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Introduction

Galileo is one of the larger than life heroes of history. This status was conferred during his lifetime and grew with each succeeding century. Not only was he the hero of the Scientific Revolution, but after his troubles with the Catholic Church he became the hero of science. Today, only the names of Newton and Einstein rival that of Galileo in popularity and imagination. But yet we must ask, to what is his popularity due? What did Galileo actually do that made his image so great and so long-standing?

Certainly, he was impressive with his telescope. The discoveries, in 1609–1610, of the mountains on the Moon, the numerous stars in the Milky Way, and, of course, the four satellites of Jupiter (which he called the Medician stars) caught the imagination of the time. His book was much remarked about, but its first edition was limited to 550 copies, and the later Frankfurt edition printing probably included not more than 1,000 or so. Mario Biagioli has commented that Galileo's control of the distribution of his book was impressive, making sure it got to the right important people.[1] Clearly, too, the invocation of the name of the Medici caused it to be looked at in court circles. Surely, too, books were even more shared and passed around then than in our own time, and, even more, the oral tradition of fame and status was still alive and accounted for a good bit of his popularity. Still, it is hard to fathom through the distance of centuries what caused such a ready reception of Galileo and his work.

Richard Westfall has noted that, at the time, Galileo had to build an audience for scientific work, while less than eighty years later, Newton could assume that such an audience was already in place.[2] So Galileo created the place of science in our intellectual life. He, of course, did not do so single-handedly; Francis Bacon had already

published his *The Advancement of Learning* in 1605. However, Bacon's fame as a spokesperson for science would have to wait until the Royal Society was founded in 1662, though the Society's secretary, Henry Oldenburg, comments on the importance of Bacon's philosophy in his letter in 1656.[3] But even if Galileo was aided in promoting science and its importance by others, certainly his was the first main effort that fired the vision of science and the world that went well beyond limited intellectual circles.

Galileo's fame grew as he published more. The *Letters on the Sunspots* (1613) were widely read and circulated and increased the fervor for learning more about the realms of the heavens, as did his later *Il Saggiatore* (*The Assayer*) (1623). But there is no doubt that it is was the 1632 publication of *Dialogue on the Two Chief World Systems* (*Dialogo*), its subsequent condemnation by the Church, and then the trial of Galileo before the office of the Inquisition that projected Galileo's name into household status. This episode in the history of thought and science has been amply and elucidatingly commented upon by many people.[4]

But my question remains: Why was this event treated as being so important? Why did not the attention and public outcry that greeted Galileo emerge earlier, say with the burning of Giordano Bruno in 1600. One can argue that Bruno was not a scientist and was large ways toward being a crank, and so his situation compelled less interest. But this just begs the question: Why had science become so important to the people (at least to a large class of people, not even just the franchised, aristocratic class)?

The earlier discoveries and innovations in science and natural knowledge had helped to prepare the ground. Nicholas Copernicus's publication of *De Revolutionibus* in 1543, and Andrea Vesalius's *De Humani Corporis Fabrica*... in the same year, certainly showed to those who cared that science could change and was advancing new conceptions of theory and knowledge. Certainly, too, the rediscovery of the Greek texts of scientists and mathematicians and the new growth in practical mathematics helped make the ground fertile so Galileo could sow his seeds.

But somehow this background is insufficient to explain the phenomenon. There had been new discoveries and new innovations, in a very real way since the fourteenth century. But what, in general, had changed since that time? There was no scientific revolution, no

enfranchisement of science as a publicly worthy and most important occupation, at that time.

I am well aware that some historians and some philosophers would challenge the claim that there really was a scientific revolution. Whatever might hang on the interpretation of the word "revolution" is unimportant to my theme. What cannot be in doubt is that between, say somewhat arbitrarily, the dates of 1543 and 1687, many things had radically changed and the world was, and was further becoming, a wildly different kind of place. Science, as any other human endeavor, does not exist in a vacuum. It is not an isolated, independent system of thought and practice. What happens in other realms of human life affects how science is practiced, perceived, and received.

At this point it might be good to quote the insightful words of the famous art historian Heinrich Wolfflin:

> Even the most original talent cannot proceed beyond certain limits which are fixed for it by the date of its birth. Not everything is possible at all times, and certain thoughts can only be thought at certain stages of the development.[5]

What is true of thinking thoughts is also true of the reception of thoughts. People are not ready to receive and act upon just any thought at any time. The way must be prepared; the need must be felt. In an evolutionary metaphor, the environment must have changed, and the resulting pressure must lead to the selection of a new trait by allowing it to reproduce more successfully than its rivals. What was the change in environment that led to Galileo's fame? Why was the world ready to select for him?

SOCIAL AND CULTURAL CONDITIONS OF LATE SIXTEENTH AND EARLY SEVENTEENTH CENTURY: THE BACKGROUND TO GALILEO AND HIS FAME

The end of the Renaissance brought in to being a new kind of person across the lands of Europe. Empowered by commerce and money, a person's goals, though often still very religious and, now, nationalistic, lay within his (and occasionally in her) own self-fulfillment, as seen to be in the accumulation of money and commodities for private use. Subjective individuality was the basis for privacy, and privacy came to mean private property and the ability to resist interference

from other people. Out of this individualistic isolationism grew the doctrine of individual human rights.

The entrepreneurial capitalist, as a fairly widespread new type of power and cultural force, debuted in the late sixteenth and early seventeenth centuries. The type probably first appeared in Italy and southern Germany, and then later in the newly burgeoning cities of the North Atlantic, as centers of commerce shifted as the result of various national endeavors toward the silver and gold of the New World and trade with the Far East. This "class" (for class is an eighteenth century term) can be characterized by its commitment to the ideal of entrepreneurial individualism, wherein the individual person was taken as, and so enabled to become, a source of social and economic power and epistemic and moral value. In northern Europe, then, status, glory, and political power became highly attached to money and professional success rather than only to land and birthright as doled out and sanctioned by the courts and crowns of Europe. This shift contrasted with parts of central and southern Europe which retained, or rather reinstituted, an almost feudal structure based on nobles and court. Of course, these were not the parts of Europe where science, philosophy, and capitalism flourished and became important.

Obviously, this change in the locus of European power was connected with the breaking down of the previously existing sovereign based social and political power structure and the rupture of heretofore extant patterns of mutual support between church and state. One consequence was that the newly enfranchised people had to become educated in ways to use their power and develop their values, but such education was not necessarily to be gained in traditional or formal institutions or to be directed toward older educational goals.

The events that contributed to and were partial and overdetermined causes and effects of these changes extend over many seemingly different aspects of life and society. They cross cultural and national boundaries, and they shatter traditional, disciplinary lines of research. But one must begin to tell the story somehow.

One theme with which to begin to unwind this age is the relatively new phenomenon of printing. By the end of the sixteenth century, the new printing culture provided readily accessible books, pamphlets, and broadsides through which both formal and informal education and communication occurred. These were read and used in old

institutions (schools and universities), new ones (ateliers, academies, and private tutorials), and, not the least, by individual readers alone in their homes. It is not just the greater accessibility, and consequent greater and more widespread literacy, among various people and classes that is worth noting. The spread of printed material across Europe, of course, meant that more people and different types of people were reading than ever had before, but much less noticed is the far-reaching consequence that education became more standardized, with many people reading the same books (and so getting the same information). This also meant that the information was presented in new forms confined to two-dimensional page layouts, in part, because this is what could be printed well and clearly (illustrations, tables, diagrams, etc.).

This new situation needs to be contrasted with what existed previously with learners hearing individual lectures or sermons, or workers and artisans being individually tutored in the idiosyncratic style of the master by whom they were taught. For the first time, someone learning anatomy in Padua would learn from the same text and diagrams that were used by another student in Pisa or even one in Paris. Even the Bible became more standardized so that many people could read the same text in their separate homes, and, though there were different editions, it was now possible for each individual to learn on his or her own and discuss what the Bible actually said, rather than rely on aural memory and the ultimate textual authority of the local priest or pastor.[6]

Printed texts were not only strings of sentences but contained representations in the form of spatial layouts, displays, tables, and pictures. These became the preferred forms of demonstration. Tables allowed a reader to follow a procedure, whether it was instruction for writing a letter, holding a civil conversation, determining the volume of a wine barrel, or performing an inductive discovery. Pictures, first reproduced as woodcuts and then as copperplates, provided visual awareness of fascinating new discoveries and forms of life from faraway lands, as well as serving as a source of knowledge and pleasure about events and practices closer to home. Diagrams and illustrations served as mechanical drawings and detailed models (as "blueprints") for those who would learn to construct and perform. This is one strong reason why geometry took on new life and excitement (while concurrently it was being revived by the reintroduction

of classical geometrical texts by the humanists and mechanics). This should not be surprising since geometry, too, depended essentially on the construction of diagrams, which now could be clearly and easily reproduced on the printed page.

It cannot be overemphasized how much this way of learning by reading something held in one's hand was a new form of knowledge acquisition. Again, it is not just that printing provided the opportunity for more people to read, and that more people because of this opportunity did learn to read, and so literacy increased. Nor is it just that more books were printed in the vernacular so that they would appeal and sell to these newly literate audiences. These were important features of the new phenomenon, but even more importantly, something fundamentally different happens when a person sits down with a book in hand, and, concentrating on a page at a time, reads in an isolated act, rather than hearing the spoken words of another person. The very cognitive form of learning and memory was essentially changed.

Much has been written recently about the impact of television and the intellectual and cultural changes that have been wrought by the demise of the printed culture and the rise of the pictorial image. And it may be that today children primarily learn by watching moving images on the television screen, supplemented only by occasional spoken words, but this change is minimal compared to that brought by the "Gutenberg revolution." The individuality of the learning act and the publicly presented standardized content of what is learned are still preserved in today's new genre. But in the sixteenth century, individual private acts were new and had to be newly mastered, and we, having grown up with books abounding, can only imagine what new interior worlds were opened up for these new readers. It is small wonder that the imagination became a topic of much speculation, discussion, and publication.

It is most important to realize that the change to the printed page cannot be understood as an isolated phenomenon. The post-Reformation and anti-Aristotelian context in which these changes were occurring also emphasized an antiestablishment, proindividual, and humanistic ideology. Yet this need to devise a new, systematic way of codifying knowledge must be seen as part of an attempt to establish intellectual and social stability. For a moment, consider that the very things that comprised knowledge, that made up the

inventory of stuff in the world – the very things that comprised the subjects to be known – had grown and changed. The voyages of exploration, east and west, introduced the Europeans to multitudinous new kinds of things, plants, animals, and peoples. These novelties caused a sense of wonder and awe and awakened a desire to collect them. Every king and every court, and, soon, every rich man would have to build his collection of the rare and wondrous. But these novelties needed to be understood.

Such new kinds of things did not fit well into the old systems of knowledge, and they raised many painful and difficult questions. There were questions about the nature of God (Did He give divine grace to the Indians, even though they were not Christians?), about the nature of human beings (Were the Indians really men at all, and what of the manlike apes from the East?), and about the natures of the flora and fauna in the world. In the late sixteenth century, botanical and zoological gardens began to be established because they provided places where the newly awakened curiosity could be appeased, and as well places to study the new natures. Such gardens were established at Padua and Parma in 1544 and in Bologna in 1568. Printed books and posters proliferated the images of the unusual for those who could not travel to see the live specimens.

The Reformation, too, played a large part in forming the intellectual and social climate of the seventeenth century. After the Reformation, many people, emotionally upset and intellectually confused, responded by pledging allegiances to a huge variety of evangelical dogmas or by retreating to a skeptical agnosticism. It was difficult for many to tell which God was the right one, or, more mundanely, to decide upon a righteous form of confessional, given the many factions that the Protestant movement took or the forms by which the Counter-Reformation responded. As in all things, though, such skeptical questions were countered by dogmatic fervor among those who had become convinced by one or another sect or retrenching movement.

There was one aspect of the new post-Reformation age that was growing among Catholics and dissenters alike: the idea of a personalized God who dwelt in the hearts of individuals. This, in varying degrees, extended individual sovereignty over Biblical interpretation and, perhaps, salvation. It also lessened the degree of obedience to whatever church hierarchy one accepted. Moreover, among all

religious factions, these changes did make legitimate, and so increase, the amount of individual and family Bible reading, which helped to shift the educational burden away from the churches and schools and into the homes.

The need for new systematization was forced not only by the many novelties and religious foment but had been spurred on intellectually by strong feelings for a need for change. This was a time in which many people felt they were at the dawning of a new age, an age unlike any other that the world had seen. This led to much intellectual debate, theory construction, and experimentation, bringing new ways of thinking about God, the cosmos, human beings, and the stuff of the world. Proposals for many new systems, new philosophies, and new religions abounded. These promulgations of anti-Aristotelians, revisionist Scholastics, alternative cosmologists, natural and magical theories, and humanistic eclectic philosophers augmented the perceived need for change and were designed to establish or show the way toward a new systematization. They all raised questions about the existing patterns of thought and opened up the space of possibilities wherein people could contemplate alternatives.

However, not just intellectual forces were at work. The social changes in law, government, and, especially, forms of commerce that came along with the greater reliance upon and recognition of individuals ironically forced people from the land and bundled them together into the cities. These, in turn, required new forms of governments and institutions and their constituent individual-indifferent bureaucracies. This increasing urbanization, as Marx well pointed out, was due, in part, to the disenfranchisement of the peasant farmers and the newly initiated poor laws that forced them into the hands of the growing capitalist class.[7] This new population density greatly increased the number of poor. And with the numerous unemployed poor and their conditions of poverty came disease, famine, and death. The tenuous character of life was obvious to all.

Add to these devastating factors the piracy on the seas, the highwaymen on the land, and the increasing crime that went with this bursting growth of the cities, and it should be easy to feel the wretched insecurity and fear of the populace across Europe. Rape, pillage, and plunder was augmented by land grabbing that forced many peasants to flee the country for the cities, where they found new urban forms of starvation and death.

The combined new bureaucratic institutions and very pressing competing colonial and capitalistic interests brought along with them many great (and small) wars: Religion fought against religion, prince against prince, and national power against rival nations. Alliances and allegiances were shifting like windblown sands, and it was never clear for long who was on what side. In this regard it is of strange significance to note that Descartes, who would later seek to become the savior and new Aquinas of the Catholic Church, fought in his earlier years for the Protestant army of Prince Maurice, Duke of Orange. Such ongoing and changing battles meant that princes had to raise money for armies, would commandeer men and property, and were always looking for more wealth to support their ambitions. The main fodder, as always, were the common people.

Death was all around. People's sense of their future and their security was at a low point. The old forms and existing structures of government and social organization began to fracture even further, and new ideas and practices began to move in to replace them.

Economic changes, too, were driven in large part by the sea vessels that plied their trade and searched for new lands to make new wealth. The galley of the Mediterranean gave way to the sailing ships of the North Atlantic. Economic competition among the seafarers and the companies that funded them was reflected increasingly in a sense of nationalism at the home ports. The desire to protect one's possessions and property (the colonies) brought new nationalistic wars and new forms of warfare. On sea and on land, cannons grew more manageable and effective, and hand guns, for the first time accurate, replaced pikes and long bows as everyone's weapon of choice.

Great amounts of money were required for gun- and cannon-based warfare and for the manufacture of such weapons. Mining for lead, iron, and copper was required for the ordnance, as well as for ships and other constructions, and, of course, gained real importance as a way to gather (hopefully) great amounts of silver and gold to restock rapidly depleting treasuries. To outfit, man, and embark a set of ships required large amounts of money, as well as skill in navigation. This required new ways of raising and deploying capital.

One new way is nicely stated by C. R. Boxer:

> A characteristic feature of seaborne trade – and other forms of business, for that matter – in the northern Netherlands was known as the *rederij*. This

was a highly flexible type of co-operative enterprise by which a group of people would join together to buy, own, build, charter, or freight a ship and its cargo ... this practice facilitated wide spread investment in shipping and a wide diffusion of ownership, integrating mercantile and maritime communities to a great extent."[8]

This form of market endeavor was the model employed not only for the production of wealth but also for knowledge. Given the rapidity of increase and the geographical extent of these money exchanges, accounting and systematized trade practices became a new big business. People had to be trained in such practices. Even Galileo made much of his money while in Padua by teaching practical mathematics to the young aspiring business types of many nations. And in Amsterdam, the Bourse was founded, and from 1585 onward it published commodity price lists for potential investors. So it was that new practices and occupations arose, driven by the new social, economic, and technical necessities. Many of these new practices did not fit well with the old educational, cultural, or political patterns.

The state of society was one of many amazing novelties – no secure governments or security from governments, increasing fear of death, and the proselytizing in the marketplace of ideas of many incongruous, if not contradictory, schemes of order that purported to be able to put things right. Not surprisingly, this state of affairs led to real, not only philosophical, widespread skepticism about any possibility the future might hold.

It also made people chary of other people. The emphasis on the individual and the recognition that no one could depend upon social institutions, let alone other people, was reinforced and augmented by a growing sense of privacy during this period. The idea of privacy really did not exist before. Before this time, there were very few single-family houses, no private bedrooms, and even no privies. In the older scheme of things, the extended family, often including quite distant relatives, was the basis for social life in the houses, while at court there was nothing that did not literally belong to the king.

Large houses had public rooms into which tables were carried for eating and then removed so that the work of the household could go on; then at night, the beds would be brought in for sleeping. [This,