authors and reviewers. And more diversity in HIST would also enrich its programs.

Recognizing the desirability of more diversity in our institutions is a necessary but not a sufficient step in making them more diverse. It is not enough to welcome and value all comers: proactive outreach is required for meaningful progress to be made.

In pointing to the need for more diversity of backgrounds and perspectives, I do not wish to deprecate the efforts already made in that direction by the *Bulletin*, by HIST, and by ACS. I close by pointing out two further opportunities to learn more about the history of African Americans in chemistry. HIST will sponsor a symposium on that subject, organized by Sibrina Collins, Taiya Fabre, and Tracey Simmons-Willis at the Fall 2021 ACS National meeting. (The Fall 2021 meeting will have a hybrid format, so it will not be necessary to be in Atlanta to partake of the programming.) And the ACS Symposium series has just published, online at least, a volume titled *African American Chemists: Academia, Industry, and Social Entrepreneurship*, edited by Sibrina Collins. Expect to see a review in the next issue of the *Bulletin*.

About the Author

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COMMENT AND RESPONSE
The Toxicity of Mercury

Volume 45, issue 2, contained a paper on mercury, its singular properties, and several of its toxic effects over time (L. C. Soares, "From 'Blue Pills' to the Minamata Convention: Mercury, a Singular Metal," *Bull. Hist. Chem.,* **2020**, *45*, 67-79). Prof. E. J. Behrman wrote with a wish that the paper had treated the varying effects of different chemical species in greater detail. Prof. Soares took the opportunity to provide some additional information differentiating the effects of different mercury species, and explaining how the less toxic metallic form still presents hazards. Prof. Behrman's letter and Prof. Soares's response are printed below.

—Editor

Comment by Prof. Behrman

Dear Editor,

I wish that the author had emphasized more strongly the importance of the chemical state of mercury in discussing toxicity. Elemental mercury is not the same as dimethyl mercury. A casual reader might be left with the impression that all forms of mercury are equally toxic from the frequent use of "mercury" rather than "mercury compounds." Elemental mercury is hardly toxic at all because it is so unreactive. (An exception is mercury vapor, produced by heating, if inhaled. However, at room temperature its vapor pressure is very low, viz. 1.84×10^{-3} mm at 25 °C vs. 760 mm at 356.9 °C, its boiling point—hence its use in vacuum systems.) Of course, even at room temperature, there is some vapor phase mercury, but the dosage matters. An analogy would be to avoid carbon and nitrogen because their combination is the cyanide ion. Schools need not be shut down because mercury has been spilled from a broken thermometer.

Indeed, mercury thermometers need not be banned. They are a small hazard and become so only when the mercury that they contain is vaporized upon destruction of the school by fire. In the author's favor, I point out that she has properly compared lethal doses (LD_{50}, species?) for mercuric chloride and mercury (100 g!) on p. 72, 2nd column, 4th paragraph, but it is not only the relative solubilities that matter but also the reactivities. It would be useful to have a table of LD_{50}'s such as that given by Von Burg (1) as well as a citation of Goldwater's book (2).

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1. R. Von Burg, "Toxicology Update: Inorganic Mercury," *J. Appl. Toxicol.*, **1995**, *15*, 483-493.
2. L. J. Goldwater, *Mercury: A History of Quicksilver*, York Press, Baltimore, 1972, Chap. 11 & 12.

Response by Prof. Soares

Dear Editor,

I thank Prof. Behrman for reading my paper and for his feedback. I really appreciated his comments. Here I take the opportunity to expand beyond what was in my original article in the areas mentioned; I hope that what follows meets his expectations.

In the text, I noted "The poisoning symptomatology depends on the dose and the exposure rate. Furthermore, biological behavior, pharmacokinetics and clinical significance vary with the chemical species." Although it was not the main aim of the paper, I really could have emphasized more strongly the importance of the mercury species in discussing toxicity.

It is true that metallic mercury (Hg^0) is much less toxic than organic mercury compounds, even than mercury salts. For example, for $HgCl_2$, the lethal dose may be less than 0.5 g, compared with 100 g of Hg^0 (1). It is also true that the toxicity of Hg^0 is dose-dependent. Hg^0 is particularly toxic in the case of acute or chronic exposure, as in several occupational cases (e.g., antique hatters, miners from artisanal/small-scale gold mining and dentists, as shown in the text).

An example of intense exposure to Hg^0 was reported by Cordy *et al*. (2) and Webster (3). Cordy *et al*. (2) reported that Antioquia department, in Colombia, shows "the world's highest per capita mercury pollution." According to the authors, because of the guerrillas and paramilitary activities in the rural areas of Antioquia, miners take their gold ores to be processed in the "processing centers" or "entables" in the town. About the Hg^0 pollution in Antioquia, Webster (3) reported:

> … it begins a few minutes after arrival with an unfamiliar, metallic taste on the tongue. Within an hour, it has crept to the back of the throat. After a couple of hours it is in the lungs. This is the taste of airborne mercury, a severe local environmental and public health problem …. Unlike in other parts of the world, where highly-toxic artisanal gold production is a largely rural industry, the persistence of a low-level civil war in Antioquia has driven gold producers into crowded cities where they have military protection. The result, according to a team of researchers from the UN Industrial Development Organization (UNIDO), is a set of serious community health risks centring on neurological, lung, and kidney damage.

Nevertheless, some cases are not so clear and can be very controversial, as the exposure to Hg^0 from dental amalgam, as noted in the article. This discussion is not new. In 1993, the dentist Hal A. Huggins published the book *It's All in Your Head: The Link Between Mercury Amalgams and Illness* (4) that alerts people to the dangers of using mercury in the amalgams to fill teeth. It describes the possible effects of mercury toxicity as multiple sclerosis, Alzheimer's disease, Hodgkin's disease and Chronic Fatigue (4). According to Bharti *et al*. (5):

> Dental amalgam is one of the most versatile restorative materials used in dentistry. … There is still no adequate economic alternative for dental amalgam. The combination of reliable long-term performance in load bearing situations and low cost is unmatched by other dental restorative material.

The discussion about damage caused by Hg amalgam dental fillings is still controversial and complex, as illustrated by many studies that have drawn attention to the connection between multi-antibiotic resistant (MAR) bacteria and metals, including mercury from dental amalgam (6-9).

The Hg^0 pharmacokinetics is explained by Bernhoft (10):

> On entry to the body, mercury vapor has great affinity for sulfhydryl groups and bonds to sulfur-containing containing amino acids throughout the body. Mercury vapor is transported to the brain, either dissolved in serum or adherent to red cell membranes. Metallic mercury passes easily through the blood brain barrier and through the placenta, where it lodges in the fetal

brain. Metallic mercury is, however, rapidly oxidized to mercuric mercury on entry to the blood stream, although not so quickly as to prevent considerable uptake by the central nervous system while still in the metallic form.

As previously mentioned, the poisoning symptomatology depends on the dose and the exposure rate and also the chemical species. Unfortunately, I cannot access the book by Goldwater recommended by Dr. Behrman but I refer here to the paper by von Burg (11). According to von Burg (11), citing Sollman (12), the oral LD_{10} for Hg^0 is 1429 mg kg^{-1} in humans, or approximately 100 g for a 70 kg adult. In Table 1 are shown the lethal dose (LD) values for some mercury compounds. In addition to von Burg (11, citing 12), Material Safety Data Sheets (MSDS) from several chemical manufacturers were consulted.

Table 1. Values of lethal dose (LD) for some mercury compounds.

Substance	CAS number	LD_{50} (mg kg^{-1})
Hg	7439-97-6	1429 (LD_{10}, human)[a]
$HgCl_2$	7487-94-7	41 (dermal rat)[a,b]
		1 (oral rat)[b]
		29 (LD_{10}, oral human)[a]
Hg_2Cl_2	10112-91-1	210 (oral rat)[c]
		166 (oral rat)[a]
		1500 (dermal rat)[a]
		180 (oral mouse)[a]
HgI_2	774-29-0	18 (oral rat)[d]
		75 (dermal rat)[d]
		110 (oral mouse)[a]
$HgSO_4$	7783-35-9	57 (oral rat)[a]
		625 (dermal rat)[a]
		25 (oral mouse)[a]
Hg_2SO_4	7783-36-0	205 (oral rat)[a]
		1175 (dermal rat)[a]
		152 (oral mouse)[a]
$Hg(CN)_2$	592-04-1	33 (oral mouse)[a]
		26 (oral rat)[a]

[a]Ref. 11 citing Ref. 12.

[b]Ref. 13.

[c]Ref. 14.

[d]Ref. 15.

Furthermore, one important peculiarity of the global biogeochemical cycling of mercury (which differs from those of other metals) is its volatility. Gaseous elemental mercury (Hg^0) has a long atmospheric lifetime (6-18 months) and can be transported around the world. Because of this, mercury is a global pollutant (16). Mercury has a complex biogeochemical cycle. A fraction of the Hg^0 emitted is oxidized by ozone, oxygen or ultraviolet light to water-soluble species (as Hg(II)). Those species return to the soil and water through rain and water vapor and can be re-emitted to the atmosphere as Hg^0, through deposition on soil or exchange at the air/water interface (17). Hg^0 can be oxidized through biotic (hydroperoxidases) or abiotic (photooxidation) processes (18). Methylmercury, for example, can be formed from the methylation of the Hg(II) ion through biotic or abiotic mechanisms (17). The stable bond between methylmercury and sulfur-containing groups of living organisms explains the processes of bioaccumulation and biomagnification in the aquatic environment, which promote methylmercury for animals of the highest trophic levels, such as fish. For more details about transformations in the mercury biogeochemical cycle, please, see the work by Barkay *et al.* (18).

In summary, we must consider that, in the environment, the complex biogeochemical cycle of mercury promotes the interconversion of different mercury species. Although Hg^0 is not as toxic, it can be oxidized to Hg(II) which can also be methylated. Because of this, the aim of the Minamata Convention on Mercury is to control anthropogenic releases of mercury throughout its lifecycle (mercury emission, storage and disposal). It is known that this may not always be so simple and it can be controversial (as the case of dental amalgam). Nevertheless, the purpose is to substitute the use of mercury whenever possible. That purpose also follows Green Chemistry principles.

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HIST at Pacifichem 2021

The 2021 International Chemical Congress of Pacific Basin Societies (Pacifichem) will take place in Honolulu, Hawaii, USA, December 16-21, 2021. The conference is sponsored jointly by the American Chemical Society, Canadian Society for Chemistry, Chemical Society of Japan, Chinese Chemical Society, Korean Chemical Society, New Zealand Institute of Chemistry, and Royal Australian Chemical Institute. It is currently scheduled as a hybrid event including sessions on site in Honolulu and online. HIST has organized a full-day symposium, "Hands across the Pacific: History of Collaborations and Exchange Programs between Countries of the Pacific Rim" for December 20. Further information about the congress can be found at pacifichem.org.