PART I

SOMETHING NEW UNDER THE SUN

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Introduction

The seventeenth century was one of the most dynamic and eventful centuries in the history of the modern world. It can be called the great divide that separated Western Europe developmentally from the rest of the world for the next three and a half centuries. During the 100 years of the seventeenth century, the scientific revolution in Europe produced an enormous flow of discoveries that transformed scientific thought. These discoveries occurred in astronomy, optics, the science of motion, mathematics, and the newly created field of physics. The Newtonian synthesis brought forth for the first time an integrated celestial and terrestrial physics within the framework of universal gravitation. Advances were also made in hydraulics and pneumatics, medicine, microscopy, and the study of human and animal anatomy. Not least of all, big steps were taken toward the discovery of electricity.

Given this extraordinary pattern of discovery, it is easy to ask why all this did not happen elsewhere. Simply put, why the West? Why did the Western world take off and become the dominant scientific, economic, and political power on this planet? Why did the great civilizations of China, India, and the Muslim Middle East, with their long records of growth and accomplishment, fall behind? Today, the prevailing view is that whatever happened culturally and developmentally in the West must have taken place elsewhere because people are basically the same in all places. The sociologist and medieval historian Benjamin Nelson called this idea *uniformitarianism*.[1]

[1] Benjamin Nelson coined this term back in the 1970s; see Nelson, *On the Roads to Modernity: Conscience, Science and Civilizations: Selected Writings by Benjamin Nelson*, ed. Toby E. Huff (Totowa, NJ: Roman and Littlefield, 1981), pp. 241–42.

The idea that people are everywhere and at all times the same overlooks the fact that human creatures are born into cultural settings or symbolic universes that often have contrasting worldviews, epistemological assumptions, and moral underpinnings. Not all those cultural universes are equally encouraging of scientific inquiry, neither are they equally supportive of original ideas.

In this study, I take the view that developmentally, Western Europe took off in the seventeenth century, charting new directions in many areas but especially in science and technology. These advances resulted in the accumulation of an enormous amount of intellectual capital absent outside Europe.

This development built on the reconstruction of European civilization that had taken place in the twelfth and thirteenth centuries in philosophy, law, institution building, and education. The reconstitution of Western civilization gave a new impetus to intellectual and scientific development that, a little more than three and a half centuries later, flowered in the scientific revolution and then in the Enlightenment of the eighteenth century.

In this book, I lay out the comparative tracks of scientific development and educational practice in Europe and in the three other great civilizations of the world: China, Mughal India, and the Ottoman Empire. To make the comparison as concrete as possible, I trace the events in Europe centered on Galileo's astronomical advances and then consider what happened in astronomy and the science of motion outside Europe during that same period. By focusing on the unique invention of the telescope in Europe in 1608, the narrative of Europe's scientific ascendancy becomes palpably visible.

Moreover, because the telescope was quickly transported around the world in the early seventeenth century by European traders, missionaries, and ambassadors, we get to see non-European reactions to this world-altering scientific instrument. This was the era when Europeans were making their early forays into China, India, and Southeast Asia. In coming into contact with the telescope, aspiring scientists in China, the Ottoman Empire, and Mughal India could have joined Europe in its ecumenical, global pursuit of modern science that culminated in the Newtonian synthesis. This path to modern science was indispensable: it laid the foundations of the modern world order – in mechanics, the science of motion, pneumatics, and ultimately electricity and the electronic society.

But the intercivilizational encounters of the seventeenth century did not result in such a new world science. The three civilizational encounters,

between Europe and China, Europe and the Mughals, and Europe and the Ottomans, did not bear much fruit. The discovery machine – that is, the telescope that set Europeans on fire with enthusiasm and curiosity – failed to ignite the same spark elsewhere. That led to a great divergence that was to last all the way to the end of the twentieth century. But it was not just the telescope's promise that was passed by: the same thing occurred with the microscope and the study of human and animal microscopy as well as electrical energy and pneumatics.

We should notice that when these encounters took place in the early seventeenth century, it was a precolonial world, a world in which Europeans were perceived and treated as supplicants. The rulers of China, Mughal India, and the Ottoman Empire all had the means of holding Europeans at bay and did so. There is little meaning to the term *European imperialism* applied in this era. The age of imperialism had yet to find a toehold outside North America.

Put differently, the worldview that Europeans brought with them (even before the completion of the scientific revolution) stood at odds with the metaphysical foundations of the other civilizations. By the end of the seventeenth century, the cultural and civilizational gap between Europe and the others was large, while the scientific and technological gap was greater than ever before. This also meant that Europeans would be on a very different intellectual track, for they no longer lived in a pre-Newtonian and prebacterial world.

At the same time, it is important to recognize that European societies were held together by a very different conception of *law and legal structure*, one that sometimes clashed with the perceptions of the other civilizations, for the idea of positive law enacted by an elected body of citizens had not emerged outside Europe. This was true even though the European legal system was itself in a constant state of reform and renewal. That idea of deliberately planned legal reform, with due consideration of the *rights* of many participants, citizens, professionals, and nobles, was quite different from the legal views prevailing in the Ottoman Empire, China, and Mughal India, as we shall see in Chapter 6.

While carrying out the analysis of this study, I do not intend to underestimate the accomplishments of Mughal India, Ming China, or the Ottomans. The Mughals did amass great wealth: the Taj Mahal is an extraordinary monument, and Mughal miniatures are exquisite objects of beauty and precision. The poetic tradition of Persia that migrated with the Mughals to India is also the product of finely tuned sensibilities that engaged probing intellects for centuries.

Likewise, Ming pottery and ceramics are things of remarkable quality and beauty. One may also acknowledge that China's hydraulic networks over the centuries were epic accomplishments. The great Confucian classics are extraordinary achievements of the intellect, and the Confucian scholars who certifiably mastered them in the Examinations were surely the best and brightest intellects of China.

In the greater Middle East, the Ottoman Turks' long reign as a self-sufficient empire (nearly 600 years), with its remarkably resilient governing structure, deserves notice. Its many architectural monuments, especially those designed by Sinan, the architect who died in 1588, stand among the most beautiful of such human constructions. Even Sinan's own story – that of a young boy "collected" from a Christian home by the Ottoman slave system, converted to Islam, and educated in the palace school – reflects an extraordinary system of education and recruitment, although it is foreign to modern sensibilities.

The issue for this study is not whether those great civilizations once achieved remarkable things; it is the question of whether their intellectual and scientific development opened the way for future progress, for themselves and for others. Whether we wish so, humankind tends to press forward, undertaking new projects, building on what is sustainable, and discarding what is not in the light of new discoveries and new ambitions. Economic systems, along with their ups and downs, evolve over time, leaving behind what were once viable enterprises. The seventeenth and eighteenth centuries were a time when the new capitalistic system was coming into being, creating a multitude of new opportunities but also making traditional patterns obsolete. In the famous words of the economist Joseph Schumpeter, capitalism is a system that thrives on creative destruction: technological innovations and new kinds of enterprises create unique business opportunities, but those novel ways of doing business close off the viability of the ones they replace.

For present purposes, and with this background in mind, focusing on the scientific revolution of the seventeenth century in close comparison with developments in all four civilizations provides a unique vantage point for understanding comparative civilizational trajectories. At the same time, it gives us a panoramic perspective that may help us come closer to understanding the contrasting developmental patterns, the attempts at alternative modernities, of the civilizations considered. Given the results presented in this study, a reader might conclude that a more probing reassessment of Middle Eastern and Asian intellectual traditions of the past is in order.

The question for this study, however, is just how Western civilization developed its inner dynamic, especially in the realms of science, technology, and education that gave it a surplus of intellectual capital, especially in the seventeenth century, before Western hegemony set in, and which surpassed that of other civilizations. From the standpoint of this study, that surplus of *human capital* was singular and did set the West on a unique developmental trajectory. As we shall see in the epilogue, the unique Western system of education and the abundant fruit spawned by the scientific revolution created a level of human capital unmatched anywhere in the world until the end of the twentieth century. Consequently, that advantage in the realm of human capacity and scientific insight enabled Europeans to achieve a level of economic prosperity from the seventeenth century onward that was to elude the rest of the world until the end of the twentieth century. The rise in European literacy in the sixteenth and seventeenth centuries was a major part of that success, as will be explored later.

There are, of course, legal and institutional dimensions to this unfolding new dynamic, and when they are considered along with the literacy revolution and the scientific revolution, we gather still further insight into the unique emergence of a public sphere that conferred still other advantages on the Western world. This is seen in the newspaper revolution of the 1640s in England, paralleled in most respects in other countries across Europe but absent in China and the Muslim world until the nineteenth century. Even then, those derivative vehicles remained pale reflections of the freedom of expression seen in the Western world.

Viewed from the angle of all these extraordinary new developments, it is apparent that Western Europe from the seventeenth century onward accrued multiple advantages on the path to intellectual, economic, and political modernization. Grasping those advantages helps us understand why the West succeeded in this singular manner.

Outline of a New Perspective

The scientific revolution of the seventeenth century stands at the center of the great transformation that we now recognize as the modern world order. For without it, the Industrial Revolution of the eighteenth century would have been impossible. As noted, during those 100 years of the seventeenth century, a large number of revolutionary *scientific* discoveries flowed out of Europe, transforming our understanding of the natural world. Those discoveries occurred in astronomy, optics, the

new science of motion, and microscopy. The outstanding advances made in hydraulics and pneumatics, medicine, and electrical studies pushed Europe far beyond the intellectual frontiers known elsewhere in the world.

It would be pleasant to think that all the peoples of the world shared equally in the extraordinary advance of thought signified by the scientific revolution, yet the European contribution far exceeded that of all the other peoples and civilizations of the globe. In the context of today's multiculturalism, this statement will sound like a Eurocentric sentiment. But as this study shows, in vast areas of scientific inquiry, such as optics, the science of motion, human anatomy, microscopy, pneumatics, and electrical studies, there were no parallels to Europe's discoveries outside the West in the seventeenth century.

Of course, there were earlier scientific developments, especially in the Middle East, that built on the Greek legacy of a still earlier age. But when we come to the advances of the seventeenth century, there is little evidence that scientific developments in China, Mughal India, or the Ottoman Empire gave any impetus to the European scientific revolution. Moreover, we must remember that science is, as the philosopher Karl Popper put it, the "unended quest." In athletic terms, it is a race of unending hurdles. In that context, it is not particularly useful to say that in 1000 B.C., China was the first to cross one or two of the early hurdles. Neither is it insightful to say that China has the longest written history of any peoples. Equally, it is not germane to point out that there was something very close to a revolution in optics among opticians in the eleventh century in the Middle East. For in science, it is always, "What have you done for me lately?"

Nevertheless, if we want to understand why Europe took the ascendancy leading to the modern world condition, then we have to explore crucial details of a number of episodes in the history of science that set Europe off from other parts of the world, for those advances laid down some of the technical foundations of the modern economic order. Neither the Industrial Revolution of the eighteenth century nor the Internet age would have been possible without the scientific advances of the seventeenth century.

Beyond Rhetoric

To grasp the all-encompassing nature of scientific curiosity that then gripped Europe, we must focus carefully on what scholars like Galileo, Kepler, and Gilbert, among others, were doing while at the same time reviewing the activities of scholars in the three other civilizations. Only

in this way can we overcome the great propensity to cast the activities of Europeans, or others, into caricatures that cloud understanding and greatly misrepresent what was actually taking place. Even the most dispassionate students of the histories of India, China, or elsewhere can hardly refrain from saying things like, when Europeans were busy burning Giordano Bruno "for heresy at the stake in the Campo dei Fiori" in 1600, the Mughals or Ottomans, or whoever, were showing acts of tolerance, amassing great wealth, and living productive lives.[2] No mention would be made of the fact that William Gilbert published a landmark study in that same year that launched the whole field of electrical studies, that the telescope would be invented eight years later, and that two years after that, Galileo would discover the craters on the moon, the satellites of Jupiter, and the phases of Venus. Meanwhile, no parallel discoveries or inventions occurred in those other places that would catapult them into the center of the scientific revolution.

To get beyond such caricatures and limited perspectives, I begin with the simple story of the invention of the telescope in Holland in 1608 and Galileo's quick use of it to make revolutionary discoveries. Then I focus on its initial transmission around the world in the following decades. For the telescope as a discovery machine is a powerful symbol of the scientific revolution. Reactions to it can serve as a sort of acid test of the levels of scientific curiosity in other parts of the world.

Eventually, we shall have to consider the nature of the educational experiences that characterized Europe and the non-European world in the century or so leading up to the time of Galileo. Only in that way can we fathom the quite different educational practices and goals that prevailed in the major civilizational areas of the world in the sixteenth and seventeenth centuries.

The New Geography

It is useful to begin our inquiry by remembering the changed global circumstances that brought Europeans and others into a new kind of proximity. The sixteenth century was a great age of discovery. It followed the voyages of Columbus, Vasco de Gama, and Amerigo Vespucci, and finally Magellan's circumnavigation of the globe. The world was fresh and new, many parts unexplored and unknown to Europeans, who were

[2] William Dalrymple, *The Last Mughal: The Fall of Dynasty: Delhi, 1857* (New York: Vintage Books, 2006), p. 5.

experiencing an unparalleled awakening. In the process, Europeans encountered hundreds of unknown peoples, many living exotic lives scattered around the world. Some of the inhabitants of the New World, on the islands of Cuba and Santo Domingo, were said to live completely naked, enjoying an Eden-like existence of warm sunshine, abundant fish, fruit, wild game, and flowers.

Less reliable reports told of warlike Amazonian women on the coast of South America as well as oddly shaped people with their head where their stomach ought to be. For Europeans sailing along the coasts of South America, West Africa, around the Cape of Good Hope to India, or through the Straits of Magellan to the wide Pacific, there were unending marvels of geography and peoples, of flora and fauna never before seen. Naturalists of all persuasions faced an overwhelming abundance of specimens, while the range of human variation gave birth to the first European inklings of the new science of man: anthropology.

While the Spanish conquistadors wreaked havoc on the native populations of Mesoamerica, the populations of Africa, India, and China and other parts of Asia were too numerous, widely dispersed, or organized for Europeans to overwhelm or subdue. Throughout the sixteenth and seventeenth centuries, apart from the Spanish military campaigns, Europeans were petitioners seeking admittance into places like Mughal India, China, and the Ottoman Empire. The last of these stretched around the Mediterranean, from Morocco to Istanbul, and then north through the Balkans to Hungary and the gates of Vienna. Only occasionally did the Ottoman Turks lose sea battles to Europeans, such as their brief setback at the battle of Lepanto off the coast of Greece in 1571. It was an extraordinary encounter involving a combined force of nearly 100,000 seaborne sailors and soldiers. The Europeans had mustered a multinational fleet of Italians, Spaniards, Germans, and others, led by Venetians. Spanish nationals, among others, had equipped merchant ships with cannons that caught the Turks off guard, destroying their fleet. But the Turks' loss at this battle had little impact on the Ottoman Empire, which was to survive another 350 years. The age of European imperialism would not start until the nineteenth century.

Prelude to the Industrial Revolution

In the interim, Europeans in the seventeenth century witnessed the scientific revolution, a harbinger of the Industrial Revolution of the eighteenth

century. Both these transformations – the scientific revolution and the Industrial Revolution – contributed significantly to the Western ascendancy that was to last into the twenty-first century. That coalescence of economic development, political power, and scientific creativity has long been seen as a puzzle. It seems inexplicable that so many human and cultural factors could come together in the domain of the Europeans but bypass the other, much larger populations of the world, especially in India and China.

How shall we think about the singularity of the rise and dominance of the Western world? Was there something more than just imperialist hubris that propelled the West into economic, scientific, and technological dominance in the eighteenth century? Did Westerners know something? Had they discovered or invented something that was not discovered in other parts of the world? Were there some intellectual breakthroughs that paved the way for the scientific revolution and the later economic salience of the European powers? One wonders if it was the mix of so many local groups and cultures that led Europeans to craft inclusive cultural and legal structures that set them apart from other parts of the world. Or were Europeans simply more inclined to think imaginatively about the political and legal structures needed to build a viable social and political world?

Max Weber's Legacy

A century ago, when it was not thought to be insensitive to ask big questions about how the world had gotten to be the way it is, the German sociologist Max Weber laid out his thoughts about these profound questions. He did so at the end of his short life of only fifty-six years, after he had searchingly probed the religious and intellectual history of China and India, Islam and ancient Judaism. He had also closely studied medieval and early modern European law and commerce. At the end of that long journey of discovery, he concluded that there were a number of striking intellectual features that arose only in the West and yet had a *universal* significance, a global impact as we would say today. As a cosmopolitan European of the early twentieth century, Weber felt compelled to ask "to what combination of circumstances the fact should be attributed that in Western civilization, and in Western civilization only, cultural phenomena have appeared which (as we like to think) lie in a line having *universal* significance and value" [emphasis in the