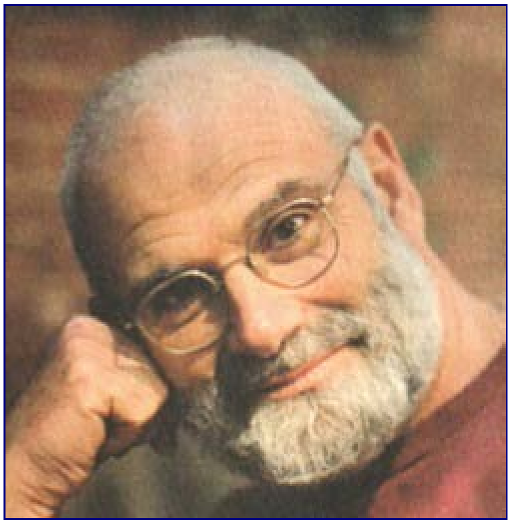
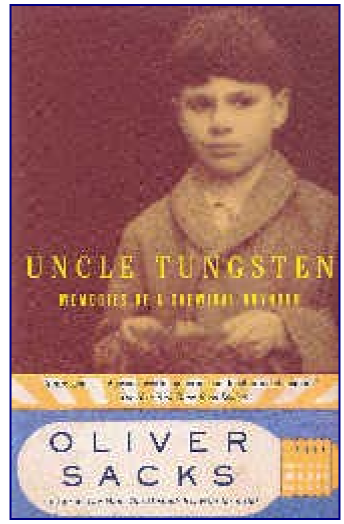


A READER'S JOURNAL

Uncle Tungsten
Memories of a Chemical Boyhood
by
Oliver Sacks

Published by Random House/NY in 2001
ARJ2 Chapter: Reading for Enjoyment
A Book Review by Bobby Matherne



In this encyclopedic book about chemistry and physics, Oliver Sacks does for these sciences what Denis Guedj does for mathematics in his novel, The Parrot's Theorem. We follow along with a teenage Sacks as he encounters the great innovators and founders of the sciences of chemistry and physics. Especially chemistry. He does his own experiments and duplicates those of these innovators in his own laboratory.

This book had a most unusual trigger for its creation: a resonant clonk when a little bar of metal fell from a package onto the floor as Oliver Sacks opened it. He recognized it at once as a sound from his childhood, "the sound of sintered tungsten" as his Uncle Tungsten would say and then add, "nothing like it." For Sacks it was the auditory equivalent of the taste of madeleines in Combray for Marcel Proust. What it triggered for Sacks was his "Remembrance of Chemicals Past".

> **[page 315] The clonk served as a sort of Proustian mnemonic, and instantly brought Uncle Tungsten to mind, sitting in his lab in his wing collar, his shirtsleeves rolled up, his hands black from powdered tungsten. Other pictures rose immediately in my mind: his factory where the lightbulbs were made, his collection of old lightbulbs, and heavy metals, and minerals. And my own initiation by him, when I was ten, into the wonders of metallurgy and chemistry. I thought I might write a brief sketch of Uncle Tungsten, but the memories, now started, continued to emerge — memories not just of Uncle Tungsten but of all the events of early life, of my boyhood, many forgotten for fifty years or more. What had started as a page of writing became a vast mining operation, a four-year excavation of two million words or more — from which, somehow, a book began to crystallize out.**

When I dropped this book on the wooden floor just now, it went THWOP! but inside of the book as I read along were all kinds of sounds (clonks, explosions, etc), sights (multi-colored metallic ores, chemicals, etc), textures (white fungus of aluminum oxide), smells (phosgene gas — like new mown hay, "stinkogens"), and tastes. Plus various chemicals, elements, molecules, compounds, liquids, gases, and metals in various shapes (solids, liquids) and molecular compounds such as oxides, halides, hydrides, and such, *ad infinitum* — with explicit directions for the reader to replicate them at home, if you dare. Some kids were given a chemistry set for Christmas when Sacks and I were kids, but Sacks lived inside of a chemistry set, it seems to me. He used an entire room in the large family home and eventually installed a venting hood under which he created hazardous and poisonous chemicals in front of his eyes by his own hands. He was just old enough to remember war-time England when an incendiary bomb, a thermite bomb, fell behind his house and "burned with a terrible, white-hot heat." Only a few years later he was creating a small scale thermite bomb under his venting hood in his own chemical "laboratory".

Like Freeman Dyson, I had the physique for physics and Sacks for chemistry (although his breadth of knowledge of physics was also awe-inspiring). He quotes Dyson from his autobiographical essay "To Teach or Not to Teach."

> **[page 26] I belonged to a small minority of boys who were lacking in physical strength and athletic prowess . . . We found our refuge in a territory that was equally inaccessible to our Latin-obsessed headmaster and our football-obsessed schoolmates. We found our refuge in science . . . We learned . . . That science is a territory of freedom and friendship in the midst of tyranny and hatred.**

One of the catalysts, the *platinum force* in Sacks's young life, if you will, was his two uncles, Dave and Abe. Dave specialized in *hot light* and Abe in *cold light*. Dave was the eponymous Uncle Tungsten, the metal most used for incandescent light bulbs, and he was the manager of a light bulb factory. Dave introduced his nephew, Oliver W. Sacks, to this metal whose chemical symbol is W. Sacks's middle name was Wolf and the chemical name for tungsten is Wolfram. So Uncle Tungsten had, in effect, a Nephew Tungsten! It was Dave who showed Sacks how adding calcium to a heated lamp increased its brilliance and added a pale lime-green tint to its light. This technique quickly was pressed into service to illuminate previously dimly lit stage shows and the expression "being in the limelight" entered the English jargon, meaning being in the spotlight on some stage. One among many *hot lights* which Uncle Dave introduced to his Nephew Tungsten, Oliver W. Sacks.

Uncle Abe, on the other hand, loved *cold light*, non-heat generating sources of illumination. He developed and patented a luminous paint, and he was intrigued by glow-worms, fireflies, phosphorescent seawater, will-o'-the-wisps, Saint Elmo's fire, and the Northern and Southern Lights. Abe explained to Oliver how the first matches had to be dipped into sulfuric acid to light them, but by adding white phosphorus to the tip, the first "lucifers" came into being — the first friction matches. How was phosphorus first discovered?

> **[page 225] Hennig Brandt of Hamburg had been the first to obtain this marvelous element, in 1669. He distilled it from urine (apparently with some alchemical ambition in mind), and he adored the strange, luminous substance he had isolated, and called it cold fire *(kaltes Feuer)*, or, in a more affectionate mood, *mein Feuer*.**

This book is filled with historical anecdotes, too many to mention in a review. It will treat any reader to a full pallette of chemical and physical shades of discovery, innovation, creation, and application. If you think you'd like to be a chemist, read this book first! If reading of Sacks's experiences does not excite you, choose another field immediately.

Platinum — where did it come from, what are its properties, how did it get its name? All things I wondered about, and Sacks came through for me in one short paragraph. This is an example of the hundreds of various elements, gases, metals, ores, and chemical compounds he discusses in this book. Uncle Dave throws his nephew a heavy platinum nugget and recalls a day when platinum was considered dirty and thrown away as trash by miners panning for gold.

> **[page 35] "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 equaling that of silver (its Spanish name, *platina*, meant "little silver").

Platinum had a very high melting point which made it ideal for crucibles for heating other metals and corrosive acids of any kind had no effect on it. Dave showed his nephew a beautiful smooth and shiny crucible which looked new, but had been in use for about 100 years! (Page 36)

Here is his story about Uncle Dave demonstrating the process of aluminum rust. One can never think the same way about aluminum as a sturdy metal after reading this story.

[page 38, 39] 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 recall kids bringing small amounts of mercury to elementary school in the 1940s, but lucky (or unlucky) for us, we had no access to any aluminum metals to try this on. But we did rub it on dirty buffalo nickels and silver dimes and quarters just to watch them immediately turn shiny. Another trick we did was dipping brown copper pennies into acetone and it would be shiny like new copper while in the liquid, but returned immediately to its brown color when removed, as I recall. Back then, hatters used liquid mercury to cure the felt in new hats and enough of the liquid got into their blood stream and brain to cause them to become hyperactive, and thus the term, "Mad Hatter", came into use.

Of all the metals, Uncle Dave had a soft spot for tungsten, and talked about it at the drop of the proverbial mercury-cured felt hat.

[page 39] 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!"

No wonder Oliver called Dave his "Uncle Tungsten." The common name of tungsten came from its ore which was very heavy. Its ore was given the name "heavy stone" or *tung sten* by the miners. This ore later was named scheelite after the Swedish Chemist Carl Wilhelm Scheele, who first showed it contained the element we now call tungsten. (Page 4)

Chemistry was not studied as a science until the last hundred years or so, but practical chemistry goes back to the stone age. How might cavemen have discovered how to smelt metals? Uncle Tungsten gave young Sacks his guess.

[page 41] He [Uncle Tungsten] 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.

The first step from the Stone Age to the Bronze Age — over a home-cooked meal one night in a local cavern. All without studying chemistry. In fact, as much as young Sacks loved practical, hands-on chemistry, he detested the school-bound desk study of his favorite subject. This was one of the reasons he became a neurologist instead of a chemist. More about that later.

But let's join Sacks as he "makes wolfie" for the first time.

> **[page 42] 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. 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.**

But Uncle Tungsten knew more than one way to "make wolfie" and this next way involved sugar and the results were explosive, like the bomb which fell during the war in Sacks' yard.

> **[page 42, 43] "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 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."**

But the lab hour was apparently not up yet and Uncle Tungsten did the measuring and Sacks calculated the density of the newly made "wolfie".

> **[page 43] 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 .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.**

Sacks was enamored of the work of chemists, especially Scheele. As you read his paean to the life of Scheele, it's easy to recognize that even though Sacks never became a chemist, he was a pioneer in the growing field of neuropathology and found there a whole undiscovered world of diseases of the nervous system in which he has specialized(1).

> **[page 44, 45] 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 into 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.**

After "Awakenings", "The Man Who Mistook His Wife for a Hat", "A Leg To Stand On", "Seeing Voices", The Island of the Colorblind, and other books by Oliver Sacks, many young doctors today want to be a neurologist like Sacks!

It never occurred to me before reading this book about the ambiguity in the company name, Louisiana Power & Light, a place I worked for fourteen years before I switched to being a full-time writer. Why both "power" and "light" I had wondered? After all, electrical power provides the light, doesn't it? Yes, it does today, but in the beginning gas provided the light more efficiently, so there was a constant shift back and forth in some areas and some homes opted for both kinds of illumination: gas and electrical. A similar seesaw effect is happening today with the choice of electricity and natural gas for heating.

> **[page 50] My uncles had told me about the fight between electric and gas lighting when they were young, and how the balance kept shifting in favor of one or the other. Many houses built in this era — including ours — had been equipped for both, as it was unclear which would win out in the end. (Even fifty years later, in my boyhood, there were many streets in London, especially in the City, that were still lit by gas mantles, and sometimes at dusk one could see the lamplighter with his tall pole, going from one street lamp to another, lighting them one by one. I loved to watch this.) But for all their virtues, the carbon bulbs had problems. They were fragile and became more so with use, and they could only be run at a relatively low temperature, so one had a dullish yellow light, not a brilliant white one.**

You know the rest of the story, the tungsten filament replaced the fragile and short-life carbon filament — the "wire of soot" Uncle Tungsten called it haughtily.

Among my many unanswered questions(2) that I found answered by this book was why the old Merck bottles we had around the house when I grew up were all a dark brown color. "Didn't they want to see what chemical compound was in the bottle?" I wondered back then. Sacks described the colored bottles in his Uncle Dave's laboratory and mentioned that the dark green or brown bottles were for light-sensitive chemicals. Obviously Merck didn't want the chemicals they were selling you as pure compounds to turn into something else while they were sitting on your shelf waiting to be used.

My dad worked at an alcohol distillery, and we had these old Merck bottles, alcohol, and lead around the house all the time. Dad molded the lead into sinkers for his home-knitted cast nets and trawls. I used it to mold lead soldiers with a soldier-making kit I got from Santa one year. Santas apparently had fewer rules to follow in those good ole days.

I liked this next story because it brings reality to the otherwise abstract atomic weights taught in chemistry class. We may all know that salt is sodium chloride, one sodium atom attached to one chlorine atom, but how much of each do you mix together to turn it all into salt? Read on how the abstract numbers Sacks had memorized take on reality show up during an experiment, piqued his curiosity, and created more unanswered questions for him.

> **[page 75] 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.**

Sacks devotes an entire chapter to smelly concoctions and explosive ones. The chapter is named "8. Stinks and Bangs". Kids will love this chapter. Parents won't. As a parent, I will skip it. See the book.

Carl Jung said that "nothing so motivates a son as what his father almost, but never quite did with his life." Guess what? In the next passage, Sacks reveals that his father almost became a neurologist:

> **[page 95, 96] My father had originally wondered about an academic career in neurology, and had been a houseman, an intern (along with Jonathan Miller's father), to Sir Henry Head, the famous neurologist, at the London Hospital. At this point, Head himself, still at the height of his powers, had developed Parkinson's disease, and this, my father said, would sometimes cause him to run involuntarily, or festinate, the length of the old neurology ward, so that he would have to be caught by one of his own patients. When I had difficulty imagining what this was like, my father, an excellent mimic, imitated Head's festination, careering down Exeter Road at an ever-accelerating pace, and getting me to catch him. Head's own predicament, my father thought, made him especially sensitive to the predicaments of his patients, and I think my father's imitations — he could imitate asthma, convulsions, paralyses, anything — springing from his vivid imagination of what it was like for others, served the same purpose.**

It seems to me that this ability in-form a patient's symptoms within oneself makes one an excellent physician. So often today, physicians do most of their diagnosis from ordered MRI's, Cat Scans, X-Rays, and such, and spend too little time in-forming themselves of what is going on inside of their living, breathing patient sitting before them in the examination room.

Earlier I mentioned that chemistry was a relatively new science, and in Robert Boyle we meet the earliest beginnings of that science in the mid-1600s. His interests were diverse as was his innovative discoveries. He made hydrogen gas by putting nails in sulfuric acid, he found that water had the unique property among liquids of expanding when frozen, that CO2 could be created by pouring vinegar on powdered coral, he considered blood transfusion to be possible, and reported a case of color blindness following a brain infection, among many other things. He set about to debunk the four elements doctrine of earth, water, air, and fire. For example, Sacks writes on page 104, "In these experiments Boyle effectively demolished the ancient belief that air was an ethereal, all-pervading medium by showing that it was a material substance with physical and chemical properties of its own, that it could be compressed or rarefied or even weighed."

Unfortunately Boyle replaced the *reality of the ancients with their spiritual perception* with his abstract fictions or laws about how air compressed, etc. Useful fictions these are, but they can be understood and used effectively without throwing away the spiritual perceptions of the ancients. Those spiritual realities are still true today, even though they are derisively scoffed at by materialistic successors in a tradition begun by Boyle. Like a *live baby*, these spiritual perceptions have been thrown out by materialistic scientists, who hold sacred only their *bathwater of abstract fictions*, up until now.

Lavoisier was the next chemist to modernize chemistry. He replaced the old chemical terms with a systematized language of hydrides, oxides, sulfide, etc. But even Sacks noted he missed the old picturesque names which provided a feeling for the chemicals' sensory qualities and histories.

> **[page 112] The language of chemistry, Lavoisier now felt, had to be transformed to go with his new theory, and he undertook a revolution of nomenclature, too, replacing the old, picturesque but uninformative terms — like butter of antimony, jovial bezoar, blue vitriol, sugar of lead, fuming liquor of *Libavius*, flowers of zinc — with precise, analytic, self-explanatory ones. If an element was compounded with nitrogen, phosphorus, or sulfur, it became a nitride, a phosphide, a sulfide. If acids were formed, through the addition of oxygen, one might speak of nitric acid, phosphoric acid, sulfuric acid; and of the salts of these as nitrates, phosphates, and sulfates. If smaller amounts of oxygen were**

> **present, one might speak of nitrites or phosphites instead of nitrates and phosphates, and so on. Every substance, elementary or compound, would have its true name, denoting its composition and chemical character, and such names, manipulated as in an algebra, would instantly indicate how they might interact or behave in different circumstances. (Although I was keenly conscious of the advantages of the new names, I missed the old ones, too, for they had a poetry, a strong feeling of their sensory qualities or hermetic antecedents, which was entirely missing from the new, systematic and scentless chemical names.)**

We can get a feeling for this lack Sacks experienced in the new nomenclature in a favorite quatrain of mine by Samuel Hoffenstein:

> **Little by little we subtract**
> **Faith and fallacy from fact**
> **The illusory from the true**
> **And starve upon the residue.**

This next passage further highlights Lavoisier's accomplishments, and in it Sacks uses marvelous phrases, *fifteen years of genius time* and *fighting his own blindnesses* (*italics* added) . No one who has not worked on projects for fifteen years can appreciate those expressions. And yet any true innovator will have experienced a measure of what Lavoisier went through to bring his revolutionary approach to chemistry into full use by all chemists.

> **[page 113] All of Lavoisier's enterprises — the algebraic language, the nomenclature, the conservation of mass, the definition of an element, the formation of a true theory of combustion — were organically interlinked, formed a single marvelous structure, a revolutionary refounding of chemistry such as he had dreamed of, so ambitiously, in 1773. The path to his revolution was not easy or direct, even though he presents it as obvious in the *Elements of Chemistry;* it required *fifteen years of genius time*, fighting his way through labyrinths of presupposition, *fighting his own blindnesses* as he fought everyone else's.**

What did Lavoisier accomplish? Sacks sums up succinctly how chemistry would be changed forever:

> **[page 113] Given this algebraic language, one might not need an actual afternoon in the lab — one could in effect do chemistry on a blackboard, or in one's head.**

Sacks was a practical joker, and as one myself (now retired), I could appreciate his delight at getting a couple of lead balloons for his 65th birthday. What's a lead balloon? Well, for Sacks it was a fulfillment of a teenager's dream.

> **[page 115] More than fifty years later (for my sixty-fifth birthday), I was able to gratify this boyhood fantasy, and had, besides the normal helium balloons, a few xenon balloons of astonishing density — as near to "lead balloons" as could be. . . If one twirled these xenon balloons in one's hand, then stopped, the heavy gas by its own momentum, would continue rotating for a minute, almost as if it were a liquid.**

Young Sacks was intrigued by the different colors he could get by replacing the silver salts with copper, uranium, or vanadium, leading to photos of green faces and green double-decker buses. His propensity for going overboard led to this report card saying one time, "Sacks will go far, if he does not go too far." The teacher should get a gold star for that statement. (Page 140)

It was Humphry Davy (the "Poet-Chemist") to whose life and achievements Sacks devoted the most coverage, basically all of Chapter 11. It was he who found that if a platinum wire was placed in an explosive gas mixture, it would glow until it ignited the flame. What a boon that would have been for our gas stoves, if I had known about that in the 1950-60s *and* could have located a piece of platinum wire — we were always looking for matches to light a balky burner. Like Sacks, Davy was always on the verge of going too far.

> **[page 131] But, crucially, it was Davy's personality that appealed to me — not modest, like Scheele, not systematic, like Lavoisier, but filled with the exuberance and enthusiasm of a boy, with a wonderful adventurousness and sometimes dangerous impulsiveness — he was always at the point of going too far — and it was this which captured my imagination above all.**

Ah, the next thing which Sacks falls in love with as a boy was taking pictures! This was another love of my youth, but one with which I had limited resources at my disposal. The only way I could afford to take photos and 8mm movies was to be the family photographer, which role was made easier by dint of my being the oldest of six. But until the advent of digital photography in the past decade, the wonders that one can do with photography in a photo-developing, printing, and enlarging studio escaped my financial means. So I read with nostalgic yearning about the opportunities to take, develop, manipulate, and print photos which young Sacks had at his disposal. He was able to make light-sensitive emulsions in his home chemical laboratory and test them out. Along the way he began to experiment with exotic chemicals which created various tones of color in his photographs.

> **[page 139] I soon spread from this to other forms of toning. Selenium toning gave a rich reddish color, and palladium- and platinum-toned prints had a fine, sober quality, more delicate, it seemed to me, than the usual silver prints. One had to start with a silver image, of course, because only silver salts were sensitive to light, but then one could replace it with almost any other metal. One could easily replace the silver with copper, uranium, or vanadium. A particularly wild combination was to combine a vanadium salt with an iron salt such as ferric oxalate, and then the yellows of the vanadium ferrocyanide and the blue of the ferri-ferrocyanide would combine to form a brilliant green. I enjoyed disconcerting my parent with pictures of green sunsets, green faces, and fire engines or double-decker buses turned green.**

It was John Dalton who brought the idea of atoms into the field of chemistry. He even made wooden balls into models of atoms, some of which were still on display in the Science Museum when Sacks visited it as a boy. As any innovator, Dalton was ridiculed by chemists, such as H. E. Roscoe, who wrote, "Atoms are round bits of wood invented by Mr. Dalton." At least Dalton had both an hypothesis and the *balls to prove it*.

Wilhelm Ostwalt wrote a sobering appraisal of Dalton's theory of atoms as the basis of chemistry in 1902. One can hear in Ostwalt's words in the passage below faint memories flowing from the future, when Alfred Korzybski's work, some thirty years later, will demonstrate that hypotheses are maps of uncertain and unknowable territory, but even so, they can be useful so long as one keeps in mind that "the map is *not* the territory".

> **[page 151, Ostwalt, 1902] Chemical processes occur in such a way as if the substances were composed of atoms . . . At best there follows from this the *possibility* that they are in reality so: not however, the *certainty* . . . One must not be led astray by the agreement between picture and reality, and confound the two . . . An hypothesis is only an *aid to representation.*"**

Rightly understood, John Dalton was a martyr to the cause of atoms, he gave his life to the defense of the usefulness of understanding atoms as the basis of all chemistry. Berzelius introduced a new symbolism which Dalton opposed because he felt it concealed the actuality of atoms.

> **[page 152] Dalton's passionate opposition to Berzelius's symbolism lasted to the end of his life, and indeed when he died in 1844 it was from a sudden apoplexy, following a**

> **violent argument defending the reality of atoms.**

As Sacks learned back then, an author or a book may have the map wrong, but still be very useful in describing the territory and how to navigate through it. One such book was J. J. Griffin's Chemical Recreations (c. 1850) which Sacks acquired at a second-hand bookstore as a youth.

> **[page 154] Griffin's book, my first guide in the laboratory, was written in the first half of the nineteenth century, and many of his formulas, and hence many of his atomic weights, were as erroneous as Dalton's. Not that any of this mattered too much in practice — not, indeed, did it affect the great virtue, the many virtues, of Griffin. His formulas and his atomic weights might indeed have been wrong, but the reagents he suggested, and their quantities, were exactly right. It was only the interpretation, the formal interpretation, that was askew.**

In learning science, as in human evolution, ontogeny recapitulates phylogeny. One must go through all the stages of understanding a science such as chemistry before one can appreciate the current state of the science.

> **[page 155,] "It often happens," Cannizzaro concluded, "that the mind of a person who is learning a new science, has to pass through all the phases which the science itself has exhibited in its historical evolution." Cannizarros' words had a powerful resonance for me, because I, too, in a way, was living through, recapitulating, the history of chemistry in myself, rediscovering all the phases through which it had passed.**

The prime virtue of this fine book is that it will help those, who like myself, did not have the good fortune to follow Sacks' methodical path through chemistry, both in his own laboratory and in his own discoveries. We have the chance through reading this book to get a feel for how atomic weights led to atomic numbers and then to Avogadro's Number, etc. Things which are so often presented as a *fait accompli* which we are expected to memorize and accept as flattened-out abstract concepts devoid of the living reality of Sacks' boyhood laboratory experiences.

One of those boyhood experiences was when Sacks removed tarnish from his mother's silverware by putting them into an aluminum dish with a warm solution of sodium bicarbonate. This was a process that Davy had innovated in his time and is being sold via infomercials on TV channels yet today. Davy proposed this as a form of cathodic protection for the bottoms of metal ships, and was ridiculed for his suggestion. Today it is used as a standard protection for ocean-going vessels. Be careful of what you ridicule today, is the message, you may be depending upon it in the near future.

In the beginnings of his crossover from chemistry to physics, Sacks began making various kinds of voltaic cells using various chemicals. By stacking these in various combinations he could produce high voltages or high currents. The old Daniell cell provided him high currents to heat up the various wires he experiment on, where voltage produced was not important as heat produced went up as the square of the current. (Page 162)

> **[page 163] If the electric battery was my introduction to the inseparable relation of electricity to chemistry, the electric bell by way of introduction to the inseparable relation of electricity to magnetism — a relation by no means self-evident or transparent, and one that was discovered only in the 1820s.**

When my wife was pregnant with our first child, I was completing my degree in Physics. I wanted to name my boy, Maxwell James Matherne. When my first boy was a girl, the name went back in the name bank. When my second and third boys were both girls, the name went back. When my fourth child was due to be born, I decided perhaps there were no boys-to-be who wanted to be saddled with the name I chose, so I opted for my first name and my father's first and sure enough, my fourth child was a boy, and he was named Robert Hilman. I mention this because this next passage by Sacks shows why I had so much respect for James Clerk Maxwell. His Uncle Abe is telling young Sacks about how Maxwell drew all the electromagnetic theory together in his four famous equations, now known as Maxwell's Equations.

> **[page 169] In this half-page of symbols, Abe said, showing the equations to me in one of his books, was condensed the whole of Maxwell's theory — for those who could understand them. Maxwell's equations revealed, for Hertz, the lineaments of "a new physics . . . like an enchanted fairyland" — not only the possibility of generating radio waves, but sense that the whole universe was crisscrossed by electromagnetic fields of every sort, reaching to the ends of the universe.**

Rarely do I read a book these days when some personal event is described in which I can see a doylic memory at the root of the feeling or reaction. Sacks recalls riding his tricycle on a summer day in 1939 when he was six years old. It was a Saturday, and his orthodox Aunt Annie pointed her finger at him, shaking her head, saying God is watching you, and fussing at him for daring to ride on the Sabbath in defiance of God.

> **[page 172] I disliked Saturdays from this time on, disliked God, too (at least the vindictive, punitive God that Annie's warning had evoked), and developed an uncomfortable, anxious, watched feeling about Saturdays (which persists, a little, to this day).**

Sacks remembers this event and how he felt. He was six years old and the event is part of his cognitive memory. The event is, however, linked to an earlier doylic memory which contains the feelings he describes above, and it remains, by his own admission, linked to it even to this day. If Sacks were to do a simple speed trace, he could convert the remains of the discomfort completely, and in under a minute. Doylic memories are events stored as bodily states until we reach five years old and then thereafter they are stored as cognitive memories, which by definition, contain no feelings but which can have already stored doylic memories linked to them, until one traces and erases them.

To show how persistent doylic memories are, take Sacks' favorite foods at the age of five, smoked salmon and Bach. If these were his favorite already at five, then they are doylicly based and would continue to this day. This is an example of a doylic memory one would wish to keep indefinitely.

> **[page 182] [My father] instilled in us an intense feeling for Bach especially, and all the hidden structure of a fugue. When I was five, I am told, and asked what my favorite things in the world were, I answered, "smoked salmon and Bach." (Now, sixty years later, my answer would be the same.)**

In Chapter 16, Sacks takes us on a guided tour through "Mendeleev's Garden", the magnificent table of the elements to which Mendeleev devoted his life. We all owe a lot to our mothers, but chemistry owes a lot to Mendeleev's mother: she walked with her son literally thousands of miles from the frozen wilderness of Siberia to Moscow and then to St. Petersburg to get her son into a university. Mendeleev held the possibility of a table of the elements as an unanswered question for over twenty years. He created a deck of cards with the properties, atomic weights and numbers, etc of each known element on one card. On long train trips, he would play a solitaire game with his cards, ever seeking some unifying and organizing principle for these diverse and seemingly unrelated elements. "If the fool would persist in his folly he would become wise." William Blake wrote, and he could have been writing of Mendeleev, for many people thought him to be a fool, and then his new Periodic Table predicted the properties of gallium before it was discovered officially.

> **[page 200] Indeed, it was said that Mendeleev had a better grasp of the properties of gallium — an element he had never even seen — than the man who actually discovered it.**
>
> **Suddenly Mendeleev was no longer seen as a mere spectator or dreamer, but as a man who had discovered a basic law of nature, and now the periodic table was**

> **transformed from a pretty but unproven scheme to an invaluable guide which could allow a vast amount of previously unconnected chemical information to be coordinated. It could also be used to suggest all sorts of research in the future, including a systematic search for "missing" elements. "Before the promulgation of this law," Mendeleev was say nearly twenty years later, "chemical elements were mere fragmentary, incidental facts in Nature; there was no special reason to expect the discovery of new elements."**

Some of the new elements, 93, 94, 95, and 96 were discovered during World War II and were kept secret till after the war. Usually one would expect the revelation of new elements to be made at a prestigious scientist conference, but these elements were revealed over a radio quiz show when a 12-year-old boy asked Glenn Seaborg, "Mr. Seaborg, have you made any more elements lately?"

Oliver Sacks was blessed in another way by one of his scientific uncles giving him a pocket spectroscope and showing him to how to use it. As a young man he would wander among the bright lights of Broadway, but instead of being dazzled by them, he would look through his portable spectroscope and note which gases were contained the various colored bulbs. The two men who together deciphered the code of the light and dark spectral lines observed in the spectroscope were Kirchhoff and Fraunhofer. Why should some lines be dark and other brightly colored? I dare anyone to find an easier-to-read explanation in college textbook than Sacks gives us.

> **[page 216] Kirchoff and others went on to identify a score of other terrestrial elements in the sun, and now the Fraunhofer mystery — the hundred of black lines in the solar spectrum — could be understood as the absorption spectra of these elements to the outermost layers of the sun, as they were transilluminated from within. On the other hand, a solar eclipse, it was predicted, with the central brilliance of the sun obscured and only its brilliant corona visible, would produce instead dazzling emission spectra corresponding to the dark lines.**

Soon the spectroscope was pressed into service to discover new elements that fit neatly into the Periodic Table of Mendeleev. Rubidium was one of these new elements, so called because of its dark red-colored spectral lines.

Another type of cold fire which his Uncle Abe showed Sacks was a type which I encountered in the 1970s when I heard of teenagers on dates crushing Wintergreen Lifesavers between their teeth to produce eerie green lights in their mouths. At first I didn't believe this possible, but a series of experiments proved it to be the case, as I crunched with a needle-nosed plier all kinds of Lifesavers and discovered that, in fact, Wintergreen produced the best effect. It took me some time, in the pre-Google world to discover that the effect was named *triboluminescence* and it had been discovered by a French scientist many years earlier. The flashes are created whenever new planes of crystals are exposed during the crunching process. Here's how Sacks discovered them.

> **[page 230] Uncle Abe also showed me other types of cold light. One could take various crystals-like uranyl nitrate crystals, or even ordinary cane sugar-and crush them, with a mortar and pestle, or between two test tubes (or even one's teeth), cracking the crystals against one another-this would cause them to glow. This phenomenon, called triboluminescence, was recognized even in the eighteenth century, when Father Giambattista Beccaria recorded:**
>
>> **You may, when in the dark frighten simple people only by chewing lumps of sugar, and, in the meantime, keeping your mouth open, which will appear to them as if full of fire; to this add, that the light from sugar is the more copious in proportion as the sugar is purer.**
>
> **Even crystallization could cause luminescence; Abe suggested that I make a saturated**

> **solution of strontium bromate and then let it cool slowly in the dark-at first nothing happened, and then I began to see scintillations, little flashes of light, as jagged crystals formed on the bottom of the flask.**

In Chapter 19 "Ma" Sacks reveals or has revealed to him how he was breast-fed by his mother during a lecture she was giving one day on the benefits and propriety of breastfeeding. The revelation took place in a publisher's office, of all places. His editor said, "You know, we've met before."

> **[page 237] "I don't think I remember," I said, embarrassed. "I can never recognize faces."**
> **"You wouldn't," she rejoined. "It was many years ago, when I was a student of your mother's. She was lecturing on breastfeeding that day, and after a few minutes she suddenly broke saying, 'There's nothing too difficult or embarrassing about breastfeeding.' She bent down and retrieved a small baby which had been sleeping, concealed behind her desk, and, unwrapping the infant, breastfed it before the class. It was in September 1933, and you were the infant."**

When Sacks then reveals on page 237 that he has his mother's "shyness, her dread of social occasions, as well as her flamboyance, her exuberance in front of an audience", it should not be surprising because all those attributes were doyles acquired from his mother before he was five years old.

In the chapter on "Madame Curie's Element" namely radium, his Uncle Abe showed Sacks a perpetual clock which used the ionizing effects of radioactive radiation as its power. This attribute of radioactivity, to ionize, is the very thing which distinguishes it from every kind of electromagnetic radiation, none of which can ionize. It is its ionizing effect which can cause disruptions in the DNA-molecules and lead to genetic defects in the fetuses in pregnant women, an effect which causes any female in a nuclear power plant to be considered as potentially pregnant when determining their maximum allowed dosage of radiation.

> **[page 263] I liked to watch Uncle Abe's radium clock, which was basically a gold-leaf electroscope with a little radium inside, in a separate thin-walled glass vessel. The radium, emitting negative particles, would gradually get positively charged, and the gold leaves would start to diverge — until they hit the side of the vessel and got discharged; then the cycle would start all over again. This "clock" had been opening and closing its gold leaves, every three minutes, for more than thirty years, and it would go on doing so for a thousand years or more — it was the closest thing, Uncle Abe said, to a perpetual motion machine.**

Atoms were considered immutable at the time. Even Marie Curie thought that radioactivity had to come from some mass in the atoms of radium being lost, but she was beaten down by the great majority of physicists and chemists who averred that to be impossible. Then a crucial observation by Ernest Rutherford proves the existence of a new substance, argon, which was being created during the radioactive decay of thorium. Luckily argon was a gas. Once more we see where in science, original ideas are more important than experiments. The experiment was known, but not what it meant, until Rutherford came up with the idea that a new element was being created.

> **[page 282] [Scientists] had found, as early as 1897, that if thorium was kept in a tightly shut bottle its radioactivity increased, returning to its previous level as soon as the bottle was opened. But they did not follow up on this observation, and it was Ernest Rutherford who first realized the extraordinary implication of this: that a new substance was coming into being, being generated by the thorium; a far more radioactive substance than its parent.**

Sometimes the idea precedes the experiment, and no more ingenious experiment can be found, in my opinion, than the one Moseley came up with to show the existence of nuclear charge. Suddenly one could call the roll of the elements for the first time ever. Any elements which did not respond were missing and we knew where in the roll call their spot was located. He basically recorded the number of protons in the nucleus of each element, which correlated exactly to the atomic number — the position of each element in the roll call.

> **[page 294, 295] Was there perhaps some atomic property that was more integral, more fundamental than atomic weight? This was not a question that could be addressed until one had a way of "sounding" the atom, sounding, in particular, its central portion, the nucleus. In 1913, a century after Prout, Harry Moseley, a brilliant young physicist working with Rutherford, set about exploring atoms with the just-developed technique of X-ray spectroscopy. His experimental setup was charming and boyish: using a little train, each car carrying a different element, moving inside a yard-long vacuum tube, Moseley bombarded each element with cathode rays, causing them to emit characteristic X-rays. When he came to plot the square roots of the frequencies against the atomic number of the elements, he got a straight line; and plotting it another way, he could show that the increase in frequency showed sharp, discrete steps or jumps as he passed from one element to the next. This had to reflect a fundamental atomic property, Moseley believed, and that property could only be nuclear charge.**
>
> **Moseley's discovery allowed him (in Soddy's words) to "call the roll" of the elements. No gaps could be allowed in the sequence, only even, regular steps. If there was a gap, it meant that an element was missing. One now knew for certain the order of the elements, and that there were ninety-two elements and ninety-two only, from hydrogen to uranium.**

Suddenly the number of protons in each element became a fundamental attribute and isotopes were understood as variations in the number of neutrons (neutral mass particles) while the number protons stay the same. Change the number of protons and you get a different element; change the number of neutrons and you get an isotope of the same element!

> **[page 295] Atomic numbers had been used before to denote the ordinal sequence of elements ranked by their atomic weight, but Moseley gave atomic numbers real meaning. The atomic number indicated the nuclear charge, indicated the element's identity, its chemical identity, in an absolute and certain way. There were, for example, several forms of lead — isotopes — with different atomic weights, but all of these had the same atomic number, 82. Lead was essentially, quintessentially, number 82, and it could not change its atomic number without ceasing to be lead.**

With all this background in the sciences of chemistry and physics, in electromagnetism and radioactivity, in both hot and cold lighting technology, in photography, in pyrotechnics, and other fields too numerous to list in a review, one can only wonder why and how the illustrious young scientific prodigy, Oliver Sacks, did not pursue one of those fields. I think I know because I was an avid reader of science fiction novels from age 7 through age 15, but gradually science fiction held no magic or mystery for me anymore. I still love a good story, and will occasionally read a Robert Heinlein novels like "Stranger in a Strange Land" or the Lazarus Long series, or watch a Star Trek Voyager episode, but science fiction novels I mostly avoid. Something like that happened to Sacks and he recounts the dramatic change for us.

> **[page 310] But it was not sudden — I did not wake up one morning and find that chemistry was dead for me; it was gradual, it stole upon me bit by bit. It happened at first, I think, without my even realizing it. It came upon me sometime in my fifteenth year that I no longer woke up with sudden excitements — "Today I will get the Clerici solution! Today I will read about Humphry Davy and electric fish! Today I will finally understand diamagnetism, perhaps!" I no longer seemed to get these sudden illuminations, these epiphanies, those excitements which Flaubert (whom I was now reading) called "erections of the mind." Erections of the body, yes, this was a new, exotic**

> **part of life — but those sudden raptures of the mind, those sudden landscapes of glory and illumination, seemed to have deserted or abandoned me. Or had I, in fact, abandoned them? For I was no longer going to my little lab; I only realized this when I wandered down one day and saw a light layer of dust on everything there. I had scarcely seen Uncle Dave or Uncle Abe for months, and I had ceased to carry my pocket spectroscope with me.**

As a youngster I began reading avidly at 6 years old, and, when the first library in our small town of Westwego first opened, I was there with my mother to take some books about dinosaurs and other wonderful things, like the original Dr. Seuss book, published in 1938, "The 500 Hats of Bartholomew Cubbins." It was about a young man who, whenever he took off his hat, a new one appeared. Oliver Sacks as a youth was like Bartholomew Cubbins, whenever he took off one of his hats, a new one appeared. He took off his hot light hat and a cold light hat appeared, he took off his chemistry hat and a physics hat appeared. Soon he had taken off all his childhood hats, and his father's hat appeared, one which remains on his head yet today, a neurologist — a neurologist who has done in his field what Dalton, Mendeleev, Maxwell, Curie, Rutherford, Moseley, Einstein, etal, did in their fields, opened them up to new vistas of possibilities for understanding the world — and for Sacks that world is the human mind.

---------------------------- *Footnotes* ---

Footnote 1. See especially Sacks' book "Awakenings" and the fine movie starring Robert DeNiro it was made into.

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Footnote 2. "What is the power of an unanswered question?" is one of my basic rules. See here: http://www.doyletics.com/mrules.htm#mrn25 .

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