INTRODUCTION TO TOXICOLOGY

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INTRODUCTION

DuBois and Geiling (1959) defined toxicology as:

"It is the branch of medical science that deals with the nature, properties, effects, and the detection of poisons. It is, therefore, the science of poisons".

Toxicology is one of the oldest branches of pharmacology. Traditionally, it has been thought of as the science of poisons affecting human lives and therefore, as a branch of medical science.

Metabolism and excretion of poisons, action of poisons and on the treatment of poisoning as well as systematic chemical and physical analyses and diagnoses all are included in toxicology.

In recent years a branch of toxicology, now known as Environmental toxicology, has grown increasingly important. Its development has been fostered by:

- The extensive use of industrial chemicals, pesticides, and natural resources.
- More intense utilization of urban, agricultural, and recreational space and marine environments.
- Heightened awareness of the hazards of chemicals to wildlife, domestic animals, and people.

The most important subfield of toxicology was industrial toxicology (DuBois and Geiling, 1959), which is concerned mainly with the safety of industrial workers and, to a much lesser extent, with that of other people who might accidentally be exposed to large doses of industrial poisons.

Pesticides

The biocidal agricultural chemicals, collectively known as pesticides are the largest group of poisonous substances that are widely broadcast today.

Pesticides include insecticides, acaricides, nematocides, rodenticides, herbicides, and fungicides. Insecticides are the most numerous and most valuable pesticides.

Insecticides have been developed mostly by empirical methods, notably by screening countless numbers of compounds that kill the pest organisms.

Insecticide toxicology does include efforts to determine tolerance levels of pesticides in man and is concerned with establishing a logical basis for selective toxicity, in order to kill insects without affecting mammals.


Pesticides emerging issues
used in agriculture

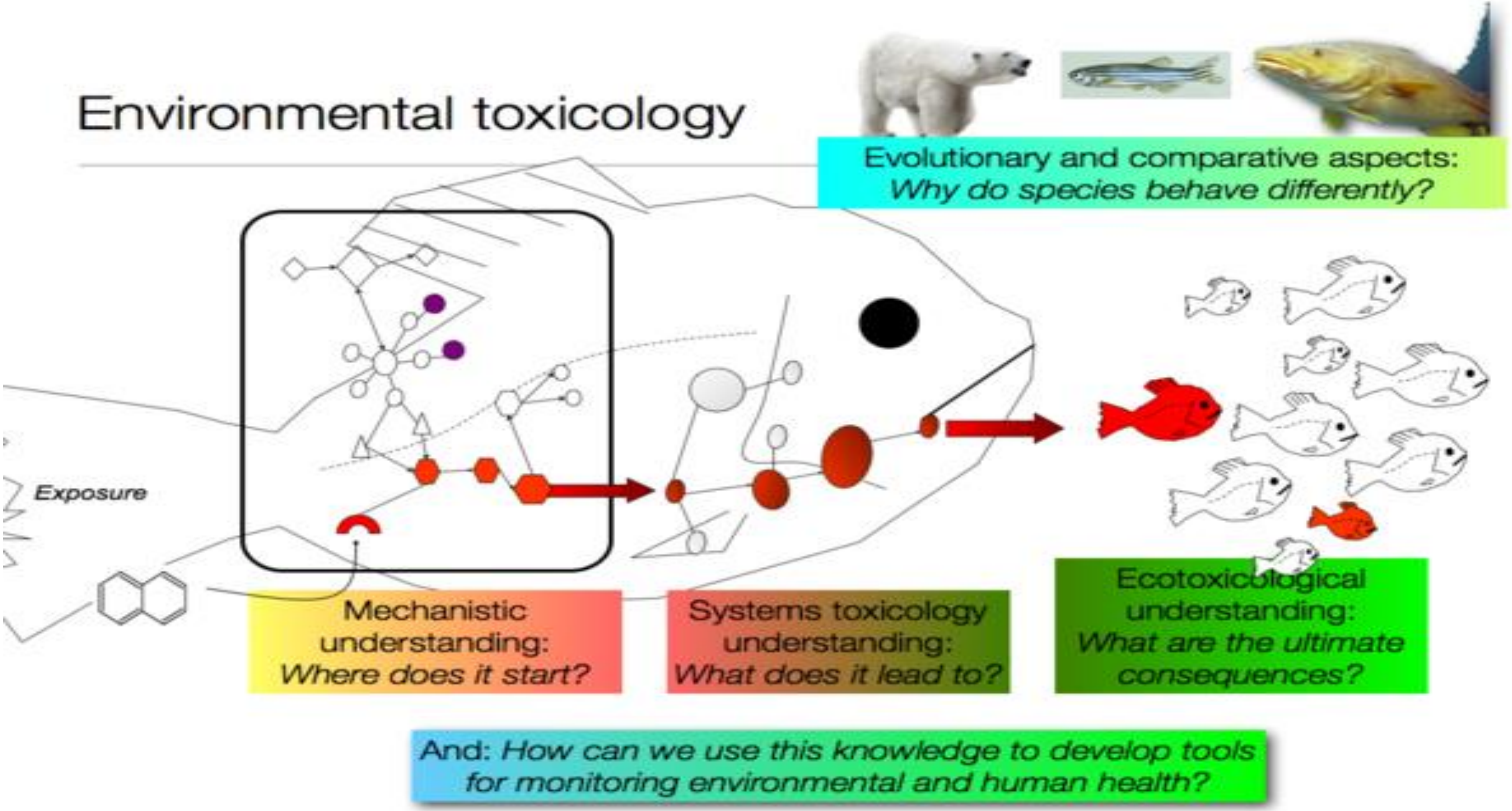

CAUTION
PESTICIDE SPRAYING
IN PROGRESS
PROCEED AT OWN RISK

Insecticide toxicology is a discipline based on the study of a particular group of toxic chemicals rather than on their effects in a particular group of animals.

They are concerned with the elucidation of the mechanisms of action of toxicants and with the differences in their inhibitory action and metabolic fate in various organisms, which may then provide an understanding of their differential toxicities.

Environmental toxicology is thus a hybrid of a wide variety of scientific disciplines; it requires of its practitioners solid fundamental knowledge of chemistry, biochemistry, physiology, and pharmacology, and, when necessary, competence with physical, mathematical, ecological, and other techniques which toxicologists employ to solve problems.

Environmental toxicology



Two factors are important in defining the field of environmental toxicology of pesticides.

- ❖First, among environmental pollutants pesticides are unique in that they are present in such minute quantities.
- ❖Second, their effects are confined exclusively to biological systems.

It is crucially important to study how animals are poisoned by insecticides and why they die, and this knowledge must then be utilized in assessing environmental impact.

Veterinary Toxicology

Radeleff (1964) describes the field by saying:

"A veterinary toxicologist, then, may be considered to be a veterinarian having a special knowledge of the poisons affecting the mammals and birds in which man is interested for his economic gain or personal pleasure, and of those substances which, when present in animal products, could be harmful to the people who may consume them.“

Veterinary toxicologists are concerned with any toxic substance that may come in contact with domestic animals, just as medical toxicologists are concerned with the effects of poisons on humans, and these poisons include pesticides.




PESTICIDE USE PATIERNS

Pesticides are chemicals and biological materials that are used by man to reduce pest organisms. Generally, any living organism that interferes with human activity in a negative way is considered a pest. The interference may be aesthetic, economic, or health-related.

The greatest use of pesticides in any country is for agriculture and forest pest control.

Kearney et al. (1969) estimated that in 1964 about 119 million acres in the United States were sprayed with herbicides, 97 million with insecticides, and about 25 million acres with fungicides and other minor pesticides.

The use of DDT continued to decline in the United States from its peak in 1959 and reached almost zero in 1973.

Total production of cyclodienes has also declined, although toxaphene and chlordane are still produced in relatively large quantities.

Total production of chlorinated hydrocarbon insecticides declined to about 100 million pounds (1978 estimate) from the all-time high of 300 million pounds in 1966.

Other insecticides produced in large amounts are ethyl- and methylparathion (60 million pounds), carbaryl, malathion, diazinon, carbofuran, disulfoton, and phorate.

Total Organic Pesticide Production Figures for the United States

Total production (millions of pounds)

Pesticide class	1966	1969	1973	1976	1978	1980
Total fungicides	178.9	182.1	153.1	142.1	147.3	161
Total herbicides	272.0	371.8	496.1	656.2	663.8	792
Total insecticides	562.2	579.5	639.2	566.1	605.4	491

Pesticide use patterns outside the United States is to examine export figures.

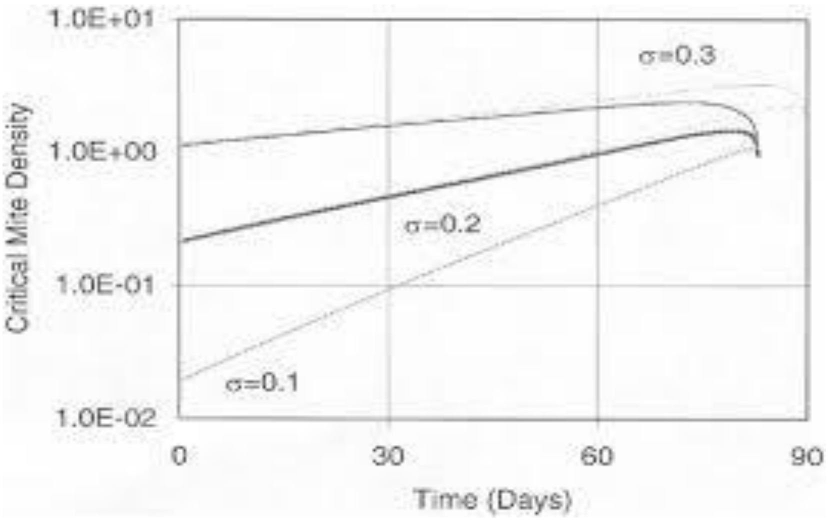
- ❖Until about 1972 the bulk of pesticides exported were insecticides, reflecting the worldwide demand for insect pest controlling agents.
- ❖The total export figure for herbicides, however, tripled from 87 to 234 million pounds per year between 1972 and 1978.
- ❖The corresponding figures for insecticides were 208 and 286 million pounds, indicating only a modest increase.

The trend could be understood in two ways.

- ❖First, the increase in herbicide exports may be due to increases in labor costs in other parts of the world.
- ❖The decline in the rate of increase of export of chlorinated insecticides may be due to the curtailment of their use in the United States.

Headley (1972) made an effort to estimate the economic threshold value. According to him, the cost of control drastically increases as the pest population decreases; that is, the cost to reduce any given population to 10% of the original level is about the same as the cost to eliminate the last 10%.

On the other hand, the rate of increase in crop yield diminishes as the pest population decreases. Thus, there must be a point (threshold value) where the increase in crop yield in terms of dollars equals the cost increase to reduce the pest population to that level. Such a threshold value would be different for each crop



Overuse of insecticides has been known to cause a variety of problems. Development of resistance on the part of pest insects may be accelerated by heavy pressure to eliminate susceptible individuals.

The elimination of natural enemies of pests, in the form of predators of parasites, is a serious problem. One of the most dramatic examples of pest resurgence as a result of insecticide use is that of increased mite populations in orchards (Croft and Hoy, 1978).

Three stages are seen in this phenomenon:

- ❖First, predator insects and mites are killed by the spray.
- ❖Second, the predators repopulate the area much more slowly than the mites, due to their longer life cycles and the lack of prey during the initial stages of their recovery.
- ❖Third, the predators develop resistance much more slowly than the mites.

Integrated Pest Management (IPM)

Integrated pest management (IPM) is a new approach to pest control.

Its aim is to achieve pest control by combining many different approaches. These include biological, chemical, physical, and economic methods

The use of the term "manage“ is important because it replaces the traditional concept of pest "eradication,“ which does not allow for the presence of pests at levels that could be tolerated.

IPM uses a variety of techniques, such as natural predators, pathogens, parasites, resistant hosts (e.g., crops), weather and other environmental factors, and appropriate chemical pesticides at correct timings.

Integration of these techniques into cohesive IPM schemes therefore requires an interdisciplinary "systems approach.“

For their part, toxicologists must know the effects of the given chemicals on the target and non-target species, including predators, alternate hosts for natural pathogens, and competing pest species against target species, metabolic changes in and the resistance developing potentials of these species, the persistence of the chemicals in the field, and the potentials of these chemicals for bioaccumulation.

Today pesticides are used with regulations and limits in order to avoid unnecessary contamination.

Ideally, the use of pesticides should be based on the knowledge of what they accomplish and what effects they may have on our planet.

Another way of regulating the use of pesticides is to prevent improper methods of application. The National Research Council (a non-government regulated body) has been active in coordinating and summarizing expert opinion and publishes regular reports on the "Safe Use of Pesticides in Food Production.“

Previously, restrictions on the initial use of pesticides were the responsibility of the Plant Pest Control Division and the Forest Service of the United States Department of Agriculture (USDA); their regulatory functions were based on the Federal Insecticide, Fungicide, and Rodenticide Act of 1947.

In an analogous situation, the Department of Health, Education, and Welfare is responsible for protecting people from pesticidal contamination and from epidemics. It works in cooperation with local (e.g., Communicable Disease Center, Public Health Service) and international agencies (e.g., World Health Organization), but has no control over the use of pesticides.

The need for a rational approach to regulation of the use of pesticides, for the protection of man, wildlife, and other animals from accumulation of low-level residual pesticides, has become increasingly apparent. Therefore, the President's Science Advisory Committee was organized, and in 1963 published the "Wiesner Report," which established guidelines:

(1) For an assessment of the levels of pesticides in man and his environment.

(2) For the development of measures which will augment the safety of present practice.

(3) For research and development of safer and more specific methods of pest control.

(4) For amendments to public law governing the use of pesticides,

(5) For public education.

In April 1963, a National Research Council committee was appointed, on the recommendation of the Food and Drug Administration, with the chief objective of establishing "negligible" or "permissible" tolerance levels to replace the scientifically untenable concept of "zero tolerance.“

In 1969, a committee headed by E. Mrak submitted a report which assessed the pesticide situation and stressed the need for studies on rational approaches to pesticide use, forecasting that the need for pesticides would increase in the future.

With increasing public concern over environmental pollution, the Environmental Protection Agency (EPA) was created by the President's Council on Executive Organization on July 9, 1970.

The EPA also acquired the authority to set tolerance levels in food (formerly a FDA assignment) and to control radiation standards (formerly the responsibility of the Atomic Energy Commission).

The FDA, however, retained the power to regulate the final limits of pesticide residues in foods through sampling, spot-checking, and, in some cases, confiscation.

The USDA retained authority to regulate the use pattern of agriculturally oriented pesticides through recommendations and through Agricultural Extension Services.