1.1: What is toxicology?

What is Toxicology?

Toxicology is traditionally defined as "the science of poisons." Over time, our understanding of how various agents can cause harm to humans and other organisms has increased, resulting in a more descriptive definition of toxicology as "the *study of the adverse effects of chemical, physical, or biological agents on living organisms and the ecosystem, including the prevention and amelioration of such adverse effects."*

Figure 1.1.1: Photos of a Gila monster anda Bothrops jararaca snake. (CC BY-SA 4.0; Leandro Avelar via source)

These adverse effects can take many forms, ranging from immediate death to subtle changes not appreciated until months or years later. They may occur at various levels within the body, such as an organ, a type of cell, or a specific biochemical. Our understanding of how toxic agents damage the body has progressed along with medical knowledge. We now know that various observable changes in anatomic or bodily functions actually result from previously unrecognized changes in specific biochemicals in the body.

Did you know?

The study of toxicology may appear to focus only on poisonings or disasters, but some toxic chemicals can have positive effects. Animal venoms, whether from bees, wasps, snakes, or Gila monsters, are composed of hundreds of chemicals that are being studied as treatments for human diseases.

For example, exantide, a drug derived from Gila monster saliva, has been approved for use in Type 2 diabetes. Captopril, which is used to treat hypertension and heart failure, was developed from studies on the chemical bradykinin-potentiating factor (BPF) in the venom of a South American snake Bothrops jararaca. Melitten, which comes from honeybee venom, is being investigated for its anticancer and antifungal properties.

Figure 1.1.1: Figure 1. Gila monster (top); Bothrops jararaca (bottom)
*(Image Source: Wikipedia, adapted under GNU Free Documentation License - **Original Images**)*

History of Toxicology

Prehistory

Poisonous plants and animals were recognized and their extracts used for hunting or in warfare.

1500 BC

Written records indicate that hemlock, opium, arrow poisons, and certain metals were used to poison enemies or for state executions.

c. 1198

With time, people began to make the connection between exposure to a specific substance and illness or death.

In 1198, Moses Maimonides wrote what may be the first collection of writings on toxicology, *The Treatise on Poisons and Their Antidotes*.

Renaissance and Age of Enlightenment

Certain fundamental toxicology concepts began to take shape. Noteworthy studies include those by Paracelsus in the 16th century and Orfila in the 19th century.

Paracelsus (16th Century)

Determined that specific chemicals were actually responsible for the toxicity of a plant or animal poison.

Documented that the body's response to those chemicals depended on the dose received.

Studies revealed that small doses of a substance might be harmless or beneficial, whereas larger doses could be toxic. This is now known as the **dose-response relationship**, a major concept in toxicology.

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."
- Paracelsus

Orfila, the founder of toxicology (19th Century)

A Spanish physician, Orfila is often referred to as the **founder of toxicology**.

Orfila was the first to describe a systematic correlation between the chemical and biological properties of poisons of the time.

Orfila demonstrated the effects of poisons on specific organs by analyzing autopsy materials for poisons and tissue damage associated with them.

20th and 21st Centuries

Marked by great advancements in the level of understanding of toxicology.

DNA and various biochemicals that maintain body functions have been discovered.

Our level of knowledge of toxic effects on organs and cells has expanded to the molecular level.

Virtually all toxic effects are recognized as being caused by changes in specific cellular molecules and biochemicals.

Remedy or Poison?

Xenobiotic is the general term that is used for a ***foreign*** substance taken into the body. It is derived from the Greek term *xeno* which means "foreigner." Xenobiotics may produce beneficial effects (such as pharmaceuticals) or they may be toxic (such as lead).

As Paracelsus proposed centuries ago, dose differentiates whether a substance will be a remedy or a poison. A xenobiotic in small amounts may be nontoxic and even beneficial, but when the dose is increased, toxic and lethal effects may result.

The following image provides some examples that illustrate this concept.

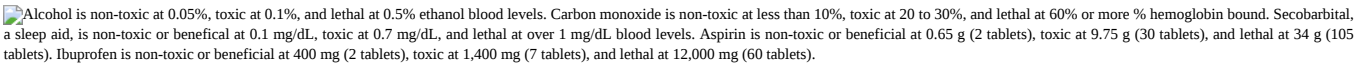

Figure 1.1.2: Figure 3. Examples of varying *doses of the same substance as non-toxic or beneficial, toxic, and lethal (Image Source: Adapted from T. Gossel and J. Bricker, eds)*