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LIFE OF GALILEO.

PART I.

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LIFE OF GALILEO.

WITH ILLUSTRATIONS OF THE ADVANCEMENT
OF EXPERIMENTAL PHILOSOPHY.

CHAPTER I.

Introduction.

THE knowledge which we at present possess of the phenomena of nature and of their connection has not by any means been regularly progressive, as we might have expected, from the time when they first drew the attention of mankind. Without entering into the question touching the scientific acquirement of eastern nations at a remote period, it is certain that some among the early Greeks were in possession of several truths, however acquired, connected with the economy of the universe, which were afterwards suffered to fall into neglect and oblivion. But the philosophers of the old school appear in general to have confined themselves at the best to observations; very few traces remain of their having instituted experiments, properly so called. This putting of nature to the torture, as Bacon calls it, has occasioned the principal part of modern philosophical discoveries. The experimentalist may so order his examination of nature as to vary at pleasure the circumstances in which it is made, often to discard accidents which complicate the general appearances, and at once to bring any theory which he may form to a decisive test. The province of the mere observer is necessarily limited: the power of selection among the phenomena to be presented is in great measure denied to him, and he may consider himself fortunate if they are such as to lead him readily to a knowledge of the laws which they follow.

Perhaps to this imperfection of method it may be attributed that natural philosophy continued to be stationary, or even to decline, during a long series of ages, until little more than two centuries ago. Within this comparatively short period it has rapidly reached a degree of perfection so different from its former degraded state, that we can hardly institute any comparison between the two. Before that epoch, a few insulated facts, such as might first happen to be noticed, often inaccurately observed and always too hastily generalize, were found sufficient to excite the naturalists' lively imagination; and having once pleased his fancy with the supposed fitness of his artificial scheme, his perverted ingenuity was thenceforward employed in forcing the observed phenomena into an imaginary agreement with the result of his theory; instead of taking the more rational, and it should seem, the more obvious, method of correcting the theory by the result of his observations, and considering the one merely as the general and abbreviated expression of the other. But natural phenomena were not then valued on their own account, and for the proofs which they afford of a vast and beneficent design in the structure of the universe, so much as for the fertile topics which the favourite mode of viewing the subject supplied to the spirit of scholastic disputation: and it is a humiliating reflection that mankind never reasoned so ill as when they most professed to cultivate the art of reasoning. However specious the objects, and alluring the announcements of this art, the then prevailing manner of studying it curbed and corrupted all that is free and noble in the human mind. Innumerable fallacies lurked every where among the most generally received opinions, and crowds of dogmatic and self-sufficient pedants fully justified the lively definition, that "logic is the art of talking unintelligibly on things of which we are ignorant." [1]

The error which lay at the root of the philosophy of the middle ages was this: – from the belief that general laws and universal principles might be discovered, of which the natural phenomena were *effects*, it was thought that the proper order of study was, first to detect the general *cause*, and then to pursue it into its consequences; it was considered absurd to begin with the effect instead of the cause; whereas the real choice lay between proceeding from particular facts to general facts, or from general facts to particular facts ; and it was under this misrepresentation of the real question that all the sophistry lurked. As soon as it is well

[1] Ménage.

understood that the general cause is no other than a single fact, common to a great number of phenomena, it is necessarily perceived that an accurate scrutiny of these latter must precede any safe reasoning with respect to the former. But at the time of which we are speaking, those who adopted this order of reasoning, and who began their inquiries by a minute and sedulous investigation of facts, were treated with disdain, as men who degraded the lofty name of philosophy by bestowing it upon mere mechanical operations. Among the earliest and noblest of these was Galileo.

It is common, especially in this country, to name Bacon as the founder of the present school of experimental philosophy; we speak of the Baconian or inductive method of reasoning as synonymous and convertible terms, and we are apt to overlook what Galileo had already done before Bacon's writings appeared. Certainly the Italian did not range over the circle of the sciences with the supreme and searching glance of the English philosopher, but we find in every part of his writings philosophical maxims which do not lose by comparison with those of Bacon; and Galileo deserves the additional praise, that he himself gave to the world a splendid practical illustration of the value of the principles which he constantly recommended. In support of this view of the comparative deserts of these two celebrated men, we are able to adduce the authority of Hume, who will be readily admitted as a competent judge of philosophical merit, where his prejudices cannot bias his decision. Discussing the character of Bacon, he says, “If we consider the variety of talents displayed by this man, as a public speaker, a man of business, a wit, a Courtier, a companion, an author, a philosopher, he is justly the object of great admiration. If we consider him merely as an author and philosopher, the light in which we view him at present, though very estimable, he was yet inferior to his contemporary Galileo, perhaps even to Kepler. Bacon pointed out at a distance the road to true philosophy: Galileo both pointed it out to others, and made himself considerable advances in it. The Englishman was ignorant of geometry: the Florentine revived that science, excelled in it, and was the first that applied it, together with experiment, to natural philosophy. The former rejected with the most positive disdain the system of Copernicus: the latter fortified it with new proofs derived both from reason and the senses.”[1]

If we compare them from another point of view, not so much in respect of their intrinsic merit, as of the influence which each exercised on the philosophy of his age, Galileo's superior talent or better fortune, in arresting the attention of his contemporaries, seems indisputable. The fate of the two writers is directly opposed the one to the other; Bacon's works seem to be most studied and appreciated when his readers have come to their perusal, imbued with knowledge and a philosophical spirit, which, however, they have attained independently of his assistance. The proud appeal to posterity which he uttered in his will, "For my name and memory, I leave it to men's charitable speeches, and to foreign nations, and the next ages," of itself indicates a consciousness of the fact that his contemporary countrymen were but slightly affected by his philosophical precepts. But Galileo's personal exertions changed the general character of philosophy in Italy: at the time of his death, his immediate pupils had obtained possession of the most celebrated universities, and were busily engaged in practicing and enforcing the lessons which he had taught them; nor was it then easy to find there a single student of natural philosophy who did not readily ascribe the formation of his principles to the direct or remote influence of Galileo's example. Unlike Bacon's, his reputation, and the value of his writings, were higher among his contemporaries than they have since become. This judgment perhaps awards the highest intellectual prize to him whose disregarded services rise in estimation with the advance of knowledge; but the praise due to superior usefulness belongs to him who succeeded in training round him a school of imitators to surpass himself.

The biography of men who have devoted themselves to philosophical pursuits seldom affords so various and striking a succession of incidents as that of a soldier or statesman. The life of a man who is shut up during the greater part of his time in his study or laboratory supplies but scanty materials for personal details; and the lapse of time rapidly removes from us the opportunities of preserving such peculiarities as might have been worth recording. An account of it will therefore consist chiefly in

[1] Hume’s England, James I.

a review of his works and opinions, and of the influence which he and they have exercised over his own and succeeding ages. Viewed in this light, few lives can be considered more interesting than that of Galileo; and if we compare the state in which he found, with that in which he left, the study of nature, we shall feel how justly an enthusiastic panegyric pronounced upon the age immediately following him maybe transferred to this earlier period. "This is the age wherein all men's minds are in a kind of fermentation, and the spirit of wisdom and learning begins to mount and free itself from those drossie and terrene impediments wherewith it has been so long clogged, and from the insipid phlegm and *caput mortuum* of useless notions in which it hath endured so violent and long a fixation. This is the age wherein, methinks, philosophy comes in with a spring tide, and the peripatetics may as well hope to stop the current of the tide, or, with Xerxes, to fetter the ocean, as hinder the overflowing of free philosophy. Methinks I see how all the old rubbish must be thrown away, and the rotten buildings be overthrown and carried away, with so powerful an inundation. These are the days that must lay a new foundation of a more magnificent philosophy, never to be overthrown, that will empirically and sensibly canvass the phenomena of nature, deducing the causes of things from such originals in nature as we observe are producible by art, and the infallible demonstration of mechanics: and certainly this is the way, and no other, to build a true and permanent philosophy."[1]

CHAPTER II.

Galileo's Birth–Family–Education–Observation of the Pendulum–Pulsilogies–Hydrostatical Balance–Lecturer at Pisa.

GALILEO GALILEI was born at Pisa, on the 15th day of February, 1564, of a noble and ancient Florentine family, which, in the middle of the fourteenth century, adopted this surname instead of Bonajuti, under which several of their ancestors filled distinguished offices in the Florentine state. Some misapprehension has occasionally existed, in consequence of the identity of his proper name with that of his family; his most correct appellation would perhaps be Galileo de' Galilei, but the surname usually occurs as we have written it. He is most commonly spoken of by his Christian name, agreeably to the Italian custom; just as Sanzio, Buonarotti, Sarpi, Reni, Vecelli, are universally known by their Christian names of Raphael, Michel Angelo, Fra Paolo, Guido, and Titian.

Several authors have followed Rossi in styling Galileo illegitimate, but without having any probable grounds even when they wrote, and the assertion has since been completely disproved by an inspection of the registers at Pisa and Florence, in which are preserved the dates of his birth, and of his mother's marriage, eighteen months previous to it.[2]

His father, Vincenzo Galilei, was a man of considerable talent and learning, with a competent knowledge of mathematics, and particularly devoted to the theory and practice of music, on which he published several esteemed treatises. The only one which it is at present easy to procure—his Dialogue on ancient and modern music—exhibits proofs, not only of a thorough acquaintance with his subject, but of a sound and vigorous understanding applied to other topics incidentally discussed. There is a passage in the introductory part, which becomes interesting when considered as affording some traces of the precepts by which Galileo was in all probability trained to reach his preeminent station in the intellectual world. "It appears to me," says one of the speakers in the dialogue, "that they who in proof of any assertion rely simply on the weight of authority, without adducing any argument in support of it, act very absurdly: I, on the contrary, wish to be allowed freely to question and freely to answer you without any sort of adulation, as well becomes those who are truly in search of truth." Sentiments like these were of rare occurrence at the close of the sixteenth century, and it is to be regretted that Vincenzo hardly lived long enough to witness his idea of a true philosopher splendidly realized in the person of his son. Vincenzo died at an advanced age, in 1591. His family consisted of three sons, Galileo, Michel Angelo, and Benedetto, and the same number of daughters, Giulia, Virginia, and Livia. After Vincenzo's death the chief support of the family devolved upon Galileo, who seems to have assisted them to his utmost power. In a letter to his mother, dated

[1] Power's Experimental Philosophy, 1663.

1600, relative to the intended marriage of his sister Livia with a certain Pompeo Baldi, he agrees to the match, but recommends its temporary postponement, as he was at that time exerting himself to furnish money to his brother Michel Angelo, who had received the offer of an advantageous settlement in Poland. As the sum advanced to his brother, which prevented him from promoting his sister's marriage, did not exceed 200 crowns, it may be inferred that the family were in a somewhat straitened condition. However he promises, as soon as his brother should repay him, "to take measures for the young lady, since she too is bent upon coming out to prove the miseries of this world." —As Livia was at the date of this letter in a convent, the last expression seems to denote that she had been destined to take the veil. This proposed marriage never took place, but Livia was afterwards married to Taddeo Galletti: her sister Virginia married Benedetto Landucci. Galileo mentions one of his sisters, (without naming her) as living with him in 1619 at Bellosguardo. Michel Angelo is probably the same brother of Galileo who is mentioned by Liceti as having communicated from Germany some observations on natural history.[1] He finally settled in the service of the Elector of Bavaria; in what situation is not known, but upon his death the Elector granted a pension to his family, who then took up their abode at Munich. On the taking of that city in 1636, in the course of the bloody thirty years' war, which was then raging between the Austrians and Swedes, his widow and four of his children were lolled, and every thing which they possessed was either burnt or carried away. Galileo sent for his two nephews, Alberto and a younger brother, to Arcetri near Florence, where he was then living. These two were then the only survivors of Michel Angelo's family; and many of Galileo's letters about that date contain allusions to the assistance he had been affording them. The last trace of Alberto is on his return into Germany to the Elector in whose service his father had died. These details include almost every thing which is known of the rest of Vincenzo's family.

Galileo exhibited early symptoms of an active and intelligent, mind, and distinguished himself in his childhood by his skill in the construction of ingenious toys and models of machinery, supplying the deficiencies of his information from the resources of his own invention; and he conciliated the universal goodwill of his companions by the ready good nature with which he employed himself in their service and for their amusement. It is worthy of observation, that the boyhood of his great follower Newton, whose genius in many respects so closely resembled his own, was marked by a similar talent. Galileo's father was not opulent, as has been already stated: he was burdened with a large family, and was unable to provide expensive instructors for his son; but Galileo's own energetic industry rapidly supplied the want of better opportunities; and he acquired, under considerable disadvantages, the ordinary rudiments of a classical education, and a competent knowledge of the other branches of literature which were then usually studied. His leisure hours were applied to music and drawing; for the former accomplishment he inherited his father's talent, being an excellent performer on several instruments, especially on the lute; this continued to be a favourite recreation during the whole of his life. He was also passionately fond of painting, and at one time he wished to make it his profession: and his skill and judgment of pictures were highly esteemed by the most eminent contemporary artists, who did not scruple to own publicly their deference at young Galileo's criticism.

When he had reached his nineteenth year, his father, becoming daily more sensible of his superior genius, determined, although at a great personal sacrifice, to give him the advantages of an university education. Accordingly, in 1581, he commenced his academical studies in the university of his native town, Pisa, his father at this time intending that he should adopt the profession of medicine. In the matriculation lists at Pisa, he is styled Galileo, the son of Vincenzo Galilei, a Florentine, Scholar in Arts, it is dated 5th November, 1581. Viviani, his pupil, friend, and panegyrist, declares that, almost from the first day of his being enrolled on the lists of the academy, he was noticed for the reluctance with which he listened to the dogmas of the Aristotelian philosophy, then universally taught; and he soon became obnoxious to the professors from the boldness with which he promulgated what they styled his philosophical paradoxes. His early habits of free inquiry were irreconcilable with the mental quietude of his instructors, whose philosophic doubts, when they ventured to entertain any, were speedily

[1] De his quae diu vivunt. Patavii, 1612.

lulled by a quotation from Aristotle. Galileo thought himself capable of giving the world an example of a sounder and more original mode of thinking; he felt himself destined to be the founder of a new school of rational and experimental philosophy. Of this we are now securely enjoying the benefits ; and it is difficult at this time fully to appreciate the obstacles which then presented themselves to free inquiry: but we shall see, in the course of this narrative, how arduous their struggle was who happily effected this important revolution. The vindictive rancour with which the partisans of the old philosophy never ceased to assail Galileo is of itself a sufficient proof of the prominent station which he occupied in the contest.

Galileo's earliest mechanical discovery, to the superficial observer apparently an unimportant one, occurred during the period of his studies at Pisa. His attention was one day arrested by the vibrations of a lamp swinging from the roof of the cathedral, which, whether great or small, seemed to recur at equal intervals. The instruments then employed for measuring time were very imperfect: Galileo attempted to bring his observation to the test before quit-tins; the church, by comparing the vibrations with the beatings of his own pulse, and his mind being then principally employed upon his intended profession, it occurred to him, when he had further satisfied himself of their regularity by repeated and varied experiments, that the process he at first adopted might be usefully employed in ascertaining the rate of the pulse, and its variation from day to day. He immediately carried the idea into execution, and it was for this sole and limited purpose that the first pendulum was constructed. Viviani tells us, that the value of the invention was rapidly appreciated by the physicians of the day, and was in common use in 1654, when he wrote.

[image]

Santorio, who was professor of medicine at Padua, has given representations of four different forms of these instruments, which he calls pulsilogies, (*pulsilogias*,) and strongly recommends to medical practitioners.[1] These instruments seem to have been used in the following manner: No. 1 consists merely of a weight fastened to a string and a graduated scale. The string being gathered up into the hand till the vibrations of the weight coincided with the beatings of the patient's pulse, the length was ascertained from the scale, which, of course, if great, indicated a languid, if shorter, a more lively action. In No. 2 the improvement is introduced of connecting the scale and string, the length of the latter is regulated by the turns of a peg at A, and a bead upon the string al. b showed the measure. No. 3 is still more compact, the string being shortened by winding upon an axle at the back of the dial-plate. The construction of No. 4, which Santorio claims as his own improvement, is nut given, but it is probable that the principal index, by its motion, shifted a weight to different distances from the point of suspension, and that the period of vibration was still more accurately adjusted by a smaller weight connected with the second index. Venturi seems to have mistaken the third figure for that of a pendulum clock, as he mentions this as one of the earliest adaptations of Galileo's principle to that purpose[2] ; but it is obvious, from Santorio's description, that it is nothing more than a circular scale, the index showing, by the figure to which it points, the length of string remaining unwound upon the axis. We shall, for the present, postpone the consideration of the invention of pendulum clocks, and the examination of the different claims to the honour of their first construction.

At the time of which we are speaking, Galileo was entirely ignorant of mathematics, the study of which was then at a low ebb, not only in Italy, but in every part of Europe. Commandine had recently revived a taste for the writings of Euclid and Archimedes, and Vieta Tartalea and others had made considerable progress in algebra, Guido Ubaldi and Benedetti had done something towards establishing the principles of statics, which was the only part of mechanics as yet cultivated; but with these inconsiderable exceptions the application of mathematics to the phenomena of nature was scarcely thought of. Galileo's first inducement to acquire a knowledge of geometry arose from his partiality for drawing and music, and from the wish to understand their principles and theory. His father, fearful lest he should relax his medical studies, refused openly to encourage him in this new pursuit; but he connived at the instruction which his son now began to receive in the writings of Euclid, from the tuition of an intimate friend, named Ostilio

[1] Comment, in Avicennan. Venetiis, 1625.

[2] Essai sur les Ouvrages de Leonard da Vinci. Paris, 1797.

Ricci, who was one of the professors in the university. Galileo's whole attention was soon directed to the enjoyment of the new sensations thus communicated to him, insomuch that Vincenzo, finding his prognostics verified, began to repent his indirect sanction, and privately requested Ricci to invent some excuse for discontinuing his lessons. But it was fortunately too late the impression was made and could not be effaced; from that time Hippocrates and Galen lay unheeded before the young physician and served only to conceal from his father's sight the mathematical volumes on which, the whole of his time was really employed. His progress soon revealed the true nature of his pursuits: Vincenzo yielded to the irresistible predilection of his son's mind, and no longer attempted to turn him from the speculations to which his whole existence was thenceforward abandoned. After, mastering the elementary writers, Galileo proceeded to the study of Archimedes, and, whilst perusing the Hydrostatics of that author, composed his earliest work,—*an Essay on the Hydrostatical Balance*. In this he explains the method probably adopted by Archimedes for the solution of Hiero's celebrated question[1], and shows himself already well acquainted with the true principles of specific gravities. This essay had an immediate and important influence on young Galileo's fortunes, for it introduced him to the approving notice of Guido Ubaldi, then one of the most distinguished mathematicians of Italy. At his suggestion Galileo applied himself to consider the position of the centre of gravity in solid bodies, a choice of subject that sufficiently showed the estimate Ubaldi had formed of his talents ; for it was a question on which Commandine had recently written, and which engaged at that time the attention of geometricians of the highest order, Galileo tells us himself that he discontinued these researches on meeting with Lucas Valerie's treatise on the same subject. Ubaldi was so much struck with the genius displayed in the essay with which Galileo furnished him, that he introduced him to his brother, the Cardinal Del Monte: by this latter he was mentioned to Ferdinand de Medici, the reigning Duke of Tuscany, as a young man of whom the highest expectations might be entertained. By the Duke’s patronage he was nominated, in 1589, to the lectureship of mathematics at Pisa, being then in his twenty-sixth year. His public salary was fixed at the insignificant sum of sixty crowns annually, but he had an opportunity of greatly adding to his income by private tuition.

[1] See Treatise on Hydrostatics.

CHAPTER III.

Galileo at Pisa–Aristotle–Leonardo da Vinci–Galileo becomes a Copernican–Urstisius–Bruno–Experiments on falling bodies–Galileo at Padua–Thermometer.

No sooner was Galileo settled in his new office than he renewed his inquiries into the phenomena of nature with increased diligence.

[end as of 12/27/2006]