THE ATMOSPHERE OF HEAVEN: THE 1799 NITROUS OXIDE RESEARCHES RECONSIDERED

by

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Thomas Beddoes’s and Humphry Davy’s accounts of the nitrous oxide experiments carried out at the Pneumatic Institution in 1799 include extravagant descriptions of its mind-altering effects. Many people, both at the time and subsequently, have considered these descriptions to be the product not of the gas but of its subjects’ overheated imaginations. To what extent were these effects ‘all in the mind’ of the experimenters? Modern understandings of nitrous oxide throw new light on this question; but it was also considered, and resolved in different ways, by Beddoes and Davy themselves.

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In early April 1799,1 less than a month after the official opening of the Medical Pneumatic Institution, Thomas Beddoes and Humphry Davy made their first full experiment with nitrous oxide. They placed crystals of ammonium nitrate in the alembic of James Watt’s apparatus, sealed the joints around it with the prescribed mixture of clay, lime and borax, and set heat under them. The crystals melted to liquid; as they maintained the heat, the gas began to collect in the hydraulic bellows, gradually displacing the water from the reservoir. Davy sat beside it, inserted a breathing tube into the air-holder, pinched his nostrils to exclude all atmospheric air, placed the breathing-tube between his lips and began to inhale.

The first thing he noticed was a curious sweet taste, followed by the slight dizziness he had felt a few days previously when testing the gas tentatively for toxicity. As he continued to breathe, however, a new feeling announced itself: ‘a sensation analogous to gentle pressure on all muscles, attended by a highly pleasurable thrilling in the chest and extremities’.2 But this heightened vibratory condition, it rapidly became clear, was only the prelude to far a more intense and profound effect. ‘The objects around me became dazzling and my hearing more acute’, he recalled. He had been seated, head bent downwards into the breathing tube, accelerating into this unfamiliar world with each inhalation; but as the crescendo of sensations built towards a ringing climax, ‘the sense of muscular power became greater, and at last an irresistible propensity to action was indulged in.’3 At this point, Beddoes recalled Davy rising to his feet and becoming a blur

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of motion, ‘shouting, leaping, running’ and emitting expressions of exhilaration like one ‘excited by a piece of joyful and unlooked-for news’ as he careened around the laboratory. Davy himself retained only vague recollections of the actions ‘various and violent’ that followed—and, had it not been for the scribbled notes that recalled them the following morning, ‘I should even have doubted their reality’.

This was a discovery that Thomas Beddoes, even in his most enthusiastic projections for the Pneumatic Institution, had never expected. After years of obstacles and delays during which he had been obliged almost daily to justify the notion of pneumatic medicine, and indeed the very idea of medical experiment, it seemed that his hopes had been surpassed. Here was a factitious air, never witnessed in nature, with properties that expanded the scope of chemical medicine beyond anything thus far imagined. Nitrous oxide was, if anything, the opposite of the agent of contagion and decay proposed by its previous investigator, Samuel Latham Mitchill: it seemed, rather, to be a source of excitation and life-force more potent even than oxygen itself. It might be regarded as a Brunonian stimulant, in the same category as alcohol but far more potent, except that it seemed to excite the metabolism without exhausting it, as Brown’s theory would demand. After his inhalation, Davy had slept lightly, ideas fizzing through his head too intensely for profound rest; the next morning he felt no hangover or lassitude, and his eyes were not bleary but gleaming, as one who had seen strange and wonderful things.

There was no doubting the efficacy of the gas, but there were a thousand unanswered questions about how its effects should be construed. By following his Baconian path of untrammelled experiment, Beddoes had entered a terra incognita beyond the reach of theory, and it was necessary to explore the terrain more thoroughly before reaching for an explanation. His first communications were tentative. He wrote within days to Erasmus Darwin of ‘something extraordinary made out’ at the Institution, but added that it would take time to establish precisely what it meant. On 23 April he informed Jos Wedgwood that he and Davy had discovered ‘a species of air’ that produced excitation ‘in the most remarkable manner’; he was unable to resist expressing the hope that the new gas might provide a cure, thus far elusive, for the chronic and mysterious illness of Jos’s brother, and that ‘we could now stimulate Tom’s torpid machine’. His hypotheses were vague—‘it seems to act by giving excitability or life’—but he was in no doubt that the discovery represented a major breakthrough. ‘I think’, he told Jos with quiet understatement, ‘it will realise the expectations and conjectures I originally started.’

Although he had thus far been reluctant to experiment on the Institution’s patients, deciding that it would be ‘prudent to waive the gases for a time, and confine ourselves to the administration of common remedies’ until he had won the trust of his clientele, Beddoes was unable to resist testing his hunch that nitrous oxide might be effective in giving muscular stimulus to sufferers from palsy, or paralysis. He began by selecting a 26-year-old man who, ‘after a course of excessive debauchery, especially with regard to fermented liquors’, had lost the power of movement down one side. Although he was palsied, there was no ‘visible organic lesion’ to account for his frozen condition, suggesting that his body might be able to respond if stimulated with sufficient force. Davy and Beddoes were obliged initially to move his head down to the mouth of the breathing-tube, but after several treatments he found he could flex his paralysed arm, and ‘at last he could grasp things without a tremor’. Encouraged, they offered the treatment to another even more severely palsied patient, ‘as shattered a human creature as can easily be met with’; but the gas demonstrated its miraculous powers once more, and the patient...
soon found himself able to walk without crutches for the first time in many years. Beddoes, after a lifetime of administering foul-tasting medicines and painful courses of treatment, was particularly struck by ‘the eagerness with which these patients looked forward for their dose of air’: as with Davy, it seemed as if the sensations produced by the gas were reason enough to inhale it, and its curative powers a delightful bonus. It was a medicine whose only side-effect seemed to be pleasure.

Davy, meanwhile, had taken to self-experimenting regularly. There was much to discover—the volume of nitrous oxide, for example, that was absorbed over a series of inhalations, and the proportion of this that made its way into the bloodstream—but he was also finding it a fascinating recreation, and breathing it simply ‘for the sake of enjoyment’. It was following their self-experimental hunches that had brought them to their discovery in the first place, and now Davy and Beddoes began to expand their trials. The effects of the gas were not restricted to the sick, and indeed Beddoes’s self-experiments had suggested that they might equally benefit the healthy. The social circle around the Institution constituted an ideal cadre of volunteer subjects whose responses might suggest new avenues of research. Most of all, though, they were bursting to share their news, and to astonish their friends with the new experience they had to offer.

Throughout the summer, as the experiments continued, the tenor of life at the Institution underwent a marked transformation. As Joseph Cottle later recalled, the nitrous oxide researches ‘quite exorcised philosophical gravity, and converted the laboratory into the region of hilarity and relaxation.’ By day, the Institution remained a clinic for the sick, and a laboratory for Davy’s animal experiments; but at day’s close it became a philosophical theatre in which the boundaries between experimenter and subject, spectator and performer were blurred to fascinating effect, and the experiment took on a life of its own. Bizarre, ‘antic’ behaviour became in many cases an unspoken expectation: subjects happily abandoned their inhibitions, and vied to produce written reports that encapsulated the experience in memorable aphorisms and turns of phrase. The only price of admission to the show was a brief but very public loss of dignity, and a willingness to have a burst of uninhibited speech or action exposed to scrutiny. It was a price that not all were prepared to pay: the nervous and censorious Joseph Cottle was among those who witnessed the ‘laughable and diversified effects produced by this new gas on different individuals’ but stood outside the fray, politely refusing the green bag. Those who took the plunge became a brotherhood, bonded by their shared initiation.

However, for the experimenters the antics and laughter were only the outward and visible signs of a physical and mental transformation that was tantalizingly difficult to pin down. Its signature effect, a wild burst of laughter with no apparent cause, was a case in point. On inhaling the gas, the mind seemed to stretch and expand, thoughts and ideas playing across an infinite space before, like the green bag itself, collapsing inwards and deflating. It was at this moment, when the first glimmers of self-consciousness returned, that the laughter, and the shouted phrases simultaneously serious and absurd, tended to bubble up and erupt. Although the subject was often unable to explain what was funny, the laughter was nevertheless more than a physical reflex: it was a response to this confusing moment of return, when the embarrassed subject suddenly perceived the gulf between their moment of epiphany and the dazed and gaping spectacle they presented to the observers. It was perhaps this same moment of confusion, embarrassment and pent-up energy to which some subjects responded by running, leaping and shouting, particularly once the idea of doing so had been planted by others. In 1792, Beddoes had been captivated by

The atmosphere of heaven

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http://rsnr.royalsocietypublishing.org/
Galvani’s demonstration of the power of electricity to twitch the muscles of a frog, proof positive that the animal machine could be directed by man-made stimuli; but nitrous oxide was stimulating not merely gross anatomical functions, but the most exalted reaches of human thought and imagination.

Yet by the late summer, as word of the nitrous oxide experiments began to make its way into the wider world, a curious new property of the gas emerged: it seemed to lose potency when experiments were attempted outside Bristol. Joseph Priestley’s son, Joseph junior, participated in the antics at the Institution, and wrote excitedly to his father to communicate them; but the original discoverer of the gas wrote back from Pennsylvania that his own trials had produced no more than an unpleasant throbbing in the head that made him discontinue after a few inhalations. James Watt and Matthew Boulton in Birmingham, as soon as they heard of Beddoes and Davy’s discovery, had promptly manufactured their own supply of nitrous oxide, but were ‘much less affected’ by it than the Bristol circle, leaving them wondering whether they had synthesized the wrong gas by mistake, or whether, as Watt speculated, the gas simply had ‘very different effects on different people’.

This second explanation was amplified by Maria Edgeworth, Beddoes’s sister-in-law, who came to Clifton in the early summer and was intrigued enough by the extraordinary tales emanating from the Institution to observe the antic experiments. ‘A young man, a Mr. Davy, at Dr. Beddoes’s’, she wrote drily to a friend, ‘enthusiastically expects wonders will be performed by the use of certain gases, which inebriate in the most delightful manner’. It was clear to Maria from the testimony of the experimenters that ‘pleasure even to madness is the consequence of this draft’, but she also suspected that ‘faith, great faith, is I believe necessary to produce any effect upon the drinkers.’ Although many volunteers were carried away by their experience, there were some for whom the anticipated effects simply failed to materialize: ‘adventurous philosophers who sought in vain for satisfaction in the bag of gaseous oxyd, and found nothing but a sick stomach and a giddy head’. There must have been more to the experience than simply the chemical properties of the gas: where, for example, were the comparable few who could drain a bottle of brandy without feeling drunk?

The sceptical interpretation of the experiments was reinforced in the wider public reception of the Pneumatic Institution, such as the satires that emerged the during following year in The Anti-Jacobin Magazine, which cast the researchers as enthusiasts who had conjured their experiences from their overheated imaginations. By 1808, a student writing a thesis for his medical degree at the University of Pennsylvania could summarize the received wisdom as follows: ‘The account which [Davy] gave of [nitrous oxide’s] operation was generally derided as extravagant and imaginary. Few believed it. The description was supposed to have proceeded from a warmed and highly excited mind.’

This reading of the experiments was further reinforced, rather than undermined, by the advent of nitrous oxide anaesthesia in the mid-nineteenth century. While this established the efficacy of nitrous oxide beyond doubt, it did so within an entirely different frame, in which it was conceived not as an excitant but as a sedative. The difference was essentially one of dosage—the dose used in surgery was a good deal larger than the contents of a green silk bag, and sustained for a good deal longer—but once the gas was conceived as an agent whose function was to suspend consciousness, the quantities inhaled at the Pneumatic Institution were seen as too small to be effective, producing at best a threshold effect on consciousness; the spectacular effects reported by the Bristol
circle, in particular their tendency to ‘antic’ performance and Davy’s extravagant accounts of his self-experiments, seemed implausibly overstated. From the late nineteenth century, as the secondary literature on the Institution came to focus on the question of whether Davy had ‘discovered’ or ‘missed’ its application as an anaesthetic, the subjective descriptions of its researches were increasingly taken to have been, to a greater or lesser extent, contaminated by a form of group hysteria.

This was, of course, a consideration of which both Beddoes and Davy had been keenly aware. From the beginning of the experiments, Davy had devised a novel method of randomized control: some volunteers were first given a bag of common air to ensure that their response was due to the gas rather than their imagination. None of the subjects seem to have been fooled: Tom Wedgwood, for example, responded to his bag of atmospheric air by announcing that it ‘confirmed him in his disbelief of the power of the gas’ that sounded too strange to be true.16 And indeed, these volunteers were only tested after both Beddoes and Davy had confirmed the effects of the gas by repeated self-experiments. Yet the determination with which Davy applied himself to these trials, and the studied objectivity with which he conveyed the results, also came to suggest a whiff of theatricality: an element of self-initiatory ordeal, a deliberate search for his own limits. He was defining himself, and his genius, by his willingness to push experiment to the utmost—pioneering researcher and fearless subject simultaneously. The role in which he cast himself was a heroic one, and it demanded heroic gestures to mark him out.

Both at the time and subsequently, then, the nitrous oxide experiments have presented something of a double image. On the one hand, they announced a dramatic discovery, which has since been abundantly confirmed by the gas’s defining medical application in anaesthesia; on the other, the suspicion has persisted that their findings were on some level imaginary, a product of the researchers’ imaginations. I would like to suggest some ways in which it might be possible to square this circle, and to see these images not as contradictory but as complementary.

First of all, it is necessary to recognize that all these readings have evolved in the absence of any solid biomedical account of the gas’s effects. The difficulty in establishing nitrous oxide’s mechanism of action on the human body and mind has been persistent and long-standing. Its defining application as an anaesthetic agent was established without any workable theory of how it achieved its effects, and it was a theory that remained elusive throughout the twentieth century. It is only in the last decade or two that its neurochemical action has been fully elucidated, and it is not, I hope, too reductive to attempt to bring this understanding to bear on Beddoes’s and Davy’s accounts.

Nitrous oxide, despite (or perhaps because of) its chemical simplicity, turns out to have an intricate complex of neurochemical effects. Over the past 20 years several researchers, notably Raymond Quock and his colleagues at the Children’s Hospital of Wisconsin, have demonstrated that it acts on the complex of opioid receptors in the brain and spinal column, and that this action produces analgesic and euphoric effects.17 These effects confirm Beddoes’s and Davy’s observations, and suggest that their vivid descriptions of them—Davy’s ‘highly pleasurable thrilling’, and Beddoes’s sensation of ‘being bathed all over with a bucket of good humour’—were not a fanciful straining for effect, but rather responses to the problem of describing pleasure itself.

However, it was only in the late 1990s that it became clear that nitrous oxide also has marked effects on an entirely different neurochemical system, the \(N\)-methyl-\(D\)-aspartate (NMDA) receptors, which are mediated by the neurotransmitter glutamate.18 Although
glutamate is the most abundant excitatory neurotransmitter in the human nervous system, its function was discovered only in the 1950s by studies on new anaesthetic agents such as phencyclidine and ketamine, which were shown to achieve their effects by blocking the brain’s supply of glutamate. This intervention has powerful consequences, including the interruption of pain signals between body and brain, the mechanism by which these so-called ‘dissociative’ anaesthetics achieve their effects; however, their onset, or use at sub-anaesthetic doses, also produces a marked alteration of consciousness: the sensation that, in various ways, the mind is being unplugged from its habitual relations with the body, and entering into a disembodied state where even fundamental qualities such as time and space drift loose from their moorings.

This suggests not only a physiological basis for many of the improbable-sounding accounts in the Institution’s researches, but a common denominator with subsequent nitrous oxide experiments that have found in it a revelation of idealist philosophies. *The Anaesthetic Revelation*, published in 1874 by the New England farmer, bodybuilder and calculating prodigy Benjamin Paul Blood, claimed that the gas had initiated him into the secret of a Platonic realm within which all worlds were contained; and William James, whose interest in nitrous oxide was originally piqued by Blood’s account, used it to explore the Hegelian philosophy in experiential ways he had previously been unable to grasp. There are no natural analogues for the glutamate inhibition produced by nitrous oxide, so the Pneumatic Institution’s researches represented the first human experience of such a state. The fact that it arrived simultaneously with the early reception in Britain of the German idealist philosophies was a remarkable conjunction that, I shall suggest later, contributed to Davy’s most enduring interpretation of the experiments.

As well as generating a biochemical account of nitrous oxide’s action, the past 20 years have seen the emergence of a global subculture of its recreational use. This, too, provides context for the Pneumatic Institution’s researches, not least in terms of dosage, because contemporary users are seeking not to anaesthetise themselves but to heighten and alter their consciousness. The long-standing characterization of the Pneumatic Institution’s dose as ‘sub-anaesthetic’, defined simply by its failure to produce anaesthesia, can now be recalibrated in the context of the hundreds of self-experimental reports of similar doses posted on the Internet, and of the method of administration that has evolved to pursue this state of consciousness. The profusion of small silver gas canisters and dew-soaked balloons witnessed at dawn across open-air dance festivals over the last few years, in Britain, Europe and America, is testimony to the curious precision with which James Watt’s airbag has been reinvented by the modern drug culture.

The recreational use of nitrous oxide was rediscovered by the emerging drug culture of the late 1960s, particularly in the USA. Tanks of gas were ‘liberated’ from their medical use for Hollywood poolside drug parties, and the Grateful Dead took to carrying one on their tour bus. But this first wave of recreational use was limited: first by the expense and logistical problems presented by acquiring a large tank of compressed gas, and second by the emerging realization that it was very easy to pass out while inhaling from a surgical mask and die from asphyxia. After several well-publicized deaths by such a misadventure, the recreational use of nitrous oxide diminished.

The current wave of nitrous oxide use, by contrast, has developed around a different method of administration: small canisters or bulbs of nitrous oxide, typically sold in catering suppliers for producing whipped cream. These are similar to the bulbs of carbon dioxide used in soda siphons, but nitrous oxide is preferred because carbon dioxide is
acidic and causes cream to curdle. As with soda siphons, the bulbs are supplied with a dispenser into which, when fitted, they release their compressed gas. A balloon can then be placed over the nozzle to capture the nitrous oxide as it is released, and the gas then inhaled.\textsuperscript{21}

This delivery system of dispensers, bulbs and balloons has made nitrous oxide more accessible to recreational users than ever before: it greatly reduces the risks of asphyxia, obviates the need for large gas cylinders and brings the cost down to about 50p for a balloon. Bulbs and dispensers are increasingly offered for sale not only by catering suppliers but at head shops and on the Internet. Naturally this is a trend that has caused official concern, which has in turn highlighted the continuing confusion among many medical professionals about what nitrous oxide actually does, and how. Last year the UK’s Medicines and Healthcare products Regulatory Agency (MHRA) moved to clamp down on the drug’s supply under Section 52 of the 1968 Medicines Act.\textsuperscript{22} Its decision was announced with the assertion that ‘the “rush” users experience is caused by starving the brain of oxygen’—to which Ben Goldacre, writing in the \textit{Guardian}, memorably responded:

\begin{quote}
To be effective in public health policy, it is generally considered that your message must be credible. I suspect most [nitrous oxide] users will already have experimented with holding their breath, and will rightly conclude that their experience on nitrous is a drug effect; and that it’s an anaesthetic used in hospitals, and in childbirth, so the effect is probably not caused by starving the brain of oxygen; and that the MHRA, of all reputable bodies, is talking nonsense.\textsuperscript{23}
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The modern recreational use of nitrous oxide has of course created its own cultural context and set of expectations, with resonances both of the Pneumatic Institution’s experiments and of the ‘laughing gas’ craze that followed it in the early decades of the nineteenth century. It has mostly developed in ‘party’ situations where other drugs are being used socially; in this context it heightens feelings of dissociation and excitement, and is typically taken as a cue for disinhibited behaviour and exuberant laughter. But although this culture may seem to be recapitulating the experiments of 1799 on a global scale, it also reveals a telling distinction. Another factor in nitrous oxide’s current popularity, along with a more practical delivery system, is the increase in the use of other drugs, particularly cannabis and ecstasy, with which it is almost always taken in conjunction. The modern cultural consensus seems to be that a balloon of nitrous oxide requires an underlying intoxication to achieve its desired effects, and that without this it produces only a mild disorientation, curious but not worth pursuing further.

This consensus offers a possible resolution to the problem of how it was that the effects of nitrous oxide might have been, as James Watt proposed, so different on different subjects, and so much more powerful in the context of the Pneumatic Institution than outside it. Few investigating nitrous oxide in 1799 were inclined to pursue these effects with the intense focus that characterized the Institution’s researches. Most, who were chemists like Priestley, Boulton and Watt, inhaled a few times, noticed a fullness in the head and a throbbing in the temples, checked their pulse and discontinued their self-experiments. It was Beddoes’s and Davy’s medically driven insight—that the gas seemed to stimulate the mechanisms of perception and sensation, and thus had the potential to reveal the material cause that underlay them—that tempted them to explore more fully nitrous oxide’s
curious tugging at the edge of the conscious mind; and it was the presence of a circle of friends who shared their passions that shaped the progress of the subsequent investigations.

Here, perhaps, was one of the paradoxes to which Baconian experiment was prone: not only might truly empirical researches lead in unexpected directions, but they might also in the process acquire their own idiosyncratic momentum, and accelerate towards perverse conclusions. The nitrous oxide researches were not based on fraud or falsehood, nor were Beddoes or Davy delusional; but the method by which they developed was nevertheless a solipsistic one, with each further trial confirming and enriching previous findings while, as Maria Edgeworth observed, making them ever more incomprehensible to those outside the laboratory. They had indeed made a momentous discovery, and it had sent them in a direction hitherto unexplored; but it was a direction to which it became ever harder to leave meaningful signposts. Their observations and descriptions of the gas built upon one another, capturing in rare detail an unfamiliar state of mind but creating a closed circle and a self-referential language as they did so. Their self-experimentation gave them, from their perspective, the perfect response to any sceptic—try it and see for yourself—but there were few prepared to make this leap of faith, and even among those who did there were many who found nothing but dizziness and a buzzing head.

It was a problem of which Beddoes was not unaware, and which he addressed in his first report on the experiments. He stressed that it was essential to keep firmly in mind the distressing failure of medicine to progress into the modern age, which meant that there could be ‘no question about how far it is necessary to strike into a new path’. To pursue novelty, then, is essential: it is by definition risky, but to take risks ‘requires only courage; and it is some reproach to the age, that it should require so much’. The real challenge at this point becomes that of finding the most productive path among the plethora of unexplored tracks, which requires not only courage but intelligence, instinct and planning. ‘Whether the persons concerned in the present undertaking have been able to discover the right path’ was an open question, but Beddoes nevertheless felt they were justified in taking the road that they had.24 The discoveries they had made were too remarkable to be of interest to them alone, and even if they were not what he or anyone else had expected, the world must sooner or later find a use for them.

But Davy’s Researches, when they emerged the following year, were far more effective than Beddoes’s Observations in bringing the nitrous oxide experiments into the purview of scientific investigation. Where Beddoes’s Observations, like his entire oeuvre, had been allusive and opinionated, full of vigorously ridden hobby-horses and generous in Shandean diversions, Davy’s Researches were tightly methodical and exhaustive in their detail. As framed by Beddoes, the effects of nitrous oxide were a curiosity, an unlooked-for outcome of medical trials that had collapsed into unanswerable questions and hurriedly configured follow-up projects; as reframed by Davy, they were the climax of a research programme that had carefully recorded every step of its progress, and in doing so had laid firm foundations for interpreting even this most unexpected outcome.

In doing so, however, Davy’s account had the effect of marginalizing the questions that the researches had originally been designed to answer: the effectiveness of pneumatic medicine and, particularly, the validity of the Brunonian system. The lines of enquiry that he followed were essentially chemical rather than medical, inductive rather than speculative; he had begun not with Brown’s theories but with his exhaustive trials of the gases themselves, and they had led him away from the broad and simplistic categories of excitation and weakness. When he finally turned to Brown’s theories in the conclusion of
the book, his assessment was brief and, in its implications for Beddoes’s project, devastating. Brown’s theory demanded that a gas such as nitrous oxide should have a fixed position on the sliding scale from stimulant to sedative, and that by introducing it into respiration the doctor should be able to shuttle the patient up and down this scale in an orderly manner; however, the experiments had shown that this ‘common theory of excitability is most probably founded on a false generalisation’.25

And if it was indeed a false generalization, it collapsed the edifice of pneumatic medicine as Beddoes had presented it. On a physiological level, nitrous oxide’s effects radiate out from the lungs through the whole organism, whereas most diseases are characterized by the malfunction of a particular organ: if factitious airs do prove to work in therapy, they must do so by a principle as yet undiscovered. ‘Pneumatic chemistry in its application to medicine’, Davy concluded in strikingly harsh terms, ‘is an art yet in its infancy, weak, almost useless.’ He supported Beddoes’s testimony that nitrous oxide had produced remarkable early results in palsy, speculating that ‘as by its operation the tone of irritable fibre is increased . . . it is not unreasonable to expect advantages from it in cases of simple muscular debility.’26 But the infant art of pneumatics still needed ‘to be nourished by facts, strengthened by exercise, and cautiously directed in the application of her powers by rational scepticism’.27 It was the hallmark of true experiment that no one should be able to predict its outcome, and that it should have the power to demolish the theory it had set out to prove; in this case, it might be said, the operation was a success, although the patient had died.

The nitrous oxide researches had demanded sacrifices of theory from Davy as well as from Beddoes. He had begun them wedded to his notion of ‘phosoxygen’, derived from his conviction that heat, light and combustion were all manifestations of the same principle, which was in turn the principle underlying all life; and he had initially theorized that the key to nitrous oxide’s effects was that it ‘contains more light in proportion to its oxygen’ than any other gas.28 But in February 1800 he had dashed off a retraction to Nicholson’s Journal, confessing ‘I beg to be considered as a sceptic with regard to my own particular theory of the combinations of light.’29 It was an embarrassing climbdown; and there were more sacrifices to come, notably his conviction that air was not a mixture but a compound. Yet it was Beddoes who was hit hardest by the conclusion of the Researches and, as its success mounted, its effect was not only to establish Davy as a groundbreaking chemist but also to crystallize the perception of Beddoes as a man whose project had failed the test of experiment on which he himself had insisted so loudly and so long.

Davy’s Researches mark the beginning of the eclipse of Beddoes’s dream of pneumatic medicine. The project, for him, had turned out to mirror curiously the effects of nitrous oxide itself: a racing of the pulse as the excitation began to take hold, building to a thrilling sense of imminent revelation as it reached its peak, before the airbag deflated and the vision receded as quickly as it had arrived, leaving only tantalizing shards impossible to assemble with any conviction, and a chorus of raspberries from the assembled spectators.

The signature achievement of Davy’s account, by contrast, was that it managed to set the researches on a firmer scientific foundation than Beddoes’s while simultaneously extending them to far more radical conclusions. On Boxing Day 1799, he enlisted the physician Robert Kinglake as his supervisor for an experiment that would dramatically extend the dosage and duration of any that had been undertaken thus far. He stripped to the waist, placed a thermometer under his armpit and entered the box, instructing Kinglake to release twenty
quarts of gas into it every five minutes. Davy sat in the sedan chair, absorbing a mixture of gas and air steadily for an hour and a quarter, until he felt the familiar muscular tremors, urge to laugh and ‘luminous points seemed frequently to pass before my eyes’. At this point, hoping that he had saturated his system, he emerged from the box and began to breathe a further twenty quarts of pure nitrous oxide.

At this dosage, the gas took Davy to a dimension he had not previously visited. Words, images and ideas jumbled together ‘in such a manner, as to produce perceptions totally novel’: he was no longer in the laboratory, but ‘in a world of newly connected and modified ideas’, where he could theorize without limits and make new discoveries at will. After an eternity, he was brought back to earth by the sensation of Dr Kinglake removing the breathing-tube from his mouth; he ‘stalked majestically’ towards Kinglake ‘with the most intense and prophetic manner’, and attempted to shape the insight that had possessed him. ‘Nothing exists but thoughts!’ he blurted. ‘The world is composed of impressions, ideas, pleasures and pains!’

This exclamation would stand in Davy’s eventual published account as the summation of his nitrous oxide experiments, and over the century to come would enter the pantheon of great moments of scientific discovery. Yet its presentation as a spontaneous ‘eureka’ moment, as with many such moments, was more carefully constructed than it appeared. Davy’s first experience of the gas, as recorded by Beddoes, was a stomping, bellowing chaos from which no coherent insights could be recovered, and which indeed could barely be remembered. This, by contrast, was a philosophical pronouncement that bore the stamp of his ‘meta-meta-physicking’ conversations with Samuel Taylor Coleridge, who he had first met in October 1799, when he had returned to Bristol after an absence of two years and Joseph Cottle had brought him to the Pneumatic Institution to make the acquaintance of the young chemist and his extraordinary discovery.

This was a moment when the Bristol circle’s enthusiasm for nitrous oxide was waning—both Robert Southey and Tom Wedgwood had pronounced that it no longer generated the pleasurable effects of their first encounters with it—but Coleridge brought a new ingredient that allowed Davy, while others were retreating, to advance further. Since his return from Germany, Coleridge had launched into an intensive study of the new German idealism that was in the throes of reconfiguring his philosophy and had, as he put it in early 1801, ‘completely extricated the notions of space and time’. In it, he was finding a way of framing and intensifying the role of subjective experience, and limiting the claims of Enlightenment science and its implicit atheism. He was leaving behind him the materialist speculations of Brown and Hartley: as he would later put it, ‘Association in philosophy is like the term stimulus in medicine: explaining everything, it explains nothing; and above all, leaves itself unexplained.’

Coleridge and Davy’s friendship would be an enduring one that would evolve through the many phases of their careers to come; but all began with a green silk bag of nitrous oxide. As Coleridge inhaled and felt its warmth diffusing through his body, he did not reach for extravagant metaphors, but stated precisely that the sensation resembled ‘that which I remember once to have experienced after returning from the snow into a warm room’. He felt no muscular urges beyond a desire to laugh at the company who had assembled to watch him, and the sensations faded almost as soon as they had begun. His second experiment, ‘after a hearty dinner’, was milder; but ‘the third time I was more violently acted upon’: this time he ‘could not avoid, nor felt any wish to avoid, beating the ground with my feet’, until ‘after the mouthpiece was removed, I remained for a few seconds
motionless, in great extacy.’ He followed this experience with a fourth trial, which initially had so little effect that he suspected he had been given common air, but he soon felt the telltale ‘warmth beginning about my chest and spreading upward and downward’ and as the effects reached a peak he found himself in a state ‘of more unmingled pleasure than I had ever before experienced’.34

The influence of Coleridge on Davy’s understanding of nitrous oxide would soon become apparent; but the influence of nitrous oxide on Coleridge remains harder to gauge. His written account for Davy would seem to situate it, for one so fascinated by the mechanics of perception and sensation, as a landmark experience. Yet he would never write about his experiences with the gas beyond the note that he submitted to Davy’s researches, nor did he discuss them in any of his surviving letters: his voluminous correspondence with Davy would include only a couple of oblique references to the gas, and neither of them detailed his own experience further. Even his private notebooks leave it unmentioned, as though he were reluctant to acknowledge to himself that the episode had taken place. A succession of experiences that climaxed with the greatest ecstasy he had ever felt left, for whatever reason, his monologue uncharacteristically stilled.

Yet this silence could perhaps be seen as characteristic in other ways. Coleridge’s use of opium, for example, which was shortly to spiral into chaotic dependence, would also remain unspoken until its severity forced it into public view, when it would be confessed only painfully and at the last resort. His acute self-examinations, undertaken to uncover the source of a curious sensation or vision, would often include his diet and digestion, his minor preoccupations and anxieties while contriving to ignore the small matter of the dozens of drops of laudanum he was consuming nightly. Coleridge’s profound ambivalence about abandonment to the voluptuous, also a hallmark of his romantic infatuations, made unalloyed pleasure a furtive and guilty experience, and perhaps imbued his surrender to the sensual embrace of the gas, in full public view, with a retrospective sense of shame.

But there was also, perhaps, another reason: for all the ineffable qualities of the gas, Coleridge could sense the direction in which the researches must ultimately tend. He had arrived late to the party, and the language in which the experience was framed had already been formed. The dimension of sensual pleasure had been explored fully and frankly, and placed at the centre of its effects by Beddoes, for whom, as for Erasmus Darwin, the increase of happiness was a laudable end in itself, and indeed the highest reasonable expectation of life. The poets had sought a more rarefied language that expressed sensations beyond mere pleasure, but they were typically cast in terms of the ‘sublime’, classically defined by the young Edmund Burke as ‘that state of the soul, in which all its motions are suspended’.35 With its dimensions of awe and a cosmic fracturing of the human sense of scale, ‘sublime’ was a term that allowed for forces more potent than reason and not susceptible to it, but one that stopped short of imputing them to a divine cause. Southey, for example, when he had used transcendent language such as ‘the atmosphere of the highest heaven’, had done so in teasing reclamation of the epiphanies of religion, ironic in its recognition that the experience, however exalted its stimulation of the highest faculties, was a factitious and chemical one that had been administered in a laboratory. For Coleridge to acknowledge the experience as truly transcendent would be to bring the fault-line between materialism and religion into a focus that he wished to avoid. By trapping transcendence itself within a material cause, it threatened to reduce the religious sense to chemistry; and Coleridge, as William Hazlitt would later observe, ‘always somehow contrived to prefer the unknown to the known’.36
Davy, however, seems to have found the novel experience of a powerful dissociative agent powerfully echoed by the idealist turn in Coleridge’s philosophy and its redrawing of the boundaries between subject and object, mind and matter. The notion that the world is composed of ‘impressions, ideas, pleasures and pains’ was one that would have been familiar to most of the experimental subjects before the trials began, drawn as it was from David Hartley’s theories of vibration and association, and it had underpinned the eloquent formulations of subjects such as Peter Mark Roget. But the conclusion that ‘Nothing exists but thoughts’ was one that had been reached by none of the experimental subjects, least of all Davy, before the composition of his researches for publication. Where Beddoes sought to convince the sceptics who suspected the effects of nitrous oxide to be all in the mind, Davy responded that the experiment, taken to its conclusion, rendered the distinction meaningless. Reality itself was constructed in the mind, from the information delivered by the senses: his culminating experiment had proved, as nothing ever had before, that an altered sensory and mental frame had the power to generate an entirely different universe.

NOTES

1 Davy’s dates for his first experiments are self-contradictory. The date given in the published version of his Researches, Chemical and Philosophical for the full experiment with Beddoes present is 17 April, but the same experiment was announced to Davies Giddy in a letter of 10 April. In the Researches Davy makes mention of an earlier experiment, before the one that Beddoes attended; this sequence is confirmed by Beddoes’s account. I take this earlier experiment to have been in the first week of April, and the letter to Giddy of 10 April, in which Davy refers to being ‘absolutely intoxicated’, to set a date of about 8 April for the experiment dated 17 April in the Researches.
3 Ibid.
4 Thomas Beddoes, Notice of Some Observations Made at the Medical Pneumatic Institution (Biggs & Cottle, Bristol, 1799), p. 8.
7 Keele University Wedgwood Archives, Etruria and Liverpool, 564-1.
11 Ibid., p. 38.
14 26 May 1799; The Life and Letters of Maria Edgeworth (Edward Arnold, London, 1894), pp. 165–166.


Beddoes, *op. cit.* (note 4), p. 34.


Letter to Tom Poole, 16 March 1801.


