Toxicology -- Relating to Environmental Health

Toxicology is the science that studies the harmful effects of overexposure to drugs, environmental contaminants, and naturally occurring substances found in food, water, air and soil.

Basic Principles of Toxicology

“The dose makes the poison” is the first principle of toxicology.

Exposure vs. Dose

To cause harm to a person (or animal), a hazard must enter the body. Merely being exposed will not cause harm if the hazard does not actually enter the body. For example, a pack of cigarettes in a man’s shirt pocket does not cause harm to him because nothing from the cigarettes has entered his body. If, however, he smokes one of the cigarettes or stands breathing next to someone smoking a cigarette, the smoke has entered his body through his lungs and can cause harm.

There are three primary ways that a hazard can enter the body:
Ingestion – Chemical or natural toxicants that are ingested enter the body by being eaten. From the digestive track, they can go to the liver or the lymphatic system and then on to the bloodstream. Some chemicals are not absorbed by the digestive track, so they pass through the body and are excreted in the feces.
Inhalation – Chemicals or natural toxicants can be breathed into the lungs, called inhalation. The inside surface of the lungs is very large and is a poor chemical barrier. Many chemicals that are inhaled can easily and quickly enter the bloodstream from the lung tissue.
Skin Absorption – Chemicals or natural toxicants can enter the body by moving through the skin. The skin is a very good barrier and provides protection from many hazards, but some substances can penetrate the skin, then enter the bloodstream and be carried to all parts of the body.

Dose / Response

The dose is the specific amount of a chemical that enters the body. When a person is exposed to a hazard, there are several things that determine the amount that actually enters the body. One way to determine a person’s dose is to do a blood test to measure the amount of chemical in their body. For many chemicals, there is no easy way to measure them in the blood. Scientists must measure other factors to estimate dose. Some measurements that can be used are:
Respiration Rate – A hazardous gas usually enters a person’s body through inhalation into their lungs. If they are breathing quickly, they will breathe in more of the gas than if they are breathing slowly. So their dose is higher if they are breathing heavily.
Hazard Concentration – A higher concentration of a hazard generally means a higher dose because there is more of the hazard to enter the body.

Frequency of Exposure – A person exposed only once is likely to have a smaller dose than a person exposed many times.

Length of Exposure – A person exposed for a short time will have a lower dose than a person exposed for a long length of time.

Properties of the Toxin – Some toxicants are not easily absorbed by the human body and exposure does not lead to as high a dose as exposure to a toxicant that is easily absorbed. In addition, different toxicants affect different functions and are processed by the body differently. The severity of the response to a toxicant will depend on how the body processes the toxicant and the physiological functions it affects.

The amount of damage (response) caused by a chemical that has entered the body depends on the dose, or amount entering the body. This relationship, called dose/response, usually follows a predictable pattern. At very low amounts, there will be no detectable effect of the chemical. In the midrange of doses, the amount of damage will increase as the dose increases. At very high doses, a maximum level of damage is reached. Thus, it is the dose of the chemical that makes the poison.

**Acute vs. Chronic Toxicity**

Acute toxicity refers to a high toxicant dose over a short period of time, whereas, chronic toxicity refers to small doses over a long period of time. Acute toxicity is commonly measured as the Lethal Dose 50 or LD₅₀. The LD₅₀ is the dose of a substance that is lethal to 50% of the animals being tested (most commonly mice or rats).

**Basic Concepts of Toxicology**

1. The dose determines the poison (risk/benefits of chemicals)

2. Toxicology research is important for protecting and improving the health of humans, animals, and their environment.

3. Main objectives of toxicology are to establish safe doses and determine mechanisms of biologic action of chemical substances.

4. Highly toxic chemicals can be life-saving when given in appropriate doses. On the other hand, an apparently nontoxic chemical can actually be toxic at high doses. In other words, it is possible to be exposed to “too much of a good thing”!

5. “Exposure” and “dose” are different concepts. Many biological and physical/chemical factors determine how much of a chemical in one’s environment
(i.e., exposure) reaches sensitive vital organs in an active form that causes harm
(i.e., dose to target organ). Thus, the amount of a chemical that is “out there” in
one’s environment is not as important a determinant of toxicity as the actual internal
dose.

A) Biological differences between species and individuals (e.g., age, gender,
metabolic status, diet, and genetic differences) play important roles in
determining toxicity.
B) The physical state of a chemical (liquid, solid, gas) at the time of exposure
determines toxic effects.

6.) Route of exposure matters. A chemical that is toxic when taken by one route of
exposure (i.e., inhalation, dermal absorption, or ingestion) may not be toxic by
another route.

7.) Source is not a reliable predictor of toxicity. Overexposure to any chemical whether
synthetic or natural — even water or oxygen — may be too much of a good thing!

8.) The work of toxicologists improves the health and prosperity of society and our
environment. For example, toxicology studies are required to identify levels of
chemicals in the environment that will not cause harm to people or animals, and
levels of valuable medicines, household and gardening chemicals, and industrial and
natural compounds that people can use without unnecessary risks.

9.) Exaggerated estimates of risk can also be “toxic” — that is, prevent life-saving
medicines and other useful chemicals from being developed and hinder economic
progress. Toxicology allows us to examine and weigh the risks vs. benefits of
chemicals and optimize our lifestyles.

10) Basing health risk assessments on objective toxicology and other sound
scientific data prevents improper regulation and ensures appropriate
expenditures of public and private funds.

Websites:
American Association of Poison Control Centers
http://www.aapcc.org/

Chemicals & Human Health Website:
http://www.biology.arizona.edu/chh/default.html

TOX RAP RUTGERS NIEHS CENTER
http://www.eohsi.rutgers.edu/rc/toxrap/index.htm

EPA Superfund Home Page
http://www.epa.gov/superfund/

TOXNET, a cluster of databases on toxicology, hazardous chemicals, and related areas

University of Wisconsin Sea Grant
http://seagrant.wisc.edu/index.asp

Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/

The EXtension TOXicology NETwork
http://ace.orst.edu/info/extoxnet/

National Institute for Environmental Health Sciences
http://www.niehs.nih.gov/

Society of Environmental Toxicology and Chemistry
http://www.setac.org/

Chemfinder
http://chemfinder.cambridgesoft.com/

ADDITIONAL REFERENCES:


