**Question From the Classroom**

By Bob Becker

**Q:** What is the most deadly poison in the world?

**A:** The answer to your question depends on how you define “poison” and what you mean by “most deadly.” You might be tempted to define a poison as being any chemical that can cause death, but this is probably not a very good definition. It would have to include water, since drowning accounts for nearly 4,000 accidental deaths each year in the United States, yet it is doubtful that anyone would ever think of water as a poison, since we need to drink it for our very survival! Webster’s defines poison as “a substance that **through its chemical action** usually kills, injures, or impairs an organism.” This definition rules out water but certainly includes a vast number of compounds for which human exposure, even at very low levels, can be fatal.

The words “most deadly” are also open to interpretation. Does this refer to the substance that causes the most deaths worldwide each year, or the substance that requires the smallest dose to cause death? If one is referring to the substance that causes the most deaths worldwide each year, the poison would have to be tobacco. It has been estimated that 500,000 people die each year of tobacco-related illnesses in the United States alone, and 4–5 million worldwide. No other poison even comes close to these numbers.

**Tobacco** is a **chronic** poison; repeated exposure to it over the long term kills. If one decides to ignore the actual death toll caused by a poison and focus instead on its sheer potency, then we need to learn how **acute** toxicity is measured. The most common method for identifying the toxicity of a substance is **LD₅₀**, which stands for lethal dose–50%. The LD₅₀ indicates the mass of the poison per kilogram of body weight necessary to kill 50% of a given population. Because individuals in any population will have a range of tolerance levels to any given toxin, it would be difficult to quantify LD₁₀₀ (the dose that would kill 100% of the population). LD₅₀ serves as a sort of average lethal dose. It is important to point out that these toxicity tests are not conducted on humans (obviously), but instead on laboratory animals such as rats and rabbits. One could certainly question how ethical such research is, or even how applicable it is to humans. Who’s to say that a substance lethal to rats would necessarily have the same effect on humans?

Nevertheless, LD₅₀ yields valuable information, especially when it comes to making decisions about what compounds to allow in a certain insecticide or building materials. It is also important to point out that the LD₅₀ of a substance depends quite a bit on the route of exposure: by inhalation (breathing in), absorption (through the skin or eyes), oral ingestion (swallowed), intravenous (injected into the vein), intramuscular (injected into the muscle), subcutaneous (injected under the skin), or intraperitoneal (injected inside the membrane that lines the interior wall of the abdomen). If one looks up the LD₅₀ for arsenic, for example, it is listed as ORL-RAT LD₅₀ 763 mg/kg and IPR-RAT LD₅₀ 13 mg/kg. This means that a rat ingesting 763 mg (about 3/4 of a gram) of arsenic per kilogram of its body weight would have a 50:50 chance of dying. A rat having only 13 mg of arsenic injected intraperitoneally would have this same risk. If this can be applied to average (75 kg) humans, it would take 57,000 mg (57 g, about 2 oz) of ingested arsenic to kill off an average human. As it turns out, compounds of arsenic are considerably more lethal than the element itself. The ORL-RAT LD₅₀ for diarsenic pentoxide (As₂O₅) is only 8 mg/kg—meaning that it would only take 600 mg (0.6 g, about half the mass of a dollar bill) of ingested As₂O₅ to kill off a 75 kg human.

As₂O₅ is toxic, but dioxin (often labeled the world’s most deadly poison) is about 400 times more deadly. With an ORL-RAT LD₅₀ of only 20 µg/kg, it would only take about 1.5 mg (the mass of this “O” if you cut it out of this magazine page) to kill an average human. In comparison, the nerve gas VX has an absorption LD₅₀ of 60 µg/kg.

Ricin, a protein found in castor beans that’s been associated with recent acts and threats of terror, has about the same toxicity level as dioxin. But all of these toxins would be considered “lightweights” compared to the protein-based **botulin toxin**, produced by botulinum bacteria and associated with botulism, the most severe form of food poisoning. It’s arguably the most deadly poison in the world. With an LD₅₀ in the range of 5–50 ng/kg, it is nearly 1000 times as toxic as dioxin.

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**Here’s a scary fact:**

Ever hear of "BOTOX" injections? Doctors actually use very dilute solutions of botulin toxin to paralyze facial muscles and remove facial wrinkles!