PROLOGUE

"Convictions are more dangerous enemies of truth than lies."
Friedrich Wilhelm Nietzsche[1]

The history of science is obviously a vast field, embracing the history of scientific discovery and the evolution of research methods. But it also encompasses the history of scientists, the women and men throughout the ages who have devoted themselves to questioning the nature of reality. In doing so they refused to let their curiosity be stifled by common prejudice or religious dogma, sandwiched between revealed truths that were beyond question and divine mysteries which were above investigation.

Thales of Miletus (624-545 BC) is widely regarded as the first philosopher to set off in search of rational explanations for the natural phenomena he observed. Thales made the bold decision to look beyond the mythological tales that were supposed to explain these phenomena — in many cases — as the consequences of conflicts between the gods. Thales was a merchant, an engineer, a mathematician and a "proto-scientist" — as well as being hailed as the godfather of astronomy — who sought to explain the observable world by "rational" means. In doing so he practiced and promoted an approach which effectively "desacralized" the "facts of nature" and helped to establish a separation between physics (from the ancient Greek *physis:* nature) and that which belongs in the domain of metaphysics (*meta-physis:* beyond nature).

1. Friedrich Wilhelm Nietzsche, *Human, All Too Human* (in french *Humain trop humain*, Paris, Livre de Poche, 1995).

On a broader scale, Lucio Russo[2] argues that *"the debt owed by contemporary Western thought to classical antiquity, particularly Greece, is much more substantial than is generally acknowledged these days."*

As disruptive and iconoclastic as his approach and discoveries must have been, Thales of Miletus was highly-esteemed during his lifetime. A widely-admired man of science and a respected political figure, Thales was one of the seven sages venerated by ancient Greek thinkers, appearing on the famous list given by Plato in *Protagoras.*[3]

In subsequent centuries, many scientists found their lives much less simple and their discoveries less warmly appreciated. Their stories are often as magnificent as they are tragic. Tragic fates certainly awaited many women and men whose research was their own undoing, a reminder of the physical risks sometimes attached to the experimentation required to produce new knowledge (Arkan Simaan has written evocatively of the potentially parlous nature of scientific discovery).[4] But more often, in Europe at least, the most severe difficulties encountered by these men and women of science arose from the conflict between science — its aspirations to freedom and its claims to reveal the nature of reality — and the dogmatic rigidity of the Catholic Church in its less "benign" eras. The example they set for posterity deserves to be remembered and celebrated. Four of these pioneering scientists had a particularly profound impact on the times in which they lived: their names were Copernicus, Bruno, Galileo and Darwin.

SCIENCE AND RELIGION: A TUMULTUOUS RELATIONSHIP

It is important to bear in mind that medieval scholars considered science, geometry and astronomy to be inextricably linked to the divine. The influence of Avicenna, Averroes and Maimonides is widely-acknowledged: they made decisive contributions to the rediscovery, and sometimes the development, of Aristotelian thought in the West. In doing so, they greatly advanced the understanding of their age and provided inspiration for later developments in medieval thought.

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2. Lucio Russo, *Perché la cultura classica,* Milan, Montadori, 2018.

3. Plato, *Protagoras*, *Œuvres complètes* (trad. Luc Brisson), Paris, Gallimard, 2008, (1st edition 2006).

4. Arkan Simaan, *La science au péril de sa vie*, Paris, Vuibert Adapt, 2006.

But this harmonious state of affairs broke down in subsequent centuries. The revealed religions founded their faith on scripture, with dogma impervious to change; science, on the other hand, is an open-ended, uninterrupted succession of new discoveries. Shaped by the contributions of Descartes (*Discourse on the Method)*[5] and the philosophy of the Enlightenment (e.g. Diderot's *Encyclopaedia*),[6] the scientific method — and particularly its experimental dimension — gradually took shape, rapidly yielding results which were not always compatible with the religious dogma of the day. This growing divergence between science and religion was increasingly difficult to reconcile, in spite of some well-meaning early attempts at uniting the two, including Thomas Aquinas' efforts to combine Aristotelian philosophy with the dictates of his faith. It is worth noting, nonetheless, that many seventeenth-century scientists were devout believers, indeed some were ordained (Copernicus, Galileo, Mariotte, Lemaître). The 18th century brought fresh controversies, not least in the field of biology, where the emerging scientific theory of epigenesis[7] came into conflict with the Catholic Church's preferred doctrine of "preformation." In the mid-19th century, Pope Pius IX was still defending the distinction between "*true science"* and "*false science,"* on the basis that "truth" was necessarily consistent with divine revelation, to which scientists should look for guidance. Science which strayed from this course served only to propagate atheism and materialism.

Times have changed, considerably.

In 1996, Pope John Paul II declared that the theory of evolution was "*more than a hypothesis,"* and the Catholic Church has refused to lend its support to the pro-creationist campaigns which continue to prosper in the USA. In 2005 George Coyne, then Director of the Vatican Observatory, also spoke out against the idea of "*intelligent design*."

From the Catholic perspective, the "*relationship between faith and reason"* is defined in the encyclical *Fides et Ratio*, issued by John Paul II to all Catholic bishops in 1998. From a non-religious and philosophical perspective, the relationship between science and religion was

5. Descartes, *Œuvres complètes, vol. III, « Discours de la méthode et Essais »*, Paris, Gallimard, TEL, 2009.

6. *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers*, published 1751-1772 under the supervision of Denis Diderot and Jean Le Rond d'Alembert.

7. Epigenesis: theory which holds that embryos form gradually within the egg, with different parts taking shape in a successive process.

notably addressed by Bertrand Russell in his 1935 essay *Science and Religion*.[8]

It is perhaps worth noting that religiously-inclined scientists appear to find it easier to reconcile their faith with their discoveries than their respective churches do. In a 2009 survey conducted by the *American Association for the Advancement of Science,* 51% of American scientists declared their belief in a higher power — with 33% identifying that power as God.

THE HISTORY OF SCIENCE: SOME STUBBORN STUMBLING BLOCKS

Even now, some scientists and the theories they champion are far from achieving universal acceptance. Recent years have furnished us with numerous examples. In Turkey, for instance, the government decided to remove the theory of evolution from the middle school and high school curriculum in 2019. Darwinism is also a very touchy subject in many parts of the Middle East. Natural selection seems to run counter to the sacred word of the Quran, which clearly states that the first man, Adam, was sculpted from clay in the hands of the Almighty. Similarly, some ultra-Orthodox Jews believe the Torah to be the sole source of "truth," maintaining that its teachings — including the Book of Genesis — are to be understood literally. By their reckoning, the world is less than 6000 years old. In the majority of *yeshivot*, meanwhile, the Talmud is still regarded as the exclusive source of true learning. Similar problems are still encountered in the USA.[9] A 2011 survey published in *Science,* conducted upon a representative sample of 926 biology teachers working in American public schools, found that the majority of these teachers either avoided the subject altogether, or else taught both Darwinian evolution and creationism as equally-valid "theories." French Catholic newspaper *La Croix* reported on 17 March 2017 that Texas had recently become the fourth state legislature — after Oklahoma, South Dakota and Indiana — to debate a law which would authorize high school science teachers to present creationist theories on an equal footing with the theory of evolution. The report cites a survey indicating that 42% of Americans believe that man was created in his current form.

8. Bertrand Russell, *Science and Religion*, Gallimard, 1990 (first edition: 1935).

9. Blandine Chelini-Pont, « Bouter Darwin hors des classes. La saga judiciaire de l'enseignement de l'évolution à l'école et ses répercussions sur la laïcité scolaire aux États-Unis », in *Théories de l'évolution et religion*, Riveneuve, 2011, (hal-archives-ouvertes.org).

SEPARATING THE SCIENTIFIC FROM SCIENTISM

Defining what constitutes the scientific is fundamentally a question of method, although other considerations abound. Scientism, on the other hand, is an ideological matter. While epistemology raises questions about the practical conditions of scientific knowledge, and indeed the very nature of this knowledge — particularly the issue of truth and its relationship to reality — it also helps to define science as a process of knowledge creation. This process requires a certain methodological rigor, conferring upon its conclusions a validity which elevates them above mere opinion. One of the essential virtues of this process is that it is always open to the possibility that knowledge can change and evolve, as long as there is sufficient evidence that previously-accepted theories were in fact mistaken. This spirit of openness and peaceful debate are, now as ever, particularly valuable qualities worthy of protection.

Nonetheless, although science is, by definition, the unique possessor of the properties which constitute its epistemological definition, it cannot exclude all other forms of personal conviction, intuition or belief. Epistemology does not deny us this right, this freedom. When it comes to determining what is scientific and what is not, epistemology's only responsibility is to rule out the non-scientific. But this distinction must in no way infringe upon our inalienable individual freedom to order and organize our own knowledge and beliefs. Nevertheless, for any scientist deserving of the name, and for any doctoral candidate embarking upon a scientific career and keen to align their work with their aspirations, this distinction stakes out the path from which they must not stray.

INTRODUCTION

"It is only necessary to take care not to abuse the liberty that we possess of imposing names, by giving the same to two different things."

Blaise Pascal[1]

The purpose of this book is to act as a first staging post on the road of epistemological questioning which all researchers must travel, whether they are aware of it or not, and, indeed, whether they like it or not. In this respect, it is intended to serve as an introduction. In a somewhat broader sense, it is a guide to be used as and when it is needed by all readers — whether or not they are researchers — with an interest in the conditions in which scientific knowledge is produced, and the resulting debates over the very status of this knowledge.

Why, then, have I decided to present this guidebook to the reader in the form of a dictionary? Because, while heeding the advice of Blaise Pascal cited above, I also share the conviction expressed so eloquently by Jean-Pierre Cléro in his treatise on the epistemology of mathematics: "*Without due rigor and terminological precision, no thought can be said to be logical and no verbally-expressed scientific knowledge can be firmly established. This is the most pressing epistemological preoccupation.*"[2]

But what exactly should an introduction to epistemology introduce? In other words, is epistemology an exercise in reflection specific to the philosophy of science, or to the philosophy of Knowledge (with a capital K) in its *totality*? If the latter is true, can this philosophy of

1. Blaise Pascal, « De l'esprit géométrique », in *Œuvres complètes*, Paris, Gallimard, La Pléiade, 1964, p. 557-598 (first edition 1658).

2. Jean-Pierre Cléro, *Epistémologie des mathématiques*, Paris, Nathan, 1990.

knowledge in its *totality* find room to accommodate a diverse array of demands and conventions regarding its ideal, or obligatory, mode of "production?" To put it another way, should we focus on examining the conditions which make it possible to produce knowledge "worthy" of being considered scientific — weighing up its true nature and scope — or should we instead concentrate our efforts — with the same degree of rigor — on examining the conditions required to produce or advance any form of "true" knowledge?

A "scientistic" response would be to suggest that these two questions are essentially one and the same, since only scientific knowledge is worthy of recognition as "true" knowledge, which is to say knowledge produced within the confines of methods which determine — at least partially — the "scientific" credentials of the disciplines in question.

The vision of epistemology embodied in this tome is more "moderate" — and perhaps more "reasonable[3] — envisioned as a reflection on the conditions in which *scientific* knowledge is produced, and on the potential nature and scope of this knowledge.

In this respect, the present volume does not seek to imply that forms of knowledge other than the scientifically-produced variety are devoid of interest, or to suggest that they have no validity for anybody, in any circumstances.

Moreover, the very fact that the term "sciences" encompasses a multiplicity of highly diverse disciplines raises an immediate and pressing question: are all sciences governed by the same epistemological considerations and demands?

The answer must, of course, be negative. Some of the demands imposed by "scientific rigor" regarding research methods, as well as the desired features of the process by which scientific results are produced, are possible — or "tenable" — in certain disciplines and impossible to satisfy — "untenable" — in others.

It is therefore important to distinguish — for example — between the conditions of scientific validity generally applied to the experimental sciences and those disciplines where the experimental method is either of limited use or frankly inapplicable: mathematics,

3. For a discussion of the slightly different meanings attached to this term in French and English, see Hervé Barreau (Hervé Barreau, *L'épistémologie*, Paris, PUF, « Que sais-je ? », 2013).

for instance, (logical and formal disciplines where experimentation is not pertinent) or history (experimentation is simply impossible).

Must we also assume that the conditions of scientific validity associated with the human and social sciences — or even to the *sciences of the artificial*[4] — are identical to those which prevail in the *natural sciences?*[5] Without wishing to deny the fact — which shall become clear over the course of this volume — that debate is ongoing on these matters (particularly in sociology), it seems safe to assert that the response is once again — at least partially — negative. The reasons are largely the same as those set out in the preceding paragraph, pertaining primarily to the more "experimental" nature of the natural sciences.

In light of all this, must we accept that it is legitimate, and perhaps even preferable, to adopt different approaches in those fields which allow for the use of explanatory modeling techniques than we would in those disciplines which demand investigative methods more clearly focused on "understanding?"

In this case, the answer — by general, or at least broad, consensus — is in the affirmative. Explanatory methods are often based upon the quantitative verification of structural models using a hypothetical, deductive approach. "Comprehension-based" approaches, meanwhile, differ from such methods for the simple reason that explaining a phenomenon requires researchers to have some prior understanding of the actors involved; this explanation sometimes requires a degree of "interpretation" of the observed facts.

Other questions — some of which may be even more fundamental in nature, and have been the subject of lively discussion for decades or more — will be touched upon only lightly in the present tome. Allow me to broach one by way of an example: are all people, or all cultures, equally "equipped" — or simply equal — when it comes to understanding "reality," however they may define it? Do they all use comparable "tools" capable of establishing identical, or at least congruent, representations of reality?

4. Marie-José Avenier, « Les sciences de l'artificiel : une conceptualisation révolutionnaire de sciences fondamentales à parachever », De Boeck Supérieur, *Proyectics, Proyéctica, Projectique*, vol. 24, n° 3, 2019, p. 43-56.

5. A distinction is generally made between the so-called hard sciences and the human and social sciences; an analogous distinction is that between formal or natural sciences and social sciences. Sciences concerned with physical and chemical objects are thus described as "natural sciences"; in contrast, sciences concerned with human and social phenomena, considered as artefacts, may thus be defined as "sciences of the artificial."

Language specialists suggest that the answer is no. Our ability to comprehend and express reality appears to be heavily dependent upon the words that we have at our disposal.

Does it necessarily follow that all sciences are restricted by relativism? Even the most cursory overview of inventions and discoveries, or indeed the impressively uniform manner in which scientists hailing from America, Russia, China, France, India and elsewhere all use the same laws of physics to launch rockets and put satellites into orbit, should make it abundantly clear that — in this field, at the very least — no such limitation exists. Mathematics is often regarded as the language of choice for representing the world, and some would hold that it is the true universal language (Galileo, *The Assayer*, 1623),[6] the only one capable of expressing "reality" — effective or supposed — seeing as it is governed by the same laws, or the same necessities, independent of any and all human factors.

Such questions are the — delicate — raw materials of epistemology, the bread and butter of epistemologists. They are questions in which specialists abound, and I must thus take this opportunity to plead for their indulgence.

In writing this book my intention has been to venture beyond the comfort zone of my academic background, resisting the temptation to produce another opus addressing questions specific to the field of the "epistemology of management sciences." On the contrary, my aim here is to offer a more general overview. Naturally, significant attention is devoted to the nature and conditions of "scientificity" in management research, including many examples taken from that particular field. Nevertheless, these arguments exist within a more general analytical framework, devoted to exploring the conditions in which scientific knowledge is produced across the whole, vast domain of the human and social sciences, as well as in the experimental and "exact" sciences.

Exacting readers may find this dictionary to be too engrossed in questions of a methodological nature, with the risk that aspects of a purely epistemological nature do not receive the exclusive attention they merit. Rightly or wrongly, this is a deliberate choice born of a desire to endow this book with a certain "praxeological" purpose. Moreover, given the two different ways in which this book may be read — continuously as a sort of "alphabetic history of science," or

6. Galileo, *The Assayer*, (original title: *Il Saggiatore*, 1623); available online via books.google.com

else piecemeal, one entry at a time in the manner of a traditional dictionary — readers must excuse a certain degree of repetition, which in places has been deemed necessary to facilitate the comprehension of the notions and concepts discussed.

In spite of the difficulties inherent to this undertaking, and the limitations discussed above, this book is an expression of my deeply-held conviction that a first foothold on some of the more slippery epistemological slopes — an inalienable aspect, even though the connection may not always be immediately apparent, of any scientific research — may be of use to those embarking upon careers in research.

With this in mind, allow me to once again insist that my guiding ambition in writing this book has been to familiarize readers with the general contours of an intellectual landscape whose complex topography has been amply explored in countless specialist tomes — more learned, perhaps, but also less accessible than the present volume. The specialist literature offers no end of opportunities for curious readers to "explore further."

Another of the undeniable limitations of this dictionary is the fact that the list of terms identified and discussed herein obviously cannot hope to be exhaustive. There are undoubtedly many other potential entries which would have merited inclusion.

This non-exhaustive selection also extends, perhaps inevitably, to the proper nouns among the entries. I have chosen to include only a certain number of philosophers and scientists whose work, particularly in so far as it pertains to man's relationship with truth or reality, has demonstrably exerted a strong influence over subsequent generations as well as their contemporaries. These thinkers have been selected for their close association with some or all of the other type of common nouns — the notions and concepts — covered in this book. This decision to include both individual thinkers and the contents of their work also strengthened my determination to maintain strict alphabetical order among the entries; I have thus eschewed the practice of separating common nouns and proper nouns into different sections, as is generally the case with dictionaries.

Last but not least, I am aware that my attempts at clarifying the topics addressed herein are sometimes — often, perhaps— personal in nature. By this I mean that not only are the entries the fruit of a potentially "debatable" process of selection; the accompanying explanations may also appear to be partial, in both senses of the term, and thus run the risk of disappointing readers.

Although epistemology seeks to examine the nature and scope of scientific knowledge, this is not to say that it is, in and of itself, an exact science.

The complexity of the subjects covered in this work, and the multiplicity of contributors and approaches involved, have in certain cases obliged me to take sides. It was not my intention to offer a scholarly compilation, an exhaustive list of the various, highly respectable, often highly influential (but undoubtedly highly divergent) positions which may exist on a given subject.

On this subject, I shall venture to invoke Montaigne — without seeking to "hide behind him" — specifically his essay *On Pedantry*:[7] *"We allow ourselves to depend so heavily on the strength of others, that we lay waste to our own vigor (...) Even if it were possible to become learned through other people's learning, the only way to become wise is by one's own wisdom."*

As such, many of the entries in this dictionary reflect a certain understanding — or vision — of matters which is specific to the author, and which is likely to be perceptible to readers. I stand by this choice, which I hope will help to imbue the book with a certain sense of cohesion, making it more "approachable" in some respects.

In addition to its ambition of being of practical use to researchers, this book also doubles as an apology for a demanding yet open form of knowledge: scientific knowledge. As well we know, scientific knowledge has often run afoul — and still does to this day — of prejudice, preconceptions and dogma, resistant as they are (sometimes violently so) to reform or reflection. Ultimately, my goal is to encourage readers to push further ahead, to expand their horizons, and to pursue an enriched personal reflection on the conditions which determine the scientificity of any research undertaking.

In a 2012 essay entitled *Geography of the Moment,*[8] Sylvain Tesson mentions a principle close to the heart of James Harvey,[9] to which he had already alluded in a previous publication.[10] He calls it the "tea leaf principle". Sylvain Tesson summarizes the idea in the following

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7. Michel de Montaigne, *Les Essais – Livre I*, p. 185, Paris, Flammarion, 1969 (my translation).

8. Sylvain Tesson, *Géographie de l'instant*, Paris, Editions des Equateurs, 2012.

9. James Harvey was an American artist. Born: Toronto, 1929, Died: New York City, 1965.

10. Sylvain Tesson, *Le souffleur de bambous*, Paris, Transboréal, 2006.

terms: *"To immerse oneself in reality, slowly soaking it up, before rising to the surface of the world and releasing your own essence."*

That is precisely what this dictionary seeks to offer readers: an immersion in a multi-faceted field, from which researchers bold enough to take up this challenge must "*arise and release their own essence."* In doing so they will be heeding the advice so succinctly expressed by Nietzsche in *The Gay Science*: *"vademecum, vadetecum."*[11]

The decision to present this introduction to the philosophy of science in alphabetical format also accounts for its metaphorical title; a title which reflects the author's intention of presenting readers with a "portrait of the sciences in fragmentary form."

11. Friedrich Wilhelm Nietzsche, *Le Gai savoir*, 1901 (aph. 7 vademecum – vadetecum).