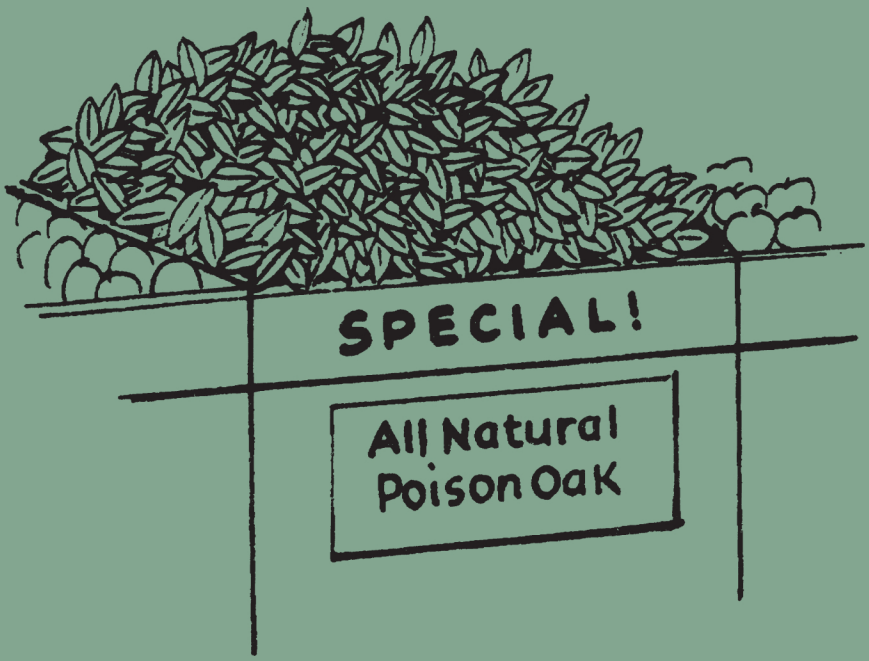
151 Myths of Everyday Science



Arthur Furst

151 Myths of Everyday Science

151 Myths

of Everyday Science

Arthur Furst

Privately published, 2002

"Faith may be defined briefly as an illogical belief in the occurrence of the improbable."

—H.L. Mencken

Contents

Preface: Science and Myth

Everyone knows that all human cancers are the result of exposure to toxic chemicals. Often we know the specific chemical involved, even if its manufacturer doesn't want to admit it.

Similarly, we all know that anyone who develops lung cancer of any type is or was a cigarette smoker, though the tobacco companies continue to maintain otherwise.

There is no question that damage to the human body can only be caused by synthetic chemicals. In fact, the decrease in lifespan in civilized countries is due to the introduction of so many synthetic chemicals. What is wrong with our government regulatory agencies? Why do they allow all these toxic, cancer-causing agents to be added to our food supply?

Worse, perhaps, is that big companies are now altering our foods with modern genetic engineering techniques. Soon Frankenstein foods will be foisted upon us.

Lucky for us, though, natural products are safe and harmless. It's a good thing that we can buy organically grown foods, which are grown without fertilizers or pesticides and have no toxic components.

All of the above are myths—or are they? Do modern-day myths have a basis in reality?

To answer this, we must first ask what a myth is. *Webster's Illustrated Encyclopedia Dictionary* defines "myth" as: **1.a.** A traditional story originating in a preliterate society, dealing with supernatural beings, ancestors, or heroes that serve as primordial types in a primitive view of the world; **b.** A body of such stories told among a given people; a mythology: as in Norse myth; **c.** All such stories collectively. **2.** Any real or fictional story, recurring theme, or character type that appeals to the consciousness of a people by embodying its cultural ideals or by expressing commonly felt emotions: the

I. Toxicity and Chemicals

1. Natural Is Good

Background

Many people among the general public believe that the contamination of our environment is a result of the introduction of synthetic chemicals. A portion of the general population believe that most illnesses are the result of exposure to synthetic chemicals. On the other hand, the same people consider natural products to be safe and best to use.

Myth

Synthetic chemicals are bad, whereas natural compounds are safe and good.

Reality

Many compounds made in laboratories and factories are absolutely identical with those found in nature. There is no difference in chemistry or biological action, and in many cases there is no difference in nutritional value.

In reality, there are very few synthetic products that are as toxic as certain natural substances. Exposure to some natural chemicals can be fatal.

Cyanide, a natural substance, is fatal at a dose of 10,000 micrograms (mcg).

Botulism is natural, and it is lethal in doses as small as 0.03 mcg; one thimbleful could wipe out half of a city's inhabitants.

Tetanus toxin is lethal at 0.7 mcg.

For cobra poison the value is 0.3 mcg.

Poison oak and poison ivy are also natural.

Scientifically speaking, general statements of "good" or "bad," "toxic" or "safe," are not adequate to describe any substance or agent.

Synthetic chemicals are ubiquitous in the modern world. The vast majority of prescription drugs are synthetic. Much of the fabric used in clothing is synthetic. Plastic bottles are everywhere. It is impossible to avoid synthetics in our daily lives.

And yet the average life expectancy has actually gone up in recent decades.

2. All Chemicals Are Toxic

Background

At some (mostly very high) dosage, every chemical becomes toxic.

Myth

All chemicals are bad, because all chemicals are toxic. Since chemicals are chemicals, their origin makes no difference. In fact, we should coin a new single word, as a contraction: "toxichemical."

Reality

In the early 1500s (the date has been variously reported) the concept of quantification of poisons was presented by Philippus Aureolus Theophrastus Bombasus von Hohenheim—who, following the tradition of his day, changed his name to Paracelsus upon receiving his doctoral degree, so as to resemble a Greek philosopher. His dictum is as useful today as it was in his time. In paraphrase, what he said was, "What is there that is not a poison? All things are poisons, and nothing is without poison. The right dose differentiates a poison from a remedy."

Following Paracelsus' cue, the modern toxicologist takes as his slogan "*The dose makes the poison.*"

When the term "chemical" is used, a certain segment of the population equates it with *synthetic* chemicals. The next thought is "toxic."

Everything in the universe is made up of chemicals, including human beings. Without chemicals there would be no universe. In a sense, every substance is potentially toxic if the dose is large enough. This includes oxygen, which is necessary to sustain life. The opposite is also true: at a low enough dose, no agent manifests toxicity; if a low enough dose is used, the chemical becomes innocuous. For every chemical, there is a threshold below which no toxicity is noticed.

There is one exception to this. By law (but not by science), there is no permissible "sub-threshold" dosage for chemicals that have been declared carcinogenic.

3. Hormesis

Background

In classical toxicology, a dose-response curve is commonly used to describe the effects of toxins. As the dose is increased, the response becomes more pronounced. As mentioned before, the opposite is also apparently true: as the dose is decreased, toxicity becomes less pronounced. Eventually, at a low enough dose, there will be no toxic response. This means a threshold has been crossed.

Myth

When a biological system is exposed to a toxic agent, there will always be some adverse effect on some organ. As noted, the greater the dose, the more injury will result. However, if the dose is lowered, there will be less harm, but there will still be harm. Only if there is *no dose* will there be no harm. There may be a dip in the curve at some "threshold" point, but this has no meaning.

Reality

It is true that as the dose is lowered, toxic response decreases. (For the record, this response is not linear). In many cases a different and little-known phenomenon takes place, which may be the reason for the dip in the dose-response curve known as a "U-dip" or "hockey stick" dip.

A pharmacological inversion may take place. At some low dose, a known toxic compound may become biologically beneficial! This phenomenon is known as *hormesis.*

Hormesis can be defined as a stimulatory effect that occurs when a substance which, at high doses, results in negative effects (growth inhibition or toxic manifestations), produces positive effects at much lower doses (growth stimulation; enzyme activation).

Examples are legion. Mice exposed to very low doses of x-rays live longer than unexposed mice used as control subjects; at higher doses, the mice develop cancer. Arsenic is a growth stimulant at very low doses; at high doses it is toxic. Cadmium, one of the most toxic metals, will stimulate the growth of cells at low doses.

REFERENCE: Calabrese, E.J. and Baldwin, L.A., eds. (2001). Special Issue: "Scientific Foundations of Hormesis." *Critical Reviews in Toxicology.* Vol. 31, nos 4–5.

4. Organic Acids

Background

Acids are corrosive to the skin. When they come into contact with skin, they can burn holes in it. People have become disfigured when they were accidentally exposed to strong acids.

Myth

I just read the label on my soft drink. It contains citric acid. Acids are acids. How dare the company put an acid in a drink? I will not drink any more of this brand!

Reality

There are hundreds of different acids. Some are corrosive, like hydrochloric, nitric, and sulfuric acids. However, there are many organic acids (i.e, those that contain carbon) that are very weak. Vinegar is an example.

Two factors influence corrosiveness: the nature of the acid, and its concentration. Citric acid is non-toxic and is a natural constituent of lemons, for example. At the concentration at which citric acid is used in soft drinks, it is safe and presents no problem. People who drink excessive amounts of soft drinks may have some physiological or medical problems, but these are not citric acid problems *per se*.

5. Arsenic

Background

Arsenic has been declared a human carcinogen, mainly because of results from epidemiological studies of environmental and occupational exposure.

Myth

Arsenic is carcinogenic because small amounts of it are retained in the body. Given enough time, a critical concentration will be reached, and cancer will result.

Reality

Arsenic is not accumulated in the body. When a person is exposed to arsenic, he or she starts to excrete it in the urine almost at once. Rates of excretion are easily followed. About 50% to 60% of ingested arsenic is excreted within a week.

Only exposure to high concentrations on a daily basis can lead to cancer. In occupational settings, such as at metal foundries, workers are constantly inhaling residues of arsenic and other heavy metals.

There is doubt as to whether the presently permitted concentration of 50 μg per liter can be carcinogenic.

REFERENCE: Vahter, M. and Marafante, E. (1988) "In vivo methylation and detoxification of arsenic." In Craig, P.J. & Glockling, F., eds., *The Biological Alkylation of Heavy Elements*. Royal Soc. Chem., London, pp. 105–199

Yager, J.W., Hicks, J.B., and Fabianova, E. (1997) "Airborne Arsenic and Urinary Excretion Of Arsenic Metabolites During Boiler Cleaning in a Slovak Coal-Fired Power Plant." *Environ. Health Per.* 105:836–842.

About the Author

Arthur Furst, Ph.D., Sc.D., is the Distinguished University Professor Emeritus at the University of San Francisco. In 1940, he started research in cancer and toxicology. He is the author of more than 300 research publications, reviews, and abstracts. Dr. Furst has received a number of honors, among them the UCLA Medal for Excellence in Professional Achievement. More recently, in 2001, he became the first and only recipient of the Lifetime Contribution Award presented by the American College of Toxicology. He is a fellow of five scientific societies.

Now retired, Dr. Furst lives in Cupertino, California.