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Primo Levi, William Henry Bragg and the atomic theory of matter

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Let me start by explaining the reasons for my special affection for Primo Levi. I have three main affinities with him: I am a chemist, Jewish and was born in Turin, and therefore I have breathed the same atmosphere. I grew up in the Jewish milieu described in *Argon* in *The Periodic Table*, lived in a regularly patterned city (Turin has preserved the pattern of the original Roman military camp) and studied chemistry in the same lecture halls, laboratories and fascinating library. Levi's tribute to W. H. Bragg gives me a further point of affinity. I do not have to explain to the readers of *Acta Crystallographica* my affection for Sir W. H. Bragg and his son for giving us, a hundred years ago, such a powerful tool, still full of promising developments.

Primo Levi (Angier, 2003; Thomson, 2004; Gordon, 2007; Mesnard, 2011) is a well known Italian writer, especially for his books *If This is a Man* and *The Truce* (Levi, 1987) describing in a most intense and moving way his experience in the Nazi death camp of Auschwitz and his adventurous return home.

Levi was born in 1919 into a Jewish family from Turin, where he received a positivistic and scientific education. Because of the race laws against the Jews, proclaimed in 1938 by the fascist government, he had to overcome several discriminations to obtain a degree in chemistry in 1941. In 1943, he joined a partisan group, but was soon captured and transferred to a detention camp in Italy and finally to Auschwitz. Primo Levi was one of the very few survivors from the Lagers and on his return from Auschwitz, as a witness of so many absurdities, he felt duty bound to tell, to describe the indescribable, so that all will know, all will ask themselves why, all will interrogate their conscience. At the same time, he began a career as an industrial chemist and manager in a varnish factory. His writing activity continued and grew after his retirement in 1975. He published a number of novels and several short stories and poems. On 11 April 1987 Primo Levi died in a tragic way.

In his careers as a chemist and a writer, science and literature always coexisted. He wrote (Levi, 1986) 'I write just because I am a chemist, one can say that my old job is largely transfused into the new' and in his most 'chemical' book, *The Periodic Table*, he added (Levi, 2000) 'Understanding matter is necessary to understanding the universe and ourselves: therefore Mendeleev's Periodic Table, ... was poetry, loftier and more solemn than all the poetry we had swallowed down in school; and come to think of it, it even rhymed!'

Levi believed that a scientific world view, as a tool for understanding the world around us, can certainly be a good instrument for an artist as well, and also has moral implications (Levi, 2000): 'Matter is also a judge, and the most impartial one. It never forgives your errors, and most often punishes them severely. When you transgress, it strikes back, like Conrad's sea.'

Driven by his rational and positivistic nature, he was especially attracted by Lucretius' (98–55 BC) atomic philosophy. The philosophical basis of the atomic

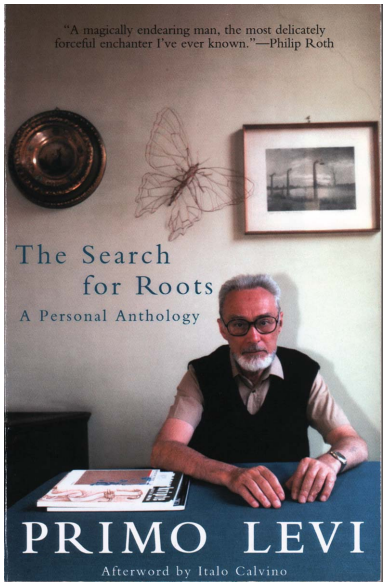

Figure 1
Front cover of *The Search for Roots* with Primo Levi at his desk; on the wall is a butterfly built by Levi using the enamel varnished wires produced in his factory.

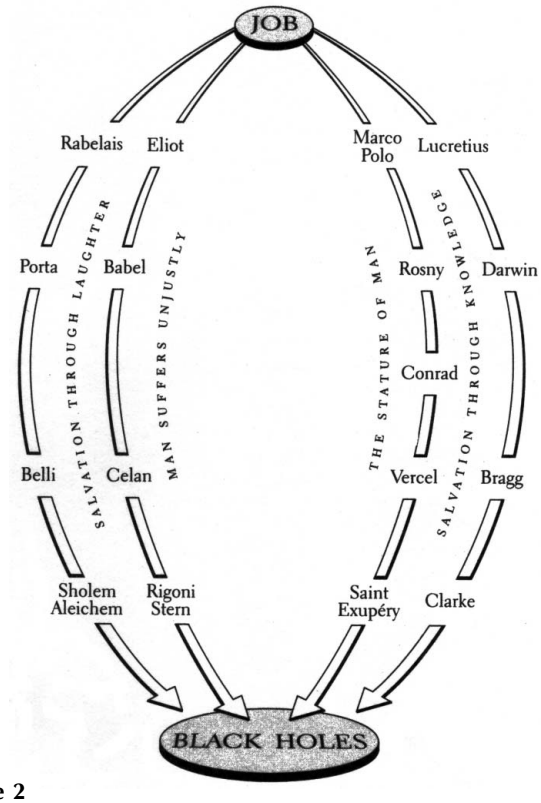

Figure 2
Elliptical figure used by Levi to suggest 'four possible routes through some of the authors in view' in his personal anthology.

theory, which states that matter is composed of discrete indivisible units called atoms, was originally formulated by the Greek philosophers Democritus and Leucippus (4th–5th century BC) and described by Lucretius' in his poem *De Rerum Natura*. These ideas were opposed and neglected for many centuries and only in the early 19th century did the discoveries made by John Dalton (1776–1884) and Amedeo Avogadro (1776–1856) in the field of chemistry prove that the philosophical theory devised by the Greek philosophers and embraced by Lucretius had a scientific foundation and it was shown that matter did indeed behave as if it were made up of particles. The idea entered the scientific mainstream, pervading all modern science.

When in 1980 Levi was asked by his publisher to compile a personal anthology, he collected thirty pieces of prose and poetry by different authors that he thought had most influenced his life and his writing. These became *The Search for Roots: a Personal Anthology* (Levi, 2003) (Fig. 1). Levi's choice of authors and pieces is extremely heterogeneous, from the *Book of Job* to K. S. Thorne's *Black Holes*, through not only Homer, T. Lucretius, C. Darwin, J. Conrad, F. Rabelais, T. Mann, I. Babel and other well known literary authors, but also citing a recipe from L. Gattermann's *Laboratory Methods of Organic Chemistry*, already mentioned in *If This is a Man* as the text that made him pass the 'chemistry exam' and saved his life by allowing him into the chemistry laboratory of the Buna plant installed by IG-Farben in Auschwitz-Monowitz to exploit slave manpower. Quite surprisingly, he even cites the *ASTM (American Society for Testing Materials) Designation* for testing the *Susceptibility of dry adhesive films to attack by roaches*! In order to make sense of the admittedly 'hybrid nature' of his choices, Levi suggests by an elliptical figure (Fig. 2) at the end of the preface 'four possible routes through some of the authors in view': *Salvation through laughter* (Rabelais, Porta, Belli, Sholem Aleichem), *Man suffers unjustly* (Eliot, Babel, Celan, Rigoni Stern), *The stature of man* (Marco Polo, Rosny, Conrad, Vercel, Saint Exupéry) and *Salvation through knowledge* (Lucretius, Darwin, Bragg, Clarke). Why do we find Sir W. H. Bragg in this last route of this uncommon collection?

Sir William Henry Bragg (1862–1942) was not only a Nobel Prize winner, who with his son William Lawrence Bragg established the basis for X-ray crystallography, but was also an outstanding teacher capable of exciting the minds of intelligent young people and addressing them to science in general and chemistry in particular. In her biography of Dorothy Hodgkin, Georgina Ferry (1999) tells us that Dorothy 'had found her life's work' after receiving, on her sixteenth birthday, the book *Concerning the Nature of Things* (Bragg, 1925) (a close translation of *De Rerum Natura*; Fig. 3) by W. H. Bragg. As already mentioned by J. Jenkin in his biography of the Braggs (Jenkin, 2011) and as we shall analyse in more

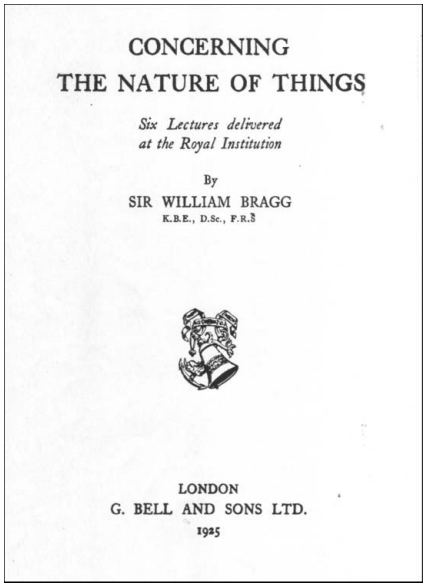

Figure 3
Cover of Sir William Bragg's book *Concerning the Nature of Things*.

detail, Primo Levi, at almost the same age, was also convinced by the same text that he would become a chemist. We will also see how the enthusiastic introduction to the atomic theory of matter in the first chapter of Bragg's book could have inspired two young people with a scientific and positivistic attitude. Their destinies will be very different: Dorothy will become an outstanding crystallographer and Nobel laureate, Primo a unique witness of a tragic period and a renowned writer. But their common admiration, since their early years, of Bragg's clear and convincing way of presenting science was certainly a sign of their unique personalities and of their future success.

In 1919, 1923 and 1925 W. H. Bragg, at the time Fullerian Professor of Chemistry at the Royal Institution and director of the Davy Faraday Research Laboratory, was invited to deliver the Royal Institution Christmas Lectures, an event initiated by Michael Faraday, establishing an exciting new venture of teaching science to young people. *Concerning the Nature of Things* is the collection of the six lectures delivered in 1923–1924 and as explained in the Preface 'Many of the facts that have come to light might well be the subject of *Lectures adapted to a Juvenile Auditory* and would be at the same time interesting and helpful; interesting because they display a beautiful order in the fundamental arrangement of Nature, and helpful because they have given us light on many old questions, and will surely help us with many that are new.'

In the headnote to Bragg's citation, entitled *To See Atoms*, Levi confesses 'I owe a great deal to this book. I read it by chance at the age of sixteen; I was captivated by the clear and simple things that it said and I decided I would become a chemist. Between the lines I divined a great hope: the models on a human scale, the concepts of structures and measurement, reach very far, towards the minute world of atoms, and towards the immense world of the stars; perhaps infinitely far? If so, we live in a comprehensible universe, one accessible to our imagination, and the dark recedes before the rapid spread of research.'

He then affirms his moral and scientific commitment to Lucretius' atomism: 'I would become a chemist. I would share Bragg's faith (which today seems very ingenuous). I would be bound up with him, and with the legendary atomists of antiquity, against the discouraging and lazy herd of those who see matter as infinitely, fruitlessly, tediously divisible.'

This is Levi's presentation of Bragg: 'Sir William Bragg, Nobel Prize winner for Physics in 1915, belonged to an epoch in which a pioneering genius could still do brilliant work in isolation. With his son, he constructed the first X-ray spectrometer, a valuable but conceptually simple instrument: it exploited the fact (already known) that the wavelength of X-rays is of the same order of magnitude as the interatomic distances, and therefore allowed us to 'see' the spatial arrangement of the atoms in crystals.'[1]

The pieces chosen by Levi, and embraced within soft pencil marks in his Italian version of the book (Bragg, 1935) (Fig. 4), kindly made available to me by his son Renzo, are the initial part of Bragg's first lecture on *The Atoms of which Things are Made* and three pages on surface tension from the third lecture on *The Nature of Liquids*.

In the first excerpt, the common enthusiastic acceptance by Levi and Bragg of Lucretius' atomic theory becomes evident from Bragg's incipit:

> Nearly two thousand years ago, Lucretius, the famous Latin poet, wrote his treatise *De rerum natura* – concerning the nature of things. He maintained the view that air and earth and water and everything else were composed of innumerable small bodies or corpuscles, individually too small to be seen, and all in rapid motion. He tried to show that these suppositions were enough to explain the properties of material things. He was not himself the originator of all the ideas which he set forth in his poem; he was the writer who would explain the views which were held by a certain school, and which he himself believed to be true.
> There was a rival set of views, according to which, however closely things were looked into, there would be no evidence of structure: however the water in a bowl, let us say, was subdivided

[1] Let me point out a small contradiction I noticed in Levi's writings. In the fascinating last chapter of *The Periodic Table* devoted to 'tell the story of an atom of carbon' he affirmed that 'until 1970 he [the chemist] did not have the techniques permitting him to see, or in any event isolate, a single atom', but then he entitled his Bragg citations *To See Atoms*. There might be several good explanations for this contradiction, but they would just be speculations.

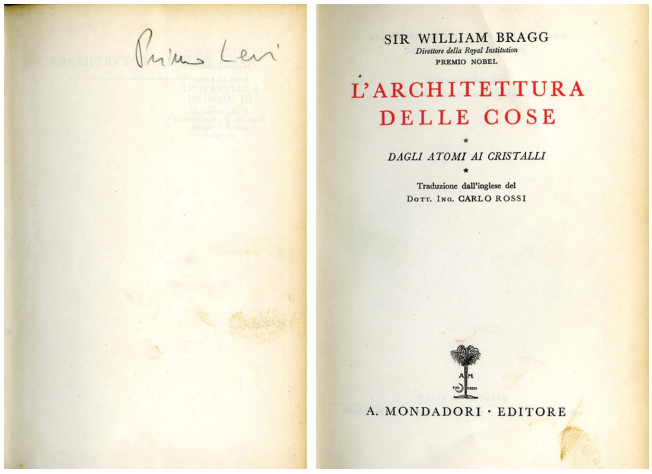

Figure 4
Cover of Levi's copy of the Italian translation of Bragg's book with his signature (courtesy of his son Renzo).

> into drops and then again into smaller drops and so on and on, the minutest portion would still be like the original bowl of water in all its properties. On the view of Lucretius, if subdivisions were carried out sufficiently, one would come at last to the individual corpuscles or atoms: the word atom being taken in its original sense, something which cannot be cut.
> There is a mighty difference between the two views. On the one, there is nothing to be gained by looking into the structure of substances more closely, for however far we go we come to nothing new. On the other view, the nature of things as we know them will depend on the properties of these atoms of which they are composed, and it will be very interesting and important to find out, if we can, what the atoms are like. The latter view turns out to be far nearer the truth than the former; and for that all may be grateful who love to enquire into the ways of Nature.

This piece is in full harmony with Levi's thought expressed in his headnote to Lucretius' citation. After saying that Lucretius is not 'willingly read in school' in Italy 'because there has always been a whiff of impiety about his verses,' Levi continues:

> For this reason, at the end of antiquity a cloak of silence was wrapped around him and today almost nothing is known of this extraordinary man. Consciously or not, for a long time he was regarded as dangerous, because he sought a purely rational explanation of nature, had faith in the evidence of his own senses, wanted to liberate man from suffering and fear, rebelled against all superstition, and described earthly love in lucid poetry. His extreme faith in the explicability of the universe is the same as that of modern-day atomists. His materialism, and hence his mechanical reductionism, is naïve and now makes us smile, but here and there appear astonishing intuitions . . . .

On the same wavelength, Bragg's piece presents the fruits of Lucretius' science in modern times and continues:

> Lucretius had no conception, however, of atomic theories as they stand now. He did not realise that the atoms can be divided into so many different kinds, and that all the atoms of one kind are alike. That idea is comparatively new: it was explained with great clearness by John Dalton at the beginning of the nineteenth century. It has rendered possible the great advances that chemistry has made in modern times and all the other sciences which depend on chemistry in any degree. It is easy to see why the newer idea has made everything so much simpler. It is because we have to deal with a limited number of sorts only, not with a vast number of different individuals. We should be in despair if we were compelled to study a multitude of different atoms in the composition of a piece of copper, let us say; but when we discover that there is only one kind of atom in a piece of pure copper, and in the whole world not many different kinds, we may feel full of enthusiasm and hope in pressing forward to the study of their properties, and of the laws of their combinations. For, of course, it is in their combinations that their importance lies.

The second excerpt on surface tension and thin films is probably a choice that might reflect Levi's later professional interest in varnishes, and gives a detailed and colourful description of how soap bubbles form.

At sixteen, Levi probably did not have a sufficient background to fully understand the significance of the last three lectures on *The Nature of Crystals* in Bragg's book, but he was certainly impressed to learn that through the new powerful research tool of X-ray crystallography, made available by W. L. Bragg and W. H. Bragg, atoms could be actually seen, and, driven by his curiosity, he followed Bragg's advice and ordered small wooden balls to 'Messrs. Maxime, Ltd., 6 Featherstone St., City Road, E.C.2' to build molecular models by connecting the balls with gramophone needles.

Later, during his university years, Levi showed a great interest for basic scientific research, but Jews were not allowed the 'honour' of an experimental thesis. Nevertheless, Levi treated three relevant research arguments: Walden inversion, Onsager linear coupling theory applied to molecular dipole moments, and 'electronic rays' with special emphasis on X-rays. The last topic was developed in a sub-thesis supervised by Professor Mario Milone, who had studied at Cambridge under the Braggs and in 1940 published the structure of Ni-dimethylglyoxime (Milone & Tappi, 1940). Like Dorothy Hodgkin, he might have followed more closely Bragg's message and have become a crystallographer, but the tragic events that occurred in Europe did not give Levi the chance of devoting his intelligence and curiosity to basic science, although his being a chemist with a scientific mind contributed to his survival. As he said in a conversation with the American writer Philip Roth (2000), his humane scientific mind gave him 'an intense wish to understand, I was constantly pervaded by a curiosity . . ., the curiosity of the naturalist who finds himself transplanted into an environment that is monstrous but new, monstrously new.' To Levi's 'salva-

tion through knowledge' Bragg contributed in an essential way through his clear and inspiring teaching that helped him to remain '*a Man*' and think in a rational way even in the most extreme situations.

I am particularly indebted to Renzo Levi, son of Primo Levi, not only for showing me his father's original copy of the Italian translation of Bragg's book *L'Architettura delle cose: dagli atomi ai cristalli* and for letting me have the scanned copies of some pages, but also for pleasant and informative conversation. Special thanks go to my friends Guido Vogliotti, Piero Ugliengo and Vera Bolis for their careful reading of this note.

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