PART I

Introduction
The Importance of the History and Sociology of Science

For the past five hundred years in the West, the pursuit of science has been more or less unfettered, far more so than in any other part of the world. It is now recognized that considerable freedom of thought and inquiry existed earlier in the universities of the twelfth and thirteenth centuries, so that we may now say that the pursuit of science in the West has been carried on undiminished for nearly nine hundred years. This unleashing of the scientific imagination was both sponsored and motivated by the idea that the natural world is a rational and ordered universe and that man is a rational creature who is able to understand and accurately describe that universe. Whether or not men and women can solve the riddles of existence, they are able to advance human understanding of the natural world by applying reason and the instruments of rationality.

The pattern of development and the pursuit of science were very different in other parts of the world: China, the Islamic world, and India.[1] These contrasting outcomes urge us to ask, what connections are there between the religious, legal, and philosophical institutions of a society or civilization and the successful pursuit of modern science?

We may also ask, can we imagine a *modern* world in which there would be no understanding of the physics of our universe, no knowledge of the existence of universal gravitation affecting every particle of daily life, no conception of electricity, no steam power, no in-depth understanding of human anatomy, and no discovery of bacteria and their ubiquity in the human and natural world?

Similarly, can we imagine a modern world in which there is no codified system of due process of law, no conception of constitutionalism, election by consent, and democratic procedures? All of these early modern innovations are related to the emergence of modern science in the West. It is the

[1] For an assessment of sixteenth- and seventeenth-century science in India, see Huff, *Intellectual Curiosity and the Scientific Revolution*, chapter 5.

task of social science to discover how these elements of social and cultural process came into existence, how they fit together, and how they promoted the advance of science.

Such comparative inquiry is not the study of the emergence of "immutable truths." As Robert Merton put it some time ago, "The rationale for the history of science is to achieve an understanding of how things came to develop as they did in a certain science or a complex of sciences." Furthermore, this includes the study of "mistaken forays, garden paths [and] temporary retrogressions."[2] Naturally, many ideas passed as "scientific" in ages past, and what historians of science need to understand is how those tentative guesses emerged and were modified so that they became much better approximations of the real structure of nature. In Karl Popper's words, science is "the unended quest."[3] Sociologists, on the other hand, want to understand how social and cultural forces aided or impeded that unended quest, as well as how new scientific results affected society, economies, and cultural life.

The Public Sphere and Neutral Space

The breakthrough that allowed freedom of scientific inquiry is undoubtedly one of the most powerful intellectual (and social) revolutions in the history of humankind. As the paradigmatic form of free inquiry, science has been given a roving commission to set all the domains of thought aright. Science is thus the natural enemy of all vested interests – social, political, and religious, including those of the scientific establishment itself – for the scientific mind refuses to let things stand as they are. The organized skepticism of the scientific ethos is ever present and always doubtful of the latest (and even the longstanding) intellectual consensus. In short, part of the story of the rise of modern science concerns the fashioning of neutral spaces within which free inquiry can be carried on. This entails both the construction of institutional spaces and less formalized cultural spaces where probing thoughts and comparison can be carried out without opprobrium.

Given this intellectual commission to investigate all forms and manner of existence, science is especially the natural enemy of authoritarian regimes. Indeed, such regimes can exist only if they repress or otherwise subvert those forms of scientific inquiry that reveal the true nature of the socio-economic, political, and medical consequences of their rule. This is

[2] Merton, *Social Theory and Social Structure, Revised and Enlarged edition* (New York: Free Press, 1968), p. 3.
[3] Karl Popper, *Unended Quest. An Intellectual Biography* (La Salle, IL: Open Court, 1974).

not to say that authoritarian regimes cannot for relatively short periods of time devote huge resources to particular areas of research such as survival rates of tortured prisoners or even nuclear weapons, but that will not put a country in a position of long-term and broad scientific leadership.

In addition, we must be careful here not to confuse journalism and the press with science. The free press is unquestionably an indispensable institution for maintaining democracy, but we should not confuse press reports, or even investigative journalism, with science. Nevertheless, both rely on the longstanding existence of a public sphere in which individuals of all walks of life are allowed to freely express their thoughts. Moreover, it is clear that journalists look to science and scientists for guidance in their inquiries. In the final analysis, good investigative journalism must meet the tests of scientific inquiry, which in the social realm demands adequacy of sampling, appropriate instruments of data gathering, and sound techniques of inference and analysis as understood by the prevailing standards of social science. In the natural realm, likewise, the so-called canons of science must be observed and the function of the press generally is to explain the findings of science to laymen, not to undertake scientific inquiry per se. Only in rare and dramatic cases do journalists undertake to determine whether a particular set of research findings were produced according to acceptable scientific standards. And in such cases, we should note, the task is the affirmation of the canons of science by pointing out their possible breach.

Social and Cultural Impacts

Once the intellectual insights of modern science become available and begin to be applied, mere mortals have the power to alter both the human and natural environments, both intentionally and unintentionally as through global climate change. Despite the flourishing of the History of Science during the last half of the twentieth century, sociologists and other social scientists have increasingly narrowed their vision so that the reciprocal effects of science on society tend to be disputed, overlooked, or converted into "technology" studies. There was a variety of scientific discoveries in the seventeenth century that were indispensable to future technological and economic progress, and thus created the foundations for major transformation of the human world, and its economic and social foundations.[4]

[4] Major contributions along these lines have been made by economists and economic historians, among others: Joel Mokyr, *The Gifts of Athena* (Princeton: Princeton University Press, 2002), *The Enlightened Economy* (2009); and Jan Luiten van Zanden, *The Long Road to the Industrial*

For example, the discovery of electric charge, including ways of measuring it, first by William Gilbert in 1600 and then the later studies of many researchers led to the discovery of electricity, and even the laboratory production of electric lighting by Francis Hawksbee in 1706. This was the early foundation of the "electric society," the harbinger of the invention of electric motors, electronic communications, and later of wireless communication, that is, the telegraph, radio, and television.

In the same seventeenth century, other scientists discovered that *air has weight*, and with the use of steam to create a vacuum, an immense new source of energy was unleashed, making steam-powered manufacturing, steam engines, and steam boats possible.

With advances in optics, all sorts of corrective lenses became available (and this as far back as the fourteenth century). With the use of the same optical skills and grinding techniques, both the telescope and microscope enabled many more discoveries in the hidden natural world. Both human and animal anatomy were probed and understood as never before. Not insignificantly, Antoni Leeuwenhoek discovered minute creatures in pond water, snow water, and so on, the first glimmerings of bacterial organisms whose taming obviously would lead to improved health for the human community.

In whatever manner one thinks of these advances, it is fair to say that the insights of modern science led to major alterations of human society, our economies, and other standards of life and health. Of course, there is a great deal more to be said about these and related advances, which is the task of the sociology and history of science.

On the other hand, and whether or not one wants to think of this as a division of labor or a matter of preference, it is evident that understanding how modern science arose must entail an analysis that includes institutional as well as cultural, religious, and philosophical factors, not just an "internal" history of ideas. Put differently, educated laymen, economists, and policy planners all want to understand how modern science arose, especially in the West, and what happened in other parts of the world, in particular the Islamic world and China. In taking up that task, one cannot assume that the cultural, institutional, and legal structures of the West (above all during its formative period in the high Middle Ages), were the same as those in the Islamic world or China. The idea of "path-dependency" (that initial assets and resources are crucial for

Revolution. The European Economy in a Global Perspective, 1000–1800 (Leiden: Brill, 2009); Richard C. Lipsey, Kenneth I. Carlaw, and Clifford T. Bekar, *Economic Transformations. General Purpose Technologies and Long Term Economic Growth* (New York: Oxford University Press, 2005).

long-term development) is not irrelevant here as one ponders how historical developments played out differently in various parts of the world. This means that such an investigative undertaking must be long-term historical as well as comparative. Those imperatives imply a *civilizational* frame of reference, one that recognizes the significance of the unique formations of such entities as the European, Islamic, and Chinese civilizational configurations.[5]

The Path Ahead

In Chapter 1, I attempt to locate the present study in the literature of the comparative and historical sociology of science. Aside from the monumental study by Joseph Needham and the seminal responses to that work by the late Benjamin Nelson, little has been done to establish a framework within which comparative studies of scientific development in "East" and "West" could be fruitfully carried out. Joseph Ben-David's inquiry into the role of the scientist provides a useful point of departure, but his complete omission of any discussion of either Arabic or Chinese science necessarily creates a narrow vision that prevents one from grasping the import of the religious, legal, and philosophical contexts within which science must always be carried on.

In Chapter 2, I provide an overview of Arabic-Islamic science that is meant to illustrate some of its achievements and limits. When I began this study, decades ago, little of this background was known to lay audiences. It was important to realize that Arabic-Islamic science had once been quite vigorous and thus there was a sociological question to be addressed. Today, however, these achievements are frequently exaggerated and mythologized.

In Chapter 3, I stress some metaphysical assumptions that underlie scientific inquiry and proceed to show how different those assumptions are from the ones embedded in the Islamic faith at its inception. An important but frequently omitted dimension concerns the considerable cargo of Greek natural philosophy translated into Arabic in the ninth and tenth centuries, which gave the Muslim world an unsurpassed platform for pursuing science.

Chapter 4 begins with a deeper analysis of the European legal revolution of the twelfth and thirteenth centuries and then contrasts that with the more static pattern of development in Islamic legal thought and practice.

[5] T. Huff, "Europe as a Civilization: The Revolution of the Middle and the Rise of the Universities," *Comparative Civilizations Review* #69 Fall (2013): 65–86.

Chapter 5 takes up the issue of how differently Islamic educational institutions were structured from those of medieval Europe. The paramount issue is, how did this difference in institutional arrangements affect scientific thought and practice?

Chapter 6 turns to the rise of European universities and their institutionalization of the study of Greek-inspired natural science. This development meant an intensification of the study of Greek and Aristotelian natural philosophy. At the same time, the European legal revolution played a singular role in the shaping of the new European civilization of Europe.

In Chapter 7, I turn to the comparative analysis of Chinese science and its philosophy of nature. I note that the Chinese worldview of the period equivalent to the European Middle Ages was radically different from the European outlook in virtually every domain, and especially with regard to legal institutions. Chapter 8 continues that analysis but focuses on Chinese educational institutions and their impact on the study and pursuit of science.

In Chapter 9, I attempt to assemble the results of Chapters 7 and 8 to give deeper insights into the impediments blocking scientific inquiry embedded in traditional Chinese science. In Chapter 10, I construct an overview of the European scientific revolution. The analysis entails a focus on the new *ideas* and *practices* as well as the new *institutional* arrangements that engendered a new ethos of inquiry that issued in the scientific revolution.

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It will become evident that, though I have placed considerable stress on the importance of science as a modern mode of rationality, I have equally stressed the importance of *legal* thought, both as an instrument of rationality and a domain of problem-solving of the utmost importance and consequences for human development.

The great intellectual struggles that went into the fashioning of the institutional foundations of modern science were grounded in the singular legal institutions of the West. They are the very ones that shaped the structures of modernity more generally. From the viewpoint of the legal revolution of the Middle Ages, its creation of a variety of neutral spaces and legally autonomous entities along with parliamentary governance, Galileo's seventeenth-century struggles with the Church take on a different cast. For while Galileo had been under serious threat and house-arrest, it seems likely that punishment for a similar offense in China or the Islamic world would have been more severe. No scholar in the Islamic world or China

would seriously and publicly challenge official doctrine or the authority of the Emperor. As I have written elsewhere, no scholar in the sixteenth century would have dared to post on the door of the Great Mosque in Damascus (or in Istanbul), or the door of the great Hall of China in Peking, a direct and open challenge to the religious and political authorities such as Martin Luther did when he posted his "Ninety-Five Theses" on the cathedral door in Wittenberg in 1517.[6] The scientific revolution of the sixteenth and seventeenth century was real and consequential, but we should not overlook its deeper legal and metaphysical foundations that go back further than the seventeenth century.

It is to be hoped that readers will recognize that this is first and foremost a sociological inquiry. In the capacity of a sociologist the author has attempted to use the very best results of historians of science to answer broader sociological questions.

[6] *Intellectual Curiosity*, p. 305.