A NOTE ON JOSEPH BLACK AND THE SMELL OF "FIXED AIR"

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Every beginning student of chemistry today knows that carbon dioxide (CO_2) is odorless and that the gas is easily generated by adding dilute acid—say, sulphuric or hydrochloric—to some form of calcium carbonate ($CaCO_3$), such as marble or chalk. I was, therefore, somewhat taken aback when I first read in Thomas Hankins' excellent book on 18th-century science that Joseph Black identified a certain gas, which he designated "fixed air," as having "a characteristic odor (when he produced it by adding acid to chalk)." In support of this assertion Hankins cites "a letter to Cullen written early in 1754" (1). My first thought was that Black's gas must have contained odoriferous impurities. To check this possibility I decided to begin by reviewing the most accessible secondary literature dealing with Black's work on fixed air. Among the writings I looked at were two by Henry Guerlac (2, 3) and one by A. L. Donovan (4). From these writings I learned, among other things, that in the fall of 1752 Joseph Black began performing a series of experiments on two well-known alkalis, lime and magnesia, in the course of which he discovered "carbon dioxide, the first of the atmospheric gases to be identified as a distinct chemical substance" (5). Also, in Guerlac's entry on Black in the *Dictionary of Scientific Biography*, I came across the statement that "the air produced when chalk was treated with acid . . . had a pronounced but not disagreeable odor" (6). Here, then, it seemed, was Hankins' source (and indeed the bibliographic essay at the end of his book mentions the volume of Guerlac's collected writings containing the *Dictionary of Scientific Biography* entry on Black) (7). But now I was faced with a fresh puzzle because any likely contaminant of Black's fixed air, I concluded, would have had a *disagreeable* odor. Thus, of the small (though steadily growing) number of (permanent) gases that were being produced, identified, and named by 18th-century chemists—the gases we know as oxygen, hydrogen, nitrogen, sulphur dioxide, ammonia, hydrogen sulphide, and various nitrogen oxides—only nitrous oxide (laughing gas) would normally be characterized as having a "not disagreeable odor," and it could scarcely have been produced from chalk and acid (even nitric acid). In fact, the likelihood of *any* contaminants in Black's fixed air is probably low in view of his explicit determination to work only with pure materials in his experiments on fixed air (8).

Reading for myself the text of the letter (dated 3 January 1754, from Black to his teacher William Cullen) on which Guerlac and Hankins were relying for their puzzling attribution of an odor to fixed air, I found Black describing "an air or vapour," produced from chalk and vitriolic (sulphuric) acid, which possessed the property of extinguishing a candle or a piece of burning paper; and, Black adds, "yet the smell of it was not disagreeable" (9). But why did Guerlac paraphrase Black's "not disagreeable" as "pronounced but not disagreeable"? And, indeed, what do Black's and Guerlac's phrases mean? In contemporary standard English usage, "not disagreeable" generally means "agreeable" (and, so far as I can see, this was also true in the 18th century) (10). The fact is, however, that in certain contexts "not disagreeable" does not necessarily mean "agreeable;" and Black's letter provides precisely an instance of such a context. For, consider the strategic placement of the word "yet" in the clause in question: Black apparently expected a gas that extinguished flames to have a dis-

agreeable smell—any such gas, that is, except fixed air (which Black eventually came to identify with the "gas silvestre" of Van Helmont, produced by burning charcoal or by alcoholic fermentation). All this I learned from Guerlac's essay on Black's research on fixed air, where Black is quoted as saying (in 1756) that "for some years, I took it for granted that all those vapours which extinguish flame, and are destructive of animal life, without irritating the lungs, or giving warning of their corrosive nature, are the gas silvestre of Van Helmont, or fixed air" (11).

At this point I thought I was done. I had succeeded in correcting a small though not trivial misreading of a remark of Black's by noticing that his phrase "not disagreeable," in its context, could—indeed, should—mean "*not* disagreeable" rather than "agreeable." And I had succeeded by appealing to the known properties of carbon dioxide gas, in particular, its odorlessness. Nevertheless, I continued to wonder how such a knowledgeable historian of chemistry as Henry Guerlac could have ascribed a "pronounced" odor of any kind to a gas which he had just a few pages before identified as carbon dioxide (12). Was Guerlac leaning over backwards so as not to judge Black's observations by later, and so irrelevant, criteria? This methodological issue had, indeed, come up earlier in Guerlac's "Joseph Black and Fixed Air" when he recounted the alleged success of certain of Black's predecessors—in fact, two of his medical professors at Edinburgh—in treating kidney stones with limewater: though "we believe today that the remedy is worthless . . . the claims made for [it] were based upon apparently convincing laboratory experiments" (13). Guerlac does not exactly give the champions of limewater the benefit of the doubt but neither does he impugn their experimental techniques. Motivated by this same attitude, then, if Black reports fixed air to have an agreeable odor, the historian may well refuse to question this observation.

Reflecting further, I began to wonder if perhaps I might not have succumbed to Whiggish preconceptions in my too confident belief that Black's fixed air could be unproblematically equated with modern chemistry's carbon dioxide. Reminding myself of Alain Corbin's thesis that an olfactory revolution occurred during the 18th century involving a heightened sensitivity to odors, pleasant and unpleasant, I even found myself raising the question of whether Black's expectations might have influenced his experience in smelling fixed air (14). Expecting any gas which extinguished flames and destroyed life to possess a disagreeable smell, when he found one which didn't, might not his olfactory experience, by some odd psychological quirk, have actually seemed agreeable (or, neither agreeable nor disagreeable but still pronounced—a distinct possibility, at least in my own personal phenomenology of odors)? But why talk of quirks? In the phenomenology of perception, to "actually seem" is to "be." It must be admitted that—at least to my knowledge—no one else in Black's day claimed to detect anything agreeable (or pronounced) in the odor of fixed air. Still, we are dealing here with a very small group of witnesses, so why shouldn't the experiences of one of the most careful observers in the group be at least as normative as anyone else's? The situation might well have been quite different, say, 25 years later, when, as the following captivating and (I suspect) exemplary incident attests, even children were experimenting with fixed air.

In 1779 Josiah Wedgwood hired an assistant of Joseph Priestley's, John Warltire, to teach his children chemistry. Since at the time Wedgwood was a patron of both Joseph Wright of Derby and George Stubbs, he thought of commissioning (but never did) one of the two painters to depict his children in the act of performing chemical experiments; more specifically, Wedgwood suggested depicting the following (15):

> Jack standing at a table making fixable air with the glass apparatus &c.; & his two brothers accompanying him. Tom jumping up & clapping his hands in joy & surprise at seeing the stream of bubbles rise up just as Jack has put in a little chalk to the acid.

The three brothers would have learned, and confirmed for themselves, that fixed air is odorless; indeed, it seems reasonable to assume that by this time a consensus had been reached on the properties of fixed air (including its odorlessness) within that small European elite familiar with elementary chemistry—a consensus extending to men, women, and children, practising chemists as well as lay scientific cognoscenti. A decade later Lavoisier was to include fixed (or fixable) air—now significantly renamed "carbonic acid"—in his new chemical system (16).

But Black's "yet" will not go away. In the last analysis, I believe my solution to the problem (or pseudo-problem) of Black's odoriferous fixed air must be assimilated to my solution of a trivial textual problem generated, once again, by Guerlac's apparent inattention to a "yet" locution. What I have in mind is that in one of Guerlac's accounts of Black's life we learn that Black's parents had "a numerous issue of eight sons and four daughters *yet alive* in 1761" (17), while in another, later, account Guerlac omits the "yet alive" phrase and refers to Joseph as simply the "fourth of their twelve

children" (18). In fact, Black's parents had 15 children of whom three had died by 1761; Joseph was the fifth son (the fourth to survive infancy) and ninth child (19).

Properties of gases, human genealogies, standard English usage: each is surely a social construction; but, equally, each is surely, in substantial measure, an intransigent and non-arbitrary feature of any coherent world—including, of course, any historical world—we undertake to construct (20).

REFERENCES AND NOTES

1. T. Hankins, *Science and the Enlightenment*, Cambridge University Press, Cambridge, 1985, p. 91.
2. H. Guerlac, "Joseph Black and Fixed Air," *Isis*, **1957**, *48*, 124–151, 433–456.
3. H. Guerlac, "Joseph Black," *Dictionary of Scientific Biography*, C. C. Gillispie, Ed., Vol. 2, Scribners, New York, 1970, pp. 173–183; reprinted in H. Guerlac, *Essays and Papers in the History of Modern Science*, Johns Hopkins Press, Baltimore, 1977.
4. A. L. Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, Edinburgh University Press, Edinburgh, 1975.
5. *Ibid.*, p. 183.
6. Reference 3, p. 176.
7. Reference 3.
8. Reference 2, 437, 446.
9. *Ibid.*, 437. Donovan also quotes this passage, without paraphrase or comment (reference 4, p. 201).
10. See, e.g., H. W. Fowler and E. Gowers, *A Dictionary of Modern English Usage*, 2nd ed., Oxford University Press, 1965, p. 384: "Generally speaking, English grammar today regards two negatives as cancelling each other and producing an affirmative." Indeed, in some contexts, as Fowler and Gowers explain (*ibid.*, p. 396), such a term as, e.g., "not ungrateful," can mean "very grateful" (an instance of the rhetorical strategy called litotes or meiosis); in view of its overuse in the recent past, however, they recommend that such usage be avoided today. It's possible, I suppose, that this usage underlies Guerlac's phrase "pronounced but not disagreeable" (understood as "very agreeable").
11. Reference 2, 452.
12. Reference 3, p. 173.
13. Reference 2, 137–8.
14. A. Corbin, *The Foul and the Fragrant: Odor and the French Social Imagination*, (trans. M. L. Kochan), Harvard University Press, Cambridge, Mass., 1986. Corbin, incidentally, cites a treatise of 1778 by Felix Vicq d'Azyr, in which the eminent zoologist maintains that the gas escaping from an opened sepulchre is Black's fixed air. Breathing this gas is responsible for observed cases of suffocation, though "like most of his contemporaries, [Vicq d'Azyr] continued to think that the principal danger lay in a 'stinking vapor'. Whereas gases 'kill immediately, the second acts more slowly on the nervous system, as well as on the fluids of animals, which it manifestly impairs' " (p. 30).
15. Wedgwood to Bentley, 30th May 1779, quoted by Benedict Nicolson, *Joseph Wright of Derby: Painter of Light*, Vol. 1, Pantheon, New York, 1968, p. 144.
16. A.-L. Lavoisier, *Elements of Chemistry*, (trans. R. Kerr), William Creech, Edinburgh, 1790 (reprinted, Dover, New York, 1965), pp. 64, 69. (This is a translation of Antoine-Laurent Lavoisier, *Traité élémentaire de Chimie*, Paris, 1789). Lavoisier characterizes several gases by their "penetrating" odor: "sulphurous acid" (sulphur dioxide), "muriatic acid" (hydrogen chloride), "ammoniac" (ammonia) (pp. 67, 70, 157). On the other hand, Lavoisier never mentions the odor of carbonic acid, which he characterizes as "the acid resulting from this combustion [of charcoal and oxygen, which] does not condense in the common temperature; under the pressure of our atmosphere, it remains in the state of gas, and requires a large proportion of water to combine with or be dissolved in" (p. 63).
17. Reference 2, 129, my emphasis.
18. Reference 3, p. 173.
19. Reference 4, p. 165.
20. Such features I take to be more or less closely related to the "material or phenomenal constraints" of some recent critical responses to the extreme social constructivist account of science; see, e.g., J. Golinski, "The Theory of Practice and the Practice of Theory; Sociological Approaches to the History of Science," *Isis*, **1990**, *81*, 494, 503.

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