PESTICIDE CHEMISTRY

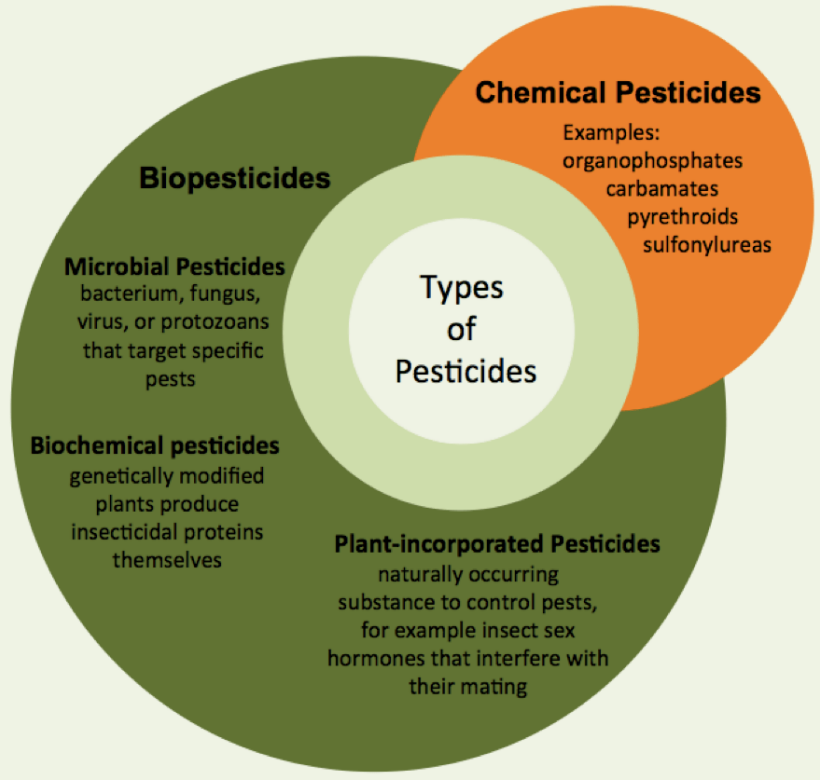


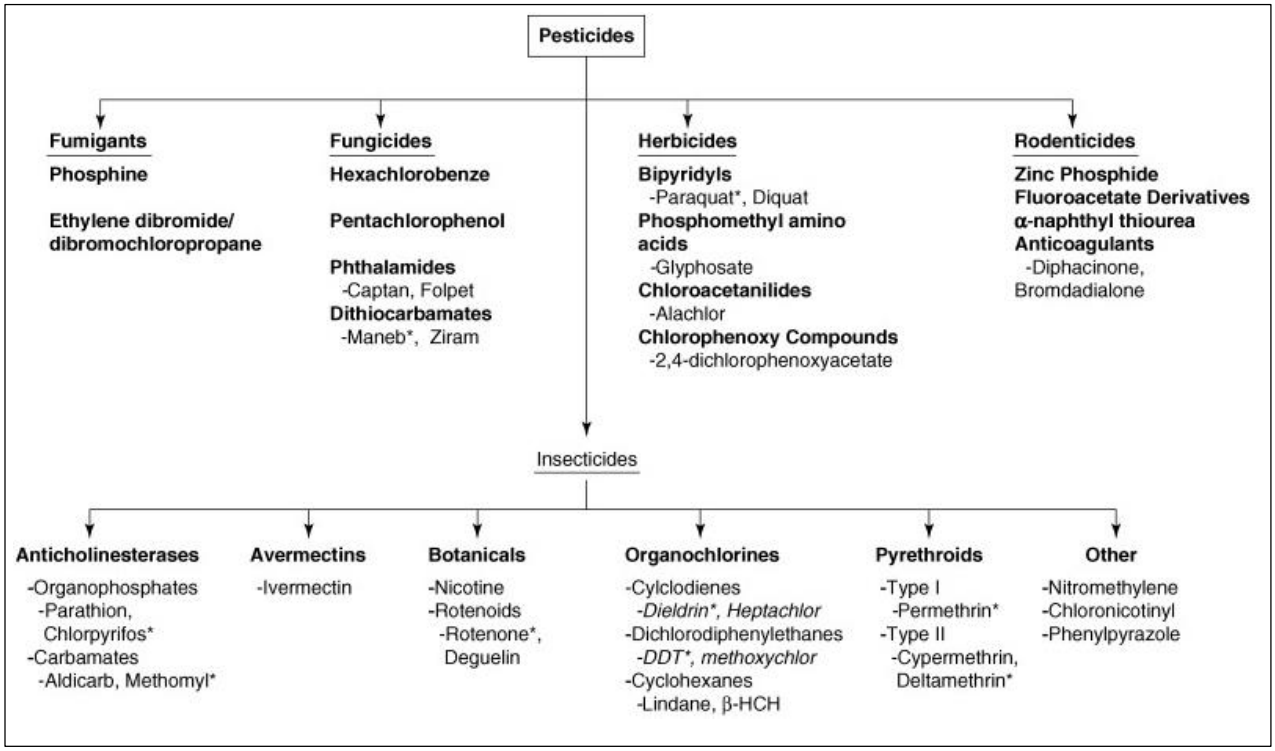
What is Pesticide?

- Pesticide is a substance which kills a pest.
- Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest such as insect, rodent, nematode, fungus, weed, other forms of terrestrial or aquatic plant or animal life or viruses, bacteria, or other microorganisms or in living man or other animals, which the administrator declares to be pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.
- A pesticide can be a chemical, biological agent, antimicrobial, disinfectant etc.
- Pesticides produce their effect by inhibiting or destroying the metabolic processes of animals.
- Many chemical pesticides are poisonous to human and animals.
- All pesticides have their own
    - Mechanism of action
    - Potency
    - Speed of effect
    - Dose required to produce effect

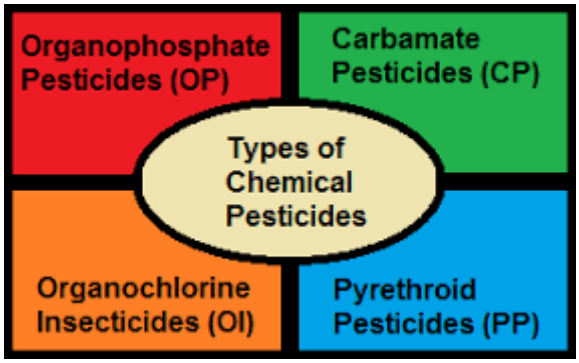
Classification:

The Pesticides can be classified in many ways on the basis of use, toxicity, mode of entry, mode of action, chemistry and formulations.

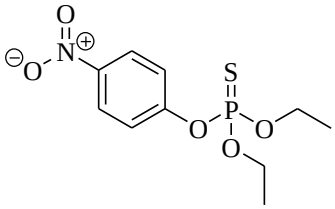




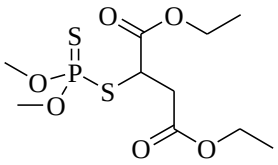
- **Chemical OR Synthetic Pesticides AND Herbicides:**



- **Organophosphate Pesticides:** These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. However, they usually are not persistent in the environment. E.g. parathion and malathion.

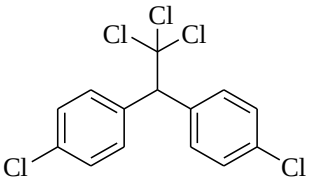


Parathion

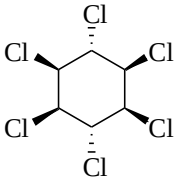


Malathion

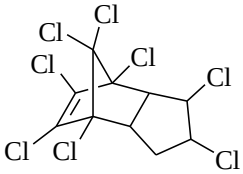
- **Organochlorine Insecticides:** These pesticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence. E.g. DDT (dichloro diphenyl trichloroethane), gammaxene (lindane) or benzene hexachloride (BHC), chlordane.



DDT

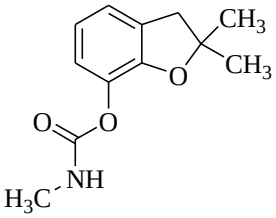


Gammaxene

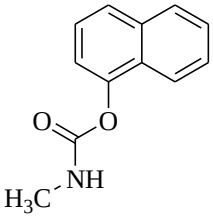


Chlordane

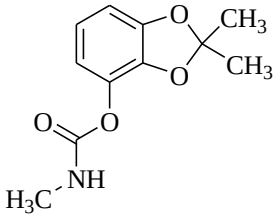
- **Carbamate Pesticides:** These pesticides also affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates. E.g. carbofuran, carbaryl, bendiocarb, methomyl and propoxur.



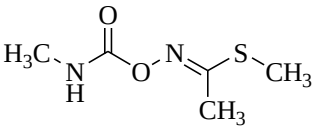
Carbofuran



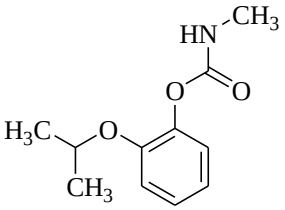
Carbaryl



Bendiocarb

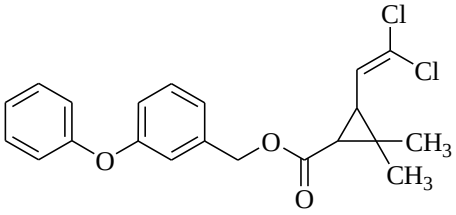


Methomyl

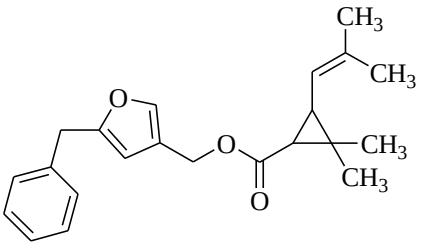


Propoxur

- **Pyrethroid Pesticides:** These pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system. E.g. permethrin, resmethrin.

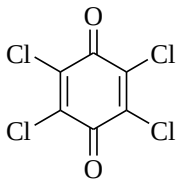


Permethrin



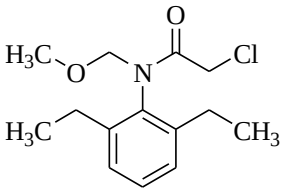
Resmethrin

- **Quinone Pesticides:** E.g. Chloranil. Chloranil is a yellow solid, used as a fungicide. It is used as an oxidizing agent in the organic synthesis especially for dye intermediates and vulcanization agent.

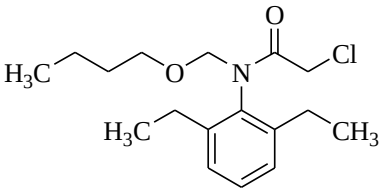


Chloranil

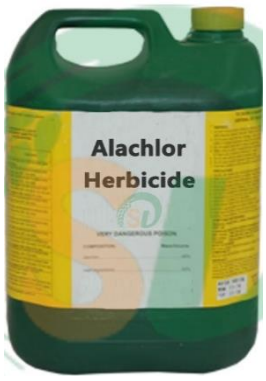
- **Anilide Herbicides:** Herbicides are a broad class of pesticides that are used to remove nuisance plants such as grasses and weeds, that may compromise the growth and yield of desired crops that are in close proximity. E.g. alachlor and butachlor. Alachlor is an herbicide from the chloroacetanilide family. It is an odourless white solid. The greatest use of alachlor is for control of annual grasses and broadleaf weeds in crops. Use of alachlor is illegal in the European Union and no products containing alachlor are currently registered in the United States. Butachlor is a herbicide of the acetanilide class. It is used as a selective pre-emergent herbicide. It is extensively used in India in the form of granules in rice as post emergence herbicide.



Alachlor

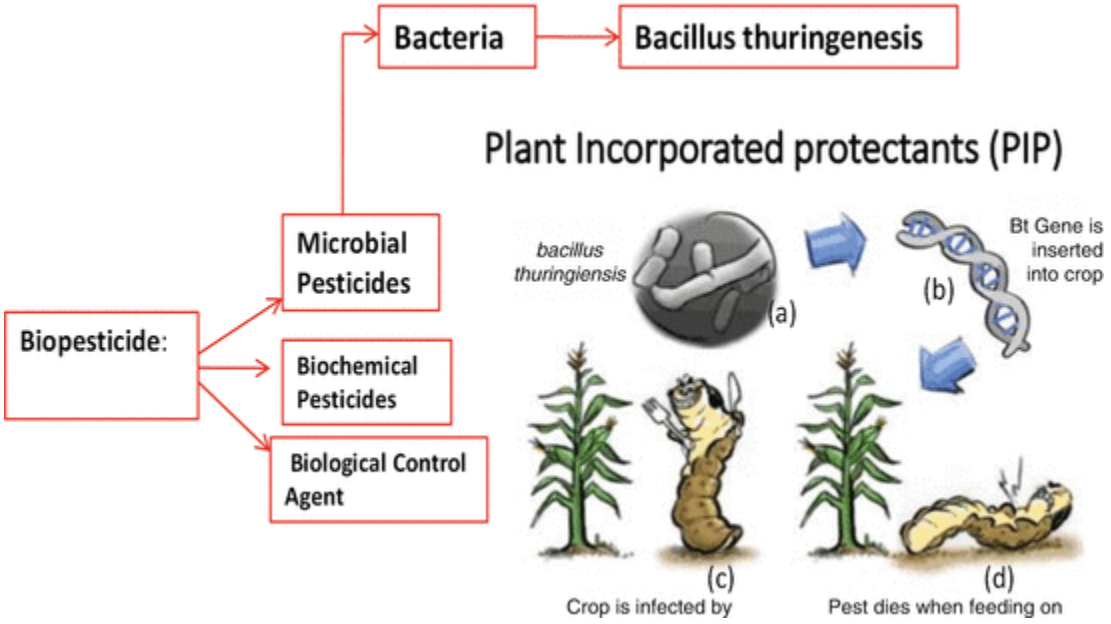


Butachlor

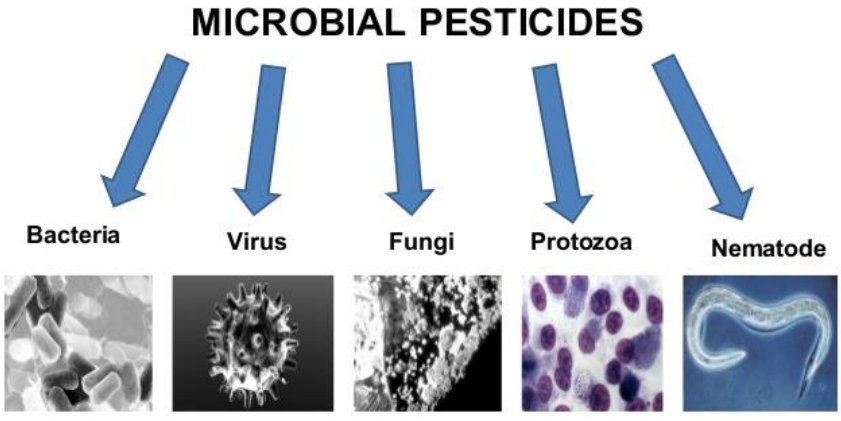


- **Biopesticides:**

All the living organisms, which are cultivated in the laboratory on large scale and are used and exploited experimentally for the control of harmful organisms are called **biopesticides**. Pesticides derived from such natural materials as animals, plants, bacteria and certain minerals are called **biopesticides**. For example, canola oil and baking soda have pesticidal applications and are considered **biopesticides**.



1. **Microbial pesticides:** These type of pesticides consist of a microorganism (e.g. a bacterium, fungus, virus or protozoan) as the active ingredient. For example, there are fungi that control certain weeds and kill specific insects.



Advantages of microbial pesticides:

- Difficult for insects to develop resistance
- Safe to natural enemies and higher organisms
- Biodegradable
- Cheaper, renewable and can be handled safely
- Most are compatible with insecticides and other agents
- Residue free

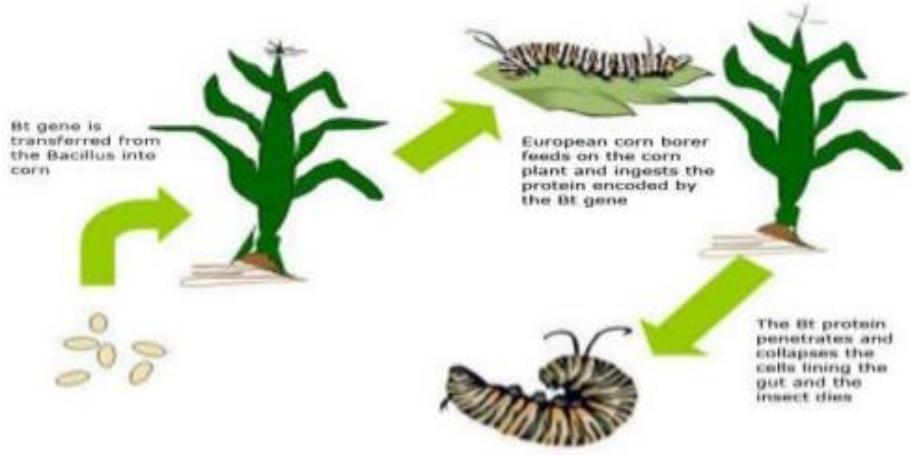
2. **Biochemical pesticides:** These are naturally occurring substances that control pests by non-toxic mechanisms. E.g. insect sex pheromones that interfere with mating and various scented plant extracts that attract insect pests to trap.

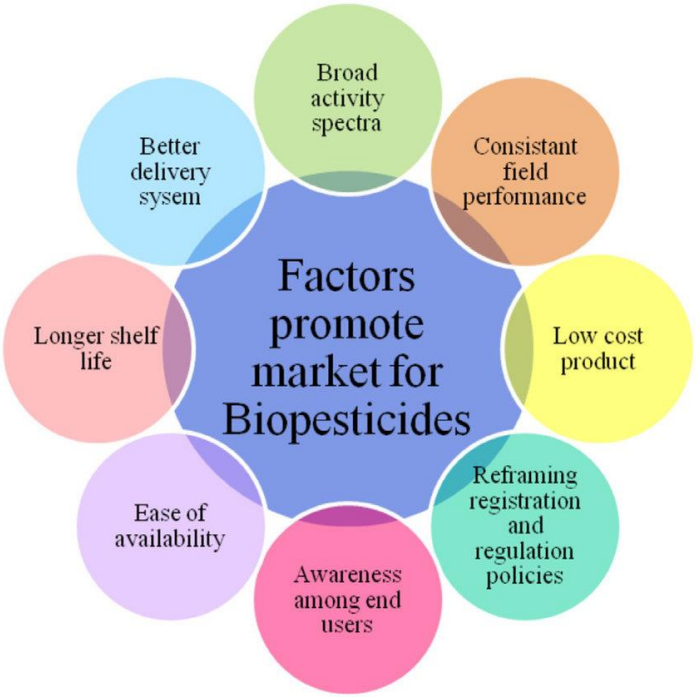
The synthetic attractants are used in one of four ways:

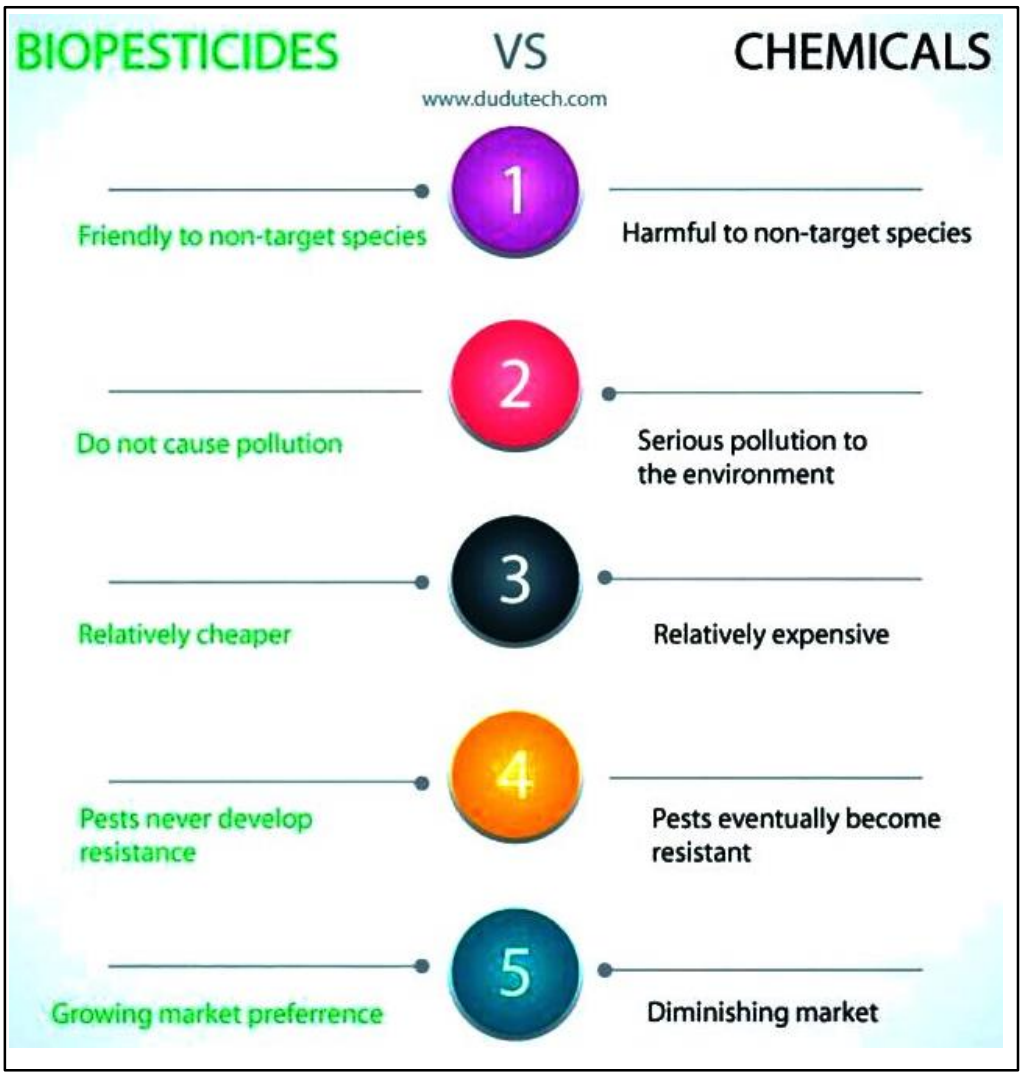
- As a tempt in traps used to monitor pest populations.
- As a tempt in traps designed to 'trap out' pest populations.
- As a broadcast signal intended to disrupt insect mating.
- As an attractant in a bait containing an insecticide.

pheromone trap

3. **Plant-incorporated protectants (PIPs):** These are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for a specific Bt (Bacillus thuringiensis, an insecticide spray used in organic farming) pesticidal protein and introduce the gene into the plant's genetic material.




Factors promote market for Biopesticides
Broad activity spectra
Consistant field performance
Low cost product
Reframing registration and regulation policies
Awareness among end users
Ease of availability
Longer shelf life
Better delivery sysem


BIOPESTICIDES
VS
CHEMICALS
www.dudutech.com
1
Friendly to non-target species
Harmful to non-target species
2
Do not cause pollution
Serious pollution to the environment
3
Relatively cheaper
Relatively expensive
4
Pests never develop resistance
Pests eventually become resistant
5
Growing market preferrence
Diminishing market

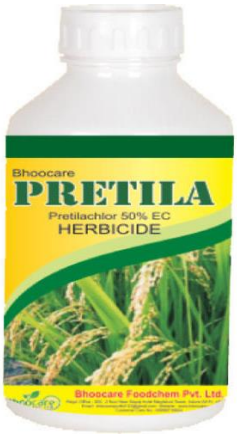
- **Classification on the basis of Chemistry:**

A large number of group of chemicals are available in the list pesticides but we will confine to the pesticides registered in India.

a) Insecticides: A pesticide that is used to kill insects, or to disrupt their growth or development. The insecticides available can be classified as Organo halogen, Organophosphorous, Carbamates, Pyrethroids, Neonicotinoids, Miscellaneous pesticides, Spinosyns (spinosad), neriestoxin (cartap), Fiproles (Phenylpyrazoles), Pyrroles (chlorfenapyr), Quinazolines (fenazaquin), Benzoylureas (diflubenzuron an IGR), Antibiotics (abamectin) etc.

b) Fungicides: These are the chemicals which are used to prevent, cure eradicate the fungi. The fungicides available are aliphatic nitrogen fungicides (dodine), amide fungicides (carpropamid), acylamino acid fungicides (metalaxyl), anilide fungicides (carboxin), antibiotic fungicides (kasugamycin), methoxyacrylate strobilurin fungicides (azoxystrobin), aromatic fungicides (chlorothalonil), carbamate fungicides or benzimidazole fungicides (carbendazim), conazole fungicides (triazoles) (hexaconazole), copper fungicides (COC), dicarboximide fungicides (famoxadone), dichlorophenyl dicarboximide fungicides (iprodione), dinitrophenol fungicides (dinocap), dithiocarbamate fungicides (mancozeb), dithiolane fungicides (isoprothiolane), morpholine fungicides (tridemorph), sulphur compounds etc.

c) Herbicides: These are the substances that are used to kill plants, or to inhibit their growth or development. The herbicides are anilide herbicides (flufenacet), chloroacetanilide herbicides (butachlor), pyrimidinyloxybenzoic acid herbicides (bispyribac), benzothiazoleherbicides (methabenzthiazuron), dinitroanilineherbicides (pendimethalin), nitrophenyl ether herbicides (oxyfluorfen), halogenated aliphatic herbicides (dalapon), imidazolinone herbicides (imazethapyr), organophosphorus herbicides (anilofos), phenoxyacetic herbicides (2,4-D), aryloxyphenoxypropionic herbicides (clodinafop), quaternary ammonium herbicides (paraquat), chlorotriazine herbicides (atrazine), triazolone herbicides (carfentrazone), urea herbicides (methabenzthiazuron), phenylurea herbicides (isoproturon), sulfonylurea herbicides (chlorimuron).



d) Rodenticides: These are the substances used to kill rats and related animals. Inorganic Rodenticides: (zinc phosphide, aluminium phosphide, magnesium phosphide). Organic Rodenticides: (bromadiolone, coumachlor, coumatetralyl).

- **The classification based on the basis of type of pest they control:**

Acaricides, Algicide, Antifeedants, Avicides, Bactericides, Bird repellents, Chemosterillant, Fungicides, Herbicide softeners, Herbicides, Insect attractants, Insect repellents, Insecticides, Mammal repellents, Mating disrupters, Molluscicides, Nematicides, Plant activators, Plant growth regulators, Rodenticides, Synergists, Virucides and Miscellaneous.

Acaricides: These are the substances that are used to kill mites and ticks, or to disrupt their growth or development. Some of the examples are DDT, dicofol, carbofuran, methiocarb, propoxur, abamectin, milbemectin, flufenoxuron, chlorpyrifos, oxydemeton methyl, phorate, phosalone, fenpyroximate, fipronil, bifenthrin, cyhalothrin, fluvalinate, permethrin, etc.

Algicide: These are the substances that are used to kill or inhibit algae. Some of the examples are copper sulfate, diuron, isoproturon, isoproturon, oxyfluorfen, simazine, etc.

Antifeedants: These are the chemicals which prevent an insect or other pest from feeding. Some of the examples are chlordimeforn, fentin and azadirachtin.

Avicides: These are the chemicals that are used to kill birds. The list includes fenthion, strychnine.

Bactericides: These are the compounds that are isolated from or produced by a microorganism e.g. a bacterium or a fungus or a related chemical that is produced artificially, which are used to kill or inhibit bacteria in plants or soil. Some of the examples are copper hydroxide, kasugamycin, streptomycin, tetracycline.

Bird repellents: These are the chemicals which act as the bird repellants and some of the examples are copper oxychloride, diazinon, methiocarb, thiram, ziram.

Chemosterillant: These are the chemicals that renders an insect infertile and thus prevents it from reproducing. Some insects that mate only once can be controlled or eradicated by releasing huge numbers of sterilized insects, which act as sterilizing substances for the insects. All of these act in one of the three ways-

(a) they inhibit the production of egg or spam. If it fails, then go to the second stages
(b) cause death of the spam or eggs
(c) If these steps are failed totally then these bring about lethal mutation on the spam or eggs material and severally damage the genetic material and chromatin material of eggs and spam. This produce zygote, but the off springs will totally lose their reproduction ability. E.g. diflubenzuron.

Fungicides: Some of the examples are cymoxanil, carpropamid, metalaxyl, metalaxyl-M, carboxin, aureofungin, kasugamycin, streptomycin, validamycin, kasugamycin, carbendazim, thiabendazole, cyproconazole, difenoconazole, flusilazole, tebuconazole, triadimefon, bordeaux

mixture, copper oxychloride, iprodione, captan, ferbam, thiram, ziram, mancozeb, metiram, propineb, zineb, isoprothiolane, tridemorph, edifenphos, fosetyl-Al, fenarimol, tricyclazole, etc.

Herbicide softeners: Chemicals that protect crops from injury by herbicides, but does not prevent the herbicide from killing weeds. Examples are benoxacor, cloquintocet, cyometrinil, cyprosulfamide.

Herbicides: Some of the examples are alachlor, butachlor, metolachlor, pretilachlor, methabenzthiazuron, pendimethalin, oxyfluorfen, imazethapyr, anilofos, glyphosate, oxadiargyl, oxadiazon, clodinafop, cyhalofop, quizalofop, paraquat, atrazine, isoproturon, linuron, metoxuron, chlorimuron, sulfosulfuron.

Insect attractant: A chemical that lures pests to a trap, thereby removing them from crops, animals or stored products. E.g. gossyplure, gyplure, muscalure (name ends with lure as they lure the pests).

Insect repellent: A chemical that deters an insect from landing on a human or an animal. Some of the examples are citronella oil, permethrin.

Insect growth regulator: A substance that works by disrupting the growth or development of an insect. Some of the examples are diflubenzuron, buprofezin.

Insecticide: Some of the examples are azadirachtin, pyrethrins, carbofuran, carbosulfan, methomyl, buprofezin, diflubenzuron, fenoxycarb, abamectin, emamectin, milbemectin, spinosad, cartap, clothianidin, thiamethoxam, acetamiprid, thiacloprid, DDT, lindane, endosulfan, dichlorvos, monocrotophos, phosphamidon, ethion, malathion, phorate, dimethoate, phosalone, azinphos-methyl, chlorpyrifos, pirimiphos-methyl, quinalphos, triazophos, cyfluthrin, cyhalothrin, lambda-cyhalothrin, cypermethrin, alpha-cypermethrin, cyphenothrin, deltamethrin, fenpropathrin, esfenvalerate, fluvalinate, imiprothrin, tofenprox, clothianidin thiamethoxam , thiacloprid, isoprothiolane.

Mammal repellent: A chemical that deters mammals from approaching or feeding on crops or stored products.

Mating disrupters: These are the chemicals that interfere with the way that male and female insects locate each other using airborne chemicals (pheromones), thereby preventing them from reproducing.

Molluscicides: These are the substances used to kill slugs and snails. Some of the examples are copper sulfate, metaldehyde, thiacloprid, thiodicarb.

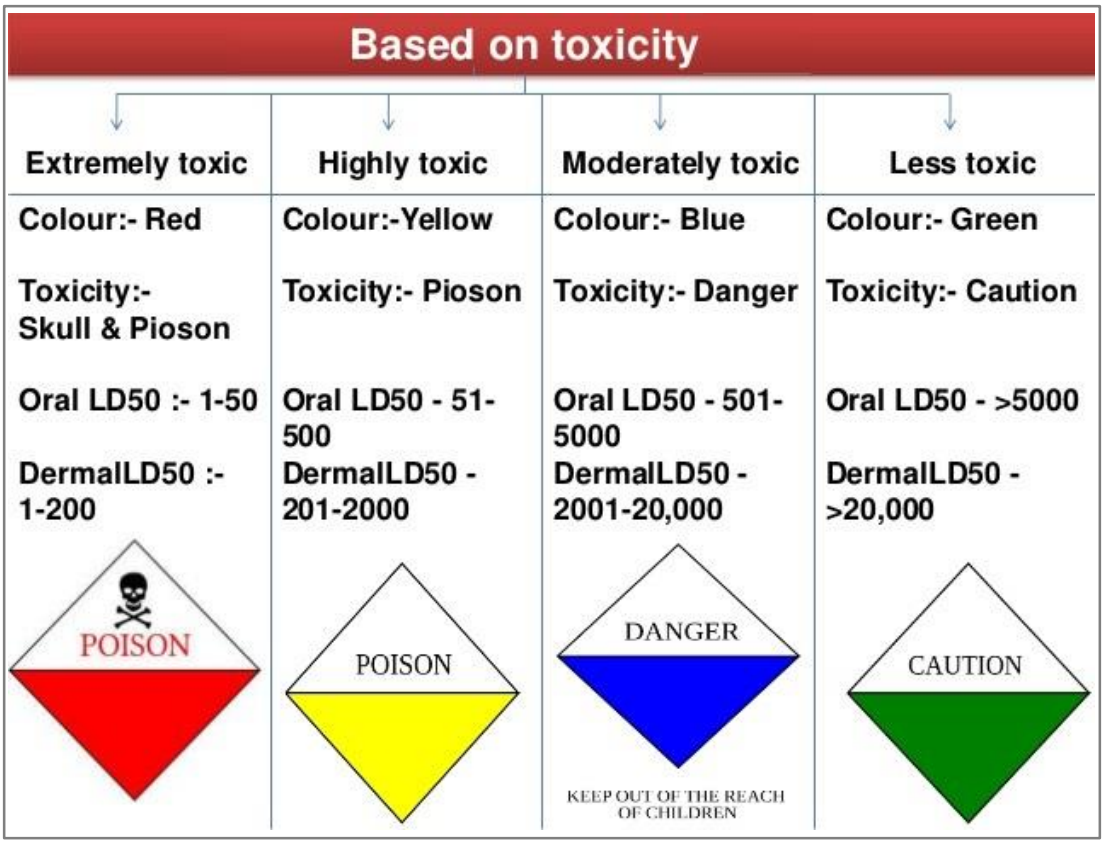
Nematicides: These are the chemicals which are used to control plant-parasitic nematodes. Nematicides have tended to be broad spectrum toxicants possessing high volatility or other propertied promoting migration through soil. Some of the examples are abamectin, benomyl, carbofuran, carbosulfan, methyl bromide, fenamiphos, phosphamidon, chlorpyrifos, dimethoate, phorate, triazophos.

Plant growth regulators: There are the substances that alters the expected growth, flowering or reproduction rate of plants. Fertilizers and other plant nutrients are excluded from this definition. Ethephon, metoxuron, gibberellic acid, chlormequat, paclobutrazol, triacontanol, are some of the examples.

Rodenticides: These are the substances used to kill rats and related animals. Some of the examples are strychnine, bromadiolone, coumachlor, coumatetralyl, warfarin, zinc phosphide, lindane, aluminium phosphide etc.

Synergist: A chemical that enhances the toxicity of a pesticide to a pest, but that is not by itself toxic to the pest. Example: piperonyl butoxide.

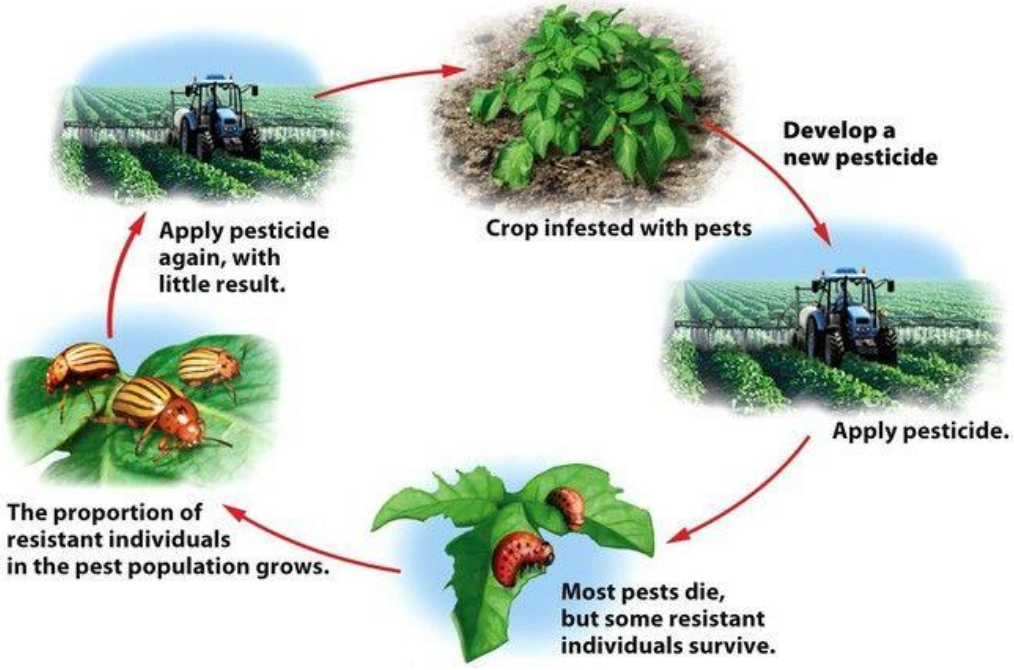
Virucide: It is an agent having the capacity to destroy or inactivate viruses. Example: Ribavirin (not available in India).



Working of pesticides:

Pesticides work in the following ways-

1. By blocking the cellular processes of the target organisms in a purely mechanical way. E.g. Spray oils, petroleum oils.
2. By destroying or altering the pest's metabolism. E.g. Rotenone and cyanide which disrupt respiratory function of pests.
3. By disrupting enzyme processes or denature proteins. E.g. Inorganic copper compounds.
4. By simulating or interfering with hormones. E.g. Phenoxy herbicides.
5. By disrupting photosynthesis and preventing the weed plant from producing or storing energy. E.g. Triazine.



Shocking Facts

- Pesticides are a major threat to bees. The systemic poisoning of flowers has killed scores of bees.
- We're simply losing too many of them. The bees and butterflies among others are pollinators and they represent a natural tour de force in perpetuating plant cycles and evolution.
- You see, they do cross pollination naturally. More than 25% of the bee colonies died in winter 2006/07. That translates to a loss of tens of billions of bees.
- And it's estimated that this loss will negatively impact the agricultural economy to the tune of $8 to $12 billion.

Benefits of pesticides:

1. They have reduced deforestation, better crop yield, less land needed.
2. Reduction in fertilizer used and less fossil fuels.
3. Food production has increased 20-50% over the last 40 years.
4. Less water needed to produce crops.
5. They are used to protect the stored food grains or livestock from insects and rodents.
6. They protect the standing crop in the field. They do not increase the crop yield like fertilizer but by protecting the crop from pests.
7. They can be used to control household pests.
8. They control disease from insects, fungus and toxic weeds.
9. Cost effective, more money for the farmers, better prices in the grocery store.

Methods of controlling pests: **Some of the methods are given as follows:**

- **Mechanical methods**
- **Biological methods**
- **Environmental methods**
- **Agricultural methods**
- **Chemical methods**

• Mechanical methods:

- Hand picking: Method of choice when pests are slowly crawling and are not able to fly, e.g. caterpillars.
- Trapping: It is used for flying pests which can't be picked by hand or burned.
- Burning: It is used for flying pests which can't be picked by hand and can cause damage. Pests are burned and waste is removed frequently.

• Biological methods:

This method is applicable for removal of animal pests. It depends on the following considerations.

- Animals and insects which feed upon smaller forms, e.g. hawk, owl, eagle, cat etc.
- Insects having small life span parasitize bigger. Some flies lay eggs on larvae of the crop which cause damage. They attack slowly moving larvae. After few days when eggs are hatched, small larvae appear and consume the body tissues of the crop larvae. Hence death of the pest occurs.

- **Environmental methods:**
  - The surrounding of the pest is changed in such a way it becomes unfavorable for its growth.
  - It can be achieved by removing food stuff needed for the growth of the pest or draining swamps, e.g. mosquito control.

- **Agricultural methods:**
  - It involves cultivation of such crops which are resistant to pests.
  - It may be achieved using biotechnology and genetic engineering.
  - Another method for removal is crop rotation.

- **Chemical methods:**

  In this method, certain chemicals are used for controlling pests. E.g.
  - Rodenticides
  - Insecticides
  - Herbicides
  - Fungicides

Hazards of pesticides:

1. The pesticide industries cause pollution of soil, water and air. The pesticidal residue washed along with rain water, is added to the nearby water resources making it unfit for drinking.
2. They enter in the food chain and cause problem of bioaccumulation or biomagnification.
3. They are not target specific hence also kills non-pest insects. It adversely affects the mechanism of entomophily.
4. Continuous and indiscriminate use of pesticides may develop resistance in insect pest like superpests and superbugs.
5. They are non-biodegradable and affect the balance of ecosystem.
6. They are highly toxic in nature and if not handled carefully, they can cause serious health problems. E.g.

- Fatigue
- Liver and kidney damage
- Nervous system damage
- Breathing problems
- Brain disorder
- Blood disorder
- Irritation to skin and eyes
- Endocrine damage- thyroid, hormonal, reproductive, metabolism
- Vomiting, diarrhea, slow heart rate
- Deformities or birth defects
- Parkinson's disease
- Thyroid
- Cancer
- Death

7. Accidents in pesticides manufacturing units cause great loss of human life. E.g. Bolsover (England, 1968), Seveso- TCDD gas (Italy, 10th July,1976, Tetrachloro dibenzodioxin), Bhopal gas tragedy- MIC gas (India, 3rd Dec, 1984, Methyl isocyanide), Visakhapatnam gas leak tragedy- Styrene gas (India, 7th May, 2020, also referred as Vizag gas leak tragedy).

The Bhopal Gas Tragedy: Pesticides in our midst

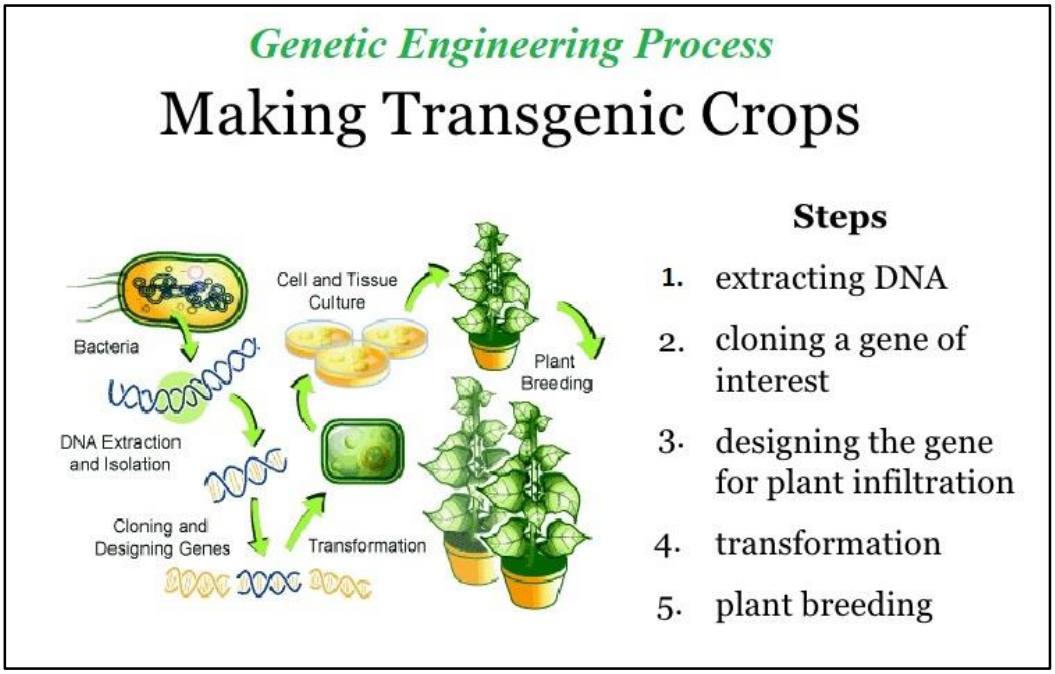
- **The worst industrial disaster in the history of the world is related to pesticide production. This Occurred at Union Carbide Factory in Bhopal, India Dec. 3, 1984.**
- **In this incident, Methyl Isocyanide (MIC) – an ingredient in the production of the insecticide Carbaryl , escaped into the atmosphere killing more than 3,000 people within a few hour.**
- **The insecticide, Carbaryl, itself is a highly toxic chemical and carcinogen (cancer causing agent) to humans.**
- **The tragedy occurred due to lack of adequate safeguards in the storing the chemical and lack of adequate warning to the public.**

(Top) Survivors of the tragedy lineup outside the factory awaiting treatment. Pesticides such as Lindane (middle) and Sevin (bottom) are still being stored in unsafe manner in the now abandoned the factory.

Advances in technology:

- **Green Pesticides:** These are biodegradable, safe, ecofriendly and natural methods are being explored. Some use cow's urine, plant leaves, shellac, sucrose and even yeast to maintain and improve crops. These would be less toxic to humans, animals and the environment.

- **Transgenic Crops:** Genetic engineering is being used to build crops, making them disease resistant, able to stand up to fertilizer better, create deeper root systems and increase yields. These make lowering the need for pesticides.



Conclusion:

- Pesticides are an important tool in modern agriculture, but the risks and benefits of using pesticides must be considered before an application takes place.
- Since we know that there are dangers associated with pesticide use, caution must be taken when using.
- Safe practices are outlined on the label that comes with each and every pesticide. Follow the label for correct and safe application.
- The label also indicates the right kind of equipment and clothing that will keep us safe during an application.
- Be safe and watch out for the safety of others when using pesticides.