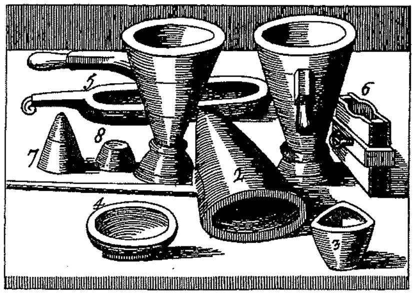
4



"AN IDEAL METAL"

I returned to London in the summer of 1943, after four years of exile, a ten-year-old boy, withdrawn and disturbed in some ways, but with a passion for metals, for plants, and for numbers. Life was beginning to resume some degree of normality, despite the bomb damage everywhere, despite the rationing, the blackout, and the thin, poor paper on which books were printed. The Germans had been turned back at Stalingrad, the Allies had landed in Sicily; it might take years, but victory was now certain.

One sign of this, for me, was the fact that my father was given, through a series of intermediaries, an unheard-of thing, a banana from North Africa. None of us had seen a banana since the start of the war, and so my father divided it, sacramentally, into seven equal segments: one each for my mother and himself, one for Auntie Birdie, and one apiece for my brothers and myself. The tiny segment was placed, like a Host, on the tongue, then savored slowly as it was swallowed. Its taste was voluptuous,

almost ecstatic, at once a reminder and symbol of times past and an anticipation of times to come, an earnest, a token, perhaps, that I had come home to stay.

And yet much had changed, and home itself was disconcertingly different, utterly changed in many ways from the settled, stable household there had been before the war. We were, I suppose, an average middle-class household, but such households, then, had a whole staff of helpers and servants, many of whom were central in our lives, growing up as we did with very busy and to some extent "absentee" parents. There was the senior nanny, Yay, who had been with us since Marcus's birth in 1923 (I was never certain how her name was spelled, but imagined, after I learned to read, that it was spelled "Yea"—I had read some of the Bible, and been fascinated by words like *lo* and *hark* and *yea*). Then there was Marion Jackson, my own nanny, to whom I was passionately attached—my first intelligible words (I am told) were the words of her name, each syllable pronounced with babyish slowness and care. Yay wore a nurse's headdress and uniform, which looked to me somewhat severe and forbidding, but Marion Jackson wore soft white clothes, soft as a bird's feathers, and I would nestle against them and feel utterly secure.

There was Marie, the cook-housekeeper, with her starched apron and reddened hands, and a "daily," whose name I forget, who came in to help her. Besides these four women, there was Don, the chauffeur, and the gardener, Swain, who between them handled the heavy work of the house.

Very little of this survived the war. Yay and Marion Jackson disappeared—we were all "grown up" now. The gardener and the chauffeur had gone, and my mother (now fifty) decided to drive her own car. Marie was due to come back, but never did; and in her stead Auntie Birdie did the shopping and cooking.[1]

[1] Only one person stayed: Miss Levy, my father's secretary. She had been with him since 1930, and though somewhat reserved and formal (it would

Physically, too, the house had changed. Coal had become scarce, like everything else in the war, and the huge boiler had been shut down. There was a small oil burner, of very limited capacity, in its stead, and many of the extra rooms in the house had been closed off.

Now that I was "grown up," I was given a larger room—it had been Marcus's room, but he and David were now both at university. Here I had a gas fire and an old desk and bookshelves of my own, and for the first time in my life I felt I had a place, a space. I would spend hours in my room, reading, dreaming about numbers and chemistry and metals.

Above all, I delighted in being able to visit Uncle Tungsten again—his place, at least, seemed relatively unchanged (though tungsten was now in somewhat short supply, because of the vast quantities needed for making tungsten steel for armor plating). I think he also delighted in having his young protégé back, for he would spend hours with me in his factory and his lab, answering questions as fast as I could ask them. He had several glass-fronted cabinets in his office, one of which contained a series of electric lightbulbs: there were several Edison bulbs from the early 1880s, with filaments of carbonized thread; a bulb from 1897, with a fil-

have been unthinkable to call her by her first name; she was always Miss Levy) and always busy, she sometimes allowed me to sit by the gas fire in her little room and play while she typed my father's letters. (I loved the clack of the typewriter keys, and the little bell that rang at the end of each line.) Miss Levy lived five minutes away (in Shoot-Up Hill, a name that seemed to me more suitable perhaps for Tombstone than Kilburn), and she arrived at nine o'clock on the dot every weekday morning; she was never late, never moody or discomposed, never ill, in all the years that I knew her. Her schedule, her even presence, remained a constant through the war, even though everything else in the house had changed. She seemed impervious to the vicissitudes of life.

Miss Levy, who was a couple of years older than my father, continued to work a fifty-hour week until she was ninety, with no apparent concessions to age. Retirement was unthinkable to her, as it was to my parents, too.

ament of osmium; and several bulbs from the turn of the century, with spidery filaments of tantalum tracing a zigzag course inside them. Then there were the more recent bulbs—these were Uncle's especial pride and interest, for some of them he had pioneered himself—with tungsten filaments of all shapes and sizes. There was even one labeled "Bulb of the Future?" It had no filament, but the word *Rhenium* was inscribed on a card beside it.

I had heard of platinum, but the other metals—osmium, tantalum, rhenium—were new to me. Uncle Dave kept samples of them all, and some of their ores, in a cabinet next to the bulbs. As he handled them, he would expatiate on their unique, sovereign qualities, how they had been discovered, how they were refined, and why they were so suitable for making filaments. As Uncle spoke of the filament metals, "his" metals, they took on, in my mind, a special desirability and significance—noble, dense, infusible, glowing.

He would bring out a pitted grey nugget: "Dense, eh?" he would say, tossing it to me. "That's a platinum nugget. This is how it is found, as nuggets of pure metal. Most metals are found as compounds with other things, in ores. There are very few other metals which occur native like platinum—just gold, silver, copper, and one or two others." These other metals had been known, he said, for thousands of years, but platinum had been "discovered" only two hundred years ago, for though it had been prized by the Incas for centuries, it was unknown to the rest of the world. At first, the "heavy silver" was regarded as a nuisance, an adulterant of gold, and was dumped back into the deepest part of the river so it would not "dirty" the miners' pans again. But by the late 1700s, the new metal had enchanted all of Europe—it was denser, more ponderous than gold, and like gold it was "noble" and never tarnished. It had a luster equalling that of silver (its Spanish name, *platina,* meant "little silver").

Platinum was often found with two other metals, iridium and osmium, which were even denser, harder, more refractory. Here

Uncle pulled out samples for me to handle, mere flakes, no larger than lentils, but astoundingly heavy. They were "osmiridium," a natural alloy of osmium and iridium, the two densest substances in the world. There was something about heaviness, density—I could not say why—that gave me a thrill, and an immense sense of security and comfort. Osmium, moreover, had the highest melting point of all the platinum metals, Uncle Dave said, so at one time it was used, despite its rarity and cost, to replace the platinum filaments in lightbulbs.

The great virtue of the platinum metals was that while they were as noble and workable as gold, they had much higher melting points, and this made them ideal for chemical apparatus. Crucibles made of platinum could withstand the hottest temperatures; beakers and spatulas of it could withstand the most corrosive acids. Uncle Dave pulled out a small crucible from the cabinet, beautifully smooth and shiny. It looked new. "This was made around 1840," he said. "A century of use, and almost no wear."

My grandfather's oldest son, Jack, was fourteen years old in 1867, when diamonds were found near Kimberley in South Africa and the great diamond rush began. In the 1870s Jack, along with two brothers—Charlie and Henry (Henry was born deaf and used sign language)—went to make their lives and fortunes in South Africa as consultants in the diamond, uranium, and gold mines (their sister Rose accompanied them). In 1873 my grandfather remarried, and had thirteen more children, and the old family myths—a combination perhaps of his elder sons' stories, Rider Haggard's tales of King Solomon's mines and the old legends of the Valley of Diamonds—caused two of the next-born (Sydney and Abe) to join their half-brothers in Africa. Later still, two of the younger brothers, Dave and Mick, joined them as well, so at one point seven of the nine Landau brothers were working as mining consultants in Africa.

A photograph that hung in our house (and now hangs in mine) shows a family group taken in 1902—Grandfather, bearded and patriarchal, his second wife, Chaya, and their thirteen children. My mother appears as a little girl of six or seven, and her youngest sister, Dooggie—the youngest of the eighteen—as a ball of fluff on the ground. The images of Abe and Sydney, one can see if one looks closely, have been grafted into place (the photographer had arranged the others to make spaces for them), for they were still in South Africa at the time—detained, and perhaps endangered, by the Boer War.[2]

The elder half-brothers, married and rooted now, stayed in South Africa. They never returned to England, though tales of them constantly circulated in the family, tales heightened to the legendary by the family mythopoeia. But the younger brothers—Sydney, Abe, Mick, and Dave—returned to England when the First World War broke out, armed with exotic tales and trophies of their mining days, including minerals of all sorts.

Uncle Dave loved handling the metals and minerals in his cabinet, allowing me to handle them, expatiating on their wonders. He saw the whole earth, I think, as a gigantic natural laboratory, where heat and pressure caused not only vast geologic movements, but innumerable chemical miracles too. "Look at these diamonds," he would say, showing me a specimen from the famous Kimberley mine. "They are almost as old as the earth. They were formed thousands of millions of years ago, deep in the earth, under unimaginable pressures. Then they were brought to the surface in this kimberlite, tracking hundreds of miles from

[2] There were fears for all the African relatives during the Boer War, and this must have impressed my mother deeply, for more than forty years later, she would still sing or incant a little ditty from this era:

> One, two, three—relief of Kimberley
> Four, five, six—relief of Ladysmith
> Seven, eight, nine—relief of Bloemfontein

the earth's mantle, and then through the crust, till they finally reached the surface. We may never see the interior of the earth directly, but this kimberlite and its diamonds are a sample of what it is like. People have tried to manufacture diamonds," he added, "but we cannot match the temperatures and pressures that are necessary."[3]

On one visit, Uncle Dave showed me a large bar of aluminum. After the dense platinum metals, I was amazed at how light it was, scarcely heavier than a piece of wood. "I'll show you something interesting," he said. He took a smaller lump of aluminum, with a smooth, shiny surface, and smeared it with mercury. All of a sudden—it was like some terrible disease—the surface broke down, and a white substance like a fungus rapidly grew out of it, until it was a quarter of an inch high, then half an inch high, and it kept growing and growing until the aluminum was completely eaten up. "You've seen iron rust—oxidizing, combining with the oxygen in the air," Uncle said. "But here, with the aluminum, it's a million times faster. That big bar is still quite shiny, because it's covered by a fine layer of oxide, and that protects it from further change. But rubbing it with mercury destroys the surface layer, so then the aluminum has no protection, and it combines with the oxygen in seconds."

I found this magical, astounding, but also a little frightening—to see a bright and shiny metal reduced so quickly to a crumbling mass of oxide. It made me think of a curse or a spell,

[3] There were many attempts to manufacture diamonds in the nineteenth century, the most famous being those of Henri Moissan, the French chemist who first isolated fluorine and invented the electrical furnace. Whether Moissan actually got any diamonds is doubtful—the tiny, hard crystals he took for diamond were probably silicon carbide (which is now called moissanite). The atmosphere of this early diamond-making, with its excitements, its dangers, its wild ambitions, is vividly conveyed in H. G. Wells's story "The Diamond Maker."

the sort of disintegration I sometimes saw in my dreams. It made me think of mercury as evil, as a destroyer of metals. Would it do this to every sort of metal?

"Don't worry," Uncle answered, "the metals we use here, they're perfectly safe. If I put this little bar of tungsten in the mercury, it would not be affected at all. If I put it away for a million years, it would be just as bright and shiny as it is now." The tungsten, at least, was stable in a precarious world.

"You've seen," Uncle Dave went on, "that when the surface layer is broken, the aluminum combines very rapidly with oxygen in the air to form this white oxide, which is called alumina. It is similar with iron as it rusts; rust is an iron oxide. Some metals are so avid for oxygen that they will combine with it, tarnishing, forming an oxide, the moment they are exposed to the air. Some will even pull the oxygen out of water, so one has to keep them in a sealed tube or under oil." Uncle showed me some chunks of metal with a whitish surface, in a bottle of oil. He fished out a chunk and cut it with his penknife. I was amazed at how soft it was; I had never seen a metal cut like this. The cut surface had a brilliant, silvery luster. This was calcium, Uncle said, and it was so active that it never occurred in nature as the pure metal, but only as compounds or minerals from which it had to be extracted. The white cliffs of Dover, he said, were chalk; others were made of limestone—these were different forms of calcium carbonate, a major component in the crust of the earth. The calcium metal, as we spoke, had oxidized completely, its bright surface now a dull, chalky white. "It's turning into lime," Uncle said, "calcium oxide."

But sooner or later Uncle's soliloquies and demonstrations before the cabinet all returned to *his* metal. "Tungsten," he said. "No one realized at first how perfect a metal it was. It has the highest melting point of any metal, it is tougher than steel, and it keeps its strength at high temperatures—an ideal metal!"

Uncle had a variety of tungsten bars and ingots in his office. Some he used as paperweights, but others had no discernible function whatever, except to give pleasure to their owner and maker. And indeed, by comparison, steel bars and even lead felt light and somehow porous, tenuous. "These lumps of tungsten have an extraordinary concentration of mass," he would say. "They would be deadly as weapons—far deadlier than lead."

They had tried to make tungsten cannonballs at the beginning of the century, he added, but found the metal too hard to work—though they used it sometimes for the bobs of pendulums. If one wanted to weigh the earth, Uncle Dave suggested, and to use a very dense, compact mass to "balance" against it, one could do no better than to use a huge sphere of tungsten. A ball only two feet across, he calculated, would weigh five thousand pounds.

One of tungsten's mineral ores, scheelite, Uncle Dave told me, was named after the great Swedish chemist Carl Wilhelm Scheele, who was the first to show that it contained a new element. The ore was so dense that miners called it "heavy stone" or *tung sten,* the name subsequently given to the element itself. Scheelite was found in beautiful orange crystals that fluoresced bright blue in ultraviolet light. Uncle Dave kept specimens of scheelite and other fluorescent minerals in a special cabinet in his office. The dim light of Farringdon Road on a November evening, it seemed to me, would be transformed when he turned on his Wood's lamp and the luminous chunks in the cabinet suddenly glowed orange, turquoise, crimson, green.

Though scheelite was the largest source of tungsten, the metal had first been obtained from a different mineral, called wolframite. Indeed, tungsten was sometimes called wolfram, and still retained the chemical symbol W. This thrilled me, because my own middle name was Wolf. Heavy seams of the tungsten ores were often found with tin ore, and the tungsten made it more difficult to isolate the tin. This was why, my uncle continued, they had originally called the metal wolfram—for, like a

hungry animal, it "stole" the tin. I liked the name *wolfram,* its sharp, animal quality, its evocation of a ravening, mystical wolf—and thought of it as a tie between Uncle Tungsten, Uncle Wolfram, and myself, O. Wolf Sacks.

"Nature offers you copper and silver and gold native, as pure metals," Uncle would say, "and in South America and the Urals, she offers the platinum metals, too." He liked to pull out the native metals from his cabinet—twists and spangles of rosy copper; wiry, darkened silver; grains of gold panned by miners in South Africa. "Think how it must have been," he said, "seeing metal for the first time—sudden glints of reflected sunlight, sudden shinings in a rock or at the bottom of a stream!"

But most metals occurred in the form of oxides, or "earths." Earths, he said, were sometimes called calxes, and these ores were known to be insoluble, incombustible, infusible, and to be, as one eighteenth-century chemist wrote, "destitute of metallic splendour." And yet, it was realized, they were very close to metals and could indeed be converted into metals if heated with charcoal; while pure metals became calxes if heated in air. What actually occurred in these processes, however, was not understood. There can be a deep practical knowledge, Uncle said, long before theory: it was appreciated, in practical terms, how one could smelt ores and make metals, even if there was no correct understanding of what actually went on.

He would conjure up the first smelting of metal, how cavemen might have used rocks containing a copper mineral—green malachite perhaps—to surround a cooking fire and suddenly realized as the wood turned to charcoal that the green rock was bleeding, turning into a red liquid, molten copper.

We know now, he went on, that when one heats the oxides with charcoal, the carbon in the charcoal combines with their oxygen and in this way "reduces" them, leaving the pure metal. Without the ability to reduce metals from their oxides, he would say, we would never have known any metals other than the handful of native ones. There would never have been a bronze age, much less an iron age; there would never have been the fascinating discoveries of the eighteenth century, when a dozen and a half new metals (including tungsten!) were extracted from their ores.

Uncle Dave showed me some pure tungstic oxide obtained from scheelite, the same substance as Scheele and the d'Elhuyars, the discoverers of tungsten, had prepared.[4] I took the bottle from him; it contained a dense yellow powder that was surprisingly heavy, almost as heavy as iron. "All we need to do," he said, "is heat it with some carbon in a crucible until it's red-hot." He mixed the yellow oxide and the carbon together, and put the crucible in a corner of the huge furnace. A few minutes later, he withdrew it with long tongs, and as it cooled, I was able to see that an exciting change had occurred. The carbon was all gone, as was most of the yellow powder, and in their place were grains of dully shining grey metal, just as the d'Elhuyars had seen in 1783.

"There's another way we could make it," Uncle said. "It's more spectacular." He mixed the tungstic oxide with finely powdered aluminum, and then placed some sugar, some potassium perchlorate, and a little sulfuric acid on top. The sugar and perchlorate

[4]The d'Elhuyar brothers, Juan José and Fausto, were members of the Basque Society of Friends for Their Country, a society devoted to the cultivation of arts and sciences that would meet every evening, discussing mathematics on Monday evenings, experimenting with electrical machines and air pumps on Tuesday evenings, and so on. In 1777 the brothers were sent abroad, one to study mineralogy, the other metallurgy. Their travels took them all over Europe, and one of them, Juan José, visited Scheele in 1782.

After they returned to Spain, the brothers explored the heavy black mineral wolframite and obtained from it a dense yellow powder ("wolframic acid") which they realized to be identical to the tungstic acid Scheele had obtained from the mineral "tung-sten" in Sweden, and which, he was convinced, contained a new element. They went ahead, as Scheele had not, to heat this with charcoal, and obtained the pure new metallic element (which they named wolframium) in 1783.

and acid took fire at once, and this in turn ignited the aluminum and tungstic oxide, which burned furiously, sending up a shower of brilliant sparks. When the sparks cleared, I saw a white-hot globule of tungsten in the crucible. "That is one of the most violent reactions there is," said Uncle. "They call this the thermite process; you can see why. It can generate a temperature of three thousand degrees or more—enough to melt the tungsten. You see I had to use a special crucible lined with magnesia, to withstand the temperature. It's a tricky business, things can explode if you're not careful—and in the war, of course, they used this process to make incendiary bombs. But if conditions are right, it's a wonderful method, and it has been used to obtain all the difficult metals—chromium, molybdenum, tungsten, titanium, zirconium, vanadium, niobium, tantalum."

We scraped out the tungsten grains, washed them carefully with distilled water, examined them with a magnifying glass, and weighed them. He pulled out a tiny, 0.5-milliliter graduated cylinder, filled it to the 0.4-milliliter mark with water, then tipped in the tungsten grains. The water rose a twentieth of a milliliter. I jotted down the exact figures, and worked them out—the tungsten weighed a little less than a gram, and had a density of 19. "That's very good," Uncle said, "that's pretty much what the d'Elhuyars got when they first made it back in the 1780s.

"Now I've got several different metals here, all in little grains. Why don't you get some practice weighing these, measuring their volume, working out their density?" I spent the next hour delightedly doing this and found that Uncle had indeed given me a huge range, from one silvery metal, a little tarnished, which had a density of less than 2, to one of his osmiridium grains (I recognized it), which was almost a dozen times as dense. When I measured the density of a little yellow grain, it was exactly the same as that of tungsten—19.3, to be exact. "You see," said Uncle, "gold's density is almost the same as tungsten's, but silver is much lighter. It is easy to feel the difference between pure gold and gilded silver—but you would have a problem with gold-plated tungsten."

Scheele was one of Uncle Dave's great heroes. Not only had he discovered tungstic acid and molybdic acid (from which the new element molybdenum was made), but hydrofluoric acid, hydrogen sulfide, arsine, and prussic acid, and a dozen organic acids, too. All this, Uncle Dave said, he did by himself, with no assistants, no funds, no university position or salary, but working alone, trying to make ends meet as an apothecary in a small provincial Swedish town. He had discovered oxygen, not by a fluke, but by making it in several different ways; he had discovered chlorine; and he had pointed the way to the discovery of manganese, of barium, of a dozen other things.

Scheele, Uncle Dave would say, was wholly dedicated to his work, caring nothing for fame or money and sharing his knowledge, whatever he had, with anyone and everyone. I was impressed by Scheele's generosity, no less than his resourcefulness, by the way in which (in effect) he gave the actual discovery of elements to his students and friends—the discovery of manganese to Johan Gahn, the discovery of molybdenum to Peter Hjelm, and the discovery of tungsten itself to the d'Elhuyar brothers.

Scheele, it was said, never forgot anything if it had to do with chemistry. He never forgot the look, the feel, the smell of a substance, or the way it was transformed in chemical reactions, never forgot anything he read, or was told, about the phenomena of chemistry. He seemed indifferent, or inattentive, to most things else, being wholly dedicated to his single passion, chemistry. It was this pure and passionate absorption in phenomena—noticing everything, forgetting nothing—that constituted Scheele's special strength.

Scheele epitomized for me the romance of science. There

seemed to me an integrity, an essential goodness, about a life in science, a lifelong love affair. I had never given much thought to what I might be when I was "grown up"—growing up was hardly imaginable—but now I knew: I wanted to be a chemist. A chemist like Scheele, an eighteenth-century chemist coming fresh to the field, looking at the whole undiscovered world of natural substances and minerals, analyzing them, plumbing their secrets, finding the wonder of unknown and new metals.