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Chap.1

Mario Bunge: An Introduction to His Life, Work and Achievements

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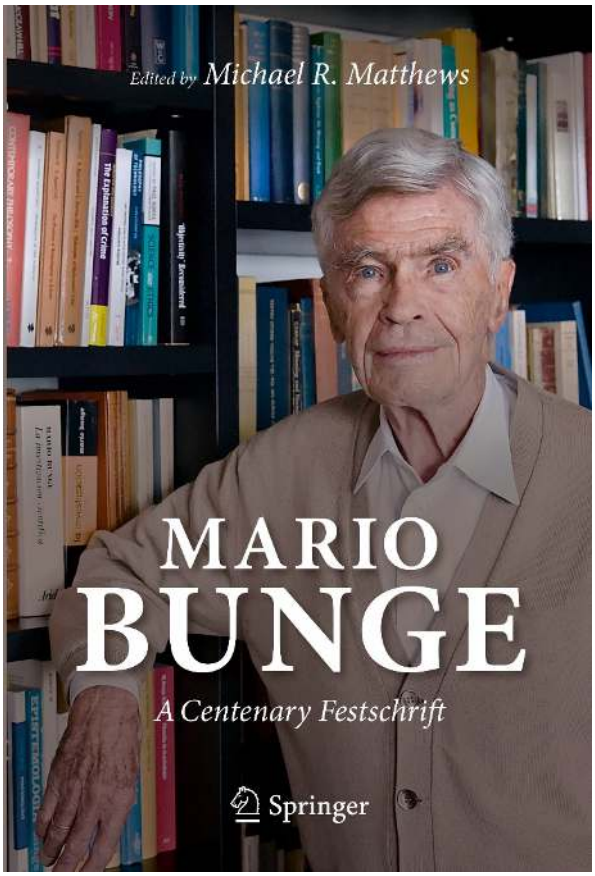

Mario Bunge is a physics-trained philosopher who has made significant contributions to an extraordinarily wide range of disciplines. He was born in Buenos Aires, Argentina on 21st September 1919. This Festschrift celebrates his one-hundred-year life, and his contributions to so many scholarly disciplines: physics, philosophy, sociology, psychology, cognitive science, and more. In terms of longevity, productivity, and liveliness of mind, he is in the same small and exclusive league as his own philosophical hero, Bertrand Russell. Bunge held chairs in physics and in philosophy at universities in Argentina (University of Buenos Aires, *Universidad Nacional de La Plata*), and visiting professorships in the USA (University of Texas, University of Delaware, University of Pennsylvania and Temple University) before his appointment as professor of philosophy at McGill University in Montreal in 1966.

He held this chair, and later the Frothingham Chair in Logic and Metaphysics, until his retirement in 2009, when he became McGill's Frothingham Professor Emeritus. He has had visiting professorships at major universities in Europe, Australasia, as well as North and South America. He has published 70 books (many with revised editions and translations) and 540 articles (including translations). Age has not wearied him. After celebrating his 95th birthday in 2014, he published three books (Bunge 2016, 2017a, 2018) and a good many articles (Bunge 2014a,b, 2015, 2017b,c,d, 2019). All titles and details are in this Festschrift's 'Bunge Bibliography'.

1.1 Recognition

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Bunge has been awarded many prestigious fellowships and prizes. In 1965 he received the German government's Alexander von Humboldt fellowship for work on the axiomatic foundation of physics at the Institute of Theoretical Physics in Freiburg. In 1969 he received a Canada Council for the Arts Killam Fellowship, awarded to 'outstanding scholars to carry out their ground-breaking projects', the bequest aiming 'to promote sympathetic understanding between Canadians and the peoples of other countries'. In 1971 he received a Guggenheim Fellowship, awarded for 'exceptionally productive scholarship'. In 1982 he became a Prince of Asturias Laureate for Communication and Humanities. In 2014 the Bertalanffy Center for the Study of Systems Science (BCSSS) in Vienna awarded him the Ludwig von Bertalanffy Award in Complexity Thinking. Bunge is one of just two philosophers in the Science Hall of Fame of the American Association for the Advancement of Science: the other is Bertrand Russell.

Bunge's work has been celebrated in festschrifts of 40 years ago (Agassi & Cohen 1982) and 30 years ago (Weingartner & Dorn 1990); more recently in Spanish anthologies (Denegri & Martinez 2000; Denegri 2014); and appraised in at least three journal thematic issues (Matthews 2003, 2012; Pickel 2004). Bunge briefly surveyed his own life and work in a chapter in an anthology on Latin American philosophy (Bunge 2003c), and later in a wonderful and engaging 500-page autobiography *Between Two Worlds: Memoirs of a Philosopher-Scientist* (Bunge 2016).

1.2 Family and Education

The Bunge family had its origins on the island of Gotland, off the Swedish coast where the village of Bunge remains. Ancestors moved to Unna in Westphalia, and then to Argentina in the early 19th century, soon after independence (Bunge 2016, chaps.1-2). Bunge's father, Augusto Bunge (1877-1943), and three of his father's eight siblings, distinguished themselves in various fields: economics, sociology, medicine, philosophy, law and literature.

Mario's father, Augusto, attended a Jesuit school, where he won all the prizes, but at 14 he lost the faith and became an atheist. He studied medicine, and in 1900 he graduated as a medical doctor with the gold medal. His doctoral thesis dealt with tuberculosis as a social disease, for it affected far more the poor than the rich. The Argentine government sent him to Germany and France to study public health policies. On his return, he published two thick tomes expounding the state of public health in those countries. During his student days he joined the young Socialist Party, and in 1916 he became a Socialist congressman, an office that he held for 20 years. In his parliamentary career he promoted several worker welfare bills, and in 1936 he introduced a national medical insurance bill whose provisions were advanced even by contemporary standards.

Augusto and his wife Mariechen (1882-1977) created a home, *El Ombú,* outside the village of Florida on the outskirts of Buenos Aires. They were avid gardeners with a 6,000m^2 plot of grape vines, fruit trees, vegetables, and 130 rose varieties. Their home was the centre for a liberal, intellectual salon including scholars and professionals from many fields. In 1943 Augusto was briefly jailed for raising funds for the Allied war effort at a time when the government supported the Nazis; shortly after his release he suffered a stroke and died at age 66 years. Mariechen was jailed for a month for criticising the newly installed military dictatorship (Bunge 2016, pp.69-71). When released from jail, she had just one tooth

remaining in her mouth.

Mario's parents wanted their son to be 'a citizen of the world'. From an early age he was set a demanding schedule of reading literature in six languages: Spanish, English, French, Italian, German and Latin, with Chinese read in translation. This early multi-lingualism was of inestimable benefit to his education, allowing him to read the classics and the best moderns in their own words. It also freed him from dependence on commercial, political and ideological judgements about what books would be translated and published in Spanish. His reading of Heisenberg did not have to wait upon Spanish translations; nor his reading of the major European and Anglo philosophers, and important Enlightenment texts whose translations were prohibited in Argentina.

One consequence of the demanding multi-lingual reading regime his parents fostered is Bunge's critical judgement of the mono-lingual limitations of the bulk of Anglo-American scholarship. In a critical review of a major book (1,120 pages) by Randall Collins on the sociology of philosophies—which has the less than modest subtitle of *A Global Theory of Intellectual Change* (Collins 1998)—Bunge laments that Collins ignores Descartes' central scientific works because 'they were not available in English translation until recently' (Bunge 1999e, p.281); that his secondary sources are all English (ibid p.280); and that he exclusively uses English translations of European philosophers even when the available translations are notoriously unreliable.

At age twelve, he gained entry to the prestigious *Colegio Nacional de Buenos Aires*. The *Colegio* was a disappointment. He relates that teachers 'instilled more fear than respect', and 'Most of our professors were not interested in teaching, and some of them were frankly incompetent' (Bunge 2016, p.27). He completed his undergraduate physics degree at the *Universidad Nacional de La Plata*, where subsequently he became a professor of physics.

1.3 Breadth and Coherence

Bunge has been enormously productive as a researcher in physics, philosophy, social science, and other fields. Many of his books have appeared variously in Spanish, Portuguese, German, Italian, French, Polish, Russian, Chinese, Arabic, Japanese, Farsi, Romanian, and Hungarian editions. Additionally, he has published books in Spanish and French that have not appeared in English.

Bunge has made substantial contributions to a remarkably wide range of fields: physics, philosophy of physics, metaphysics, methodology and philosophy of science, philosophy of mathematics, philosophy of psychology, philosophy of social science, philosophy of biology, philosophy of technology, moral philosophy, social and political philosophy, medical philosophy, criminology, legal philosophy, and education.

Beyond breadth, Bunge's work is noteworthy for its coherence. In the past half-century, the pursuit of systemic philosophy, 'big pictures', 'grand narratives' or even cross-disciplinary understanding has waned, with fewer and fewer scholars having serious competence beyond their own narrow field of research. As Susan Haack wrote:

> Our discipline becomes every day more specialized, more fragmented into cliques, niches, cartels, and fiefdoms, and more determinedly forgetful of its own history. (Haack 2016, p.39).

The disciplinary norm has shrunk from scientifically-informed philosophers with wide systemic concerns, to those with narrow-focus pursuits.

Philosophers of science are usually, and understandably, just philosophers of science; it is uncommon for them to also be scientists, much less to make contributions to other areas of philosophy, and other disciplines. The pattern of graduate studies, and the pressures of finding a position and securing tenure, fuel this move to specialization and discipline-specific research programmes; to a narrowing of the disciplinary mind. Bunge defied this trend maintaining that:

> A philosophy without ontology is invertebrate; it is acephalous without epistemology, confused without semantics, and limbless without axiology, praxeology, and ethics. Because it is systemic, my philosophy can help cultivate all the fields of knowledge and action, as well as propose constructive and plausible alternatives in all scientific controversies. (Bunge 2016, p.406)

1.4 Vocation of an Academic

As an academic, Bunge has had a life-long commitment not just to research, but also to the social and cultural responsibility of academics; he has never been seduced by the 'Ivory Tower' option, comfortable though it would have been at many stages of his life. In other contexts, and in former ages, his version of academic commitment might be called 'a vocation'.

While in high school Bunge became interested in physics, philosophy, and psychoanalysis, and wrote a book-length criticism of the latter. In 1938 he was admitted to the *Universidad Nacional de La Plata*, where he studied physics and mathematics. Shortly thereafter he founded a Workers School (the *Universidad Obrera Argentina*). In doing this he was inspired by the Mexican socialist and educator, Vicente Lombardo Toledano (1894-1968), who had established in 1936 the Workers University of Mexico (still in existence today as part of Mexico's national university system). This was quintessential Enlightenment thinking and practice about education. The school's effectiveness prompted its closure by the government five years later in 1943. At the time it had 1,000 students enrolled.

In 1944, along with involvement in the UOA, Bunge founded the journal *Minerva: Revista Continental de Filosofía*, in order to facilitate the development of contemporary, science-informed, modern philosophy in Latin America. It did not have just a scholarly purpose. The first issue announced that the journal was 'armed and in combat: armed of reason and in combat for reason and against irrationalism'. In the subsequent 80 years, Bunge has never wavered in this commitment. As he said in his *Memoirs*:

> I had the idea of organizing a sort of rationalist common front to fight irrationalism, in particular existentialism. This pseudo-philosophy had started to rule in the Latin American schools of humanities: it rode on the fascist wave and hid behind the phenomenological veil. (Bunge 2016, p.105)

The Argentina of Bunge's youth, and beyond, was a society with a conservative and reactionary Catholic church, a comfortable ruling elite, and an authoritarian, proto-fascist government that supported Hitler and maintained diplomatic relations with Germany through to 1944. It gave little support to science or to workers' education or their rights. Neither government nor church supported 'free thinking', much less critical philosophy.

The reactionary religious-cultural-political circumstance of Argentina was pervasive throughout most of Latin America. The USA-supported military dictatorships in Paraguay, Uruguay and Chile, set the common standard for anti-democratic authoritarianism. The Enlightenment's advocacy of the separation of Church and State fell largely on deaf ears of the Latin American religious, political, and economic elites. Contraception was illegal, divorce was impossible (it was only legalised in Argentina in 1987), homosexuality was both a sin and a crime, abortion was illegal, censorship of ideas, books, films, theatre was rife, and on and on. The Church had inordinate influence on education, including on the writing of curricula, the training of teachers, and the appointment of principals. In many state universities, passing 'Thomism 101' was a condition of graduation; it was likely a condition in all Catholic universities in Latin America.

Latin America, of course, had no monopoly on religion-based state reaction. Ireland, the Philippines, Portugal, and Spain had comparable Catholic-informed regimes. And the situation was as reactionary in all countries where Islam dominated; and of course, in the USSR, China, East Europe and elsewhere where Marxist ideology dominated. In such regimes, through to the present, it was very costly for academics to make the kind of critical interventions (speeches, papers, books) that now are barely noticed in the liberal West, that take no courage and have zero career consequences. In Bunge's time, in Argentina, non-appointment, fines, dismissal, or jail were the common costs for liberal and socialist dissent. He paid these prices.

Indicative of Bunge's sense of responsibility to the growth of knowledge is that he has always devoted time and energy to the institutions and activities required for it. Bunge has founded and edited journals and book series; he has founded and contributed to scholarly associations in at least five countries; and he has planned and hosted numerous conferences and research seminars, always along with his own constant research and publishing. All of this 'structural' or academic community work is time-consuming, it does not beget research dollars or promotion, and it detracts from writing and personal time. Few scholars have been prepared to make the required monetary, time and career sacrifices. Bunge has.

Alberto Cordero has given a comprehensive account of the history of philosophy of science in Latin America. Of Bunge's publications, translations, 'community building', and international impact, Cordero says: 'No Latin American philosopher had achieved anything comparable before in cosmopolitan philosophy'. He adds that as a

> citizen of the world, perhaps the most universalist of philosophers in the subcontinent, Bunge is nonetheless very South American (it is hard to imagine him growing up anywhere else but in cosmopolitan Argentina). (Cordero 2016)

1.5 Beginnings

Bunge graduated in physics from La Plata in 1942. In 1943 he started to work on problems of nuclear and atomic physics under the guidance of Guido Beck (1903-1988), an Austrian refugee who had been an assistant of Heisenberg in Leipzig. Beck was the inventor of the layer model of the atomic nucleus, the first to propose the existence of the positron, and pioneered the study of beta decay. Bunge believes Beck might have received the Nobel prize for physics had he been working in North instead of South America (Bunge 2016, p.77). He does thank Beck for 'teaching me not to allow politics to get in the way of my science'

(Bunge 1991a, p.524). Bunge obtained his PhD in physics in 1952 from La Plata with a dissertation on the kinematics of the relativistic electron. 'My doctoral diploma did me no good, because it was not accompanied by the Peronist party card without which I could not even get a job as a dogcatcher' (Bunge 2016, p.89). Nevertheless, the thesis was subsequently published as a book (Bunge 1960).

Bunge made his international philosophical debut at the 1956 Inter-American Philosophical Congress in Santiago, Chile. He was then aged 37 years. Willard Van Orman Quine, in his autobiography, mentions attending this congress, and the only thing about the congress that he thought worth recording was:

> The star of the philosophical congress was Mario Bunge, an energetic and articulate young Argentinian of broad background and broad, if headstrong, intellectual concerns. He seemed to feel that the burden of bringing South America up to a northern scientific and intellectual level rested on his shoulders. He intervened eloquently in the discussion of almost every paper. (Quine 1985, p.266)

1.6 Systemism

Bunge is a systemist and argues for the unity, not the disunity, of knowledge; for the need for science, social science, and philosophy to be advanced in partnership; and for science education to convey this seamless, interdependent canvas of human knowledge. For some, Bunge is overly systemic, too precise, and ambitiously inter-connected in his writing. But beyond this stylistic commitment, there is a philosophical commitment to systemism as an ontology, as a view about how the natural and social worlds are constituted. Bunge has developed a philosophical system that can be characterized as: materialist (or naturalist) but emergentist rather than reductionist; systemist rather than either holist or individualist; ratio-empiricist rather than either rationalist or empiricist; science-oriented; and exact, that is, built with the help of logical and mathematical tools rather than depending upon purely verbal articulation.

Bunge's philosophical system is laid out in detail in his monumental eight-volume *Treatise on Basic Philosophy* (1974-1989). Its nine individual books are devoted to semantics (one to meaning, another to interpretation and truth), ontology (one to the basic stuff or 'furniture' of the world, another to systems), epistemology (one to exploring the world, another to understanding it), philosophy of science and technology (one to the formal and physical sciences, another to life science, social science and technology), and ethics. He has applied his systems approach to issues in physics, biology, psychology, social science, technology studies, medicine, legal studies, and science policy.

Bunge points to William Harvey introducing systemism into science (natural philosophy) with his study of the heart as part of a cardiovascular system (*De motu cordis,* 1628); and Newton promoting systemic thinking in his postulation of universal gravitation, which led to his unification of planetary and terrestrial motions, the bringing of the heavens down to earth. Early modern philosophers paid little, if any, attention to this scientific innovation.

His systemism is laid out in the first volume of his *Scientific Research,* titled *The Search for System* (Bunge 1967a); the fourth volume of his *Treatise,* titled *A World of Systems* (Bunge 1979a); and in various articles (Bunge 1977a,c, 1979b, 2000a, 2014b). In

2014, he gave a plenary talk ('Big questions come in bundles, hence they should be tackled systemically') at the Vienna congress of the Society for General Systems Research (Bunge 2014b), and there received the Society's Bertalanffy Award.

From the outset, he has been at pains to distinguish his systemism from holism. He regards all variants of holism as more than just philosophically mistaken and obscurantist; they are politically dangerous as they give comfort to statism (Bunge 2016, p.252).

1.7 Causation

Bunge's first major book in philosophy was his 1959 book *Causality: The Place of the Causal Principle in Modern Science* (Bunge 1959). The book was recommended to Harvard University Press by Quine and reviewed favourably by the physicist-philosophers Henry Margenau and Victor Lenzen (Bunge 2016, p.127). The book was an instant success and put Bunge, and Latin American philosophy of science, firmly on the international map. It came out of the philosophical 'left field': it was among the few books ever written by Latin American philosophers of science to receive international recognition and review up to the 1950s. The work was translated and published in German, Hungarian, Italian, Japanese, Polish, Russian and Spanish editions. Twenty years later, a third, revised edition was published as a Dover paperback, *Causality and Modern Science* (Bunge 1979c).

The book was a landmark in the subject. For decades, under the influence of positivism and logical empiricism, philosophers had eschewed all serious investigation of causation as understood and investigated by scientists. Outside of Thomism (Wallace 1972), the Humean picture was widely accepted: there was no causation or necessary connection in nature; there was just regularity to which the mind brought the label 'causation'. In Hume's words: 'Upon the whole, necessity is something, that exists in the mind, not in objects' (Hume 1739/1888, p.165).

Philosophers brought detailed philosophical analysis and debate to the *consequences* of this position, but rarely questioned its empiricist presuppositions (Sosa 1975). Bunge brought detailed *scientific knowledge* of natural processes into the philosophical analysis of causation (Bunge 1961, 1962, 1982). He mounted informed arguments against Humean empiricist and positivist accounts that made causation 'imaginary'; accounts that replaced real-world causation with correlation; that kept the 'causation' label, but denied it had any ontological reference.

Bunge also argued in detail against popular interpretations of quantum mechanics that supposedly had also consigned causation to the Humean bin. Bunge rejected this because it was fanciful philosophy and displayed great ignorance of science. As he wrote in *Causality*:

> The trend of recent science points neither to the decausation preached by positivism in favor of purely descriptive statements or uniformity, nor a return to traditional pancausalism. Present trends show, rather, a *diversification* of the types of scientific law, alongside of an increasing realization that several categories of determination contribute to the production of every real event. (Bunge 1959, p.280)

But his work also bears upon contemporary, sophisticated non-empiricist accounts of causation. Rögnvaldur Ingthorsson, in his Chapter 12 contribution to this Festschrift, observes that:

> Proponents of powers-based accounts [of causation] seem not to be aware of Bunge's critique of the Aristotelian view of causation, and therefore arguably continue to build on a flawed conception of causal influence, one that is incompatible with the theories and findings of modern science.

1.8 Theory Analysis

Whilst visiting professor of philosophy and of physics at the University of Delaware (1965-66) Bunge convened a seminar on the 'Foundations of Physics' (Bunge 1967c). His own opening contribution was titled 'The structure and content of a physical theory' (Bunge 1967d), which in turn began with this statement:

> In analysing a physical theory, we may distinguish at least four aspects of it: the background, the form, the content, and the evidence—if any. By the *background* of a theory we mean the set of its presuppositions. By the *form* or structure, the logico-mathematical formalism quite apart from its reference to physical objects or its empirical support. By the *content* or meaning, that to which the theory is supposed to refer, quite apart either its form or the way the theory is put to the test. And the *evidence* a theory enjoys is of course the set of its empirical and theoretical supporters. (Bunge 1967d, p.15)

This clear and simple fourfold division of the components of the scientific-philosophical analysis of theory represents what Bunge had been doing for the twenty years leading up to the Delaware Seminar, and what he would continue doing for the following sixty years. He analysed theories in physics, chemistry, biology, psychology, economics, sociology, criminology and more, in terms of their *background*, *form*, *content* and *evidence*.

1.9 Axiomatization

The foregoing is the background to Bunge's persistent concern with the axiomatization of theories, a concern which reappears in one of his recent publications, 'Why axiomatize?' (Bunge 2017b). For Bunge, axiomatization simply becomes part of what scientific theorising is, and it is the philosopher's task to both make this clear and to contribute to it; it is scientific work that philosophers can do.

Bunge maintains that any reasonably clear theory can be axiomatized. If it cannot, then it is not clear; and if it is not clear, then it is a deficient or maybe even useless theory. Vagueness, hunches, instincts, feelings are all part of science; they can influence what research paths to take, what might constitute evidence, and so on, but to the extent that they figure in actual outcomes, or scientific theory, then the theory is flawed. Further:

> Contrary to widespread opinion, axiomatization does not bring rigidity. On the contrary, by exhibiting the assumptions explicitly and orderly, axiomatics facilitates correction and deepening. (Bunge 1999c, p.28)

In his *Foundations of Physics* Bunge axiomatized five theories: point-particle and continuum mechanics, classical electrodynamics, Einstein's theory of gravitation, and non-relativistic quantum mechanics (Bunge 1967c). Each was presented in a logically ordered sequence: primitive concepts—defined concepts—postulates—theorems. He recognised, of course, that 'this is an artificial logical reconstruction, very different from the rather messy way theories are invented and developed' (Bunge 2016, p.196). But it facilitated better

understanding of the theory, and a clearer grasp of its philosophical commitments and implications. The structure brings clarity to judgements about the defining features of a theory, and what changes would constitute a different theory, or a 'neo' version of it.

Bunge's account of scientific methodology was elaborated in his two-volume *Scientific Research* (Bunge 1967a,b). There are striking similarities between Bunge's analysis of scientific theory and theory change and Imre Lakatos's account of 'rational reconstruction' in history of science (Lakatos 1971) and Lakatos's separation of 'hard core' and 'protective belt' commitments in scientific research programmes (Lakatos 1970) - these being published some four years after Bunge's account. The similarities were not unnoticed by Bunge, and along with other matters, led to a falling out between the two philosophers (Bunge 2016 p.201).

Clear-headed axiomatization is a prerequisite to the successful 'marriage' of different theories or research programmes; axiomatization makes clear what either side needs to give up, what price is to be paid for the marriage. For example, reducing optics to electromagnetic theory; joining thermodynamics with classical mechanics; synthesising evolutionary theory and genetics; and so on. In all these cases, vagueness and ambiguity are exposed by the effort of axiomatization. Vagueness advances nothing in science, though it can do a great deal in politics, religion, and countless pseudo-sciences.

A contributor to the Delaware Seminar, Paul Bernays, a Swiss logician and mathematician, reflected Bunge's own view of the merits of axiomatization:

> Such a strengthened consciousness is valuable whenever the danger exists that we may be deceived by vague terminology, by ambiguous expressions, by premature rationalizations, or by taking views for granted which in fact include assumptions. Thus, the distinction between inertial mass and gravitational mass makes it clear that their equality is a physical law—something which might be overlooked by speaking of mass as the quantity of matter. (Bernays 1967, p.189)

In his 'Why Axiomatize?' (Bunge 2017b), Bunge says axiomatizing consists in subjecting a theory that has been built in an intuitive or heuristic fashion to the following operations:

> 1. Exactification of intuitive constructs, that is, replacing them with precise ideas, as when substituting 'set' for 'collection', 'function' for 'dependence', and 'derivative with respect to time' for 'rate of change';
> 2. Grounding and justification of postulates, bringing hidden assumptions to light—assumptions that, though seemingly self-evident, may prove to be problematic;
> 3. Deductively ordering a heap of known statements about a given subject. (Bunge 2017b)

1.10 Ontology

Bunge is an ontological realist. He believes there is an external, non-subject-dependent world. Nature pre-dated humans, and presumably will post-date them. Further, both the observable and unobservable entities proposed in mature scientific theories—planets, fault lines, elements, chromosomes, genes, waves, atoms, phlogiston, economic class, intelligence, instincts, and so on, are assumed to exist, and that is why they are postulated. And if on appropriate experimental investigation they are found not to exist, then the theory needs to be

rejected, or at least this specific postulation within the theory needs to be abandoned. Ontological realism has been refined, and has taken various forms in contemporary philosophy, with selective realism, structural realism, perspectival realism and entity realism being four competing versions (Agazzi 2017). All versions are in conflict with the equally long tradition of ontological idealism, stated loudly in the present day by constructivists. In the words of one proponent:

> …For constructivists, observations, objects, events, data, laws, and theory do not exist independently of observers. The lawful and certain nature of natural phenomena are properties of us, those who describe, not of nature, that is described. (Staver 1998, p.503)

Beyond being an ontological realist, Bunge is a realist of the materialist kind (Bunge 1981c, 2000 Pt.1). This is in contrast to immaterialist realists who countenance the existence of non-material explanatory entities—ghosts, spirits, angels, chi, jinns, ancestors, and so on. Bunge's materialism is science-informed; or more strongly, science-dependent. It is scientific materialism. In a recent paper on 'Gravitational Waves and Space-Time', he writes:

> As long as we confine ourselves to macrophysics, we must admit that the recent detection of gravitational waves suggests the counterintuitive thesis that spacetime is a material entity, so that we must rethink our conceptions of matter and materialism, much as people did when Faraday and Maxwell added the concept of an electromagnetic field to that of a body. (Bunge 2017c)

1.11 Epistemology

Bunge is also a realist in epistemology, meaning that the entities and mechanisms postulated by science not only are supposed to exist, but their properties and characteristics can be known. Further, they can be objectively known. That is, the knowledge sought is not subject dependent; knowledge of the entity does not vary from observer to observer, from one knower to another. There are not different Christian, Hindu, Jewish, Islamic, black, white, American, children's, female knowledges of the supposed scientific entities or unseen mechanisms; there is just knowledge, partial knowledge or ignorance of the entities and mechanisms held by people of various nationalities, beliefs, race, age or gender. Everyone is entitled to their own opinion but not to their own facts; let alone 'alternative' facts.

Assuredly the putative knowledge does not come out of the sky. It is created by concrete individuals and groups in specific historical and cultural circumstances, but the knowledge is not constrained by or limited to those circumstances (Minazzi 2017, Musgrave 1993). It is simply a conceptual mistake to talk about 'Christian Science', 'Islamic Science', 'Hindu Science', 'Indigenous Science', 'Children's Science', or 'National Socialist Science', though these labels are, and have been, widely used. There is simply science, good, bad or indifferent; formulated by Christians, Muslims, Hindus, Native peoples, children, or Nazis. The titles can have a short-hand purpose, and they have a legitimate anthropological function, but a limited philosophical one.

Bunge's position had been well expressed by Pierre Duhem, the French Catholic and positivist philosopher, in a 1915 series of lectures on 'German Science'. At a time when it was not fashionable, prudent or a good career move in France to acknowledge the contributions of German thinkers to the development of science, Duhem did so. He elaborated wonderfully and carefully on the achievements, and limitations, of Boltzmann,

Einstein, Gauss, Haeckel, Hertz, Kékulé, Mach, Neumann, Weber and many others. He concludes:

> … if the national character of an author is perceived in the theories he has created or developed, it is because this character has shaped that by which these theories diverged from their perfect types. It is by its shortcomings, and by its shortcomings alone, that science, distanced from its ideal, becomes the science of this or that nation. … There is no trace of the English mind [*esprit*] in Newton, nothing of the German in the work of Gauss or Helmholtz. In such works one no longer divines the genius of this or that nation, but only the genius of humanity. (Duhem 1916/1991, p.80)

This Duhem-Bunge 'universalist' position is rejected by postmodernists, and by most adherents of the 'Sociology of Scientific Knowledge' (SSK), or the 'Edinburgh Strong Programme', traditions. Bunge cautions that:

> In particular, epistemology must take into account that scientific research is just one cultural activity, hence the study of it cannot be isolated from the study of other branches, in particular philosophy and ideology. In short, epistemology, if it is to be realistic (not just realist), must be not only structural but also psychological, sociological, and historical. (Bunge 1981d, p.116)

Bunge believes—*contra* contemporary individualisms, subjectivisms, idealisms, and relativisms—that science can, and does, give us demonstrably the best knowledge of the natural and social worlds. Not perfect or absolute knowledge but the best available. He writes:

> Contrary to a widespread opinion, scientific realism does not claim that our knowledge of the outer world is accurate: it suffices that such knowledge be partially true, and that some of the falsities in our knowledge can eventually be spotted and corrected, much as we correct our path when navigating in new territory. (Bunge 2006, p.30)

Further, as well as empirical adequacy, there are theoretical virtues or characteristics that can be used to judge competing theories or knowledge accounts against each other, and so to determine which is currently superior. Such considerations also allow identification of the best knowledge-advancing research programmes. These theoretical virtues include empirical testability, plausibility or consistency with extant knowledge, guidance to causal connections, absence of *ad hoc* elements, and having heuristic value for further research. So, theories are not judged just on empirical adequacy: with sufficient *ad hocness* most competing theories in any domain can be reconciled with empirical evidence; but not all can make testable, novel predictions and have them experimentally confirmed.

For Bunge, such typically scientific knowledge is the only sound basis for moral decision making, social and political reform, and personal flourishing. This affirmation brings the charge of scientism down upon him; a charge he happily pleads guilty to—provided it does not entail agreeing to crass, amateurish or plainly mistaken understandings of science (Bunge 1986b, 2014a). He is consequently a critic, indeed a trenchant one, of social forces and academic movements that diminish, or reject, the intellectual authority of reason and science (Bunge 1996b).

1.12 Physics

Before and after being awarded his physics PhD, alone or jointly with his former student Andrés J. Kálnay (1932-2002), Bunge published several articles on a number of problems in quantum mechanics. Their subjects included the total spin of a system of particles, the mass defect of the hydrogen atom, new constants of motion, the quantum Zeno paradox, and the measurement process (Bunge 1944, 1945, 1955a,b, 1956; Bunge & Kálnay 1969). Thirty years ago he wrote that one of his 1955 papers —'A New Picture of the Electron' —was 'my best scientific paper':

> In this paper I introduced a new position coordinate (sometimes called the Feynman-Bunge-Corben operator), proved the existence of six new constants of motion of the relativistic electron, and suggested that this particle has an internal structure. (Bunge 1990b, p.678)

Between 1966 and 1969 Bunge met and discussed quantum physics with Werner Heisenberg, and later contributed to Heisenberg's *Festschrift* (Bunge 1977d). A point that he makes over and over regarding Heisenberg is that his deservedly famous 'Principle'—$\Delta p\, \Delta x \geq h/4\pi$ (the product of the dispersions of the values of the momentum (hence the velocity) and the position of a microparticle is at least $h/4\pi$, where h is Planck's constant)—is not a principle at all, but it is rather a theorem. It is a derived formula that follows rigorously from the axioms and definitions of quantum mechanics. Because the formula is a theorem, to interpret it correctly one must examine the premises that entail it. Bunge maintains that such an examination shows that the formula is quite general, but not in the way most believe it to be. In particular, it refers neither to macrophysical entities, nor to a particle under observation. It is a law of nature for the microphysical, just as much as Schrödinger's equation, which is the basic formula of non-relativistic quantum mechanics. Thus, the popular name 'Uncertainty Principle' is incorrect. As Bunge notes, uncertainty is a state of mind, and quantum mechanics is not about minds but about physical things, most of which are beyond the experimenter's reach.

Much of his work in theoretical physics is gathered in his *Foundations of Physics* (Bunge 1967c) and *Philosophy of Physics* (Bunge 1973). His contributions to theoretical physics have continued to the present day. In his early eighties he published 'Velocity Operators and Time-Energy Relations in Relativistic Quantum Mechanics' (Bunge 2003b); in his nineties he published on the Aharonov-Bohm Effect (Bunge 2015) and on Gravitational Waves (Bunge 2017c).

In a comprehensive collection of studies of Bunge's *Treatise,* Manfred Stöckler, a German physicist and philosopher, correctly remarked that:

> There are two characteristic qualities of Mario Bunge's papers on quantum mechanics. Firstly, more than most philosophers he is intimately acquainted with the details of the theory, both with the theoretical structure and with the practice of its applications. So he corrects numerous philosophical claims which are just misunderstandings of physics. Secondly, more than many other experts in the foundations of physics he looks at quantum mechanics from an explicitly philosophical point of view. So most of his writings about the philosophy of quantum mechanics are guided by his fight against people using quantum mechanics in order to refute realism. (Stöckler 1990, p.351)

Bunge rejected both the popular Copenhagen indeterminist and Bohm understandings, and proposed his own non-local realist interpretation of quantum mechanics. This keeps the mathematical formalism but modifies the positivist interpretation proposed by Bohr, Heisenberg, Pauli, and Born. For example, Bunge interprets the square of the absolute value

of the state function not as the probability of finding the object in question in a unit volume (an intrinsically subjective notion), but rather as the probability that it is within a unit volume (an objective version of the former). Bunge argues that electrons and the like are neither particles nor waves, although they appear as such under special circumstances. Talk of waves and particles is metaphorical, an allusion back to classical notions from which quantum mechanics emerged. Bunge maintains:

> Physics cannot dispense with philosophy, just as the latter does not advance if it ignores physics and the other sciences. In other words, science and sound (i.e., scientific) philosophy overlap partially and consequently they can interact fruitfully. Without philosophy, science loses in depth; and without science philosophy stagnates. (Bunge 2000d, p.461)

Physicists have acknowledged the impact of Bunge's work. In 1989 the *American Journal of Physics* asked its readers to vote for their favourite papers from the journal, from its founding in 1933 to 1989. In the resulting 1991 list of most memorable papers, alongside classics from Nobel Prize winners and luminaries such as Bridgman, Compton, Dyson, Fermi, Kuhn, Schwinger, Wheeler, and Wigner, was Bunge's 1956 'Survey of the Interpretations of Quantum Mechanics' (Romer 1991). In 1993, the journal repeated the exercise, asking readers for the most influential papers in the journal's first 60 years. In this list, Bunge's 1966 paper—'Mach's Critique of Newtonian Mechanics'—took its place alongside his 1956 article (Romer 1993). This recognition by physicists of someone who is at once a philosopher, a physicist, and a social scientist, is extraordinary.

1.13 Psychology and Philosophy of Mind

Bunge has had a serious interest in psychology since his adolescent years. As he writes in his *Memoirs*: 'Psychology had intrigued me, since at age 16, I read some of Freud's books, which sold for a few cents at subway kiosks' (Bunge 2016, p.43). At the same time, he read Bertrand Russell's *Problems of Philosophy* (Russell 1912). He quickly surmised that the former was 'psychobabble ... and sheer fantasy' (Bunge 2016, p.43). Through the eight decades he has spent on appraising Freudianism and psychoanalysis, these initial evaluations did not change, they only strengthened.

Bunge has contributed to some first-order issues in psychology, including language acquisition, where amongst other things he rejects Noam Chomsky's account of a neurologically-embedded Universal Grammar, and Chomsky's consequent generative linguistics programme (Bunge 1983, 1984, 1986a, c, 1999b). Bunge has written on methodological issues in psychology, with his arguments being stated in articles (Bunge 1985, 1989b, 1990a), and the book *Philosophy of Psychology*, written with Rubén Ardila (Bunge & Ardila 1987).

His philosophy of mind is advanced in a series of papers (Bunge 1977b, 1981a, 1987, 1991b), and two major books: *The Mind-Body Problem* (Bunge 1980) and *Matter and Mind: A Philosophical Inquiry* (Bunge 2010). He oft says that he is 'against brainless psychology and mindless cognitive science' (Bunge 1981a). He is against all dualisms in theory of mind, and advances his emergent materialist, monist theory as the only theory of mind consistent with current scientific knowledge of mental processes and consciousness. In a recent paper, he writes:

> nearly all the important findings in psychology, in particular the localization and

> interdependence of a number of mental processes, from anxiety to morality, have been so many successes of the psychoneural program. (Bunge 2017d, p.458)

Having said this, Bunge's theory of mind, along with his theory of everything else, is not reductionist. His commitment to systemism (everything except the universe as a whole belongs to some larger system) prevents all radically reductionist moves. This is elaborated in many places (Bunge 1977e, 1991c), summarised in a chapter titled 'A Pack of Failed Reductionist Projects', where he lays out and critiques physicalism, computationism, linguistic imperialism of both the positivist and hermeneutical variety, sociobiology, evolutionary psychology, psychologism, sociologism and rational-choice theory (Bunge 2003a, pp.149-167). The roll-call of influential theorists whose different reductionist programmes ('everything is a case of ….') are rejected in this chapter includes John Wheeler, Daniel Dennett, Patricia Churchland, Otto Neurath, Rudolf Carnap, Edward Wilson, Richard Dawkins, Steven Pinker, Wilhelm Dilthey, George Homans, Lev Vygotsky, Michel Foucault, Bruno Latour, Clifford Geertz, and Sandra Harding.

A sense of all these critiques is given in his closing comments on rational-choice theory:

> Rational-choice theory, is currently in vogue, presumably because it looks scientific in addition to purporting to explain much with little, thus producing the illusion that it unifies all the social sciences around a single postulate. However, it can be shown that rational-choice theory is conceptually fuzzy, empirically groundless, or both. Indeed, when the utility functions in a rational-choice model are not specified, as is generally the case, untestability is added to vagueness. (Bunge 2003a, p.165)

1.14 Social Science

Bunge believes that the lessons learnt from the hard-won successes of natural science should be applied to social science; that the inquiry template forged by the best of natural science can and should be applied to the social and psychological worlds.[2] The disparate Enlightenment philosophers of the 18th century were all committed to this thesis. Condorcet, for example, in his influential *Sketch for a Historical Picture of the Progress of the Human Mind* (Condorcet 1795/1955) wrote:

> The sole foundation for belief in the natural sciences is this idea, that the general laws directing the phenomena of the universe, known or unknown, are necessary and constant – why should this principle be any less true for the development of the intellectual and moral faculties of man than for the operations of nature. (Condorcet, 1795/1955, p.173)

Bunge concurs.

Bunge regards bad philosophy as the major obstacle to the advance of social science. He sees the philosophical deficiencies as logical, ontological, epistemological, and ethical. The logical flaws are conceptual fuzziness and invalid inference; the ontological culprits are individualism and holism; the epistemological errors are sectoralism or tunnel vision, subjectivism, apriorism, pragmatism and irrationalism (Bunge 1998a, p.452).

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[2] Two issues of the journal *Philosophy of the Social Sciences* were devoted to appraising the implications of Bunge's systemism for social science research (Pickel 2004). He contributed to each issue (Bunge 2004a,b).

For Bunge, there are two major moral lapses that contribute to the backwardness of social science:

> One is the frequent violation of the ethos of science, first ferreted out by Merton (1938). Such violation occurs, in particular, when the universality of scientific knowledge is denied, dogmatism is substituted for 'organized scepticism'….and rigorous testing, or at least testability is jettisoned. The second moral culprit is the attempt to pass off ideology (left, centre or right) for science in basic research, the pretence of moral or political neutrality when tackling practical issues. (Bunge 1998a, p.453)

Bunge's systemism implies a relatively seamless move from the science of physics, through psychology to sociology and beyond. He does not shy from the label 'scientism', derogatorily applied by others to such a unified theory of knowledge and family resemblance of research methodology (Bunge 1986b, 2014a). Although he rejects Marxist dialectical materialism as 'either unintelligible, too sketchy to be useful, or just plain false' (Bunge 2016, p.263), he is sympathetic to historical materialism and praises the work of some Marxist historians, such as Eric Hobsbawm, Edward Thompson and Fernand Braudel. His systems concept of society avoids the well-known problems of individualism and holism (Bunge 1979b, 2000a,b).

Tuukka Kaidesoja, a Finnish philosopher who has written extensively on the philosophy of social science, has provided a detailed appraisal of the parallel work of Roy Bhaskar (founder of the 'Critical Realist' programme in social science) and Mario Bunge, and concludes:

> Roy Bhaskar and Mario Bunge have both developed influential realist philosophies of social science. Both of them use the ontological concept of emergence and advocate a doctrine of emergent materialism in their social ontologies. … I argued that Bunge's perspective on emergence enables one to conceptualize levels of organization in complex systems including social systems, while Bhaskar's account of levels of reality is problematic. (Kaidesoja 2009, p.318)

1.15 Probability and Bayesian Inference

Consistent with his overall realist programme in ontology and epistemology, Bunge has concerned himself with probability and statistical inference in science (Bunge 1951, 1976, 1981b, 1988b, 2003a, 2008). The theory of probability is a branch of pure mathematics. It requires interpretation to be connected to the world; either to understand the world or guide actions in the world. Bunge rejects *subjectivist* interpretations of probability, wherein the probability of a statement is a measure of its credibility, or of the conviction a person has in its truth. He rejects *frequentist* interpretations, wherein probability is the long-run relative frequency of observed events. Instead of either, he argues for a *propensity* (or as he also calls it, *objectivist* or *realist*) interpretation of probability, wherein probability is an objective measure of the possibility that some proposed event or state will occur (Bunge 2006, p.103). He argues that only the third interpretation is compatible with science.

Bunge places Bayesianism, in any of its many forms, within the subjectivist or personalist interpretation of probability; indeed, he believes Bayesianism now occupies the entire subjectivist domain, with no alternatives. Bunge belongs to the minority of philosophers and scientists unequivocally critical of its use in science, social science and

medical research. Anti-Bayesianism is a thread through all his writings in the field.

The statistician Leonard Savage, who brought Bayesianism into mainstream statistics and probability theory, stated that 'probability measures the confidence that a particular individual has in the truth of a particular proposition, for example, the proposition that it will rain tomorrow' (Savage 1954, p.3). Savage used the term 'personalist' probability and defended such Bayesian accounts against relative frequency or objective accounts of probability (Savage 1964). Michael Shaffer states that in Bayesianism 'probabilities are degrees of belief defined over a complete space of propositions' (Shaffer 2012, p.117).

Beginning almost 70 years ago, in 'What is Chance?' (Bunge 1951), Bunge has continually criticised the popular, subjectivist interpretations of Bayes' Theorem. He sees the theorem as a 'legitimate piece of basic mathematics, which does not refer to the real world' (Bunge 2008, p.167), but rejects Bayesianism, in particular the 'mindless application of the theorem' (Bunge 2006, p.101). Not that it works poorly, rather it simply cannot work as routinely interpreted: 'nobody knows how to go about assigning a probability to scientific laws or to scientific data … in these fields [science and technology] one assigns probabilities to states and events.' (Bunge 1988b, p.216). Elsewhere he states the matter as:

> … in the Bayesian perspective there is no question of objective randomness, randomization, random sample, statistical test, or even testability: it is all a game of belief and credence. (Bunge 1999a, p.81)

Bunge's central objection is to the Bayesian linking of probability to 'credence', 'degree of belief', 'confidence', 'expectations', 'conviction', or any such psychological state. For Bunge, psychological states belong to the subjective domain, and should not, in principle, play a determinative role in scientific evaluation or theory appraisal. There are lots of roles that psychological states and conditions can and do play in science, but they have no role in proper theory evaluation. To the degree that they come into theory evaluation, then it is corrupted and arbitrary science. In one long treatment, Bunge says:

> Bayesian statistics and inductive logic are triply wrong: because they assign probabilities to statements; because they conceive of probabilities as subjective; and because they invoke probabilities in the absence of randomness. Adding arbitrary numbers to any discourse does not advance the search for truth: it is just a disguise of ignorance. (Bunge 2008, p.177)

He is not alone in his rejection of Bayesianism. Ronald Fisher, the statistician and biologist who was largely responsible for the 'modern synthesis' in biology, regarded Bayes' Theorem as measuring 'merely psychological tendencies, theorems respecting which are useless for scientific purposes' (Fisher 1926/1947, p.7). Bunge favourably cites Fisher's advocacy of randomization in the formation and distribution of control and experimental groups in natural and social science experimentation, and notes that 'Bayesians do not practice randomization …. for them, chance is only in the eyes of the beholder' (Bunge 2008, p.173). Bunge consistently develops Fisher's claim that measures of psychological states have no place in properly scientific evaluation of theories or hypotheses. Others have also rejected the Bayesian programme because of its inherent subjectivity (Glymour 1980, Kyburg 1978, Levi 1974, Mayo 2004).

An increasing number of statisticians and researchers have abandoned subjective Bayesianism and moved to objectivist versions of the theory, where assigning a numerical value to the prior is done in strict accordance with empirical evidence and/or rational

principles, and so is supposedly inter-subjective, trans-subjective or objective (Franklin 2001, Jaynes 2003, Salmon 1990, Shimony 1970). Wesley Salmon writes:

> I proposed that the problem of prior probabilities be approached in terms of an objective interpretation of probability, in particular, the frequency interpretation. I suggested three sorts of criteria that can be brought to bear in assessing the prior probabilities of hypotheses: formal, material and pragmatic. (Salmon 1990, p.184)

He does acknowledge that while Bayes' theorem provides a mechanical algorithm, 'the judgements of individual scientists are involved in procuring the values that are to be fed into it' (Salmon 1990, p.181). In some cases, for instance counter-factual hypotheses, there can be no appeal to evidence in quantifying the prior. This because the hypothesis is about what would happen if states of affairs were different from what they are. This is the common case of abstracted or idealised hypotheses and theories in science; for instance, Galileo's claims about what would be the parabolic motion of projectiles in the absence of the known host of actual impediments (Shaffer 2012, pp.122-124).

Harold Brown surveys the Bayesian retreat and writes:[3]

> The major point urged, with varying degrees of vigor, is that while the use of appropriate algorithms is an important part of the process of arriving at rational evaluations, it is only a part. Judgement is required in order to choose appropriate algorithms and to govern their intelligent application. An account of reason that omits the central role of judgement in determining the inputs to our algorithms and in determining whether and which algorithms to use will be radically incomplete. (Brown 1994, p.368)

Of this 'retreat', Bunge might say: 'you should not have gone there in the first place'. An informed account of science would have ruled out *a priori* any flirtation with the subjectivist interpretation of probability, much less with bestowing on it the badge of scientificity. For Bunge, throwing around random numbers and utilising them in long calculations is a hallmark of pseudoscience (Bunge 2008). He lists eight errors with Bayesianism, and concludes:

> Verisimilitude and credibility are often equated with probability. … This conflation of an epistemological category (verisimilitude), a psychological one (credibility), and an ontological one (probability) is a root of the subjectivist or Bayesian theory. (Bunge 2003a, p.226)

Bunge develops his 'probability as propensity' account in a number of places (Bunge 1988b, pp.222-226, 1999c, p.107-108), and in doing so rejects the frequentist alternative to subjective Bayesianism. His central argument is that:

> … contrary to the frequency view, probability is *not a collective* or ensemble property, i.e., a property of the entire set *F*, but a property of every *individual* member of *F*, namely its propensity to happen. … while each probability function *Pr* is a property of the ensemble *F*, its values *Pr(x)* are properties of the members of *F*. (Bunge 1988b, p.223)

He recognises that frequencies can be *indicators* of probability but they are not the

[3] There is a huge literature on this topic. See at least Brown (1994), Corfield & Williamson (2001), Mayo & Spanos (2010), Swinburne (2002).

probability of an event or episode. The latter is an ontological claim about the event; frequency is not. He writes:

> … probabilities are theoretical whereas frequencies are empirical (observed or measured). So much so that, unlike probabilities, frequencies depend not only on the sample size (relative to the total population) but also on the sampling method. (Bunge 1999c, p.108)

Of his own view, he writes:

> In short, the propensity interpretation of probability is consistent with the standard theory of probability and with scientific practice, as well as with a realist epistemology and possibilist ontology. Hence, it solves the old tension between rationality and the reality of chance. None of its rivals has these virtues. (Bunge 1988b, p.226)

1.16 Enlightenment Project

The unifying thread of Bunge's life and research is the constant and vigorous advancement of the Enlightenment project, and criticism of cultural and academic movements that deny or devalue the core principles of the project: naturalism; the search for objective, trans-personal, non-subjective truth; the universality of science; the value of rationality; and respect for individuals. His commitment to the Enlightenment project began in his early 20s when he was Secretary General of the *Federación Argentina de Sociedades Populares de Educación*. During this time, he wrote his first book, *Temas de Educación Popular* (Bunge 1943), dealing with the principles and practice of popular (workers') education. This was an example of his *practice* of Enlightenment principles; he has no time for un-practised principles, even Enlightenment ones.

Bunge condenses the historical Enlightenment ideology into ten principles:

1. Trust in reason.
2. Rejection of myth, superstition, and generally groundless belief or dogma.
3. Free inquiry and secularism.
4. Naturalism, in particular materialism, as opposed to supernaturalism.
5. Scientism or the adoption of the scientific approach to the study of society as well as nature.
6. Utilitarianism in ethics, as opposed to both religious morality and secular deontologism.
7. Respect for praxis, especially craftmanship and industry.
8. Modernism, progressivism, and trust in the future.
9. Individualism together with libertarianism, egalitarianism (to some degree or other), and political democracy (though not yet for women or slaves).
10. Universalism or cosmopolitanism, for example, human rights and education. (Bunge 1999a, p.131)

Through his entire scholarly life, he refines and defends each of the foregoing Enlightenment commitments. But he is not uncritical or blinded. In an essay—'Counter-Enlightenment in Contemporary Social Studies'—he states:

> The Enlightenment gave us most of the basic values of contemporary civilized life, such as trust in reason, the passion for free inquiry, and egalitarianism. Of course, the Enlightenment did not do everything for us: no single social movement can do everything for posterity—there is no end to history. For instance, the Enlightenment did not foresee the abuses of industrialization, it failed to stress the need for peace, it exaggerated individualism, it extolled

> competition at the expense of cooperation, it did not go far enough in social reform, and it did not care much for women or for the underdeveloped peoples. However, the Enlightenment did perfect, praise, and diffuse the main conceptual and moral tools for advancing beyond itself. (Bunge 1994a, p.40)

1.17 Education

Missing from Bunge's above ten Enlightenment 'commandments' is Education. This should take its place on the list as an eleventh principle. All the 18th century English, French and German founders of the Enlightenment were advocates of a new, different and revitalised education. They saw education as essential for the reformation of current society, and for the more radical thinkers, the creation of a new society. Locke, Priestley, Rousseau, Kant, all wrote works on education (Parry 2007). They established the Enlightenment education tradition whose modern contributors have been Ernst Mach, Thomas Huxley, Frederick Westaway, John Dewey, Philipp Frank, Herbert Feigl, and Gerald Holton (Matthews 2015, chap.2).

The tradition is characterised by a commitment to the growth of knowledge of the natural and social worlds, the responsibility of the state for the education of all citizens, the extension of knowledge by both formal and informal education, and the utilisation of knowledge for the amelioration of social problems and the betterment of life. These cognitive and applied goals are shared with the Liberal education tradition, and both traditions might broadly be contrasted to utilitarian (whether State or personal) and progressivist movements in education.

Bunge contributes to this tradition, with his very first publication being *Temas de educación popular - Issues in popular education* - (Bunge 1943). He despairs of a great deal of counter-Enlightenment education. He writes of many University Faculties of Arts that:

> Here you will meet another world, one where falsities and lies are tolerated, nay manufactured in industrial quantities. The unwary student may take courses in all manner of nonsense and falsity. Here some professors are hired, promoted, or given power for teaching that reason is worthless, empirical evidence unnecessary, objective truth non-existent, basic science a tool of either capitalist or male domination, or the like. … This is a place where students can earn credits for learning old and new superstitions of nearly all kinds, and where they can unlearn to write, so as to sound like phenomenologists, existentialists, deconstructionists, ethnomethodologists, or psychoanalysts. (Bunge 1996b, p.108)

One educational case he did address in detail was the responsibility of science teachers in dealing with the inevitable 'conflicts' between scientific accounts of the world (its origins, biological evolution, explanations of sickness and healing, natural disasters, historical events, and so on) and alternate 'authoritative' cultural or religious accounts of the same things (creation stories, special creations, divine vengeance, efficacy of prayer, miracles, Chosen People, etc.). Martin Mahner and Bunge contributed a long article on this subject to the journal *Science & Education,* saying that ontologically, metaphysically, and epistemologically, the rival claims of science and religion were inconsistent, and minimally students need to be told this (Mahner & Bunge 1996a).

Mahner and Bunge's many pages of detailed arguments added up to a rejection of the popular, non-confrontational, widely-embraced, 'Non-Overlapping Magisteria Argument' (NOMA) of Stephen Jay Gould (Gould 1999), which has become the almost universal default

position in science education. The exceptions being, on the one hand, those adherents to religious, cultural, or ideological positions who maintain that such systems of belief can correct specific claims of science; and rationalists who believe the reverse. The arguments of Mahner and Bunge were responded to by educators, theologians, and philosophers; the authors replied (Mahner & Bunge 1996b). Bunge returns to the criticism of NOMA in his *Political Philosophy: Fact, Fiction and Vision* (Bunge 2009).

In 1929 a popular text used for the preparation of English science teachers was published. The author, F.W. Westaway (1864-1946) shared many of Bunge's pre-occupations: he was trained as a scientist. he wrote on scientific method (Westaway 1919/1937), on the history of science (Westaway 1934), on the responsibility, or otherwise, of science for the exaggerated and sophisticated carnage of the Second World War (Westaway 1942), and he was His Majesty's Inspector for Science in English Schools (Brock & Jenkins 2014). On the opening page of his 1929 textbook Westaway characterised a successful school science teacher as one who:

> knows his own subject . . . is widely read in other branches of science . . . knows how to teach . . . is able to express himself lucidly . . . is skilful in manipulation . . . is resourceful both at the demonstration table and in the laboratory . . . is a logician to his finger-tips . . . is something of a philosopher . . . is so far an historian that he can sit down with a crowd of [students] and talk to them about the personal equations, the lives, and the work of such geniuses as Galileo, Newton, Faraday and Darwin. More than this he is an enthusiast, full of faith in his own particular work. (Westaway 1929, p.3)

Bunge embodies Westaway's characterisation of a successful science teacher. He takes for granted Westaway's ideal and is puzzled that anyone would not.

1.18 The Festschrift

This Festschrift of 40 essays and a comprehensive all-languages bibliography, amplifies and evaluates Mario Bunge's systemic thinking and writing across the diverse fields to which he has contributed. The sections are:

(1) An Academic Vocation	3 essays
(2) A Philosophical System	12 essays
(3) Physics and Philosophy of Physics	4 essays
(4) Cognitive Science and Philosophy of Mind	2 essays
(5) Sociology and Social Theory	3 essays
(6) Ethics and Political Philosophy	3 essays
(7) Biology and Philosophy of Biology	3 essays
(8) Mathematics	3 essays
(9) Education	2 essays
(10) Varia	3 essays
(11) Bibliography	

The hope is that the collection will suitably celebrate Mario Bunge's long life; do justice to his intellectual labours, both by elaborating them and pointing to deficiencies and problems to which they give rise; and bring to the attention of students, teachers, and researchers the commendable, Enlightenment-affirming example of wide and serious scholarship in opposition to obscurantism and pseudoscience, and for the service of human betterment, that Bunge so well represents.

Bernulf Kanitscheider (1939-2017), a German philosopher of science, some thirty-five years ago wrote:

> Few extraordinary personalities have the chance to decisively shape the intellectual geography of a scientific epoch. Mario Augusto Bunge belongs to the small circle of important philosophers of science whose works have already become landmarks in the spiritual landscape of world philosophy. (Kanitscheider, 1984, p.viii, cited by Heinz Droste in this *Festschrift*)

The contributions in this Festschrift by scholars from a dozen different disciplines and a dozen different countries, give reason for such high, though optimistic, valuation of Mario Bunge's work. Contributors, readers, and all associated with production of the Festschrift wish the philosophical scientist and the scientifically-driven philosopher well for his centenary birthday.

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