Preface

A widely prevalent myth is that books are inanimate, ineffective, nearly futile objects belonging to the shades and quiet environment of libraries, monasteries, and other retreats from the real world. Contrary to this misinterpretation and misunderstanding, books can be dynamic and vital elements of culture. They can be full of ideas and experience, capable of changing the direction of events.

From fiction to drama, philosophy, science, technology, finance, models of thought, poetry, and essays, books have been cornerstones to the evolution of society. They are the means to spread wider (often contradictory) concepts underpinning the march of civilization, and they have gone way beyond supposedly static objects to dynamic entities able to make immense contributions.

Much to their credit, books have been instrumental in promoting *thinking*, which is important inasmuch as thinking must be part of everybody's education. Thomas Watson, Sr., one of the most resourceful businessmen, used the logo THINK almost at par with that of his company, IBM. And on August 31, 1837, in his Cambridge lecture Ralph Emerson said: "If one is a true scientist, then he is one who THINKS."

Niels Bohr, the nuclear physicist, was teasing his peers and his students by telling them: "You are not thinking, you are only being logical." Great scientists and technologists have always appreciated that thinking means doubting and experimenting. Because it is based on thinking, scientific experimentation is the mother of research and of the applications to which technology is being put.

Science is the process of creating new knowledge, not just interpreting the old in an ever greater but uncertain detail. Scientists make progress by distinguishing between what they regard as meaningful and what they consider as being secondary or unimportant. The meaningful is dynamic; typically, the less important is static.

Technology amplifies and applies to daily life products and processes based on the breakthroughs of science. Technologists who are worth their salt know that the work they do is in full evolution. *If* they fail to steadily develop their skills, their tools, and their methods, *then* they will only be as good as their last design and at the risk of becoming obsolete.

Whether we talk of new products, novel processes, or advanced systems, the deliverables of scientists and technologists who look at their work through the prism of a narrow discipline are necessarily restricted. In a complex society like ours we have to broaden—and to do so our focus we must espouse interdisciplinary approaches, effectively using our critical spirit and being able to see the difference between a project that goes nowhere and one that actually works.

Because it is a salient problem and a most challenging issue to our society at the present time, power production has been chosen as a case in point in technological development. The discussion of possible alternatives in energy sources, the advantages but also costs and obstacles confronted by each of them, confirm the view that technology must be in touch with common citizens to satisfy their needs and answer their fears about the future. This has been classically philosophy's remit, but it is no less true that philosophy, science, and technology correlate.

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The theme of Chap. 1 is natural philosophy, a term which preceded that of science all the way from antiquity to Isaac Newton's time, and it is still in use. To appreciate the intellectual effort that has been invested over the centuries, the text describes the parallel evolution of philosophical ideas and scientific thought, prior to making a distinction between basic and applied research. This is followed by examples of work on the very small (molecules) and the very large (astrophysics). Lasers are taken as a case study on development, followed by work that targets improvements in the quality of life.

Chapter 2 turns back to the fundamentals by concentrating on philosophy and the work of thinkers which led, since antiquity, to the evolution of science's first principle. What is generally considered as having been a speculative natural philosophy was based on observation, intuition, and reason, which can be found at the roots of every science. In ancient Greece, two schools confronted one another in terms of what philosophy is or should be:

- The Sophists regarded philosophy as education and training on how to do things.

This has been the practical side of natural philosophy exemplified by the work and teachings of Protagoras and (to a lesser extent by Pythagoras), whose deeds are discussed in Chap. 2.

- Socrates looked at philosophy as a process of acquiring knowledge of the nature of things.

This was quite a different approach than that of the sophists. The questioning method underpinning the Socratic Method can be seen as the spinal cord of present-day basic research—a reason why the text explains it in detail (in connection to the education necessary to promote the work of scientists and technologists).

To Socrates and the followers of his method, the successful pursuit of any occupation demanded the mastery of a particular knowledge, skill, or technique. Politicians, generals, other philosophers, poets, and craftsmen came under the scrutiny of questioning. To his dismay the ancient Greek philosopher had discovered that except craftsmen none of them knew the meaning of the words he used.

Research in the physical sciences is addressed in Chap. 3, starting with the concept and practice of scientific experimentation which can be looked at as a direct descendant of the Socratic Method. The best thinkers of antiquity devoted a good deal of interest to the heart of matter, but the effort to provide proofs more or less eluded them. It has taken huge investments in present-day scientific laboratories and thousands of man-years of investigation to reveal some of the secrets of the physical world through documented evidence.

Scientific investigation, as well as the development of new products have been significantly assisted through mathematical analysis, models, and simulation which is the subject of Chap. 4. The text places emphasis not only on simulated environments but also, and most importantly, on flawed computer-based and other models—and on the need that the hypotheses we make, the algorithms we develop and use, as well as (postmortem) the forecasts and other insights that they provide are put to test.

The subject of Chap. 5 is education for science and technology—starting with the most important theme of them all: Learning how to learn. Cornerstone to this are the goals that we wish to reach, which essentially means the use of knowledge. The experimental work of Louis Pasteur, the renowned biologist, on symmetries and asymmetries is taken as an example. Learning how to learn must start at the early student years, because it is difficult to change attitudes later on. At the end of the day, the best way to judge the quality of learning, for reasons of selection and promotion, is through deliverables.

Chapter 6 introduces to the reader the concept and practice of technology related to but distinct from science. Technology has a direct impact on everyday life and biomedical engineering is taken as a positive example. Because technology and society correlate, more so than science and society, it is quite important to properly evaluate both the upside and the downside of technological developments. Even projects that are daring and correct in terms of engineering may have adverse effects. The Aswan Dam has been chosen as a case study.

Chapters 7–9 share the themes associated to energy production. This has been a deliberate choice because energy is the moving gear of the civilization and the technology in which we live. Every source of energy has its advantages and its perils; pollution is one of the latter. The critical question is how to balance the advantages against the costs—not just the financial costs but also the relative destruction of the environment that accompanies each solution of energy extraction and consumption.

Chapter 7 provides the reader with a general appreciation of technological challenges connected to energy supplies. However, understanding the sources of energy is important but not enough. There is no better way to come to conclusions, in a factual and documented way, than to examine each source of energy individually and then compare the obtained results. Chapter 8 does so with coal, gas, biofuels, shale gas and oil, solar energy, and wind power as the main issues.

The remit of Chap. 9 is the challenges presented by nuclear energy production, in terms of their own merits (or demerits) and in comparison to the alternative sources of energy discussed in Chap. 8. This presentation starts with an introduction to nuclear power, followed by case studies in France, where nuclear power represents about 80 % of electricity production; Germany, where for political reasons the government veered away from nuclear power production; and Japan, where nuclear power experienced an unprecedented catastrophe. Other important subjects included in Chap. 9 are the lifecycle of nuclear plants and challenges posed by their decommissioning.

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