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Toxicology: it's not just the dose that makes the poison

History

Toxicology began as the science of poisons. History shows that civilizations actually used their knowledge of poisons to murder and replace numerous kings and emperors. The concept of the use of chemical substances changed in the 15th century when Paracelsus, considered the father of modern toxicology, stated, "It's the dose that makes the poison." He understood that for every substance there is a dose which is harmful and a dose which is therapeutic or not harmful.ⁱ

Toxicology

This concept has been extremely important, because of the industrial revolution and especially in the last century. People are now exposed to many different chemicals. The average person is contaminated with up to 200 chemicals starting from conceptionⁱⁱ ⁱⁱⁱ and so knowledge of the toxicological properties of these chemicals is extremely important in order to protect public health. Toxicology has evolved from the science of poisons to include the science of safety. However, despite efforts to consolidate the published toxicity data, there are thousands of environmental chemicals for which little to no data currently exist.^{iv} ^v





More than one dose?

We now know that more than one dose makes the poison, that toxins can exert different effects with different doses. For example, there are chemicals, such as plasticizers, that can interfere with hormone actions at tiny doses, yet can exhibit different effects at higher doses. This is known as a nonmonotonic response.^{vi vii}

Size makes the poison

Toxins come in all sizes, such as the particulate matter that dominates air pollution. The smaller the size of the particulates, the deeper they can penetrate the lungs, the easier they are absorbed, and the more likely they can enter organs and cells and exert their toxic effects. Size makes the poison.^{viii ix}

Timing makes the poison

There are different windows of increased vulnerability to toxins during our lives. Timing makes the poison too. We are vulnerable in utero, and the potential damage depends on which organ is developing the most when the exposure occurs.^x Children are also more vulnerable because their organs are still developing. Pregnant women are more at risk for specific conditions such as preeclampsia.^{xi} And seniors are more at risk too. For example, there are worse survival rates after a stroke, depending on the levels of pollution where one lives.^{xii}

Duration makes the poison

Duration of exposure also makes the poison. We are now seeing that exposures starting in utero and early childhood increase the likelihood that in later life we will develop chronic cardiovascular, respiratory and or immunological diseases, or some cancers.^{xiii}

Real life complex mixtures make the poison

Toxicology studies chemical exposures in the laboratory to look for the toxic dose. Real life studies are done by epidemiologists, who look for patterns of change in the population associated with chronic exposures. In real life, exposures are multiple and simultaneous, yet constantly in flux. We know that living cells function through the interactions of different molecules. Systems biology studies these biological networks,^{xiv} ^{xv} and systems toxicology studies the perturbations in these biological networks following exposure to chemical substances.^{xvi} One thing we know from systems toxicology is that pollution exposures can stimulate and sensitize cell surface receptors that respond to a multitude of chemicals,^{xvii} and that developing multiple chemical sensitivities is a risk from pollution exposures.^{xviii}



Real life – our bodies and our surroundings are contaminated with synthetic chemicals. Remember that just because a chemical is used commercially does not mean that it has been adequately tested and is safe. The best advice is to adhere to the Precautionary Principal^{ix} and try to reduce or eliminate exposures to pollutants whenever you can. One dose might not make a poison. But multiple, simultaneous doses for your whole life likely do.

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