Chemistry Lessons

A person spends almost his entire adult life quietly practicing the profession, chemistry, for which he was trained, and finally he dies in the same house where he was born. What life could sound more tranquil? Yet when that life is interrupted, as Primo Levi's was, by the 20th century's ultimate horror, then such tranquility can only be superficial, a mockingly deceptive appearance. In 1943, fighting Fascists and Nazis as a Jewish-Italian partisan, Primo Levi was captured and deported to the Nazi concentration camp at Auschwitz. Prisoner 174517 (with the number tattooed on his arm), Levi would have gone the way of most other camp prisoners had it not been for his specific training as a chemist, which the Nazis found useful. Although he remained, as he said, "a chemist by conviction" after Auschwitz, he had also acquired "an absolute need to write." Levi's memoirs and his novel of daily life in the death camps are considered the triumph of lucid intelligence over modern barbarism, and they made him internationally famous. Yet he continued his career as a chemist, working in a Turin paint factory for almost 30 years. His understanding of chemistry not only saved his life but made him, he believed, the kind of writer he was. In his autobiography, *The Periodic Table*, he organized each chapter of his experience around the character of a particular chemical element. The shy and unassuming chemist Levi—whom Philip Roth called "a magically endearing man, the most delicately forceful enchanter I've ever known"—here shows how the language of chemistry is a human language, and that chemistry, too, can be a humanistic pursuit.

by Primo Levi

I

Although their trade is more recent than that of theologians, vintners, or fishermen, chemists too, since their origins, have felt the need to equip themselves with a specialized language of their own. Nevertheless, unlike all other trade languages, that of chemists has had to adapt itself to rendering a service which I believe is unique in the panorama of the numerous specialized jargons: It must be able to indicate with precision, and if possible describe, more than a million distinct objects, because that is the number (and it grows every year) of the chemical compounds found in nature or constructed by synthesis.

Now, chemistry was not born all of a piece like Minerva, but laboriously, through the patient but blind trials and errors of three generations of chemists who spoke different languages and often communicated with each other only by letter. Therefore the chemistry of the past century was gradually consolidated through a terrible confusion of tongues, whose vestiges still survive in the chemistry of today. Let us leave aside inorganic chemistry, whose problems are relatively simpler and deserve a separate discussion. In organic chemistry, that is, in the chemistry of carbon compounds, at least three different modes of expression flow together.

The most ancient is also the most lithe and picturesque; it consists in giving each newly discovered compound a fanciful name which harks back to the natural product from which it was isolated for the first time: Names like carotene, lignin, aspargine, abietic acid express fairly well for us neo-Latins the origin of the substance but say nothing about its constitution. A little more obscure is adrenaline, which was so named because it was isolated from subrenal capsules (*ad renes*, that is, renal, close to the kidneys).

Also, benzine derives its name (in Italian and German) from a natural product, but through a strange and tangled chemico-linguistic history. At the beginning there is benzoin, a scented resin which for at least two thousand years was imported from Thailand and Sumatra and which at one time was used not only for perfumes but also for therapy: I do not know on what grounds, perhaps only because of the dangerous reasoning according to which substances that have a pleasant smell are "good for you." The trade in this resin and many other spices was in the hands of Arab merchants and navigators. Since the penchant for advertising and, with it, the protection of commercial secrets are as old as trading itself, Arabs sold the product under a pretty but deliberately misleading Arab name: They called it *luban jawi*, which means "Java incense," although benzoin was not a real incense and although it did not come from Java at all.

In Italy and France the first syllable was mistaken for an article and has fallen off. What remained of the name, that is, *banjawi*, was pronounced and written in various ways until it became established as *benzoe*, *beaujoin*, *benjoin*, and *benzoin*. More centuries passed, until in 1833 a German chemist was the first to think of subjecting benzoin to dry distillation, heating it at a high temperature in the absence of water. It was believed at that time, more or less consciously, that this treatment served to separate the volatile, noble, "essential" part of a substance (not for nothing is gasoline still called "essence" in French) from the inert residue which remained at the bottom of the retort. In short, it was believed that a soul was being separated from a body. In fact, in many languages the word "spirit" designates the soul as well as alcohol and other liquids which evaporate easily. Thus the German chemist obtained the "soul," the "essence" of benzoin and called it *benzine*.

A second chemical language, less fanciful but more expressive, is the one composed of the so-called raw formulas. To say that common sugar is $C_{12}H_{22}O_{11}$ or the old pyramidion, dear to country practitioners, is $C_{13}H_{17}ON_3$ gives us no indication of their origin nor the uses of the two substances, but represents their inventory. It is, precisely, a raw, incomplete language: It tells us that to build a molecule of pyramidion, 13 atoms of carbon are needed, 17 of hydrogen, one of oxygen, three of nitrogen, but it tells us nothing about the order or the structure in which

those atoms are linked together. In short, it works as if a typographer extracted from his type font the letters, *e, a, c, r,* and claimed he had in this way expressed the word *care.* The reader who is not initiated or assisted by the context could also "read" *race, acre,* or who knows what other anagram. It is a summary way of writing which has the sole value (precisely typographical) of fitting neatly into the printed line.

The third language has all the above advantages, and only one disadvantage; this last being the fact that its "words" do not fit the usual printed line. It tries (or expects) to give us a portrait, an image of the minuscule molecular edifice. It has renounced a good part of the symbolism which is characteristic of all languages, and has regressed to pictography. It is as if, instead of the word *acre,* the image of the acre were printed or drawn. The system reminds us of the scholar in the country of the Balnibarbi, about whom Swift speaks in *Gulliver's Travels*: According to him, one must reason without speaking, and he suggests keeping on hand, in place of words, "such things as were necessary to express the particular business they are to discourse on," that is, a ring if the talk is about rings, a cow if cows are being talked about, and so on. In this way, the scholar argued, "it would serve as a universal language to be understood in all civilized nations." There is no doubt that the objective, in fact objectified, language of the Balnibarbi and the structural formulas of chemists approach perfection from the point of view of understandability and internationality, but both involve the inconvenience of bulk, as the unhappy compositors of organic chemistry textbooks know only too well.

Naturally, despite its claims to portraiture, and unlike Balnibarbi, the language of structural formulas, by the very fact of being a true language, has remained partially symbolic: Its portraits are not life-size, but in a "scale" (that is, in a huge enlargement) of about one to a hundred million; furthermore in place of the atoms' shape, these "portraits" contain their graphic symbol, that is, their abbreviation.

Finally, the represented object generally has a thickness, a three-dimensional structure, whereas the portrait is, of course, flat because the page on which it is printed is flat. And yet, despite these limitations, if these conventional models are compared with the "true," almost photographic portraits which have been obtainable by subtle techniques for a few decades, their resemblance is striking. The molecules, the little drawings derived from reasoning and experimentation, are indeed very similar to the particles of matter which the ancient atomists had intuited when seeing motes of dust dancing in a beam of sunlight.

II

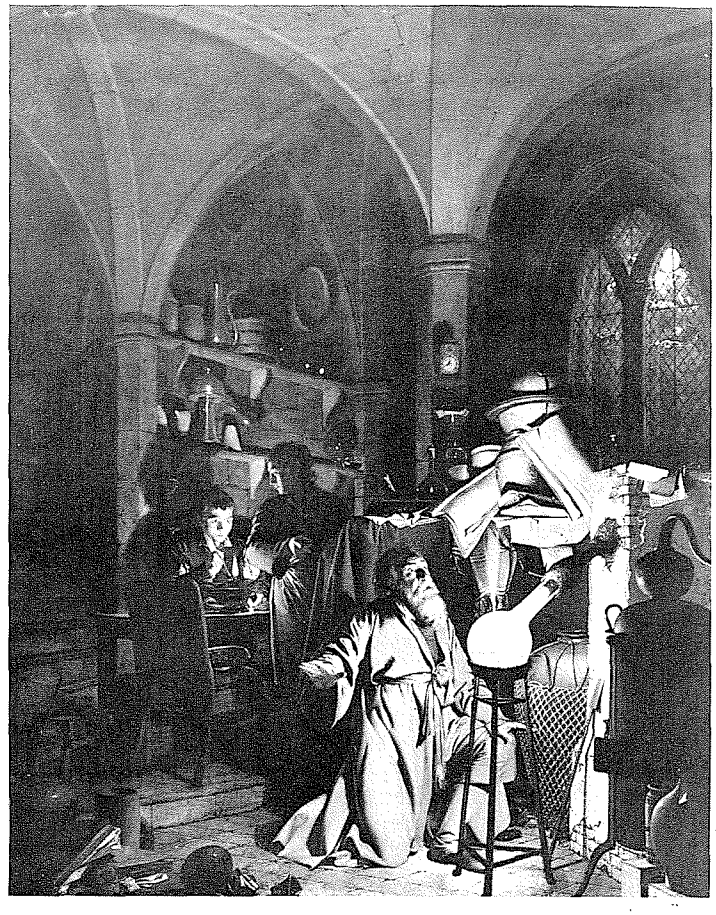
When I was a working chemist I suffered from heat, frost, and fear, and I would never have thought that, after leaving my old trade, I could feel any nostalgia for it. But it happens, during empty moments, when the human apparatus spins in neutral, like an idling motor. It happens, thanks to the singular filtering power of the mind, which lets happy memories survive and slowly stifles the others. I have recently seen again an old fellow prisoner and we had the usual conversations of veterans. Our wives noticed and pointed out to us that in two hours of conversation we had not brought up even a single painful memory, but only the rare moments of remission or the bizarre episodes.

I have before me the table of chemical elements, the "periodic system," and I am filled with nostalgia, as if I were looking at old school photographs, the boys with their little ties and the girls in their modest black smocks: "One by one I recognize

Primo Levi, *a chemist and noted Holocaust writer, was born in Turin, Italy on July 31, 1919. He studied chemistry at the University of Turin and received a degree in 1941. Among his books are* Survival in Auschwitz *(1947),* The Reawakening *(1963),* The Drowned and the Saved *(1986), and various works of fiction. Levi died in Turin on April 11, 1987, under circumstances which suggested suicide. This essay is taken from* Other People's Trades *copyright © 1989 by Summit Books.*

you all...." The struggles, defeats, and victories that have tied me to certain elements I have already recounted elsewhere, as I also told of their characters, virtues, vices, and oddities. But now my trade is a different one. It is the trade of words, chosen, weighed, fitted into a pattern with patience and caution. Thus for me also the elements tend to become words, and instead of the thing, its name and the why of its name interests me acutely. The panorama is different but just as varied as that of the things themselves.

Everyone knows that "proper" elements, those existing in nature, both on earth and in the stars, are 92, from hydrogen to uranium (actually the latter during the last decades has lost a bit of its good repute). Well, their names, passed in review, constitute a picturesque mosaic which extends in time from far-off prehistory until the present day, and in which appear perhaps all the Western languages and civilizations: our mysterious Indo-European fathers, ancient Egypt, the Greek of the Greeks, the Greek of the Hellenists, the Arab of the alchemists, the nationalistic prides of the past century, right down to the suspect internationalism of this postwar period.



Joseph Wright of Derby's painting (c. late 1700s) of an alchemist. Modern chemistry diverged from alchemy during the 18th century.

We begin with the best known and least exotic elements, nitrogen and sodium. Their international symbols, that is, the single letter or the group of two letters which abbreviate their conventional and original name are respectively N and Na, the initials of the Latin terms *nitrogenium* and *natrium*. And here come to light the vestiges of ancient misunderstanding. *Nitrogenium* means "born from nitro," and *natrium* means "substance of *natro*": Now, originally, in the language of ancient Egypt *nitro* and *natro* were the same thing.

In the complicated script of that language, vowels were considered superfluous, perhaps because carving stone is more strenuous than using a ball-point pen, and cutting down on vowels saved the stonecutters work. The consonants *ntr* generically indicated either the saline efflorescence found on old walls (which in Italian is still called *salnitro*, and in other languages, more expressively, *saltpeter*, that is salt of stone) or the "salt-like" substance that the Egyptians extracted from quarries and used for mummification. This last is mainly composed of soda or sodium carbonate, while saltpeter is composed of nitrogen, oxygen, and potassium.

Both, in brief, were "nonsalt salt," sub-

A CHEMISTRY EXAMINATION

When Primo Levi was sent to Auschwitz in 1943, he realized he was not that rare, sturdy person who, with luck, survives conditions in a concentration camp. The Nazis needed chemists, however, and at Auschwitz they began interrogating the few Häftlinge *(prisoners) who had chemistry backgrounds. So came up Levi's one slim chance for survival: a chemistry examination for mortal stakes.*

With these empty faces of ours, with these sheared craniums, with these shameful clothes, [we have] to take a chemistry examination. And obviously it will be in German; and we will have to go in front of some blond Aryan doctor, hoping that we do not have to blow our noses, because perhaps he will not know that we do not have handkerchiefs, and it will certainly not be possible to explain it to him. And we will have our old comrade hunger with us, and we will hardly be able to stand still on our feet, and he will certainly smell our odor, to which we are by now accustomed, but which persecuted us during the first days, the odor of turnips and cabbages, raw, cooked, and digested.

Down came Alex [our Kapo] into the magnesium chloride yard and called us seven out to go and face the examination. We go like seven awkward chicks behind the hen, following Alex up the steps of the *Polimerisations-Büro*. We are in the lobby; there is a brass-plate on the door with the three famous names. Alex knocks respectfully, takes off his beret and enters. We can hear a quiet voice; Alex comes out again. *"Rube, jetzt. Warten,"* wait (in silence).

The door opens . . . . This time it really is my turn . . . .

Pannwitz is tall, thin, blond; he has eyes, hair, and nose as all Germans ought to have them, and sits formidably behind a complicated writing-table. I, *Häftling* 174517, stand in his office, which is a real office, shining, clean, and ordered, and I feel that I would leave a dirty stain on whatever I touched.

When he finished writing, he raised his eyes and looked at me.

From that day I have thought about *Doktor* Pannwitz many times and in many ways. I have asked myself how he really functioned as a man; how he filled his time . . . . Above all when I was once more a free man, I wanted to meet him again, not from a spirit of revenge, but merely from a personal curiosity about the human soul.

Because that look was not one between two men; and if I had known how completely to explain the nature of that look, which came as if across the glass window of an aquarium between two beings who live in different worlds, I would also have explained the essence of the great insanity of the Third Reich.

One felt in that moment, in an immediate manner, what we all thought and said of the Germans. The brain which governed those blue eyes and those manicured hands said: "This something in front of me belongs to a species which it is obviously opportune to suppress. In this particular case, one has to first make sure that it does not contain some utilizable element." And in my head, like seeds in an empty pumpkin: "Blue eyes and fair hair are essentially wicked. No communication possible. I am a specialist in mine chemistry. I am a specialist in organic syntheses. I am a specialist . . . "

And the interrogation began, while in the corner that third zoological specimen, Alex, yawned and chewed noisily.

"Wo sind Sie geboren?" [Where were you

stances with a saline appearance soluble in water, colorless, but with a taste different from that of common salt. Glassmakers soon realized that in the manufacture of glass one could be replaced by the other without a great difference in the end product, which for us is quite understandable: At the temperature of the glassmakers' crucible both salts decompose, the acid part leaves, and in the fused mass only the oxide of the metal remains. The Greeks and later the Latins, transliterating the Egyptian writing, introduced vowels in accordance with largely arbitrary criteria, and only then did the variant *nitro* begin to indicate specifically saltpeter, the father of nitrogen, and *natro* to indicate soda, the mother of sodium.

In running through a list of names of minerals, one is confronted by an orgy of

born?] He addresses me as *Sie*, the polite form of address: *Doktor* Ingenieur Pannwitz has no sense of humor. Curse him, he is not making the slightest effort to speak a slightly more comprehensible German.

I took my degree at Turin in 1941, summa cum laude—and while I say it I have the definite sensation of not being believed, of not even believing it myself; it is enough to look at my dirty hands covered with sores, my convict's trousers encrusted with mud. Yet I am he, the B.Sc. of Turin; in fact, at this particular moment it is impossible to doubt my identity with him, as my reservoir of knowledge of organic chemistry, even after so long an inertia, responds at request with unexpected docility. And even more, this sense of lucid elation, this excitement which I feel warm in my veins, I recognize it, it is the fever of examinations, *my* fever of *my* examinations, that spontaneous mobilization of all my logical faculties and all my knowledge, which my friends at university so envied me.

The examination is going well. As I gradually realize it, I seem to grow in stature. He is asking me now on what subject I wrote my degree thesis. I have to make a violent effort to recall that sequence of memories. so deeply buried away: It is as if I were trying to remember the events of a previous incarnation.

Something protects me. My poor old "Measurements of dielectrical constants" are of particular interest to this blond Aryan who lives so safely: He asks me if I know English, he shows me Gatterman's book, and even this is absurd and impossible, that down here, on the other side of the barbed wire, a Gatterman should exist, exactly similar to the one I studied in Italy in my fourth year, at home.

Now it is over. The excitement which sustained me for the whole of the test suddenly gives way and, dull and flat, I stare at the fair skin of his hand writing down my fate on the white page in incomprehensible symbols.

"Los, ab!" Alex enters the scene again, I am once more under his jurisdiction. He salutes Pannwitz, clicking his heels, and in return receives a faint nod of the eyelids. For a moment I grope around for a suitable formula of leave-taking: but in vain. I know how to say to eat, to work, to steal, to die in German; I also know how to say sulphuric acid, atmospheric pressure, and short-wave generator, but I do not know how to address a person of importance.

Here we are again on the steps. Alex flies down the stairs. He has leather shoes because he is not a Jew; he is as light on his feet as the devils of Malabolge. At the bottom he turns and looks at me sourly as I walk down hesitantly and noisily in my two enormous unpaired wooden shoes, clinging on to the rail like an old man.

It seems to have gone well, but I would be crazy to rely on it. I already know the *Lager* well enough to realize that one should never anticipate, especially optimistically. What is certain is that I have spent a day without working, so that tonight I will have a little less hunger, and this is a concrete advantage, not to be taken away.

To re-enter Bude, one has to cross a space cluttered up with piles of cross-beams and metal frames. The steel cable of a crane cuts across the road, and Alex catches hold of it to climb over: *Donnerwetter*, he looks at his hand black with thick grease. In the meanwhile I have joined him. Without hatred and without sneering, Alex wipes his hand on my shoulder, both the palm and the back of the hand, to clean it; he would be amazed, the poor brute Alex, if someone told him that today, on the basis of this action, I judge him and Pannwitz and the innumerable others like him, big and small, in Auschwitz and everywhere.

personalities. It would seem that no mineralogist was ever resigned to ending his career without linking his name to a mineral, adding to it the ending *-ite* as a laurel wreath: garnierite, senarmontite, and thousands of others.

Chemists have always been more discreet; in my review I have found only two names of elements that their discoverers decided to dedicate to themselves, and they are gadolinium (discovered by the Finn Gadolin) and gallium. This last has a curious history. It was isolated in 1875 by the Frenchman Lecocq de Boisbaudran; *cocq* (today written *coq*) means "cock," (*Gallus* in Latin) and Lecocq baptized his element *gallium*. A few years later, in the same mineral examined by the Frenchman, the German chemist Winkler discovered a new element. Those were years of

great tension between Germany and France; the German assumed gallium to be a nationalistic homage to Gaul and baptized his element *germanium* in order to even the score.

Besides these two, only a few personal names have been given to the newest, unstable elements, those which are heavier than uranium and have been obtained by man in minimal quantities in nuclear reactors and in the enormous particle accelerators—elements dedicated respectively to Mendeleev, Einstein, Madame Curie, Alfred Nobel, and Enrico Fermi.

More than a third of the elements have received names that refer to their most striking properties, arrived at by more or less tortuous linguistic itineraries. So it is for chlorine, iodine, chromium, from Greek words which respectively mean "green," "purple," and "color," referring to the color of their salts or vapors (or, in other cases, to the color of the spectral emission lines). Thus barium is "the heavy," phosphorus is "the luminous," bromine and osmium are, in different degrees, "the stinkers." (But what chemist worthy of the name could confuse these two most unpleasant odors?)

Still in this spirit, which I would call descriptive, and which attests to modesty and good sense, hydrogen and oxygen were named, respectively, "generated by water" and "by acids. But since the baptism was performed (or confirmed) by the Frenchman Lavoisier, the German chemists did not consider it valid and imitated it with two approximate translations: *Wasserstoff* and *Sauerstoff*, that is, respectively, "the substance of water" and "of acids," and the Russians did the same, coining the couple *vodorod* and *kisslorod*.

Only three of the elements that have received "descriptive" names bear witness to a leap of the imagination: dysprosium ("the impervious"), lanthanum ("the hidden"), and tantalum. In this last denomination, the discoverer (Ekeberg, 1802: a Swede, a neutral, and therefore the name chosen by him was not subjected to changes) referred to Tantalus, the mythical sinner described in *The Odyssey*; he is immersed in water up to the neck, but undergoes the agonies of thirst, because every time he bends to drink, the water recedes, uncovering arid ground. The same ordeal had been suffered by him, the pioneering chemist, in the hopes and disappointments through which he had finally succeeded in discovering his element.

Besides the already mentioned germanium, about 20 elements have received names that more or less clearly commemorate the country or city in which they were discovered: For example, lutetium from the ancient name of Paris and scandium from Scandinavia.

I have deliberately left aside the history of the veteran elements, known to everyone, characterized and exploited by the most ancient civilizations thousands of years before the first chemist was born: iron, gold, silver, copper, sulfur, and several others. It is a complicated and fascinating story, worth being told elsewhere.

III

The bond between a man and his profession is similar to that which ties him to his country; it is just as complex, often ambivalent, and in general it is understood completely only when broken: by exile or emigration in the case of one's country, by retirement in the case of a trade or profession. I left the trade of chemist several years ago, but only now feel the necessary detachment to see it in its entirety and understand how much it pervades me and how much I owe it.

I do not refer to the fact that during my imprisonment in Auschwitz it saved my life, nor to the reasonable livelihood I got from it for 30 years, nor to the pension to which it entitled me. Instead I would like to describe other benefits that I think I have obtained from it, and which are all related to the new trade I have gone on to, that is, the trade of writing. A need for qualification immediately arises: Writing is not really a trade, or at least in my opinion it should not be one. It is a creative activity and therefore it balks at schedules and deadlines, commitments to customers and bosses. Nevertheless, writing is a way of "producing," indeed a process of transformation. The writer transforms his experi-

ences into a form that is accessible and attractive to the "customer" who will be the reader. The experiences (in the broad sense: life experiences) are therefore raw material. The writer who lacks them works in a void; he thinks he's writing but his pages are empty. Now, the things I have seen, experienced, and done during my preceding incarnation are today for me, as writer, a precious source of raw materials, of events to narrate, and not only events: also of those fundamental emotions which are one's way of measuring oneself against matter (an impartial, imperturbable, but extremely harsh judge: if one makes a mistake, one is pitilessly punished) and thus of winning and losing. This last is a painful but salutary experience without which one does not become adult and responsible. I believe that every colleague of mine in chemistry can confirm this: More is learned from one's errors than from one's successes. For example, to formulate an explanatory hypothesis, believe in it, grow fond of it, check it (oh, the temptation of falsifying data, of giving them a small flick of the thumb!), and in the end discover that it is mistaken—this is a cycle that in the chemist's trade is encountered only too often "in a pure state," but can easily be recognized in numerous other human itineraries. He who goes through it honestly issues from it matured.

There are other benefits, other gifts, that the chemist offers the writer. The habit of penetrating matter, of wanting to know its composition and structure, foreseeing its properties and behavior, leads to an insight, a mental habit of concreteness and concision, the constant desire not to stop at the surface of things. Chemistry is the art of separating, weighing, and distinguishing: These are three useful exercises also for the person who sets out to describe events or give body to his own imagination. Moreover, there is an immense patrimony of metaphors that the writer can take from the chemistry of today and yesterday, which those who have not frequented the laboratory and factory know only approximately. The layman too knows what to filter, crystallize, and distill means, but he knows it only at second hand. He does not know "the passion infused by them," he does not know the emotions that are tied to these gestures, has not perceived the symbolic shadow they cast. Also, just on the plane of comparisons the militant chemist finds himself in possession of unsuspected wealth: "black as . . . ," "bitter as . . . ."; viscous, tenacious, heavy, fetid, fluid, volatile, inert, flammable: These are all qualities the chemist knows well, and for each of them he knows how to choose a substance which contains it to a prominent and exemplary degree. I, an ex-chemist, by now atrophied and ill-equipped if I were to go back to a laboratory, am almost ashamed when in my writing I derive profit from this repertory: I feel I am enjoying an illicit advantage vis-à-vis my new writer colleagues who do not have a militancy like mine behind them.

For all these reasons, when a reader expresses amazement at the fact that I, a chemist, have chosen the road of the writer, I feel authorized to answer that I write precisely because I am a chemist: My old trade has been largely transfused into my new one.