Were there any Indian Galileos?

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Why, in recent centuries, has science and technology made much greater strides in Western Europe than in the Middle East, India or China? Why, in particular, have all the scientific and industrial revolutions been kindled in the West? And how is it that, for the last two centuries, the world has revolved around those rising in the West? David Cosandey sets out a vast general theory on the conditions favouring scientific progress.

Review of David Cosandey's *Le Secret de l'occident. Vers une théorie générale du progrès scientifique (The secret of the West. Towards a general theory of scientific progress),* Paris, Flammarion, coll. « Champs », 2007, 864 p., 15 euros.

The wood surrounding Galileo

Historians of science agree on one thing at least : Galileo's statement of the Law of Falling Bodies in or around 1604 represents the real birth of « modern » physics. This discovery – the famous « Galilean breakthrough » – brought time into the realm of physics by making it into a mathematical variable : a decisive step in the development of kinematics. Until this point, time as a concept had remained focused on everyday preoccupations and was mainly used by men as a means of orientation within their social universe, in harmony with the overall course of events on earth. Galileo, however, wanted to endow time with a status, so as to enable the measurement of motion and the creation of a real science of dynamics. This quest led him to the discovery that if time (rather than distance travelled) is chosen as the variable, bodies falling in a vacuum obey a simple law : the speed reached is proportional to the time spent falling and is independent of the body's mass or make-up. This was a major, revolutionary result, contradicting Aristotle's two-thousand-year-old theory whereby the speed at which a body falls is greater for bodies of greater mass.

This account is true in the main. However by telling it this way, one is deluded into thinking that the invention of kinematics was due to the genius of a single man, Galileo, an unexpected ray of light, unpredictable, miraculous, a person who illuminated mankind thanks to his superior intelligence, like a heavenly envoy – whereas in reality a huge number of people collaborated on what we now call « Galileo's body of work ».

To start with: Galileo was by no means the first. Long before his time, many other great thinkers had turned their attention to problems of kinematics, proposing various theories of motion, all of which he was able to draw upon, if only to point out their errors. Furthermore, Galileo was not at all working in isolation : he took part in debates occurring within cultivated, educated and even military circles. And finally, Galileo's theories still needed to be copied, disseminated and taught after their publication – without which they would have been completely forgotten. This final condition is not fulfilled as often as one might think: the case of the great Chinese algebraists of the 8^{th} century, completely obliterated from the field of thought over the course of the following centuries, shows that it is entirely possible to forget discoveries, even strokes of genius, when the necessary channels of transmission are lacking in a given society.

It was therefore necessary for Galileo to be surrounded by many people – in his lifetime, of course, but also in a certain way after his death, in order for him to become the great scientist that he has since become in everyone's eyes. If he hadn't been part of a vast group ; if he hadn't been linked to a multi-secular network, we wouldn't recognise him today as the discoverer of kinematics. And yet the individualist, naive viewpoint slumbering within all Westerners today tends precisely to draw a veil over these vital points. In a way, Galileo is like a great tree obscuring the wood from which he came and without which he would not have been able to spread his branches. Consequently, if one wishes to understand certain characteristics of and phases within the history of science, one must *also survey* the vast wood surrounding those few giant trees whose names have been preserved by history.

Giving science this broader, global context is all the more necessary since the historical individual *Galileo Galilei* may perhaps not have been crucial to the discovery of the laws of kinematics. Could a different person have come up with these ideas somewhere else in the world twenty years later? Given Europe's level of knowledge and intellectual buzz at the time, one is certainly entitled to consider – without being able to prove this – that this discovery was in the very nature of things and would have surfaced in any case. Without detracting from Galileo's genius in any way, it is surely reasonable to suppose that people of brilliance crop up regularly throughout the course of history, without always being able to leave fertile traces behind them. For this, they must exist in a social arena where they are able to express themselves. Thus the issue is not so much one of why there was never an « Indian Galileo » or a « Chinese Galileo » – there were certainly hundreds of Indian or Chinese Galileos across the millennia – but rather, why other civilisations' potential Galileos were unable to deploy their talents or embed themselves in their fellow countrymen's memory.

Nothing is certain

In a famous letter written in 1953, Albert Einstein declared that « the development of Western science is based on two great achievements, the invention of the formal logical system (in Euclidean geometry) by the Greek philosophers, and the discovery of the possibility of finding out causal relationships by systematic experiment (Renaissance). In my opinion one need not be astonished that the Chinese sages did not make these steps. The astonishing thing is that these discoveries were made at all. » In the view of the founder of relativity, the genesis of science in Europe was nothing short of a totally unexpected phenomenon, whose explanation falls far beyond the limits of our understanding of the world. He is talking, in effect, of a sort of « miracle ». This term, to be specific, performs no miracles of its own as regards our understanding. Albert Einstein (an anagram of whose name is « rien n'est établi » – i.e. nothing is certain !) would have no trouble in agreeing that his opinion, which remains an opinion, certainly deserves to be re-examined, even criticised, inasmuch as our knowledge of the history of Arabic, Chinese and Indian science is so much greater today than it was in his time.

But before embarking on a hunt for possible explanations we must first slip science back within its mortal coil and analyse the social conditions which gave birth to it. For only by embracing science in its general surroundings do we have any hope of uncovering the forces driving it, the obstacles slowing it and the impulses speeding it.

David Cosandey[1] understands this well and, after a sequence of other queries, poses the following questions: Why, in recent centuries, has science and technology made much greater strides in Western Europe than in the Middle East, India or China ? Why, in particular, have all the scientific and industrial revolutions been kindled in the West ? And how is it that, for the last two centuries, the world has revolved around those rising in the West?

In a book more than 800 pages long, with a detailed, constructive preface by the historian Christophe Brun, Cosandey attempts to compile an inventory of the historical and geographical differences behind the initial forging of the dynamics of scientific and technical innovation. Out of these dynamics came Western Europe’s and then the East’s invention of modern science, affording them a form of world-wide superiority. Giving an account of the West’s global identity is not the issue for Cosandey; rather, he isolates a small number of factors capable of creating an « exception » of it, with regard to other civilisations equivalent to the West in terms of their creations, riches and strengths.

Normally, when an attempt is made to explain the uniqueness of the West, a limited number of the same old core theories are brought up, referring either to religious ideas, cultural orientation or to the innate predispositions of Europeans. The climate, Greek heritage, colonial plundering, Judeo-Christian moral code and autonomisation of the individual are also called upon to various degrees or, when all else fails : luck, pure and simple. But in Cosandey’s judgement, recent advances in the historiography of science require that all of these theories be put into perspective, or even dismissed.

Let us examine, for example, what has happened to the theory that Europeans are particularly and permanently predisposed towards practising science. This idea fits badly with the now well-established fact that some non-European civilisations were

[1] David Cosandey is remarkable for his non-adherance, academically, to the main disciplines illuminating his work such as history, geography, economics and sociology. He is, in fact, a doctor of theoretical physics and works in Switzerland as a banker.

much more advanced than Europe at certain periods. The Chinese had a scientific golden age of their own at approximately the same time as the Greeks, that is, between the 7th and 2nd centuries BC. They experienced a further blossoming of science between the 2nd and 8th centuries AD : a time when the West was not being particularly dazzling. And India distinguished itself, particularly in the fields of mathematics and astronomy, between the 3rd and 7th centuries AD.

Cosandey doesn't make a clean sweep of the traditional explanations, however. He concedes that cultural or religious dimensions could have played an important role in the development of science and technology. But in his view, their effect was on a reduced scale, at the level of the individual and only for short periods – which leads him to reject the idea that they could have steered the great trends of history. He therefore proposes a more general theory of scientific progress, made up of two « levels ». The upper level sets out, in quite classic construction, the political and economical conditions for scientific progress. This part of the theory aims to be determinist in the sense that progress shall occur within science and technology whenever good political and economic conditions coincide, and only in this event. The lower, more original level describes what he sees as the deeper, underlying causalities, which are purely geographical in nature. This level is supposed to be probability-driven in the sense that, provided that it has good geographical conditions, a civilisation has more chance in the long term – although no certainty – of experiencing the emergence of a political and economical environment conducive to the advance of science and technology.

The articulated coastline

Let us first touch upon the theory's upper level, which deals with political and economical conditions. According to Cosandey, only two conditions suffice and are necessary for scientific progress in a given civilisation : economic expansion and stable political division. In other words, the civilisation in question must be enjoying satisfactory economic growth and must be sub-divided into several enduring states. In short, it must have what Cosandey calls a « *stable and prosperous system of states* ». His view (and that of many others) is that any such system cannot help having a benign influence on scientific and technical progress thanks to several consequences. Firstly, economic prosperity generates a surplus, which permits expensive and not immediately essential activities such as research to be carried out. Secondly, given the science-friendly mentality of tradesmen and bankers and their focus on precision, figures, measurements and calculations, their increased power in a given society can only be of benefit to science. Thirdly, businessmen put communication infrastructures in place and tend to push for new boundaries, both of which favour the exchange of ideas and discoveries. As for stable political division: this also favours science, notably because the system's different member states will be engaging in prestige struggles, where scientists become assets. Furthermore, every government strives to modernise its factories, its infrastructure and its navy, thereby creating a stimulating environment for its engineers and technicians.

The theory's upper level attempts to identify which sort of region most facilitates the long-term combination of freedom and security necessary for intellectual innovation. Cosandey introduces the sound concept of an « articulated coastline », a term he uses to designate the regional shaping which, in his view, enables the formation and enduring existence of a « system of stable and prosperous states » : a grouping of countries simultaneously separated and linked by the sea, which plays a dual role in providing both an obstacle and a link. On the one hand, the sea allows relatively sheltered, rival political entities to determine their own identities and perpetuate themselves. On the other hand, in conjunction with navigable stretches of water, it turns these political entities into partners as well as competitors, by enabling large-scale exchanges together with the circulation of people.

But how do you measure the extent to which a given region's coastline is articulated ? One initial measure consists of relating the length of coastline – measured with extreme precision – to the total land area. The resulting « development index » clearly places Western Europe far in front of the three other historical civilisations. Western Europe has the benefit of roughly four to five times as many access routes to the sea per square kilometer of surface area than the Middle East, India or China, which are essentially vast continental masses, whose topologies are unsuited to cross-fertilisation. A second index, which is more awkward to define, is known by mathematicians as the « fractal dimension ». This measures the sinuosity of complex curves, which are infinitely folded and re-folded upon themselves, as are coastlines. This measure brings out the same advantage for Western Europe as the development index. It is thus possible to affirm, with supporting statistics, that the shape of Western Europe is actually more articulated and complex that that of its competitors. These measurements also go some way towards explaining the divergence between the western and eastern halves of Europe: the East is an immense, mainly landlocked territorial mass with insufficient access to the sea and has thus suffered from a less dynamic trading profile than the West, together with greater border instability.

These issues are all extremely interesting, but are they sufficient authorisation for the conclusion that Europe benefited from enduring political and economical conditions favourable to science thanks to its geographical location and to the specific contours of its coastline? Cosandey thinks that they are. In any case, and in the pure tradition of Fernand Braudel, his work has the merit of setting out a general theory on the stability and prosperity of systems of states, which is based explicitly on geography, and which additionally has the outlines of empirical corroboration stretching across nearly three millennia of the history of civilisations. And yet the explanation of events of such importance by such a limited number of factors, whilst having its attractions, remains a difficult pill to swallow. It is therefore now up to geographers, historians, sociologists and economists to submit this theory to the test of their scholarship and their own descriptions. We shall then have to see in detail if the predictions, which follow from this (and which Cosandey sets out at the end of his work) are borne out. It is, in short, only after history has occurred that one can say to what extent it is still being driven by geography.

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