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Flatus: Chemistry In The Wind

There’s chemistry going on in that digestive tract of yours. As for the products of those reactions? Solids, liquids, and a whole lot of gas!

By Claudia Vanderborght

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No doubt you’ve heard many words for it. We’re going to go with flatus.

A topic of serious scientific study, flatus research has been conducted since the early 19th century.

During World War II, the U.S. Air Force was faced with a problem. As new fighter planes broke ever higher altitude records, pilots experienced ever more painful intestinal cramps.

Think about Boyle's law, and you'll find the explanation: The volume of a gas increases as the pressure on the gas decreases, when kept at a constant temperature.

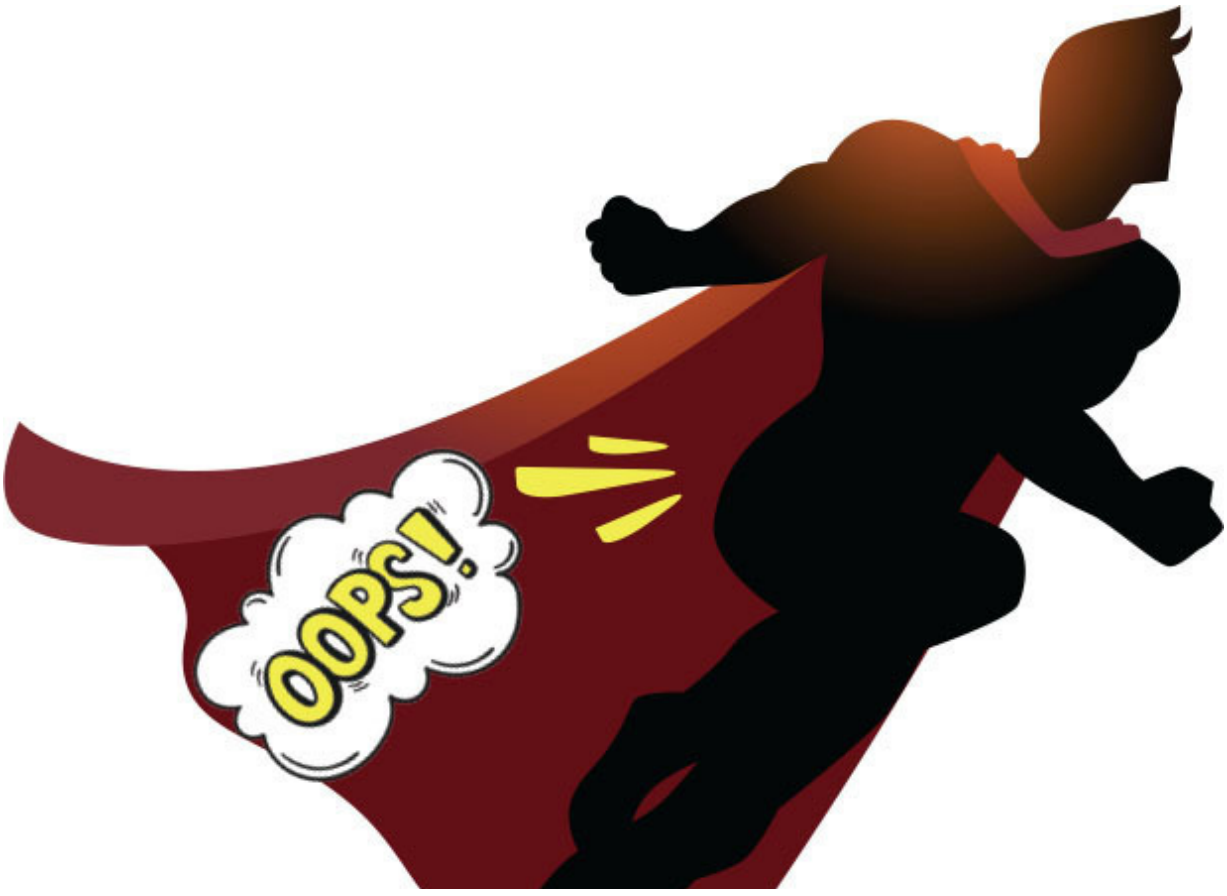
flat·u·lence (fla-ch-l ns) n.

The presence of excessive gas in the digestive tract.

Self-importance; pomposity.

fla·tus (flā-təs) n.

1. Gas generated in or expelled from the digestive tract, especially the stomach or intestines. [Latin flatus, *to blow*; see bhl- in IndoEuropean roots.]



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WHAT CAUSES EXCESS GAS

For the pilots, the expansion of gas was all too personal. As altitude increases, atmospheric pressure decreases. The digestive gases trapped in the pilots' intestines were just following Boyle's law as they expanded to proportions that were very painful.

The Air Force decided that dried beans and peas, vegetables of the cabbage family, carbonated drinks, and beer were off the menu for pilots. All of those items were known to be particular culprits for producing intestinal gas.

In 1976, a patient walked into Dr. Michael Levitt's office in the Minneapolis Veteran's Hospital complaining of frequent flatulence. Most people pass gas between 5 and 15 times each day, each time resulting in 35–90 milliliters, or about 1-3 oz. (You've always wanted to know that! Admit it.)

But this unfortunate patient was producing far more gas than the average individual. Had he lived in medieval Europe, this would have been considered a sign of manly strength and a source of pride. But Levitt's patient was physically and socially miserable.

Levitt checked the medical literature and found very few quantitative or qualitative studies on flatulence. What was unique about this patient? Levitt knew that some people just pass more gas than others.

THE ROLE OF DIET

Vegetarians produce more gas than meat eaters because they eat more gas-producing carbohydrates. He considered that not everyone grows the same species of bacteria in their digestive tracts. Different bacteria produce different

gaseous products from the same foods.

Excess gas may also be caused when key digestive enzymes are missing—generally an inherited condition. In the United States, 25% of adults of European descent and 75% of adults of African or Asian descent do not produce sufficient lactase.

Lactase is the digestive enzyme needed to digest a milk sugar called lactose. Dr. Levitt finally arrived at the conclusion that his patient was lactose intolerant. As soon as the patient stopped consuming milk products, his flatulence returned to more normal and more comfortable levels.

It might surprise you that the odorless gases nitrogen, oxygen, hydrogen, carbon dioxide, and methane account for more than 99% of human flatus. Nitrogen (N_2), which diffuses from the blood, is usually present in the greatest quantities; oxygen, the least.

The volumes of the other three gases vary for individuals, their diets, and even the time of day.

THE ROLE OF BACTERIA

The amount of hydrogen, carbon dioxide, and methane in flatus depends on the population of hydrogen-consuming bacteria in your digestive tract. Each day, you produce about 1 liter of hydrogen (H_2) in your intestinal colon.

But other bacteria may be present to use some of that hydrogen to produce methane (CH_4) and other gases.

Here's an interesting fact. Only about one-third of people in the Western Hemisphere are methane producers. If you are one of them, you produce a lower volume of gas, and your stools tend to float in water.

Methane production by animals is considered a contributor to global warming. Termites alone produce an estimated 165 million tons of methane each year. A typical cow probably emits 200 liters of methane into the atmosphere each day. What does this have to do with climate change?

Methane has about 25 times the global warming potential as carbon dioxide. In New Zealand, the government has even considered levying a special tax on grazing animals. The goal is to reduce their greenhouse gas emissions by 300,000 tons per year.

Herders and cattle producers are seeking feed additives for controlling the amount of methane generated during digestion.

Methane, the typical fuel for laboratory Bunsen burners, is quite combustible. Early in the space race, U.S. National Aeronautics and Space Administration scientists worried that gas emitted from the astronauts could accidentally explode within the sealed spacecraft.

To date, no astronauts have died from exploding flatulence, but at least one surgical patient has! In one notable incident, a surgeon touched an electrode to a patient's colon, accidentally igniting the contained gases.

The hydrogen and methane exploded, blowing the surgeon back to the wall of the room.

BURNING QUESTION ABOUT GETTING RID OF ODORS

In a *Boston Globe* interview, flatus researcher Michael Levitt commented on the custom of lighting matches to rid the air of flatus odor. He said the strong odor of the burning match probably masks most of the odors.

But it's likely that combustion does change some of the offending molecules so they no longer bind with the same smell receptors in the nose.

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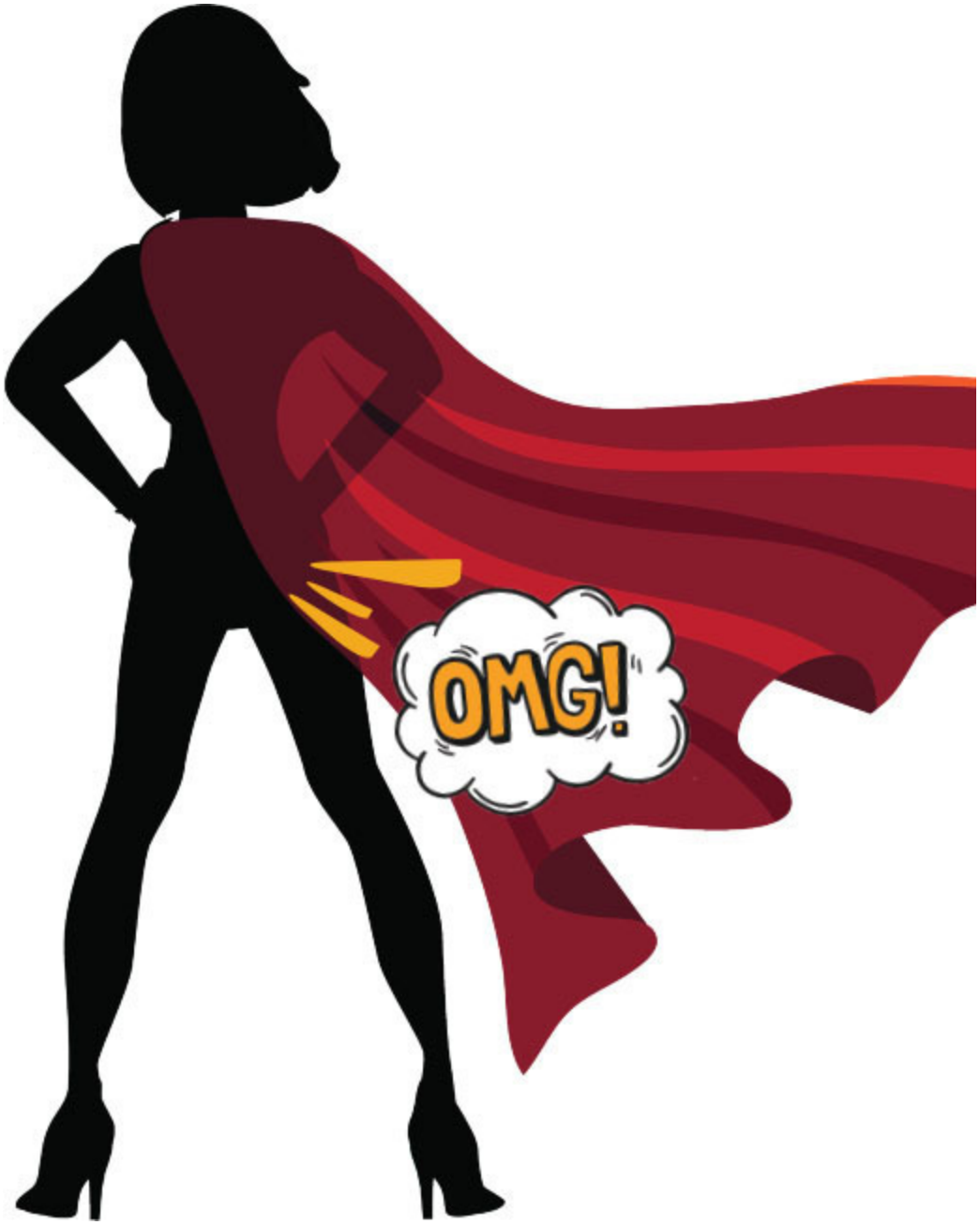
$$4\,H_2 + CO_2 \rightarrow CH_4 + 2\,H_2O$$

Five moles of gas react to form one mole of methane. Gas volume reduces dramatically in the process!



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WHAT CAUSES THE STENCH

But what about the more personal connection between flatus and air quality?

Qualitative research on flatus requires some sophisticated and some not-so-sophisticated methods.

Gas chromatography identifies compounds in a complex gaseous mixture; infrared spectroscopy identifies molecules by how they interact with infrared radiation; and mass spectrometry identifies gases by measuring their molecular masses.

One recent study adopted a lower-tech approach by using people with sensitive noses to identify flatulence gases. The subjects held syringes 3 centimeters (a little more than an inch) from their noses where they slowly ejected the gas, taking several sniffs.

Despite what many women may believe, studies show that they release the same volume of flatus as men, with the same—um, qualities. But studies do show that women may score higher on sensitivity to odors.

Both men and women can distinguish tens of thousands of odors, but only three sulfur-containing compounds give flatus its characteristic odor.

Hydrogen sulfide (H_2S), sometimes called "rotten egg gas," is the main culprit. Our noses begin to detect H_2S in concentrations of 0.005 parts per million (ppm).

In flatus, its concentration averages 0.36 ppm. At concentrations of 50 ppm, most find H_2S very offensive; and at concentrations of 300 ppm, H_2S is deadly—literally!

Two other gases—methanethiol (CH_3SH) and dimethyl sulfide (CH_3SCH_3)—are present in much smaller concentrations, but our noses are very sensitive to their presence.

Blame your bacteria and your diet for the odors in flatus. Sulfur-containing foods, such as onions, eggs, broccoli, beer, and some beans, are often not fully digested when they reach the large intestine.

If your intestinal bacteria can ferment sulfur-containing compounds, the resulting gas products will register it. But there is some good news. Four moles of hydrogen gas are consumed to make one mole of methane. At least the volume of flatus diminishes in the process.

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NEED HELP? SEVERAL PRODUCTS PROMISE GAS RELIEF

Beano helps break down the complex sugars found in beans, cabbage, and several other "gassy" carbohydrates found in high-fiber diets. It contains an enzyme, alpha-galactosidase, for breaking these offending sugar molecules into ones that our bodies can comfortably digest.

Similarly, Lactaid supplies the enzyme lactase to those whose bodies are lacking sufficient amounts to successfully convert the milk sugar, lactose, into digestible products.

By accomplishing these chemical steps, Beano and Lactaid work to prevent gas. Since the active ingredients in both products are proteins, you can't add them to foods before cooking.

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The high heat will alter the shape of the enzyme active site, rendering it ineffective. Beano and Lactaid are recommended for people over the age of 12.

Other weapons in the war against gaseous discomfort are products, such as Gas-X, which contain the active ingredient simethicone. These products work on gas bubbles by reducing the surface tension and thereby disrupting or breaking the bubble.

A neat trick is to place a few drops into a foamy beverage and watch the bubbles disappear.

When gas bubbles are trapped in the stomach or lower bowel, simethicone medications release the gas for belching or flatus. They do not prevent the formation of gas in the first place.

[Ed. Note] Some updates since 2003: The sound that flatus makes is caused by gas passing through the sphincter muscles at the exit of the anus. The tone can vary based on the amount of gas, the shape and tension of the sphincter muscles, and the rate the gas moves through the anus.

Since 2003, the amount of methane released by livestock was reduced through a series of measures, including changes in feed and the handling of urine and manure. New Zealand's tax on livestock emissions is scheduled to take effect in 2025.

At the time of publication, **Claudia Vanderborght** was a chemistry teacher and science writer in Swanton, Vt. Her article, "Hot Air Balloons—Gas and Go," appeared in the April 2002 issue of *ChemMatters*.

REFERENCE

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