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Research Article

Chemistry and Literature: Disciplines in Dynamic Equilibrium

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Abstract. This article examines the complex and multifaceted topic of the link between chemistry and literature. Instead of scouring the literary works of the various epochs in search of links with chemical thought or reasoning only on those literary works that are clearly imbued with chemistry (Primo Levi first and foremost, but also Gadda, Calvino and Sinisgalli in Italy, or, in the world arena, Sacks, Hoffmann, Goethe, Wells), a different approach is proposed, a third way that moves from a suggestive hypothesis of chemistry and literature as very different disciplines, but in constant dynamic equilibrium. To illustrate this thought and point of view, a number of themes are identified that are of fundamental importance in both chemistry and literature, albeit with profoundly different implications. The themes are events and their *why* and *how*, the *before* and *after*, that is, time and its irreversible arrow, the interpretation of the present, reality and unreality, questions and answers, and the value of discovery. In six separate paragraphs, these themes are analysed with significant and original references to discoveries and innovations in chemistry combined with reflections on works of international literature, attempting to highlight consonances and dissonances between chemistry and literature and arriving at a synthesis that identifies how chemistry and literature have behaved, over the centuries, like two planets revolving around the same sun of culture and knowledge, sometimes moving apart, sometimes coming closer together.

Keywords: History of Chemistry, Chemistry Discoveries, Literature, Scientific and Humanistic Culture, Knowledge Contamination.

1. INTRODUCTION

Reflecting on the link between chemistry and literature¹ is an arduous and complex undertaking that can be approached in basically two ways: by scouring the literary works of the various epochs in search of links with chemical thought² or by reasoning only on those literary works that are manifestly imbued with chemistry³ (Primo Levi first and foremost, but also, Gadda, Calvino and Sinisgalli in Italy, or, in the world arena, Sacks, Hoffmann, Goethe and Wells as typical examples). In both cases, the risk of concluding that, regardless of the approach, no suture or integration can be established due to the inherent, abnormal distance between the two disciplines is highly probable. The attempt that I am proposing in this meditation on such apparently antithetical univers-

es of knowledge is to try to take a third way, which starts from an intriguing hypothesis of the electronic engineer Ludovico Ristori, very shrewd and particularly open to the contamination of knowledge. In an article he published on the 'Scienza in Rete' (*Science on the Net*) website, entitled *Scienza e letteratura, discipline in equilibrio dinamico* (*Science and literature, disciplines in dynamic equilibrium*),⁴ he begins by asking whether science and literature are opposing worlds, or entities that interact dynamically, finding different equilibriums depending on historical moments and protagonists. Dichotomous opposition, then, or correspondence, albeit dynamic and articulated in a kind of interpenetration? On this basis, Ristori develops his reflections by bringing arguments and positions of the critics in favour of one or the other hypothesis and finally concludes with these words.

We can, therefore, say, with an image, that science and literature can be seen as two planets revolving around the same sun. Objects in permanent equilibrium, coming closer at certain times and moving away at others. Each with its own specificities, however, because, as Battistini notes⁵ in his article *Nuovi licei: l'avventura della conoscenza* (*New high schools: the adventure of knowledge*), if 'it is deforming to ignore common traits, as if humanity proceeds in its knowledge by watertight compartments, equally deforming is to believe that one can erase all differences, making them trivial or, worse, pretending they do not exist'.^{4,6}

The considerations here obviously also apply to the relationship between chemistry and literature, chemistry being a branch of science. Since the differences are obvious and less interesting, in my opinion, than the convergences, I will try to impress the reader with some thoughts about the common traits. It will be inferred, moreover, that from the analysis of common traits, differences and even dichotomies and antinomies will naturally arise, paradoxically demonstrating the evocative power of assonances, proving the essential need for contemporary humans to keep the rudder straight towards a unitary vision of knowledge and culture. I have chosen to revolve this reflection around a few fundamental themes in chemistry and literature, albeit with profoundly different implications. These are the six themes: events and their 'why' and 'how', the 'before' and 'after', which means time and its irreversible arrow, the interpretation of the present, reality and unreality, questions and answers, and the value of discovery. For each one, I will try to illustrate the common traits, which, of course, at the same time reveal substantial differences, going along with Ristori's intuition about disciplines neither opposing nor interpenetrating but differing in their depths, albeit in constant dynamic equilibrium.

2. THE EVENTS: THE WHY AND THE HOW

The events are certainly the starting point for chemistry and literature. And when I speak of events, I mean this in the widest sense of the term: things that happen in the widest possible sphere. In nature, of course, this is the main realm of scientific investigation, but also in human history, personal history and thus in the psyche of those who witness what is happening around or within them. A fine popular science book by Italian physicist Andrea Frova is entitled *Perché accade ciò che accade* (*Why what is happening happens*)^{6,7} and tells how science has managed to answer this question in an extraordinary variety of cases. And, of course, answering the question of why what is happening happens also often means creating the conditions to predict what has not yet happened. Therein lies the enormous conceptual strength of the framework of modern science, namely its predictive power. The story is told⁸ that Tsar Peter the Great was aware of the importance of culture and education in combating superstitions and beliefs: he was convinced that eclipses had to be explained to the people so they would not regard them as miracles. Something that is known before it happens cannot be considered miraculous. "*That which is foretold ceases to be a miracle*" is the most concise and acute representation of one of the most fascinating sides of scientific thinking: its power of predictability. Chemists, as all scientists, are strongly attracted to the nature of phenomena and why they manifest themselves in a certain way. They may be moved by an eclipse, a rainbow or a sunset, the blue colour of the sky, i.e. by *how* the event manifests itself, but undoubtedly it is the *why* that fascinates and disturbs them. They want to understand *why*, on a certain day, at a certain time, in bright sunlight, that fantastic lamp, goes out for a short time or *why* the bright yellow sickle is hidden in the night. Literature, even when it takes its cue from the same natural phenomena, is attracted by the *how*, by the emotions aroused: what does it matter to know *why* what is happening happens, if I then take pen and paper and describe *how* it happens and *how* the happening reverberates within me, I find the right and best words to share with the world not a formula, but a sensation, an emotion, a psychological mark? Let's read Mario Luzi on the eclipse of the moon in the poem *Non andartene*^{6,9} (*Do not go*):

Do not go,
do not leave
the eclipse of you
behind in my room
He who seeks you is the sun,
does not pity your absence.

The sun finds you even in random
places
where you passed,
in the places you left
and in those where you have
inadvertently been
it burns
and equates
to nothingness all
your fervent day.
Yet it was,
it was
none of its hours
is thwarted.

Or Emily Dickinson:¹⁰

Sunset at night is natural,
But sunset in the dawn
Reverses Nature, Master,
So midnight due at noon,

Eclipses be predicted
And Science bows them in,
But so one face us suddenly -
Jehovah's watch is wrong.¹⁰

But also, Italo Calvino's amusing and brilliant definition in *The Cosmicomics*:^{6,11} "As for eclipses, with Earth and Moon stuck together the way they were, why, we had eclipses every minute: naturally, those two big monsters managed to put each other in the shade, constantly, first one, then the other." To end with Erri De Luca, who, in his book *Sulla traccia di Nives* (*On the Trail of Nives*), with much insight, makes us literally reflect on the fact that the 'why' of what happens, even in the remote pre-scientific world, has prevailed over the 'how' of what happens and its emotional-psychological implications.

The human species has felt the respiratory need to widen its bronchi and trespass beyond the edges of its assigned existence. This need was more important than organising itself into social communities. The numbers that allow the calculations of the heavens precede the legislatures; Pythagoras comes before Pericles and Plato. The discovery of the cycle of comets and eclipses precedes the polis. The rules of the triangle appear before politics.^{6,12}

In this dichotomous viewpoint, science, i.e. the reasoning intellect, *versus* literature, i.e. emotion-sensation, Ristori dwells on "a strong argument for those who support the thesis of the opposition, namely the supposed difference in purpose." He adds,^{5,6} "Literature would be different precisely because of its tension to deny and tran-

scend the rigidities and limitations of scientific reasoning. Giacomo Leopardi is considered one of the main authors to support this, based on statements by the poet from Recanati such as 'the heart remakes life that the intellect destroys.'" Apart from the fact that recently Gaspare Polizzi¹³ has punctually argued that even the second Leopardi, that of 'cosmic pessimism' and mistrust of science, in reality, does not represent signs of a break with scientific thought, but rather a disillusionment with a certain way of doing science. We could even venture, with the examples that follow, that, in reverse, in literature, the heart remakes in its own way the life that the intellect constructs!

Continuing on the theme of the events that arouse the interest and curiosity of *Homo chemicus*, I would like to bring to the fore a topic that engaged 19th-century chemistry and physics for about half a century from the early 1800s:¹⁴ we are talking about the phenomenology associated with electricity, magnetism and also, albeit in a still rudimentary way, the relationship between these two branches of physics and chemistry and light, in the studies of Faraday, Ampère, and Ørsted, mainly.

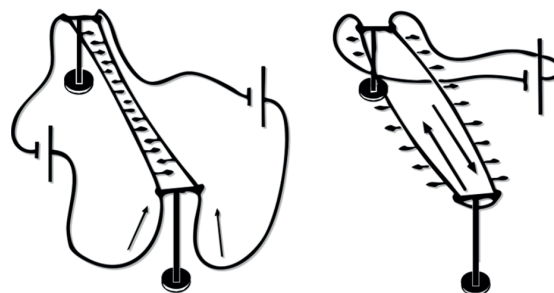


Figure 1. Ampère discovered that wires carrying an electric current exert forces towards each other.

Aspects related to attractions/repulsions between electric charges and between magnetic poles were topics that engaged the chemists and physicists of the time to a great extent, starting with the Italians Luigi Galvani and Alessandro Volta. The events that intrigued and aroused curiosity were essentially related to the fact that electrical phenomena influenced magnetic ones and vice versa and, above all, the resounding novelty of the mechanics of moving bodies concerned with action at a distance (see Fig. 1). For the first time, it had to be understood *why* it happens that two bodies – for example, a magnet and a copper wire in which electricity flows, or the needle of a compass in the vicinity of a wire in which an electric current flows (see Fig. 2) – interact at a distance even if I create a vacuum, i.e. remove the air.

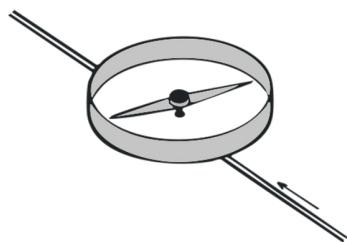


Figure 2. Ørsted discovered that a current-carrying wire deflected the needle of a compass. This stimulated Faraday's work in electromagnetism.

Science works by analysing experiments and looking for causal links. Thus, it came to be understood that moving a magnet close to a copper wire would generate current in the wire, or, in reverse, running current through a wire coiled around an iron nail would turn the nail into a small magnet.

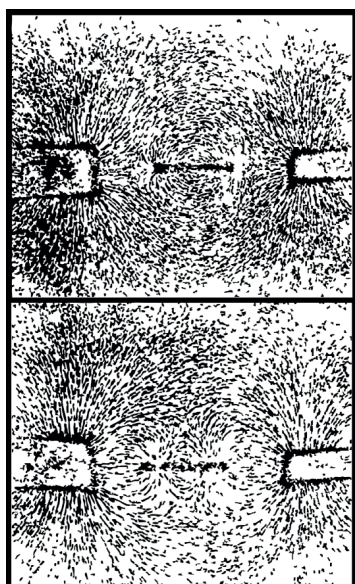


Figure 3. A favourite experiment of Faraday's to illustrate the reality of lines of force was to sprinkle iron powder on a sheet of paper beneath which a magnet was placed. On gently tapping the paper, the iron particles 'revealed' the lines of force.

The way was open for electric motors, dynamos, and turbines generating enormous electrical energy by rotating huge magnets wrapped in copper coils. What makes these magnets rotate? From a trivial bicycle wheel to make light in the headlamp, one arrives at mighty turbines set spinning by water rushing down from a reservoir or by immense volumes of expanding water vapour produced by huge boilers fuelled by coal,

gas, and oil fuels not to mention those events that show that chemical reactions can generate electricity, thanks to what we will later call batteries and which will make the fortune of the element lithium. Or that the opposite can happen, by using current and its associated electrical energy, *ad hoc* chemical reactions can take place to plate metal objects of little value with thin layers of silver or gold. Such events are being investigated and dissected in those years. Scientists seem obsessed with *why* what is happening happens and especially with the fact that electricity and magnetism make each other feel at a distance. Michael Faraday performed the famous experiment of the magnet that, at a distance, with air, but also without it, manages to orient iron powder in a geometrically well-defined way (see Fig. 3).¹⁵ He imagined, with an idea far removed from reality, that there is a mysterious force field around that magnet that only comes into action if I make it interact with iron filings.

And what does this have to do with literature? Let's try and find out. Roughly at the same time, two great writers are attracted by completely different events: of the social type or concerning customs and psychological interiority – in short, they are attracted by human stories. Unlike chemists, in their literary inventions, they do not question *why* what is happening happens. They merely describe *how* it happens, but the literary invention is not science fiction, unreal. It mirrors the becoming of society that moves relentlessly and inexorably around them. I am referring to Flaubert's *Madame Bovary*¹⁶ and Tolstoy's *Anna Karenina*.¹⁷ Again, this action is at a distance, sparking love and passion. But there's something else. An ambiguous morality permeated the society of the time: the celebration of male conquests in which the man's mistress, preferably bejewelled, enhanced the prestige of the man himself and, at the same time, the stigmatisation and condemnation of the 'lost woman'. Adultery was permitted exclusively to women of the upper classes but only if discreetly concealed; otherwise, if publicly revealed, strongly deprecated.¹⁸ And what captures these stirrings in society if not literature? Not only does it capture them, but it also filters, distils, and then crystallises them into a novel, which stands there as an eternal mirror of an era, transcending it and making it timeless. And just as in scientific research, the immense experimental work and interpretation of data is condensed into a law, an utterance, an equation, a formula, so too in the case of literature, beyond the hundreds of pages of which the novel is composed there are gems, the distillation into words rather than numbers, like this masterful and crystalline passage from *Madame Bovary*.

But a woman is forever hedged out. By nature, both flexible and sluggish, she has to struggle against the weakness of the flesh and the fact that, by law, she is dependent upon the others. Her will, like the veil fastened to her hat by a string, eddies in every wind. Always she feels the pull of some desire, the restraining pressure of some social restriction.¹⁹

The beauty and originality of the image of the contrast between “*passionate desire and restraining pressure painted in the veil of a hat fastened by a string that eddies in every wind*” is unique and lends the narrated story authenticity and credibility, making it convincing. Aristotle wrote in *Poetics*: “*A likely impossibility is always preferable to an unconvincing possibility.*”²⁰ This means that for the purposes of a story, an impossible but plausible and convincing thing is preferable to an unconvincing possibility. And that is indeed how literature is: we read avidly, we get excited, but at the same time, we murmur to ourselves: ‘*What an impossible story, it just doesn’t make sense, that’s not how it happens*’, but our eyes may be moist because evidently the story is credible, authentic and has convinced us.

Similarly, Tolstoy’s *Anna Karenina*, a novel published in instalments between 1875 and 1877, paints a fresco in which an entire society is mirrored in the evolution of social conventions, tradition, turmoil, changes in customs, in the patchwork of feelings of hypocrisy, jealousy, faith and fidelity, carnal desire, passion, and in the turmoil of the changes that will characterise the coming decades regarding the role of the family, marriage, society, progress, all revolving around the Anna-Vronsky-Levin-Kitty quartet.²¹ Again, Tolstoy is interested in the ‘*how*’ of events, which he perceives and transfigures into high literature. The conclusion for the woman is dramatic, with the epilogue of suicide on a par with Emma; Tolstoy dedicates a memorable page to this. And here we again discover that trait common to chemistry and literature of condensing the sum of events into a limited space, again chemistry answering the *why*, literature immortalising with a lapidary juxtaposition of words the *how*. This is how Tolstoy reveals to us the ‘*how*’ of those moments before suicide.

That familiar gesture brought back into her soul a whole series of girlish and childish memories, and suddenly, the darkness that had covered everything for her was torn apart, and life rose up before her for an instant with all its bright past joys. But she did not take her eyes from the wheels of the second carriage.²²

The literature could have stopped here, as the passage foreshadowed the outcome. The ‘*literary creator*’ knew what he would narrate; he knew what would hap-

pen; he just had to bring it to life and shape it with ink on paper. We can imagine him hesitating and thinking about what the world would be like if Tolstoy had stopped there, if that second bandwagon had suddenly halted its course. Without a last word, we would have had a much poorer humanity in the years to come. Instead, Tolstoy goes on and continues his narration. And so it was that Anna made the insane gesture, and that train, that station, that ironworker became legend. The act of suicide is not the most important thing, as it was already foretold. Tolstoy is interested in that moment that radicalises Anna’s life, bringing it to a conclusion.

And the light by which she had read the book filled with troubles, falsehoods, sorrow, and evil, flared up more brightly than ever before, lighted up for her all that had been in darkness, flickered, began to grow, and was quenched for ever.²²

The connection between the candle’s flame and life juxtaposed with death as its ultimate extinction is resounding, on a par, to my mind, albeit in a completely different way, with that madly visionary intuition of the electric and magnetic field evoked by Faraday.

The years of the great discoveries around electricity and magnetism, as well as the beginning of profound changes in customs that were immediately grasped by literature, are also years in which chemistry encounters events that concern a hypothesised but still totally unknown world, the sub-microscopic world of atoms and molecules, a reality that will produce an extraordinary revolution in scientific thought generating quantum mechanics. But isn’t the dilemma of the unknown the theme of *Moby Dick*?²³ One of the peculiar characteristics of chemistry is the constant quest to find solutions, to undress the unknown and to clothe it with intelligible meanings. In this prodigious and noble purpose, an obsession can also lurk, even before we realise the possibility of finding the right clothes that make the unknown known. This characteristic, typical of chemical research, finds a sublime transfiguration in the relationship between Ahab - the chemist obsessed with chasing the *why* of his phenomena - and the so-called white whale - actually a sperm whale - representative of the unknown. Alongside fear and terror, there is awe, diversity, and the emotions that characterise the progress of science, which, in a way, is also a fantastic and fascinating adventure novel. The voyage of the Pequod is both an allegory of the condition of human nature and, at the same time, represents a bit of a compelling parable of nineteenth- and twentieth-century science, ready to take off towards seemingly unattainable destinations full of,

at times dramatic repercussions. When we think of the prodigious discoveries in the field of nuclear energy – truly the deepest unknown – and Hiroshima and Nagasaki, we can only sum up the bewilderment and despair with Starbuck's invocation of Ahab: "*Moby Dick seeks thee not. It is thou, thou, that madly seekest him!*"²⁴

The intention of the above examples was to show this first common, and in many ways different, aspect that characterises science and literature, namely the *why* or *how* of what happens. The final measure and stigma of this trait in chemistry and literature can be found in a passage from Stendhal's *The Red and the Black*.²⁵

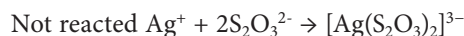
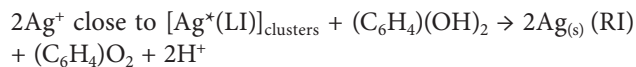
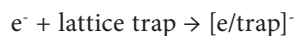
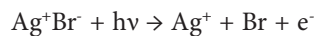
Yes, monsieur, a novel is a mirror which goes out on a highway. Sometimes, it reflects the azure of the heavens, sometimes the mire of the mud pools on the way, and the man who carries this mirror in his knapsack is forsooth to be accused by you of being immoral! His mirror shows the mire, and you accuse the mirror! Rather, accuse the main road where the mud is, or rather the inspector of roads who allows the water to accumulate and the mud to form.²⁶

Not only is the novel a mirror, but chemistry, too, is a mirror reflecting on the blue of the skies and the mud of the quagmires. Literature tells us how blue and wonderful the sky is and how ugly and brown the mud is; chemistry only explains why the sky is blue and the mud brown. Ugly and wonderful do not pertain to it.

3. BEFORE AND AFTER, OR THE IRREVERSIBLE ARROW OF TIME

We now come to the second aspect: the *before* and *after*, the irreversible arrow of time. The discoveries and achievements of chemistry in its evolution and progress always determine that our humanity changes profoundly *before* and *after* a chemical discovery, not least because of the impact chemistry has had on everyday life, especially in the last 150-200 years. Chemical discoveries from Lavoisier to the present day, the infinitely small, electricity, magnetism, light and electromagnetic radiation, the DNA double helix, drugs, thermodynamics, and quantum mechanics, have dramatically altered humanity's relationship with the world around it and thus determined a *before* and an *after*. When I refer to the irreversible arrow of time, I mean to scientifically connote the usual and well-known statement: '*There is no going back*'. I could give thousands of examples of this '*before and after*' of a strikingly different chemical discovery. Still, I will choose two that are perhaps among the most easily understood and suggestively

dense. Photography²⁷ and cinematography²⁸, on the one hand – I am talking about the nineteenth and twentieth centuries – and recording sound sources, on the other – around 1935.



Scheme 1. The main reactions involved in the photographic process: LI = latent image, RI = real image.

The watershed between *before* and *after* is here truly striking. To fix instants of life and make them eternal or to cast images, sounds and then moving dialogues on a white sheet represent a resounding break of symmetry in the evolution of *Homo sapiens*. Not to mention the recording on magnetic tape – the first device was made by *Telefunken* in 1937²⁹ – which, for the first time in human history, made it possible to preserve sound sources and no longer just documents, books, paintings, sculptures, drawings and then photographs. Again, chemistry enables the miracle of photography and cinematography, thanks to the reactions shown in the diagram Scheme 1. Humanity's relationship with the world around it changes radically: the senses of hearing and sight expand the acoustic and visual range to an enormous extent, the unthinkable just a few years before is seen and heard. Stories are no longer confined only to the world of literature and books; they burst into everyday life, obviously in an uncontrolled and increasingly uncontrollable manner. Music, a fleeting art of choice intimately connected to the irreversible arrow of time, can be set in minute magnets and be heard again tomorrow, a year from now, decades from now, or centuries from now. Those who, like the writer, were born in the second half of the 20th century, have the good fortune to have experienced decades of extraordinary scientific breakthroughs, becoming eyewitnesses to this *before* and *after* in numerous fields: *before* and *after* increasingly refined and powerful drugs, *before* and *after* non-invasive diagnostic techniques for our health, *before* and *after* the internet, mobile phones and the personal computer, *before* and *after* mobility on a planetary scale. But also, as the law of counterpoise has it, *before* and *after* the rapidly changing climate.

Well, something similar also happens with literature. Let us see in what sense. People's relationship with themselves, the world around them, and their fellow human beings *before* and *after* reading a great work of literature is strikingly different, irreversibly so. We are no longer the same after reading Dostoevsky's *Crime and Punishment*³⁰ or Kafka's *The Metamorphosis*³¹. Their literary works have affected our psyche similarly to the quantum mechanics revolution, the Copernican revolution, or eventually Darwinism, have had, not on the individual, but on the whole of humanity. Here is the difference: chemistry, with its waves of innovation, bathes the whole of humanity, and when the water recedes, life starts again, profoundly changed. Literature performs a similar flood, however, not only on the level of humanity as a whole, but also on the level of individual readers: certainly, the individuals come out better off. On humanity it remains to be seen whether the *after* is better than the *before*, and this applies to both literature and chemistry. Why did I choose Dostoevsky and Kafka to demonstrate this crazy change in our understanding of the world that their works induce in us, an irreversible metamorphosis like that of Gregor Samsa? To realise what I mean by the *after* being irreversibly different from the *before* following the reading of these two literary masterpieces, focus on the two incipits and the two endings of both stories that anticipate the dramas of the contemporary person.

On an exceptionally hot evening early in July, a young man came out of the garret in which he lodged in S. Place and walked slowly, as though in hesitation, towards K. bridge. He had successfully avoided meeting his landlady on the staircase. His garret was under the roof of a high, five-storied house and was more like a cupboard than a room. The landlady who provided him with garret, dinners, and attendance, lived on the floor below, and every time he went out, he was obliged to pass her kitchen, the door of which invariably stood open. And each time he passed, the young man had a sick, frightened feeling, which made him scowl and feel ashamed.³²

Raskolnikov feels a morbid and vile sensation of which he is ashamed, leading him to twist his face into a grimace. Morbidity, cowardice, and shame: three strong themes are introduced, but still, everything seems to be shrouded in an atmosphere in which neither crime nor punishment hovers. We shall now read Kafka.

As Gregor Samsa awoke one morning for uneasy dreams, he found himself transformed in his bed into a gigantic insect. He was lying on his hard, as it was armour-plated, back, and when he lifted his head a little, he could see his dome-like brown belly divided into stiff arched segments

on top of which the bed-quilt could hardly keep in position and was about to slide off completely. His numerous legs, which were pitifully thin compared to the rest of the bulk, waved helplessly before his eyes.³³

Here, the drama is presented immediately with unprecedented, bursting and minute reality: the theme of metamorphosis is clear and manifest in just a few lines. As if Kafka had read *Crime and Punishment* and thus did not need the development present in the Russian novel, but instead entered immediately *in medias res*, precisely forged by the metamorphosis of the student-murderer Rodja. The evolution of the two novels, obviously completely different in scope and content, nevertheless contains the essence that will make them archetypes of the existential dramas of the man to come. And if the beginning is the *before*, equally dazzling are the two endings, the *after*.

But that is the beginning of a new story—the story of the gradual renewal of a man, the story of his gradual regeneration, of his passing from one world into another, of his initiation into a new unknown life. That might be the subject of a new story, but our present story is ended.³⁴

There is a *before* and an *after* in Raskolnikov, too, as well as in us readers, and in between is that terrible ordeal of suffering, the real punishment, not the seven years of imprisonment, which will be another story. And we are irreversibly changed by the first story, which leaves an indelible mark on us as soon as it is finished. Kafka, in his own way, is even more tragic; alienation admits of no redemption and so he concludes.

They grew quieter, and half unconsciously exchanged glances of complete agreement, having come to the conclusion that it would soon be time to find a good husband for her. And it was like a confirmation of their new dreams and excellent inventions that at the end of their journey, their daughter sprang to her feet first and stretched her young body.³⁵

And here, too, the beginning and finale establish this *before* and *after* with the nectar of the literary masterpiece in between. Gregor “*was lying on his hard, as it was armour-plated, back,*” while his sister, after the metamorphosis and the drama of her brother's exit metamorphosed into an insect by self-annihilation, “*sprang to her feet first*” from the tram seat where she is with her parents, “*stretching her young body*”, also ready for new life, but not Gregor, he has no rebirth, total alienation has led him to self-destruction. I hope I have given you a sense of why these two literary works do change us irreversibly and why the *after* can never be like the *before*.

4. THE INTERPRETATION OF THE PRESENT

Before and *after* stand for the past and the future, but chemistry and literature are also very much concerned with the present. Chemistry seeks to interpret phenomena that present themselves to it and that concern all matter and its incredible transformations; the more obscure they are, the more exciting and exhilarating the challenge. For example, at the end of the 19th century, a phenomenon undermined present-day theories: blackbody radiation. Without going into detail, the problem of that present was to interpret how a black-painted furnace, with a small hole connecting it to the outside, was able to absorb all the radiation coming from outside and at the same time emit it when properly heated. The blackbody was like the inside of a church, in which the small hole is the door ajar: light enters, but looking at the door from outside, you can only see black, as all the light bounces back into the walls and almost nothing comes out.^{36,37} If we were able to heat the church to a high temperature, however, we would see the light coming out, first red-hot (from the Latin *rūbens*, i.e. reddening, a derivation of *rūbēre*, i.e. being red) and then white-hot or “incandescent” (from the Latin *candescere*, i.e. whitening)! Unlike the church, the furnace can be heated, and this is what happens: the blackbody lights up: radiation visible to the naked eye comes out of the little hole and becomes red, then orange-yellow and then all the colours together, i.e. white, the higher the temperature. The type of light, red or white, correlated to the blackbody’s temperature. Furthermore, the curves obtained all had a single-peak shape, moving towards smaller and smaller wavelengths but still tending to zero at both very small and large wavelengths. This could not be properly explained with the theories known at the time. A scientist, Max Planck, decides to face the situation and solves it, as Heinlein so aptly put it, by denying the obvious and accepting the impossible.^{36,38} Indeed, he formulated a theory (see Eq. 1: Given B the spectral radiance, λ the wavelength, T the temperature in Kelvin, h the Planck constant, c the light velocity, k the Boltzmann constant) that accounted for the experiments, but totally upset old paradigms. In particular, energy no longer presented itself for certain phenomena as a continuous function, but as a discrete one, i.e. transmitted in packets, what would later be called quanta. Here, then, is the present experienced and ultimately interpreted by science with a revolution of thought that marks a milestone in its history.

$$B_{\lambda}(\lambda, T) = (2hc^2/\lambda^5) \cdot [1/(e^{hc/\lambda kT} - 1)] \quad (1)$$

And what is the present in literature? It is society, customs, politics, living conditions, inner drives, and how all this flows into human psychology. New physics challenges old paradigms. Roughly at the same time as the quantum-mechanical revolution in chemistry and physics, at the turn of the 20th century, Italo Svevo and Thomas Mann did the same in their field of literary creativity. Let us see how. As with the quantum-mechanical revolution, two themes burst into the history of literature that somehow deny the obvious and accept the impossible, as Heinlein suggested for advances in physics. This time, the present shows up with the double face of the blackbody of the unconscious and the crisis and decadence of the European bourgeoisie. Let us not forget that these two great writers are coeval with the birth and development of Freud’s psychoanalysis. For the first time in the history of thought, Freud attempts to establish correlations between the vision of the unconscious, i.e. the symbolic representation of real processes and its components, with the physical structures of the human mind and body. These theories will find partial confirmation in modern neurology and psychiatry. The unconscious is the huge iceberg block that lies hidden inside the sea, containing the essence of our human being: emotions, dreams, fantasies, creativity, instincts, impulses, and intuition. The two writers, therefore, totally immersed in the present, distil it into literary works, bringing about a real revolution in the novel’s history. Ervino Pocar,³⁹ in his introduction to the Italian edition of *The Magic Mountain* in 1965, vividly captures precisely the immersion in the present. He writes that *The Magic Mountain*

is a faithful, complex, comprehensive portrait of Western civilisation in the first decades of the 20th century and, in its enchanting fusion of prose and poetry, of scientific vastness and refined art, is perhaps the most magnificent book written in the first half of the century.^{6,40}

The theme of illness, which dominates the entire novel, is only apparently the lung disease treated in the sanatorium. In reality, the illness is essentially mental and moral: the great drama of 20th-century humanity that the writer feels, perceives and condenses in his work.

On the one hand, the reflection on the moral illness of the bourgeoisie of Western civilisation. On the other hand, the mental illness of the individual self of Zeno’s conscience. It is, therefore, no coincidence that *The Magic Mountain* was published in 1924, barely a year after the release of the novel *Zeno’s Conscience*.⁴¹ On the subject of illness, Svevo’s vision shifts from society to the individual:

Unlike other sicknesses, life is always fatal. It doesn't tolerate therapies. It would be like stopping the holes that we have in our bodies believing them wounds. We would die of strangulation the moment we were treated.⁴²

The revolution is thus accomplished in literature as well. This inexplicable blackbody of the unconscious, investigated and eviscerated, opens up new visions of the self and, more generally, of the existential crisis that is beginning to appear in the face of the Western world: a society impoverished of all values. It would be Albert Camus who, a few decades later, would receive this baton and carry it forward. The analogy with the break made by quantum chemistry also extends to how these two scientific and literary revolutions relate to the pre-existing. Quantum chemistry does not disregard the value of classical physics and chemistry, which continue well to describe an extremely conspicuous harvest of natural phenomena; it simply complements them when dealing with the infinitely small.

Similarly, Svevo and Mann represent a further development, marking a definite break with the past, in the history of world literature. They also stand alongside the giants of world literary history who continue to represent eternal and universal themes. Svevo and Mann of the present scrutinise and re-interpret the drama of humanity grappling with the anxieties of living, as well as of the relations between peoples and nations: everything that literature intuitively and crystallises in two works mentioned that have become milestones, will manifest itself with incredible and crude harshness in the tragic landfalls during the nascent century.

5. REALITY AND UNREALITY

If the theme of the present is, as we have seen, a significant one in trying to demonstrate the dynamic equilibrium in which chemistry and literature oscillate, equally rich in intriguing and interesting aspects is the reality/unreality pair. That chemistry, and more in general science, is concerned with reality is almost a tautology, but beware, it can often be the case that it is a reality explained through models and theories that are far removed from reality, at least from that reality linked to sensory perception. A reality, we might venture, explained in a quite unrealistic way. Think of the postulate of the existence of atoms and molecules, the discovery of x-rays and elementary particles, and the very 'unreal' theoretical construction of quantum mechanics, which then gives rise to real objects (the laser, for example). Or even to evolutionary theory, apparently very

'unreal' at its formulation and perhaps for some even afterwards! Not to mention relativity and the dissolution of the concept of time in physics with a theory far removed from what common sense identifies with reality. It is said that Einstein liked Charlie Chaplin so much that he addressed this exclamation to him: "*What I most admire about your art, is your universality. You don't say a word, yet the world understands you!*" And Chaplin's wonderfully shrewd response about the distance from reality and common sense of Einsteinian theories: "*True. But your glory is even greater! The whole world admires you, even though they don't understand a word of what you say.*"^{43,44} As can be seen, to dismiss chemistry as a discipline that deals with reality while ignoring all unreality is very simplistic.

All great chemical discoveries give rise to a reality that is often presented as profoundly unreal at the time of discovery. The example of x-rays is paradigmatic.⁴⁵⁻⁵² The physicist Konrad Röntgen realised in 1895 that near a glass tube in which he was conducting electrical discharges, totally obscured by tin foil and black cardboard and therefore invisible from the outside, there was a substance that normally fluoresces with a yellow-green colour when illuminated. The room where he did the experiment was completely dark because the aim was to test whether light was coming from those tubes. He was so surprised to see luminescence from that substance: who had turned it yellow-green? To the eye, nothing could be seen coming out of the glass tube; it was covered with black cardboard, so even if light had formed inside, it could not have come out. Röntgen repeated the experiment many times, always with the same result: the fluorescent substance only glowed when he produced electrical discharges inside the tube, but nothing could be seen coming out of it. There was, therefore, an element of objective reality: the fluorescent screen lit up. But then again, this reality coexisted with the unreality that no light ray came out of the tube, as it was totally 'wrapped' in black cardboard. He then imagined something unreal, which he could not in any way prove, namely, that mysterious, invisible rays were coming out, able to pass through the black cardboard. Such rays, when hitting the screen substance nearby, made it glow. Since they were mysterious and unknown – and, I would add, as such, very unreal – he named them after the unknown in mathematics, namely x. So far, a discovery by chance; now comes the genius that makes unreality realistic. Let's see how. Between the tube that emitted the mysterious rays and a photographic plate, he first placed a closed wooden box with the metal weights of a scale inside, then the barrel of his rifle and finally his wife's hand. And what kind of real-

ity emerged incontrovertibly? Three fundamental applications that would change the world. The three developed plates revealed the clear shapes of the small brass weights for the precision scales inside the closed box; an imperfection inside the gun barrel, invisible from the outside, of course; the skeleton of his wife's hand with a clear image of her metal ring.⁴⁵⁻⁵² The road to metal detectors, quality control of metal artefacts, and radiographic medical diagnostics was paved. He had discovered that x-rays were very penetrating, and that only sufficiently heavy atoms could block them. So, calcium and phosphorus from the bones stopped the x-rays and did not blacken the plate, while the soft matter in our bodies made of carbon, hydrogen, oxygen and nitrogen could easily be passed through. We can conclude, not surprisingly, that the brilliant German physicist made unreality realistic. French poet, essayist, playwright, dramatist, writer, librettist, director, and actor Jean Cocteau, to whom Marcel Proust wrote: "*I crack with jealousy to see how in your extraordinary pieces on Paris you are able to evoke things that I have felt and have only been able to express in a very feeble way*,"^{56, 53} gave a beautiful definition of cinema, which goes like this. "*Vive la jeune Muse Cinéma, car elle possède le mystère du rêve et permet de rendre l'irréalité réaliste*."^{54, 55} (*Long live the young Muse Cinema, since she possesses the mystery of the dream and allows for the rendering of realistic unreality*)⁶. Well, if Röntgen made the unreality of x-rays realistic with his ingenious experiments, literature also responds perfectly to this definition that Cocteau adopted for the cinema.

To illustrate this theme of the reality/unreality relationship in literature, I will give three examples: *Orlando Furioso*, late 19th-early 20th-century verism and naturalism, and science fiction literature. In Astolfo's journey to the moon to recover Orlando's lost wits due to Angelica's betrayal, there is the distillation of this continuous contrast between unreality and reality.⁵⁶ After having visited Hell, Astolfo reaches the summit of the Earthly Paradise on the back of a hippogriff, and here he is welcomed by St John the Evangelist, who then escorts him to the moon aboard Elijah's chariot and acts as his guide. A classic, phantasmagorical imaginative apotheosis – today, we would say science fiction – a condensation of images manifestly dripping with unreality, yet full of fascination. But at the same time, as prodigious as it is unreal, this journey becomes an opportunity to blame the reality of man's folly in wasting time in pursuit of and thus losing his wits over vain illusions. Still, it also allows the author to polemise against a petty reality, that "*of service lost in court*"^{56a} ("*servir de le misere corti*"), a subject that also recurs in

other works by Ariosto, that of deploring real human miseries with these fantastic, fairytale-like flourishes results from brilliant creativity and literary mastery. Lost sense is the ingenious gimmick of linking unreality to reality, "*a body moyst and soft*"^{56b} ("*un liquor sottile e molle*") that gives an account, when lost, of numerous, real human miseries.

On the other hand, the theme of reality in literature was to characterise French naturalism and Italian verism, with the two great writers Emile Zola and Giovanni Verga. Reality becomes an obligatory theme: it is spoken of almost in terms of a theoretical manifesto. And if in French naturalism, perhaps for the first time, science and literature go almost hand in hand, in the verism of Verga and Capuana, the positivist influence of Comte dissolves. Reality is analysed and described not in the same way as a scientific investigation, as seen in some of Zola's novels, but with lyricism and attention to human passions and even, in this antinomian to French naturalism, with distrust in scientific progress, which is pessimistically indicated as responsible for a modernisation that makes the condition of the less well-off classes ever more miserable. In both cases, however, reality becomes not only a relevant theme but also a pretext and a cue to bring the nameless into the limelight, be they the fishermen of *Acì Trezza* or the miners of *Germinal*. It is the reality of outcast men and women, with a spasmodic focus on certain *things* that become almost iconic. Two striking examples: *Providence*,⁵⁷ the *Malavoglia's* fishing boat, and *Lison*,⁵⁸ the locomotive from *La bête humaine* (*The Beast Within*).

Two different ways of making the real the focus of literary invention. At the same time, as we have seen happen with science during the quantum-mechanical and relativistic revolution, a literature was born in England and France that made the unreal, the so-called sci-fi, its focus: Jules Verne⁵⁹ and Herbert George Wells.⁶⁰ Verne lived between 1828 and 1905, Wells between 1866 and 1946; Zola between 1840 and 1902 and Verga between 1840 and 1922. As you can see, reality and unreality in literature elbow to elbow: just to give you an idea, Verne published between 1863 and 1905 his 54 novels in the collection *Voyages extraordinaires* (among which the best known, *Around the World in 80 Days*, *From the Earth to the Moon*, *Twenty Thousand Leagues Under the Sea*), in 1895 Wells published *The Time Machine*, *I Malavoglia* was published in 1881, *Mastro don Gesualdo* in 1889, *Germinal* in 1885 and *La bête humaine* in 1890. In short, truly a literary apotheosis of reality and unreality!

6. QUESTIONS AND ANSWERS

We now come to the fifth and final theme, since the sixth, namely the value of discovery, will be more of a final coda, a kind of homage to science and chemistry on the part of literature. Questions and answers. Chemistry has been constantly asking questions and searching for answers since time immemorial; not only since the advent of modern chemistry born in the 18th century but also before, when pre-chemistry was only a philosophy of nature. A typical example of chemical questions and answers distilled in literature several centuries before the advent of modern science is Lucretius' *De rerum natura*.⁶¹ Nature itself, with its phenomenology, is often a natural experiment that poses questions. The rainbow, the blue sky and white clouds, lightning, light, fire and heat, wind and much more ask to be explained, silently manifesting themselves spontaneously and available to our heuristic activity as *Homo sapiens*. The question I choose, as an example is: what is wind? Lucretius' literary answer already contains the scientific notion we know today for wind, i.e., the volume of a gaseous mixture moving more or less rapidly from higher pressure to lower pressure areas. "*Wherefore again and yet again I say | That winds have hidden bodies, since they rival | In character and action mighty rivers | Possessed of bodies plain for all to see.*"⁶² The molecules that make up the gaseous atmosphere in which we are immersed are the *invisible* moving *bodies*, just like other molecules, *visible* and touchable, that move due to the difference in level in the great rivers. Modern science would establish the primacy of the *experimentum* with its reproducibility and the introduction of mathematical-geometric formalism. But the *experimentum* is ultimately designed and executed to answer one or more questions. A wonderful example of a chemical question and answer sublimated into a literary passage comes from Primo Levi. In an article in the Italian newspaper *La Stampa* about 'Signs on Stone', later published in the volume *Other People's Trades*,⁶³ Levi describes what can be seen on the pavements when walking around Turin. After discussing the signs caused by the bombings of the Second World War, Levi inserts a brief warning ("*Other signs are less sinister and more recent*"). He abruptly poses a question that has no answer, highlighting an apparently irredeemable contradiction in our technological civilisation. Why is it that "*the effort made to establish the excellence of a particular material's resistance and solidity can often lead to serious difficulties when it comes to eliminating the material itself after it has fulfilled its functions?*"⁶⁴ And from this unanswered question comes the amazing and astounding literary example of chewing gum leaving precisely those less sinister and more recent signs on stone.

The demand for a gum which resists, which changes form without being destroyed, and can undergo the torment of mastication, which consists in pressure, heat, humidity and enzymes, has resulted in a material which stands up only too well to trampling, rain, frost and the summer sun. [...] Alongside more obvious and trivial elements, these are the signs one sees on the pavement when the soul clings to it like a chewing gum, because of sloth, laziness or fatigue.⁶⁵

This is one of the many passages that justify Primo Levi's selection as the best science writer of all times.

Literature, too, is full of questions and answers, or lack of answers. The quintessence of this can be seen in the famous '*to be or not to be, that is the question*'. Moreover, Federico Bertoni very shrewdly writes in the afterword to the Italian edition of *The Red and the Black*.

At the end, close the book, look back and you will see some fundamental questions take shape. What things are worth living for? Do genuine passions exist in a hopelessly corrupt and prosaic world intoxicated with vanity and careerism? Can one act with vital fullness without being paralysed by thought or an abstract must-be? Is it art imitating life, or perhaps, as Oscar Wilde put it, life imitating art? How can one act sensibly in a dull world, impervious to any inner strength? Can one look for a key in novels without getting trapped in the imaginary, without exhausting one's passions in a delirium of suspended actions that do not catch up with reality and history? In the end, Julien acts. He shoots and condemns himself to ruin. He exits his novel and finishes it as he pleases. Who knows whether that gesture is the point of coincidence with itself or yet another mystification in which the truth is always behind, a little further away?⁶⁶

On these probably unanswered questions, and on all the others that almost always characterise the legacy of a literary work, it is worth mentioning, finally, the illuminating reading of the chapter *Pasternak and the Revolution* in Italo Calvino's *Why Read the Classics?*⁶⁷ At one point, Calvino asks himself, after a careful reading of the novel, "*Who is this Zhivago?*"⁶⁸ And the non-answer he gives is intriguing: at the centre of the novel is, in fact, the story of Lara, rather than that of Doctor Zhivago:

[...] Lara's life is in its linearity a perfect story of our time, almost an allegory of Russia (or the world), of the possibilities that have gradually opened up to her (or it), or which were all presented to her (or it).⁶⁹

But Pasternak's novel also questions us on the big issues of history, nature and how humanity is in it with its *doing*. The writer's answer is defiant pessimism about this *doing* of humanity. Nature cannot be changed but only understood with science – *why* what is happening

happens – and with poetry, suggesting *how* what is happening happens. History, then, is made neither by great individuals nor by nameless little ones: “*It moves like the plant kingdom, like the wood changing in springtime, [...] as a solemn coming into being, transcending man.*”⁷⁰ If Pasternak asks questions and suggests answers according to his feelings, he nevertheless leaves the field open, precisely by the answers he gives, to reflections and consequent responses of an opposite sign. We are back, then, to the great tradition of the Russian epic, which, not surprisingly, will feature in the motivations for the Nobel Prize in 1958.⁷¹

7. THE VALUE OF DISCOVERY

I feel at this point that I should conclude this study and reflection on chemistry and literature and the dynamic equilibrium that from time to time brings them closer together or pulls them apart, but always in orbits having a common universal centre of gravitation, by evoking the last point that I have called the value of discovery, which for chemistry is obviously a must. Chemistry is a continuous discovery and, at the same time creates more mysteries to be unravelled. It is not trusting one's senses, it is always doubting that one is in the right and assuming even absurdities, overcoming any prejudice or belief. As we have seen, it is denying the obvious and accepting the impossible. The ‘icing on the cake’ of this reflection on chemistry and literature comes precisely from the homage that literature pays to the value of the discovery; whether it be that of America or an important new molecule, it matters little. Its value is exalted a few moments before the discovery, in the knowledge that Columbus and the great discoverer chemists, in the end, do not really know what great things they have discovered, and the value lies in the path that brought them a step closer to the finish line, that is, in the adventure of living. The great Dostoevsky, with his astonishing novel *The Idiot*,⁷² reveals to us the intimate and profound value of discovery.

Oh, you may be perfectly sure that if Columbus was happy, it was not after he had discovered America, but when he was discovering it! You may be quite sure that he reached the culminating point of his happiness three days before he saw the New World with his actual eyes when his mutinous sailors wanted to tack about and return to Europe! What did the New World matter after all? Columbus had hardly seen it when he died; in reality, he was entirely ignorant of what he had discovered. The important thing is life–life and nothing else! What is any ‘discovery’ whatever compared with the incessant, eternal discovery of life? ⁷³

It is worth recalling, at the end of this zigzag between chemistry discoveries and literary inventions, a passage from a witty article by Cesare Garboli that appeared in the Italian newspaper *Il Corriere della Sera* on 7 March 1977 entitled *Questo poeta è uno scienziato* (*This poet is a scientist*)^{6,74}.

After all, what did we learn from Montale? Like all true poets, Montale is a scientist. He does not send messages but discovers and legislates. It was Montale who expressed in poetic terms the true, great discovery of the century that our life is ‘quantum’, intermittent, discontinuous, between being and non-being.^{6, 74}

Perhaps that dynamic equilibrium between the two planets, chemistry and literature, which revolve around the same sun of culture and knowledge, sometimes moving apart, sometimes coming closer together, is summed up precisely in this iconic and almost desecrating juxtaposition of poetry and science.

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