CRAZY ABOUT VITAMINS

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One half of Americans take vitamins regularly, according to a Gallup poll (Swift, 2013). Indeed, 78 percent agree that "dietary supplements are a smart choice for a healthy lifestyle" (Council for Responsible Nutrition, 2015). People seem crazy about vitamins (Figure 1).

But does this mean that the population is well informed about the biological function of vitamins, or that such knowledge guides personal decision making about nutrition and health? Perhaps not. Reliance on supplements might actually indicate a poor basic understanding of a complete and balanced diet. Taking high doses of vitamins may also reflect unjustified beliefs about their power in curing various maladies, despite the lack of any substantive scientific evidence. Perhaps we might unravel the pervasive Sacred Bovine that vitamins have some extraordinary powers beyond their very particular nutritional roles?

No biologist, surely, will question the general importance of vitamins or the diseases—such as beriberi, scurvy, or pellagra—that result from their deficiencies. "For example," as the National Institutes of Health notes, "calcium and vitamin D are important for keeping bones strong and reducing bone loss; folic acid decreases the risk of certain birth defects; and omega-3 fatty acids from fish oils might help some people with heart disease" (Office of Dietary Supplements, 2011). In these cases, the molecular mechanisms involving the vitamins are well known.

But at other times, claims about the efficacy of vitamins are speculative or with no scientific grounding whatsoever. Yet such unfounded beliefs proliferate. Sometimes, with great conviction. Indeed, people can be "crazy" about vitamins. How does such trenchant dismissal of science originate? Why does it persist?

○ Crazy about Vitamin C

One might gain insight from the history of vitamin C and its purported role in fighting the common cold. For many years, popular belief (sometimes masquerading as conventional wisdom) was that megadoses of vitamin C would help cure or prevent the common cold. In most circles, that myth has been properly debunked. Yet in other spheres, its allure remains.

The claim originally came from someone with an impressive scientific pedigree. It was promoted by no less than renowned chemist Linus Pauling, with two Nobel Prizes to his credit. His 1970 book, *Vitamin C and the Common Cold*, became a rallying point. However, subsequent research has repeatedly not supported his enthusiastic claims (Vorvick, 2016).

Why, then, did Pauling support this position? His personal history is telling. At a public lecture in 1966, Pauling expressed his thrill at the prospect of living longer, to experience more scientific discovery. Irwin Stone, a biochemist who attended that lecture, recommended that he take megadoses of vitamin C. Stone had industrial experience with ascorbic acid as an anti-oxidant and food preservative, and had developed an untested theory about the cause of scurvy as genetic, not nutritional. Following Stone's informal advice, Pauling, along with his wife, simply began to take vitamin C. Pauling's personal experience of feeling better seemed to convince him of the significance of vitamin C (Pauling, 1992).

Pauling later surveyed the research literature for properly controlled studies. But his initial beliefs biased his scientific interpretations. A retrospective analysis of sources available at the time shows that Pauling disregarded or discounted negative studies (Knipschild, 1994). Pauling's reasoning thus exhibited two common cognitive errors: primary reliance on anecdotal rather than systematic evidence (coupled with a hope-laden viewpoint), and confirmation bias, the tendency to reinforce initial beliefs (*Sacred Bovines*, Aug., 2010). Pauling's advocacy reflected a common view of vitamins. A bit of wishful idealization, combined with cherry-picking of evidence, allows for conclusions that *seem* scientifically sound but are not. The conventional version of the scientific method goes awry here.

Pauling's error about vitamin C is a valuable cautionary tale. Even the scientifically minded are susceptible to unconscious bias. History can help us gain awareness of fads and popular crazes by providing a more remote, neutral perspective. Retrospect can help us tease apart the roles of evidence versus emotional fervor.

○ Crazy about Vitamin D

The craze today seems to be about vitamin D. Consider one headline in the "lifestyles" section of a major city newspaper: "Doctor preaches wonder cure: Vitamin D." The next line elaborated: "It reduces pain. It reduces illness. There is almost nothing that vitamin D can't help, and that's Dr. Greg Plotnikoff's point" (Marcotty, 2008). Extraordinary claims. Inspiring even. But for that very reason, also suspect. They do not reflect scientific consensus. Such is

The American Biology Teacher, Vol. 79, No 8, pages. 688–691, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: https://doi.org/10.1525/abt.2017.79.8.688.

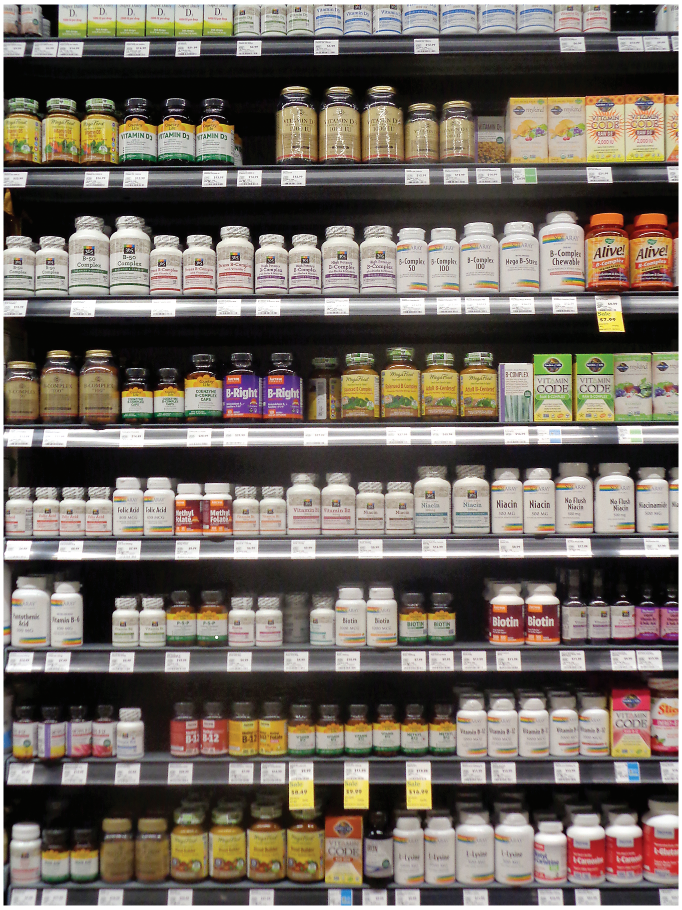

Figure 1. Vitamins—and more vitamins.

the enthusiasm for vitamins that even customary journalistic caution seemed worth abandoning.

Four years later, the same doctor was featured again, this time for a study on the effect of vitamin D in the workplace (Crosby, 2012). Again, it seemed that a small investment in vitamins would yield great benefits—this time, in worker productivity (Plotnikoff et al., 2012). The study correlated blood levels of vitamin D to attentiveness at work (called "presenteeism"). The results relied on self-reporting for a one-week period. There were correlations, but the trend was not consistent. The differences in perceptions of worker attention (based on vitamin D levels) were *statistically* significant, yet they were not significant in an ordinary sense of being large enough to matter. The estimates of the economic impact used some generous, but dubious, assumptions linking employees' informal perceptions to actual work performance and value. The conceptual substitution was a mostly unnoticeable, but unjustified sleight of hand. Other relevant variables (such as seasonal behavior and general discipline) might easily have explained the observations, yet were not fully researched. Overall, the methods inflated the apparent importance of vitamin D blood levels. Ironically, 41 percent of the study participants reported already taking vitamin D supplements. Yet the researchers deemed that for 85 percent, their levels were "deficient."

The newspaper did not report on an obvious question: who funded this study? The research cost over one million dollars. Answer: DiaSorin, a firm that had recently released a new vitamin D blood test. Dr. Plotnikoff was identified as a DiaSorin consultant, thus with a conflict of interest. Little wonder the research might exhibit telltale flaws. The newspaper elected to blindly celebrate the virtues of vitamin D and those who advocated them. With the generally favorable reputation of vitamins, perhaps, how could they not?

Concern over Vitamin D blood levels has skyrocketed, with little evidence that there has been an "epidemic" of deficiency, as Plotnikoff suggested. Screening, likewise, has increased dramatically. Among Medicare patients, testing has increased by a whopping factor of 83 over ten years (from 2000 to 2010; Kolata, 2017). The tests almost always show that Vitamin D levels are sufficient by conventional norms. But testing labs that adopt high cutpoints can report apparent "deficiencies" (apparently also validating the choice to pay for such tests). Faced with the hype and uncertainty, a specialized panel of the National Academy of Sciences (the government's nonpartisan body of experts) reviewed target levels of vitamin D in 2010, concluding that Americans generally do indeed get sufficient amounts in their diet (excluding rare special cases) (Institute of Medicine, 2010b). As the wave of testing continued, the U.S. Preventive Services Task Force (an independent government panel) reviewed the status in 2014 and found no clear justification for such testing. Still, other voices continue to appeal to the residual unknowns and leverage the uncertainty into a precautionary mandate for testing and prescribing vitamin D supplements (sometimes ten times the daily recommendation). Who benefits most from such pronouncements? Who bears the costs?

The contemporary case of vitamin D further highlights the challenges in heeding what is scientifically validated and rejecting what is not, and how cultural and cognitive factors beyond the evidence may shape beliefs and actions.

○ Just Crazy

The health-conscious consumer faces the awesome task of distinguishing genuine science from "what counts as science" in the public realm (*Sacred Bovines*, April, 2012). Misleading claims about vitamins scatter the media landscape. They hardly announce their own flaws. The individual is left to make sense of a concoction of anecdote, hidden advertising, social networks, and promotional literature, along with statements by bodies of experts and independent public institutions. Understanding science, it seems, includes being able to assess expertise and credibility, and acknowledging the potential for science con-artists (*Sacred Bovines*, Nov., 2012).

The corresponding challenge for teachers is just as formidable. By the time students arrive in a biology class, they already have well-entrenched ideas. As children, their parents likely bombarded them for years with admonishments to take their daily vitamins. Even knowing nothing about what vitamins do. Something (vaguely) about growth and strong bodies. The term "vitamin" itself conjures images of "vital" ingredients and "vitality"—a potent connotative prejudice relevant to educators. Imagery can trump fact.

Teachers might also consider the future cognitive environment where lessons from schooling will compete with other influences. Anecdotal reports, like those of Pauling and Plotnikoff, abound. Further, emotions about maintaining optimal health and youthful vigor can strongly color thinking. An effective lesson must anticipate how science is typically discounted or eclipsed in real-life contexts. How does one prepare students to recognize circumstances that may mislead them? Recall all those folks who take supplements. Likely they all had a biology class. What did they ultimately learn?

So, what might an effective lesson on vitamins look like? Well, it will hardly focus on just a list of vitamins, their cellular functions and deficiency diseases, or the foods that contain them. All that is soon forgotten. And easily dismissed. Rather, one might first plan to instill the very notion of vitamins as essential micronutrients. They are *not* "curative factors," but fill *very particular* roles in normal physiology. That concept is foundational to countering impressions that vitamins might contribute vaguely to overall well-being or alleviate miscellaneous chronic conditions. Students should become skeptical by default about vitamins doubling in non-nutritional roles. (For a sample classroom activity, see the interactive story of Nobel Prize winner Christiaan Eijkman's search for the cause of beriberi: http://shipseducation.net/modules/biol/beriberi.htm.)

Second, one might engage students in determining for themselves a target daily intake. It's a very plain-thinking challenge: what are the appropriate dietary requirements to be healthy? The rationale should not be a mystery. Here, one can see how easily the lesson will generalize to all nutrients, and even to other aspects of "black-boxed" science. Having engaged in this activity, students are primed to compare their ideas with the professionals'—how all those familiar RDA figures on food labels are determined (see the summary by Institute of Medicine, 2010a). Next, perhaps, how does one meet all those requirements (Mayo Clinic Staff, 2014)? What does a complete and balanced diet look like, and honestly, does it *really* matter? One can demystify science by making the process personal.

Third, help students interpret and cope with "science in the wild"—scientific claims beyond the textbook. How does one interpret messy controversy and contradictory claims that vie for legitimacy in an untamed society? A historical case such as Pauling's may be a fruitful prelude. Personal biases matter. Even for famous scientists. Students need to work through contemporary scenarios where scientific evidence can easily become irrelevant, such as the vitamin D case. For example, many advocates of vitamins opine that it is difficult to overdose on vitamins, so why not take supplements just to "play it safe"? Can students see the needless expense? Who pays and who benefits? Indeed, over $14 *billion* is spent annually on vitamins and minerals (quite apart from other nutritional supplements—another $22 billion; Nutrition Business Journal, 2015). Vitamins are big, *big* business (Goldacre, 2008, 2010). Then there is the dilemma of personal testimony such as, "My aunt takes vitamin D to treat her arthritis and she swears by it." Why do people go crazy about vitamins? If half the population takes vitamins, does that prove their worth? Why would respectable scientists call all those supplements nonsense (Coghlan et al., 2014; Guallar et al., 2013; Hensrud, 2013)? All this leads students to articulate more personally and deeply why they should trust science at all—and who they should trust to speak on behalf of science. What is the nature of scientific expertise, credibility, and authority (*Sacred Bovines*, May, 2012)? One cannot expect science to triumph unless students learn tools to resolve such challenges.

All this may seem like a hefty chunk of class time for a "simple" lesson on vitamins. But of course, it is not a "simple" lesson at all. And surely is not about vitamins only.

Exhortations to "simply" heed facts about vitamins mean little without understanding the nature of science. The craze about vitamins seems a prime occasion to foster functional scientific literacy. We can nurture consumers and citizens who are more reflective and informed—not about the facts, but about how science crafts trustworthy claims.

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