There are harmful chemicals all around us. And this is fine.

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Chemicals are in the food we eat, the air we breathe, the water we drink, the earth we stand on. And they are in us – in our urine, blood, bone and tissues. Many of these chemicals are known to be carcinogenic; others are suspected. All are potentially toxic.

Are you alarmed? Naturally. Who wouldn't be?

Toxicologists, for one. The scientists who understand the harm that chemicals can do would find that opening paragraph to be both accurate and meaningless. "How much?" they would say.

There are often gaps between what feels true and what science says is true, but few gaps are as big as the one between intuitions about chemicals and what toxicologists know. And few gaps are as consequential.

The irrational fear of chemicals – chemophobia – is rampant. Activists constantly publish scary reports about food and bodies contaminated by pesticides and other chemicals. Talk shows and books tell the fearful how to avoid toxic terrors and purge contaminants from their bodies. "Organic" has become the most desirable label in consumer marketing – one that commands a substantial premium – largely on the strength of vague fears that chemicals are killing us.

The distinguishing feature of this chemophobia is that it underplays, or ignores altogether, what toxicologists say makes all the difference.

To the chemophobe, the danger posed by a chemical isn't conditional on amount. It's inherent in the substance. Poison is poison. The only safe exposure is zero. But if that were true, we'd all be dead.

Consider that drinking water is routinely contaminated with (I'll stick to the letter "a" to keep this simple) arsenic, ammonia or asbestos. Sometimes these chemicals come from pollution. Far more often, they occur naturally. And they are utterly trivial. Below levels well known to science, and set out in government regulations, these chemicals have no effect on human health – so drinking a glass of arsenic-laced water is perfectly safe.

"The dose makes the poison" is a very old saying credited to Paracelsus, the 16th-century proto-scientist, that expresses the core insight of toxicology. It cuts both ways. Tiny amounts of arsenic in water may not be dangerous, but even the most benign substances can be toxic in large amounts: Drink 10 to 20 litres of water contaminated with traces of arsenic over a few hours and the arsenic won't do the slightest harm – but the water will cause the body's sodium levels to crash, leading to coma and even death.

Potassium is emblematic of the dual-edged nature of all substances. It isn't merely safe in low doses. It's essential. We must have it. For patients whose levels run low, doctors prescribe potassium chloride – the same potassium chloride used in lethal-injection executions. The dose truly makes the poison.

It's a simple idea. So five centuries after Paracelsus, why hasn't the message sunk in?

Scientific ignorance doesn't help. Notice that throughout this column I've referred to chemicals as if they are a sub-class of substances. Most people do. Or they think chemical means something that is produced in a factory, not nature. But every substance is a chemical, or made of chemicals – from water to peanut butter and diamonds – whatever its origins, and it is what it is, whether it came out of a plant or a beaker. If people don't know even this, it's a small wonder they make bigger mistakes. The news media are also responsible. The New York Times recently informed its readers that "some hair straighteners contain formaldehyde, a known carcinogen"– without offering a word about quantity (much less noting that formaldehyde is so common it is found in broccoli, baked bread and every healthy human body). Late last month, USA Today informed readers that tests detected "the controversial weed killer glyphosate" in 19 out of 20 wines and beers sampled, including organic products. To be fair, USA Today went on to report that the activist group responsible for the testing had

acknowledged that “the levels of glyphosate we found are not necessarily dangerous but are still concerning given the potential health risks” – a statement seemingly designed to protect against accusations of ignoring the science while also pushing the science aside lest it reduce fear. Unfortunately, these examples are typical of news reports about chemicals. The underlying assumption is always that the mere presence of a scary-sounding substance is itself significant. If the toxicologists’ concern of “how much?” is even acknowledged, it is buried in the story, and is usually expressed by an industry spokesperson – which makes elementary toxicology sound like corporate spin.

But the root of the problem lies much deeper. Psychologist Paul Slovic and his colleagues call it "intuitive toxicology.”

Like us, our ancestors had to decide what was safe to eat and drink, but the only tools available to them were their senses. In that environment, it made sense for quantity to be irrelevant. If our ancestors could see, smell or taste contamination – such as feces in drinking water – it was pointless to ask “how much?” Any detectable amount was too much.

This was the reality for virtually the entire history of our species, along with the history of the species we evolved from. It shaped our brain’s evolution. Intuitive toxicology is hardwired. It shapes how we naturally think about chemicals today.

But we don’t live in the world that our brains evolved in. Today, thanks to science and technology, we can detect inconceivably tiny quantities. A part per million. Or billion. Or even trillion. How little is one part per trillion? The inimitable science communicator and chemist Joe Schwarcz has a vivid illustration: Imagine a football field surrounded by six-metre-high boards and filled to the brim with sand. Buried in there somewhere is one particular grain of sand. That is one part per trillion. To understand information such as that, “intuitive toxicology” is worse than useless.

For toxicologists, “the poison makes the dose” is banal, obvious, almost second nature. But for the rest of us, it is profoundly counterintuitive – even bizarre – to shrug and drink a glass of arsenic-laced water. Poison is poison, we feel. And it’s hard to ignore feelings shaped by hundreds of thousands of years of evolution.

And yet, we are not slaves to intuition. Toxicologists are human, too. The fact that they are able to see the world as they do demonstrates that people can rein in “intuitive toxicology” and let the real thing guide our decisions.

It takes education and effort. But most of all, it takes a dogged insistence on asking a simple question: “How much?”

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