surfaces
- May need to be incorporated into soil or planting medium
- May need moisture to activate pesticide
- May be hazardous to non-target species, especially waterfowl and other birds that mistakenly feed on the seed-like granules
- May not be effective under drought conditions; the A.I. isn't released in sufficient quantity to control the pest
- More costly than WPs or ECs
- Can't apply to wood or concrete surfaces, can't apply during rain

Water-dispersible Granules (WDG or Dry Flowables (DF)

They are like wettable powders, except instead of being dust-like, they are formulated as small, easily measured granules. They must be mixed with water to be applied. Once in water, the granules break apart into fine particles similar to wettable powders.

Advantages:

- Easy to store, transport and handle
- Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals and surfaces
- Easily measured and mixed
- Less skin and eye absorption than ECs and other liquid formulations
- Good to use outside/sits on top of porous surfaces where it can easily be picked up by pests
- Less inhalation hazard to applicator when handling (measuring & mixing) than wettable powders

Disadvantages:

- Requires good and constant agitation in the spray tank and quickly settles out if the agitator is off
- Abrasive to many types of pumps and nozzles, causing them to wear out quickly
- Often clogs nozzles and screens
- Residues may be visible on some treated surfaces

Baits (B)

A.I. + attractive food substance = Bait

Advantages:

- Ready to use
- Long residual activity and only a small amount of bait may control the pest
- Entire area need not be covered, because the pest goes to the bait
- Controls pests that move in and out of an area

Disadvantages:

- Can be attractive to children and pets
- May kill domestic animals and non-target wildlife outdoors
- Pest may prefer other food to the bait
- Dead vertebrate pests may cause an odor problem
- Other animals may be poisoned as a result of feeding on the poisoned pests
- If baits are not removed when the pesticide becomes effective, they may serve as a food supply for the target pest or other pests
- Slow control
- Pests must find the bait and eat it to be effective

Solutions (S)

A.I. + petroleum solvent = Oil-based solution*

A.I. & water = Water-based solution

Advantages:

- Relatively easy to handle, transport and store
- They remain in solution and little agitation is required
- They are not abrasive to equipment
- They will not plug screens and nozzles of equipment
- They leave little visible residue on treated surfaces

Disadvantages*:

- They are difficult to keep the pesticide on target and have a high drift hazard
- Specialized equipment is required
- Easily absorbed through the skin of humans and animals

- Solvents may cause rubber or plastic hoses, gaskets and pump parts and surfaces to deteriorate
- Calibration and application must be done very carefully because of the high concentration of the A.I.
- Used for space treatment/fogging (ULV or ULD products), 1 to 30 micron diameter droplets of product dispersed into the air

Fumigants

Liquid A.I. under pressure. When released, forms a gas at certain temperatures

Advantages:

- Toxic to a wide range of pests
- Penetrates structures, soils, grains, stored food ingredients, etc. to kill pests within
- Single treatment will usually kill most of the pests in the area being fumigated

Disadvantages:

- Target site must be enclosed or sealed to prevent the fumigant gas from escaping
- It is non-specific and highly toxic to humans and all other organisms
- It requires the use of specialized protective equipment (SCBAs) that is specifically approved for use with fumigants
- It requires the use of expensive monitoring and clearing devices to monitor the concentration of fumigant being confined and to declare the structure safe for re-entry
- Special training is required of fumigators
- Site preparation and clearing procedures must be followed precisely

Liquid Rodenticide Baits

Advantages:

- Can sometimes control rodents that are not feeding on dry baits because of food competition, but do not have easy access to water

Disadvantages:

- Spillage hazard if any contact with liquid bait stations
- Liquid baits are subject to fast deterioration
- Baits must be re-freshened every few days to be attractive to rodents