Chemical recreations

In Chapter 7 of his book, *Uncle Tungsten: Memories of a Chemical Boyhood,* **Oliver Sacks** recalls his discovery of the delights of chemistry.

My parents and my brothers had introduced me, even before the war, to some kitchen chemistry: pouring vinegar on a piece of chalk in a tumbler and watching it fizz, then pouring the heavy gas this produced, like an invisible cataract, over a candle flame, putting it out straightaway. Or taking red cabbage, pickled with vinegar, and adding household ammonia to neutralize it. This would lead to an amazing transformation, the juice going through all sorts of colors, from red to various shades of purple, to turquoise and blue, and finally to green.

After the war, with my new interest in minerals and colors, my brother David, who had grown some crystals when he did chemistry at school, showed me how to do this myself. He showed me how to make a supersaturated solution by dissolving a salt like alum or copper sulfate in very hot water and then letting it cool.

One needed to hang something – a thread or a bit of metal – in the solution to start the process off. I did this first with a thread of wool in a copper sulfate solution, and in a few hours this produced a beautiful chain of bright blue crystals climbing along the thread. But if I used an alum solution and a good seed crystal to start it off, I discovered, the crystal would grow evenly, on every face, giving me a single large, perfectly octahedral crystal of alum.

I later commandeered the kitchen table to make a 'chemical garden', sowing a syrupy solution of sodium silicate, or water-glass, with differently colored salts of iron and copper and chromium and manganese. This produced not crystals but twisted, plantlike growths in the water-glass, distending, budding, bursting, continually reshaping themselves before my eyes[1]. This sort of growth, David told me, was due to osmosis, the gelatinous silica of the water-glass acting as a 'semipermeable membrane', allowing water to be drawn in to the concentrated mineral solution inside it. Such processes, he said, were crucial in living organisms, though they occurred in the earth's crust as well, and this reminded me of the gigantic nodular, kidneylike masses of hematite I had seen in the museum – the

[1] *Thomas Mann provides a lovely description of silica gardens in* Doctor Faustus:
I shall never forget the sight. The vessel… was three-quarters full of slightly muddy water – that is, dilute water-glass – and from the sandy bottom there strove upwards a grotesque little landscape of variously coloured growths: a confused vegetation of blue, green, and brown shoots which reminded one of algae, mushrooms, attached polyps, also moss, then mussels, fruit pods, little trees or twigs from trees, here and there of limbs. It was the most remarkable sight I ever saw, and remarkable not so much for its appearance, strange and amazing though that was, as on account of its profoundly melancholy nature. For when Father Leverkühn asked us what we thought of it and we timidly answered him that they might be plants: "No," he replied, "they are not, they only act that way. But do not think the less of them. Precisely because they do, because they try to as hard as they can, they are worthy of all respect."

label said this was 'kidney ore' (thought Marcus had once told me they were the fossilized kidneys of dinosaurs).

I enjoyed these experiments, and tried to envisage the processes that were going on, but I did not feel a real chemical passion – a desire to compound, to isolate, to decompose, to see substances changing, familiar ones disappearing and new ones in their stead – until I saw Uncle Dave's lab and his passion for experiments of all kinds. Now I longed to have a lab of my own – not Uncle Dave's bench, not the family kitchen, but a place where I could do chemical experiments undisturbed, by myself. As a start, I wanted to lay hands on cobaltite and niccolite, and compounds or minerals of manganese and molybdenum, of uranium and chromium – all those wonderful elements which were discovered in the eighteenth century. I wanted to pulverize them, treat them with acid, roast them, reduce them – whatever was necessary – so I could extract their metals myself. I knew, from looking through a chemical catalog at the factory, that one could buy these metals already purified, but it would be far more fun, far more exciting, I reckoned, to make them myself. This way, I would enter chemistry, start to discover it for myself, in much the same way as its first practitioners did – I would live the history of chemistry in myself.

And so I set up a little lab of my own at home. There was an unused back room I took over, originally a laundry room, which had running water and a sink and drain and various cupboards and shelves. Conveniently, this room led out to the garden, so that if I concocted something that caught fire, or boiled over, or emitted noxious fumes, I could rush outside with it and fling it on the lawn. The lawn soon developed charred and discolored patches, but this, my parents felt, was a small price to pay for my safety – their own, too, perhaps. But seeing occasional flaming globules rushing through the air, and the general turbulence and abandon with which I did things, they were alarmed, and urged me to plan experiments and to be prepared to deal with fires and explosions.

Uncle Dave advised me closely on the choice of apparatus – test tubes, flasks, graduated cylinders, funnels, pipettes, a Bunsen burner, crucibles, watch glasses, a platinum loop, a desiccator, a blowpipe, a retort, a range of spatulas, a balance. He advised me too on basic reagents – acids and alkalis, some of which he gave me from his own lab, along with a supply of stoppered bottles of all sizes, bottles of varied shapes and colors (dark green or brown for light-sensitive chemicals), with perfectly fitting ground-glass stoppers.

Every month or so, I stocked my lab with visits to a chemical supply house far out in Finchley, housed in a large shed set at a distance from its neighbors (who viewed it, I imagined, with a certain trepidation, as a place that might explode or exhale poisonous fumes at any moment). I would hoard my pocket money for weeks – occasionally one of my uncles, approving my secret passion, would slip me a half crown or so – and then take a succession of trains and buses to the shop.

I loved to browse through Griffin & Tatlock as one would browse through a bookshop. The cheaper chemicals were kept in huge stoppered urns of glass; the rarer, more costly substances were kept in smaller bottles behind the counter. Hydrofluoric acid – dangerous stuff, used for etching glass – could not be kept in glass, so it was sold in special small bottles made of gummy brown gutta-percha. Beneath the serried urns and bottles on the shelves were great carboys of acid – sulfuric, nitric, aqua regia; globular china bottles of mercury (seven pounds of this would fit into a bottle the size of a fist), and slabs and ingots of the commoner metals. The shopkeepers soon got to know me – an intense and rather undersized schoolboy, clutching his pocket money, spending hours amid the jars and bottles – and though they would warn me now and then, "Go easy with that one!" they always let me have what I wished.

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My first taste was for the spectacular – the frothings, the incandescences, the stinks and the bangs, which almost define a first entry into chemistry. One of my guides was J. J. Griffin's *Chemical Recreations*, an 1850ish book I had found in a secondhand bookshop. Griffin had an easy, practical and above all playful style; chemistry was clearly fun for him, and he made it fun for his readers, readers who must often have been, I decided, boys like myself, for he had sections like 'Chemistry for the Holidays' – this included the 'Volatile Plum Pudding' ("when the cover is removed … it leaves its dish and rises to the ceiling"), 'A Fountain of Fire' (using phosphorus – "the operator must take care not to burn himself"), and 'Brilliant Deflagration' (here, too, one was warned to "remove your hand instantly"). I was amused by the mention of a special formula (sodium tungstate) to render ladies' dresses and curtains incombustible – were fires that common in Victorian times? – and used it to fireproof a handkerchief for myself.

The book opened with 'Elementary Experiments', experiments first with vegetable dyes, seeing their color changes with acids and alkalis. The most common vegetable dye was litmus – it came from a lichen, Griffin said. I used some of the litmus papers that my father kept in his dispensary, and saw how they turned red with different acids or blue with alkaline ammonia.

Griffin suggested experiments with bleaching – here I used my mother's bleaching powder in place of the chlorine water he suggested, and with this I bleached litmus paper, cabbage juice, and a red handkerchief of my father's. Griffin also suggested holding a red rose over burning sulfur, so that the sulfur dioxide produced would bleach it. Dipping it in water, miraculously, restored its color.

From here Griffin moved (and I with him) to 'sympathetic inks', which became visible only when heated or specially treated. I played with a number of these – lead salts, which turned black with hydrogen sulfide; silver salts, which blackened when exposed to light; cobalt salts, which became visible when dried or heated. All this was fun, but it was chemistry, too.

There were other old chemistry books lying around the house, some of which had been my parents' when they were medical students, and some, more recent, belonging to my older brothers Marcus and David. One such was Valentin's *Practical Chemistry,* a workhorse of a book – straight, uninspired, pedestrian in tone, designed as a practical manual, but nevertheless, for me, filled with wonders. Inside its cover, corroded, discolored, and stained (for it had done time in the lab in its day), it bore the words "Best wishes and congratulations 21/1/13 – Mick" – it had been given to my mother on her eighteenth birthday by her twenty-five-year-old brother Mick, already a research chemist himself. Uncle Mick, a younger brother of Dave, had gone to South Africa with his brothers, and then worked in a tin mine on his return. He loved tin, I was told, as much as Uncle Dave loved tungsten, and he was sometimes referred to in the family as Uncle Tin. I never knew Uncle Mick, for he died of a malignancy the year I was born – he was only forty-five – a victim, his family thought, of the high levels of radioactivity in the uranium mines in Africa. But my mother had been very close to him, and his memory and image stayed vividly in her mind. The notion that this was my mother's own chemistry book, and of the never-known, young chemist uncle who gave it to her, made the book especially precious to me.

There was a great popular interest in chemistry in the Victorian era, and many households had their own labs, as they had their ferneries and stereoscopes. Griffin's *Chemical Recreations* had originally been published around 1830 and was so popular that it was continually revised and brought out in new editions; I had the tenth, published in 1860.[2]

A companion volume to Griffin's, published at much the same time and in the same green and gilt binding, was *The Science of Home Life,* by A. J. Bernays, which focused on coal, coal gas, candles, soap, glass, china, earthenware, disinfectants – everything that might be contained in a Victorian home (and much of which was still contained in houses a century later).

Very different in style and content, though equally designed to awake the sense of wonder ("The common life of man is full of Wonders, Chemical and Physiological. Most of us pass through this life without seeing or being sensible of them…") was *The Chemistry of Common Life,* by J. F. W. Johnston, written in 1859. This had fascinating chapters on 'The Odours We Enjoy', 'The Smells We Dislike', 'The Colours We Admire', 'The Body We Cherish', 'The Plants We Rear', and no less than eight chapters on 'The Narcotics We Indulge In'. This introduced me not only to chemistry, but to a panorama of exotic human behaviors and cultures.

A much earlier book, of which I was able to get a battered copy for sixpence – it had no covers, and a few pages missing – was *The Chemical Pocket-Book* or *Memoranda Chemica,* written in 1803. The author was a James Parkinson, of Hoxton, whom I would reencounter in my biology days as the founder of paleontology, and then again, when I was medical student, as the author of the famous *Essay on the Shaking Palsy* – which came to be known as Parkinson's disease. But for me, at eleven, he was just the author of this delightful little pocket book of chemistry. I got a strong sense, from his book, of how chemistry was expanding, almost explosively, at the beginning of the nineteenth century; thus Parkinson spoke of ten new metals – uranium, tellurium, chromium, columbium (niobium), tantalum, cerium, palladium, rhodium, osmium, iridium – all having been discovered in the preceding few years.

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It was from Griffin that I first gained a clear idea of what was meant by 'acids' and 'alkalis' and how they combined to produce 'salts'. Uncle Dave demonstrated the opposition of acids and bases by measuring out precise quantities of hydrochloric acid and caustic soda, which he mixed in a beaker. The mixture became extremely hot, but when it cooled, he said, "Now try it, drink it." Drink it – was he mad? But I did so, and tasted nothing but salt. "You see," he explained, "an acid and a base come together, and they neutralize each other; they combine and make a salt."

[2] *Griffin was not only an educator at many levels – he wrote* The Radical Theory in Chemistry *and* A System of Crystallography, *both more technical than his* Recreations *– but also a manufacturer and purveyor of chemical apparatus: his 'chemical and philosophical apparatus' was used throughout Europe. His firm, later to become Griffin & Tatlock, was still a major supplier a century later, when I was a boy.*

Could this miracle happen in reverse, I asked? Could salty water be made to produce the acid and the base all over again? "No," Uncle said, "that would require too much energy. You saw how hot it got when the acid and base reacted – the same amount of heat would be needed to reverse the reaction. And salt," he added, "is very stable. The sodium and chloride hold each other tightly, and no ordinary chemical process will break them apart. To break them apart you have to use an electric current."

He showed me this more dramatically one day by putting a piece of sodium in a jar full of chlorine. There was a violent conflagration, the sodium caught fire and burned, weirdly, in the yellowish green chlorine – but when it was over, the result was nothing more than common salt. I had a heightened respect for salt, I think, after that, having seen the violent opposites that came together in its making and the strength of the energies, the elemental forces, that were now locked in the compound.

Here, too, Uncle Dave showed me, the proportions had to be exact: 23 parts of sodium, by weight, to 35.5 of chlorine. I was struck by these numbers, for they were already familiar: I had seen them in lists in my books; they were the 'atomic weights' of these elements. I had learned these numbers by rote, in the same mindless way one learns multiplication tables. But when Uncle Dave brought up these selfsame numbers in relation to the chemical combination of two elements, a slow, underground questioning started in my head.

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In addition to my collection of mineral samples, I had a collection of coins, housed in a small wooden cabinet of highly polished mahogany, with doors that opened like the doors of a toy theater, revealing a series of slim trays with velvet-covered circles for the coins – some as small as a quarter-inch across (this for groats, for silver threepenny pieces, and for Maundy money, tiny silver coins given on Easter to the poor), others almost two inches across (for crowns, which I loved, and even larger than these, the gigantic twopenny pieces made at the end of the eighteenth century).

There were also stamp albums, and the stamps I most loved were those of remote islands, with pictures of local scenes and plants, stamps which could themselves provide a vicarious voyage. I adored stamps showing different minerals, and peculiar stamps of various sorts – triangular ones, imperforate ones, stamps with inverted watermarks or missing letters or advertisements printed on the back. One of my favorites was a strange Serbo-Croat stamp from 1914 which was said to show the features of the murdered Archduke Ferdinand when viewed from a certain angle.

But the collection closest to my heart was a singular collection of bus tickets. Whenever one took a bus in London in those days, one got a colored oblong of cardboard bearing letters and numbers. It was after getting an O 16 and an S 32 (my initials, also the symbols of oxygen and sulfur – and added to these, by a happy chance, their atomic weights, too) that I decided to make a collection of 'chemical' bus tickets, to see how many of the ninety-two elements I could get. I was extraordinarily lucky, so it seemed to me (though there was nothing but chance involved), for the tickets accrued rapidly, and I soon had a whole collection (W 184, tungsten, gave me particular pleasure, partly because it provided my missing middle initial). There were, to be sure, some difficult ones: chlorine, irritatingly, had an atomic weight of 35.5, which was not a whole number, but, undismayed, I collected a Cl 355 and inked in a tiny decimal point. The single letters were easier to get – I soon had an H 1, a B 11, a C 12, an N 14 and an F 19, besides the original O 16. When I realized that atomic numbers were even more important than atomic weights, I started to collect these as well. Eventually, I had all the known elements, from H 1 to U 92. Every element became indissolubly associated with a number for me, and every number with an element. I loved carrying my little collection of chemical bus tickets with me; it gave me the sense that I had, in the space of a single cubic inch, the whole universe, its building blocks, in my pocket.

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