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THE MARTYRS OF SCIENCE,

OR

THE LIVES

OF

GALILEO, TYCHO BRAHE, AND KEPLER.

BY

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TO THE

RIGHT HON. FRANCIS LORD GRAY,

F.R.S., F.R.S.E.

MY LORD,

In submitting this volume to the public under your Lordship's auspices, I avail myself of the opportunity thus afforded me of expressing the deep sense which I entertain of the friendship and kindness with which your Lordship has so long honoured me.

Although in these days, when Science constitutes the power and wealth of nations, and encircles the domestic hearth with its most substantial comforts, there is no risk of its votaries being either persecuted or neglected, yet the countenance of those to whom Providence has given rank and station will ever be one of the most powerful incitements to scientific enterprise, as well as one of its most legitimate rewards. Next to the satisfaction of cultivating Science, and thus laying up the only earthly treasure which we can carry along with us into a better state, is that of having encouraged and assisted others in the same beneficent labours. That your Lordship may long continue to enjoy these sources of happiness is the earnest prayer of,

MY LORD,

Your Lordship's

Most faithful and obedient servant,

DAVID BREWSTER.

ST LEONARDS, ST ANDREWS,

October 12, 1840.

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LIFE
OF
GALILEO.

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The history of the life and labours of Galileo is pregnant with a peculiar interest to the general reader, as well as to the philosopher. His brilliant discoveries, the man of science regards as his peculiar property; the means by which they were made, and the development of his intellectual character, belong to the logician and to the philosopher; but the triumphs and the reverses of his eventful life must be claimed for our common nature, as a source of more than ordinary instruction.

The lengthened career which Providence assigned to Galileo was filled up throughout its rugged outline with events even of dramatic interest. But though it was emblazoned with achievements of transcendent magnitude, yet his noblest discoveries were the derision of his contemporaries, and were even denounced as crimes which merited the vengeance of Heaven. Though he was the idol of his friends, and the favoured companion of princes, yet he afterwards became the victim of persecution, and spent some of his last hours within the walls of a prison; and though the Almighty granted him, as it were, a new sight to descry unknown worlds in the obscurity of space, yet the eyes which were allowed to witness such wonders, were themselves doomed to be closed in darkness.

Such were the lights and shadows in which history delineates

> “The starry Galileo with his woes.”[1]

But, however powerful be their contrasts, they are not unusual in their proportions. The balance which has been struck between his days of good and evil, is that which regulates the lot of man, whether we study it in the despotic sway of the autocrat, in the peaceful inquiries of the philosopher, or in the humbler toils of ordinary life.

Galileo Galilei was born at Pisa, on the 15th of February, 1564, and was the eldest of a family of three sons and three daughters. Under the name of Bonajuti, his noble ancestors had filled high offices at Florence; but about the middle of the 14th century they seem to have abandoned this surname for that of Galileo. Vincenzo Galilei, our author’s father, was himself a philosopher of no mean powers; and though his talents seem to have been exercised only in the composition of treatises on the theory and practice of music, yet he appears to have anticipated even his son in a just estimate of the philosophy of the age, and in a distinct perception of the true method of investigating truth.[2]

The early years of Galileo were, like those of almost all great experimental philosophers, spent in the construction of instruments and pieces of machinery, which were calculated chiefly to amuse himself and his schoolfellows. This employment of his hands, however, did not interfere with his regular studies; and though, from the straitened circumstances of his father, he was educated under considerable disadvantages, yet he acquired the elements of classical literature, and was initiated into all the learning of the times. Music, drawing, and painting were the occupations of his leisure hours; and such was his proficiency in these arts, that he was reckoned a skilful performer on several musical instruments, especially the lute; and his knowledge of pictures was held in great esteem by some of the best artists of his day.

Galileo seems to have been desirous of following the profession of a painter: but his father had observed decided indications of early genius; and, though by no means able to afford it, he resolved to send him to the university to pursue the study of medicine. He accordingly enrolled himself as a scholar in arts at the university of Pisa, on the 5th of November, 1581, and pursued his medical studies under the celebrated botanist Andrew Cæsalpinus, who filled the chair of medicine from 1567 to 1592.

In order to study the principles of music and drawing, Galileo found it necessary to acquire some knowledge of geometry. His father seems to have foreseen the consequences of following this new pursuit, and though he did not prohibit him from reading Euclid under Ostilio Ricci, one of the professors at Pisa, yet he watched his progress with the utmost jealousy, and had resolved that it should not interfere with his medical studies. The demonstrations, however, of the Greek mathematician had too many charms for the ardent mind of Galileo. His whole attention was engrossed with the new truths which burst upon his understanding; and after many fruitless attempts to check his ardour and direct his thoughts to professional objects, his father was obliged to surrender his parental control, and allow the fullest scope to the genius of his son.

From the elementary works of geometry, Galileo passed to the writings of Archimedes; and while he was studying the hydrostatical treatise[3] of the Syracusan philosopher, he wrote his essay on the hydrostatical balance,[4] in which he describes the construction of the instrument, and the method by which Archimedes detected the fraud committed by the jeweller in the composition of Hiero’s crown. This work gained for its author the esteem of Guido Ubaldi, who had distinguished himself by his mechanical and mathematical acquirements, and who engaged his young friend to investigate the subject of the centre of gravity in solid bodies. The treatise on this subject, which Galileo presented to his patron, proved the source of his future success in life.

Through the Cardinal del Monte, the brother-in-law of Ubaldi, the reigning Duke of Tuscany, Ferdinand de Medici was made acquainted with the merits of our young philosopher; and, in 1589, he was appointed lecturer on mathematics at Pisa. As the salary, however, attached to this office was only sixty crowns, he was compelled to enlarge this inadequate income by the additional occupation of private teaching, and thus to encroach upon the leisure which he was anxious to devote to science.

With this moderate competency, Galileo commenced his philosophical career. At the early age of eighteen, when he had entered the university, his innate antipathy to the Aristotelian philosophy began to display itself. This feeling was strengthened by his earliest inquiries; and upon his establishment at Pisa he seems to have regarded the doctrines of Aristotle as the intellectual prey which, in his chace of glory, he was destined to pursue. Nizzoli, who flourished near the beginning of the sixteenth century, and Giordano Bruno, who was burned at Rome in 1600, led the way in this daring pursuit; but it was reserved for Galileo to track the Thracian boar through its native thickets, and, at the risk of his own life, to strangle it in its den.

With the resolution of submitting every opinion to the test of experiment, Galileo's first inquiries at Pisa were directed to the mechanical doctrines of Aristotle. Their incorrectness and absurdity soon became apparent; and with a zeal, perhaps, bordering on indiscretion, he denounced them to his pupils with an ardour of manner and of expression proportioned to his own conviction of the truth. The detection of long-established errors is apt to inspire the young philosopher with an exultation which reason condemns. The feeling of triumph is apt to clothe itself in the language of asperity; and the abettor of erroneous opinions is treated as a species of enemy to science. Like the soldier who fleshes his first spear in battle, the philosopher is apt to leave the stain of cruelty on his early achievements. It is only from age and experience, indeed, that we can expect the discretion of valour, whether it is called forth in controversy or in battle. Galileo seems to have waged this stern warfare against the followers of Aristotle; and such was the exasperation which was excited by his reiterated and successful attacks, that he was assailed, during the rest of his life, with a degree of rancour which seldom originates in a mere difference of opinion. Forgetting that all knowledge is progressive, and that the errors of one generation call forth the comments, and are replaced by the discoveries, of the next, Galileo did not anticipate that his own speculations and incompleted labours might one day provoke unmitigated censure; and he therefore failed in making allowance for the prejudices and ignorance of his opponents. He who enjoys the proud lot of taking a position in advance of his age, need not wonder that his less gifted contemporaries are left behind. Men are not necessarily obstinate because they cleave to deeply rooted and venerable errors, nor are they absolutely dull when they are long in understanding and slow in embracing newly discovered truths.

It was one of the axioms of the Aristotelian mechanics, that the heavier of two falling bodies would reach the ground sooner than the other, and that their velocities would be proportional to their weights. Galileo attacked the arguments by which this opinion was supported; and when he found his reasoning ineffectual, he appealed to direct experiment. He maintained, that all bodies would fall through the same height in the same time, if they were not unequally retarded by the resistance of the air: and though he performed the experiment with the most satisfactory results, by letting heavy bodies fall from the leaning tower of Pisa, yet the Aristotelians, who with their own eyes saw the unequal weights strike the ground at the same instant, ascribed the effect to some unknown cause, and preferred the decision of their master to that of nature herself.

Galileo could not brook this opposition to his discoveries; nor could the Aristotelians tolerate the rebukes of their young instructor. The two parties were, consequently, marshalled in hostile array; when, fortunately for both, an event occurred, which placed them beyond the reach of danger. Don Giovanni de Medici, a natural son of Cosmo, had proposed a method of clearing out the harbour of Leghorn. Galileo, whose opinion was requested, gave such an unfavourable report upon it, that the disappointed inventor directed against him all the force of his malice. It was an easy task to concentrate the malignity of his enemies at Pisa; and so effectually was this accomplished, that Galileo resolved to accept another professorship, to which he had been previously invited.

The chair of mathematics in the university of Padua having been vacant for five years, the republic of Venice had resolved to fill it up; and, on the recommendation of Guido Ubaldi, Galileo was appointed to it, in 1592, for a period of six years.

Previous to this event, Galileo had lost his father, who died, in 1591, at an advanced age. As he was the eldest son, the support of the family naturally devolved upon him; and this sacred obligation must have increased his anxiety to better his circumstances, and therefore added to his other inducements to quit Pisa. In September 1592, he removed to Padua, where he had a salary of only 180 florins, and where he was again obliged to add to his income by the labours of tuition. Notwithstanding this fruitless occupation of his time, he appears to have found leisure for composing several of his works, and completing various inventions, which will be afterwards described. His manuscripts were circulated privately among his friends and pupils; but some of them strayed beyond this sacred limit, and found their way into the hands of persons, who did not scruple to claim and publish, as their own, the discoveries and inventions which they contained.

It is not easy to ascertain the exact time when Galileo became a convert to the doctrines of Copernicus, or the particular circumstances under which he was led to adopt them. It is stated by Gerard Voss, that a public lecture of Mœstlin, the instructor of Kepler, was the means of making Galileo acquainted with the true system of the universe. This assertion, however, is by no means probable; and it has been ably shown, by the latest biographer of Galileo,[5] that, in his dialogues on the Copernican system, our author gives the true account of his own conversion. This passage is so interesting, that we shall give it entire.

"I cannot omit this opportunity of relating to you what happened to myself at the time when this opinion (the Copernican system) began to be discussed. I was then a very young man, and had scarcely finished my course of philosophy, which other occupations obliged me to leave off, when there arrived in this country, from Rostoch, a foreigner, whose name, I believe, was Christian Vurstisius (Wurteisen), a follower of Copernicus. This person delivered, on this subject, two or three lectures in a certain academy, and to a crowded audience. Believing that several were attracted more by the novelty of the subject than by any other cause, and being firmly persuaded that this opinion was a piece of solemn folly, I was unwilling to be present. Upon interrogating, however, some of those who were there, I found that they all made it a subject of merriment, with the exception of one, who assured me that it was not a thing wholly ridiculous. As I considered this individual to be both prudent and circumspect, I repented that I had not attended the lectures; and, whenever I met any of the followers of Copernicus, I began to inquire if they had always been of the same opinion. I found that there was not one of them who did not declare that he had long maintained the very opposite opinions, and had not gone over to the new doctrines till he was driven by the force of argument. I next examined them one by one, to see if they were masters of the arguments on the opposite side; and such was the readiness of their answers, that I was satisfied they had not taken up this opinion from ignorance or vanity. On the other hand, whenever I interrogated the Peripatetics and the Ptolemeans—and, out of curiosity, I have interrogated not a few—respecting their perusal of Copernicus's work, I perceived that there were few who had seen the book, and not one who understood it. Nor have I omitted to inquire among the followers of the Peripatetic doctrines, if any of them had ever stood on the opposite side; and the result was, that there was not one. Considering, then, that nobody followed the Copernican doctrine, who had not previously held the contrary opinion, and who was not well acquainted with the arguments of Aristotle and Ptolemy; while, on the other hand, nobody followed Ptolemy and Aristotle, who had before adhered to Copernicus, and had gone over from him into the camp of Aristotle;—weighing, I say, these things, I began to believe that, if any one who rejects an opinion which he has imbibed with his milk, and which has been embraced by an infinite number, shall take up an opinion held only by a few, condemned by all the schools, and really regarded as a great paradox, it cannot be doubted that he must have been induced, not to say driven, to embrace it by the most cogent arguments. On this account I have become very curious to penetrate to the very bottom of the subject."[6]

It appears, on the testimony of Galileo himself, that he taught the Ptolemaic system, in compliance with the popular feeling, after he had convinced himself of the truth of the Copernican doctrines. In the treatise on the sphere, indeed, which bears his name,[7] and which must have been written soon after he went to Padua, and subsequently to 1592, the stability of the earth, and the motion of the sun, are supported by the very arguments which Galileo afterwards ridiculed; but we have no means of determining whether or not he had then adopted the true system of the universe. Although he might have taught the Ptolemaic system in his lectures after he had convinced himself of its falsehood, yet it is not likely that he would go so far as to publish to the world, as true, the very doctrines which he despised. In a letter to Kepler, dated in 1597, he distinctly states that he *had, many years ago, adopted the opinions of Copernicus*; but that *he had not yet dared to publish his arguments in favour of them, and his refutation of the opposite opinions*. These facts would leave us to place Galileo's conversion somewhere between 1593 and 1597, although *many* years cannot be said to have elapsed between these two dates.

At this early period of Galileo's life, in the year 1593, he met with an accident which had nearly proved fatal. A party at Padua, of which he was one, were enjoying, at an open window, a current of air, which was artificially cooled by a fall of water. Galileo unfortunately fell asleep under its influence; and so powerful was its effect upon his robust constitution, that he contracted a severe chronic disorder, accompanied with acute pains in his body, and loss of sleep and appetite, which attacked him at intervals during the rest of his life. Others of the party suffered still more severely, and perished by their own rashness.

Galileo's reputation was now widely extended over Europe. The Archduke Ferdinand (afterwards Emperor of Germany), the Landgrave of Hesse, and the Princes of Alsace and Mantua, honoured his lectures with their presence; and Prince Gustavus Adolphus of Sweden also received instructions from him in mathematics, during his sojourn in Italy.

When Galileo had completed the first period of his engagement at Padua, he was re-elected for other six years, with an increased salary of 320 florins. This liberal addition to his income is ascribed by Fabbroni to the malice of one of his enemies, who informed the Senate that Galileo was living in illicit intercourse with Marina Gamba. Without inquiring into the truth of the accusation, the Senate is said to have replied, that if "he had a family to support, he had the more need of an increased salary." It is more likely that the liberality of the republic had been called forth by the high reputation of their professor, and that the terms of their reply were intended only to rebuke the malignity of the informer. The mode of expression would seem to indicate that one or more of Galileo's children had been born previous to his re-election in 1598; but as this is scarcely consistent with other facts, we are disposed to doubt the authenticity of Fabbroni's anecdote.

The new star which attracted the notice of astronomers in 1604, excited the particular attention of Galileo. The observations which he made upon it, and the speculations which they suggested, formed the subject of three lectures, the beginning of the first of which only has reached our times. From the absence of parallax, he proved that the common hypothesis of its being a meteor was erroneous, and that, like the fixed stars, it was situated far beyond the bounds of our own system. The popularity of the subject attracted crowds to his lecture-room; and Galileo had the boldness to reproach his hearers for taking so deep an interest in a temporary phenomenon, while they overlooked the wonders of creation which were daily presented to their view.

In the year 1606, Galileo was again appointed to the professorship at Padua, with an augmented stipend of 520 florins. His popularity had now risen so high, that his audience could not be accommodated in his lecture-room; and even when he had assembled them in the school of medicine, which contained 1000 persons, he was frequently obliged to adjourn to the open air.

Among the variety of pursuits which occupied his attention, was the examination of the properties of the loadstone. In 1607, he commenced his experiments; but, with the exception of a method of arming loadstones, which, according to the report of Sir Kenelm Digby, enabled them to carry twice as much weight as before, he does not seem to have made any additions to our knowledge of magnetism. He appears to have studied with care the admirable work of our countryman, Dr Gilbert, “De Magnete,” which was published in 1600; and he recognised in the experiments and reasonings of the English philosopher the principles of that method of investigating truth which he had himself adopted. Gilbert died in 1603, in the 63d year of his age, and probably never read the fine compliment which was paid to him by the Italian philosopher—“I extremely praise, admire, and envy this author.”

CHAPTER II.

Cosmo, Grand Duke of Tuscany, invites Galileo to Pisa—Galileo visits Venice in 1609, where he first hears of the Telescope—He invents and constructs one, which excites a great sensation—Discovers Mountains in the Moon, and Forty Stars in the Pleiades—Discovers Jupiter's Satellites in 1610—Effect of this discovery on Kepler—Manner in which these discoveries were received—Galileo appointed Mathematician to Cosmo—Mayer claims the discovery of the Satellites of Jupiter—Harriot observes them in England in October 1610.

In the preceding chapter we have brought down the history of Galileo's labours to that auspicious year in which he first directed the telescope to the heavens. No sooner was that noble instrument placed in his hands, than Providence released him from his professional toils, and supplied him with the fullest leisure and the amplest means for pursuing and completing the grandest discoveries.

Although he had quitted the service and the domains of his munificent patron, the Grand Duke of Tuscany, yet he maintained his connection with the family, by visiting Florence during his academic vacations, and giving mathematical instruction to the younger branches of that distinguished house. Cosmo, who had been one of his pupils, now succeeded his father Ferdinand; and having his mind early imbued with a love of knowledge, which had become hereditary in his family, he felt that the residence of Galileo within his dominions, and still more his introduction into his household, would do honour to their common country, and reflect a lustre upon his own name. In the year 1609, accordingly, Cosmo made proposals to Galileo to return to his original situation at Pisa. These overtures were gratefully received; and in the arrangements which Galileo on this occasion suggested, as well as in the manner in which they were urged, we obtain some insight into his temper and character. He informs the correspondent through whom Cosmo's offer was conveyed, that his salary of 520 florins at Padua would be increased to as many crowns at his re-election, and that he could enlarge his income to any extent he pleased, by giving private lectures and receiving pupils. His public duties, he stated, occupied him only sixty half-hours in the year; but his studies suffered such interruptions from his domestic pupils and private lectures, that his most ardent wish was to be relieved from them, in order that he might have sufficient rest and leisure, before the close of his life, to finish and publish those great works which he had projected. In the event, therefore, of his returning to Pisa, he hoped that it would be the first object of his serene highness to give him leisure to complete his works without the drudgery of lecturing. He expresses his anxiety to gain his bread by his writings, and he promises to dedicate them to his serene master. He enumerates, among these books, two on the system of the universe, three on local motion, three books of mechanics, two on the demonstration of principles, and one of problems; besides treatises on sound and speech, on light and colours, on the tides, on the composition of continuous quantity, on the motions of animals, and on the military art. On the subject of his salary, he makes the following curious observations:—

"I say nothing," says he, "on the amount of my salary; being convinced that, as I am to live upon it, the graciousness of his highness would not deprive me of any of those comforts, of which, however, I feel the want of less than many others; and, therefore, I say nothing more on the subject. Finally, on the title and profession of my service, I should wish that, to the title of mathematician, his highness would add that of philosopher, as I profess to have studied a greater number of years in philosophy, than months in pure mathematics; and how I have profited by it, and if I can or ought to deserve this title, I may let their highnesses see, as often as it shall please them to give me an opportunity of discussing such subjects in their presence with those who are most esteemed in this knowledge."

During the progress of this negotiation, Galileo went to Venice, on a visit to a friend, in the month of April or May 1609. Here he learned, from common rumour, that a Dutchman had presented to prince Maurice of Nassau an optical instrument, which possessed the singular property of causing distant objects to appear nearer the observer. This Dutchman was Hans or John Lippershey, who, as has been clearly proved by the late Professor Moll of Utrecht,[8] was in the possession of a telescope made by himself so early as 2d October 1608. A few days afterwards, the truth of this report was confirmed by a letter which Galileo received from James Badorere at Paris, and he immediately applied himself to the consideration of the subject. On the first night after his return to Padua, he found, in the doctrines of refraction, the principle which he sought. He placed at the ends of a leaden tube two spectacle glasses, both of which were plain on one side, while one of them had its other side convex, and the other its second side concave, and having applied his eye to the concave glass, he saw objects pretty large and pretty near him. This little instrument, which magnified only three times, he carried in triumph to Venice, where it excited the most intense interest. Crowds of the principal citizens flocked to his house to see the magical toy; and after nearly a month had been spent in gratifying this epidemical curiosity, Galileo was led to understand from Leonardo Deodati, the Doge of Venice, that the senate would be highly gratified by obtaining possession of so extraordinary an instrument. Galileo instantly complied with the wishes of his patrons, who acknowledged the present by a mandate conferring upon him for life his professorship at Padua, and generously raising his salary from 520 to 1000 florins.[9]

Although we cannot doubt the veracity of Galileo, when he affirms that he had never seen any of the Dutch telescopes, yet it is expressly stated by Fuccarius, that one of these instruments had at this time been brought to Florence; and Sirturus assures us that a Frenchman, calling himself a partner of the Dutch inventor, came to Milan in May 1609, and offered a telescope to the Count de Fuentes. In a letter from Lorenzo Pignoria to Paolo Gualdo, dated from Padua, on the 31st of August 1609, it is expressly said, that, at the re-election of the professors, Galileo had contrived to obtain 1000 florins for life, which was alleged to be on account of an eye-glass like the one which was sent from Flanders to the Cardinal Borghese.

In a memoir so brief and general as the present, it would be out of place to discuss the history of this extraordinary invention. We have no hesitation in asserting that a method of magnifying distant objects was known to Baptista Porta and others; but it seems to be equally certain that an *instrument* for producing these effects was first constructed in Holland, and that it was from that kingdom that Galileo derived the knowledge of its existence. In considering the contending claims, which have been urged with all the ardour and partiality of national feeling, it has been generally overlooked, *that a single convex lens*, whose focal length exceeds the distance at which we examine minute objects, performs the part of a telescope, when an eye, placed behind it, sees distinctly the inverted image which it forms. A lens, twenty feet in focal length, will in this manner magnify twenty times; and it was by the same principle that Sir William Herschel discovered a new satellite of Saturn, by using only the mirror of his forty-feet telescope. The instrument presented to Prince Maurice, and which the Marquis Spinola found in the shop of John Lippershey, the spectacle maker of Middleburg, must have been an astronomical telescope consisting of two convex lenses. Upon this supposition, it differed from that which Galileo constructed; and the Italian philosopher will be justly entitled to the honour of having invented that form of the telescope which still bears his name, while we must accord to the Dutch optician the honour of having previously invented the astronomical telescope.

The interest which the exhibition of the telescope excited at Venice did not soon subside: Sirturi[10] describes it as amounting almost to phrensy. When he himself had succeeded in making one of these instruments, he ascended the tower of St Mark, where he might use it without molestation. He was recognised, however, by a crowd in the street; and such was the eagerness of their curiosity, that they took possession of the wondrous tube, and detained the impatient philosopher for several hours, till they had successively witnessed its effects. Desirous of obtaining the same gratification for their friends, they endeavoured to learn the name of the inn at which he lodged; but Sirturi fortunately overheard their inquiries, and quitted Venice early next morning, in order to avoid a second visitation of this new school of philosophers. The opticians speedily availed themselves of the new instrument. Galileo's tube,—or the double eye-glass, or the cylinder, or the trunk, as it was then called, for Demisiano had not yet given it the appellation of *telescope*,—was manufactured in great quantities, and in a very superior manner. The instruments were purchased merely as philosophical toys, and were carried by travellers into every corner of Europe.

The art of grinding and polishing lenses was at this time very imperfect. Galileo, and those whom he instructed, were alone capable of making tolerable instruments. It appears, from the testimony of Gassendi and Gærtner, that, in 1634, a good telescope could not be procured in Paris, Venice, or Amsterdam; and that, even in 1637, there was not one in Holland which could shew Jupiter's disc well defined.

After Galileo had completed his first instrument, which magnified only *three* times, he executed a larger and a better one, with a power of about *eight*. "At length," as he himself remarks, "sparing neither labour nor expense," he constructed an instrument so excellent, that it bore a magnifying power of more than *thirty* times.

The first celestial object to which Galileo applied his telescope was the moon, which, to use his own words, appeared as near as if it had been distant only two semidiameters of the earth. He then directed it to the planets and the fixed stars, which he frequently observed with "incredible delight."[11]

The observations which he made upon the moon possessed a high degree of interest. The general resemblance of its surface to that of our own globe naturally fixed his attention; and he was soon able to trace, in almost every part of the lunar disc, ranges of mountains, deep hollows, and other inequalities, which reverberated from their summits and margins the rays of the rising sun, while the intervening hollows were still buried in darkness. The dark and luminous spaces he regarded as indicating seas and continents, which reflected, in different degrees, the incidental light of the sun; and he ascribed the phosphorescence, as it has been improperly called, or the secondary light, which is seen on the dark limb of the moon in her first and last quarters, to the reflection of the sun’s light from the earth.

These discoveries were ill received by the followers of Aristotle. According to their preconceived opinions, the moon was perfectly spherical, and absolutely smooth; and to cover it with mountains, and scoop it out into valleys, was an act of impiety which defaced the regular forms which Nature herself had imprinted. It was in vain that Galileo appealed to the evidence of observation, and to the actual surface of our own globe. The very irregularities on the moon were, in his opinion, the proof of divine wisdom; and had its surface been absolutely smooth, it would have been “but a vast unblessed desert, void of animals, of plants, of cities, and of men—the abode of silence and inaction—senseless, lifeless, soulless, and stripped of all those ornaments which now render it so varied and so beautiful.”

In examining the fixed stars, and comparing them with the planets, Galileo observed a remarkable difference in the appearance of their discs. All the planets appeared with round globular discs like the moon; whereas the fixed stars never exhibited any disc at all, but resembled lucid points sending forth twinkling rays. Stars of all magnitudes he found to have the same appearance; those of the fifth and sixth magnitude having the same character, when seen through a telescope, as Sirius, the largest of the stars, when seen by the naked eye. Upon directing his telescope to nebulæ and clusters of stars, he was delighted to find that they consisted of great numbers of stars which could not be recognised by unassisted vision. He counted no fewer than *forty* in the cluster called the *Pleiades*, or *Seven Stars*; and he has given us drawings of this constellation, as well as of the belt and sword of Orion, and of the nebula of Præsepe. In the great nebula of the Milky Way, he descried crowds of minute stars; and he concluded that this singular portion of the heavens derived its whiteness from still smaller stars, which his telescope was unable to separate.

Important and interesting as these discoveries were, they were thrown into the shade by those to which he was led during an accurate examination of the planets with a more powerful telescope. On the 7th of January 1610, at one o’clock in the morning, when he directed his telescope to Jupiter, he observed three stars near the body of the planet, two being to the east and one to the west of him. They were all in a straight line, and parallel to the ecliptic, and appeared brighter than other stars of the same magnitude. Believing them to be fixed stars, he paid no great attention to their distances from Jupiter and from one another. On the 8th of January, however, when, from some cause or other,[12] he had been led to observe the stars again, he found a very different arrangement of them: all the three were on the west side of Jupiter, *nearer one another than before*, and almost at equal distances. Though he had not turned his attention to the extraordinary fact of the mutual approach of the stars, yet he began to consider how Jupiter could be found to the east of the three stars, when but the day before he had been to the west of two of them. The only explanation which he could give of this fact was, that the motion of Jupiter was *direct*, contrary to astronomical calculations, and that he had got before these two stars by his own motion.

In this dilemma between the testimony of his senses and the results of calculation, he waited for the following night with the utmost anxiety; but his hopes were disappointed, for the heavens were wholly veiled in clouds. On the 10th, two only of the stars appeared, and both on the east of the planet. As it was obviously impossible that Jupiter could have advanced from west to east on the 8th of January, and from east to west on the 10th, Galileo was forced to conclude that the phenomenon which he had observed arose from the motion of the stars, and he set himself to observe diligently their change of place. On the 11th, there were still only two stars, and both to the east of Jupiter; but the more eastern star was now *twice as large as the other one*, though on the preceding night they had been perfectly equal. This fact threw a new light upon Galileo's difficulties, and he immediately drew the conclusion, which he considered to be indubitable, "*that there were in the heavens three stars which revolved round Jupiter, in the same manner as Venus and Mercury revolve round the sun*." On the 12th of January, he again observed them in new positions, and of different magnitudes; and, on the 13th, he discovered a fourth star, which completed the *four* secondary planets with which Jupiter is surrounded.

Galileo continued his observations on these bodies every clear night till the 22d of March, and studied their motions in reference to fixed stars that were at the same time within the field of his telescope. Having thus clearly established that the four new stars were satellites or moons, which revolved round Jupiter in the same manner as the moon revolves round our own globe, he drew up an account of his discovery, in which he gave to the four new bodies the names of the *Medicean Stars*, in honour of his patron, Cosmo de Medici, Grand Duke of Tuscany. This work, under the title of "Nuncius Sidereus," or the "Sidereal Messenger," was dedicated to the same prince; and the dedication bears the date of the 24th of March, only two days after he concluded his observations.

The importance of this great discovery was instantly felt by the enemies as well as by the friends of the Copernican system. The planets had hitherto been distinguished from the fixed stars only by their relative change of place, but the telescope proved them to be bodies so near to our own globe as to exhibit well-defined discs, while the fixed stars retained, even when magnified, the minuteness of remote and lucid points. The system of Jupiter, illuminated by four moons performing their revolutions in different and regular periods, exhibited to the proud reason of man the comparative insignificance of the globe he inhabits, and proclaimed in impressive language that that globe was not the centre of the universe.

The reception which these discoveries met with from Kepler is highly interesting, and characteristic of the genius of that great man. He was one day sitting idle, and thinking of Galileo, when his friend Wachenfels stopped his carriage at his door, to communicate to him the intelligence. "Such a fit of wonder," says he, "seized me at a report which seemed to be so very absurd, and I was thrown into such agitation at seeing an old dispute between us decided in this way, that between his joy, my colouring, and the laughter of both, confounded as we were by such a novelty, we were hardly capable, he of speaking, or I of listening. On our parting, I immediately began to think how there could be any addition to the number of the planets without overturning my 'Cosmographic Mystery,' according to which Euclid's five regular solids do not allow more than six planets round the sun…. I am so far from disbelieving the existence of the four circumjovial planets, that I long for a telescope, to anticipate you, if possible, in discovering *two* round Mars, as the proportion seems to require, *six* or *eight* round Saturn, and perhaps *one* each round Mercury and

Venus."

In a very different spirit did the Aristotelians receive the "Sidereal Messenger" of Galileo. The principal professor of philosophy at Padua resisted Galileo's repeated and urgent entreaties to look at the moon and planets through his telescope; and he even laboured to convince the Grand Duke that the satellites of Jupiter could not possibly exist. Sizzi, an astronomer of Florence, maintained that as there were only *seven* apertures in the head—*two* eyes, *two* ears, *two* nostrils, and *one* mouth—and as there were only *seven* metals, and *seven* days in the week, so there could be only *seven* planets. He seems, however, to have admitted the visibility of the four satellites through the telescope; but he argues, that as they are invisible to the naked eye, they can exercise no influence on the earth; and being useless, they do not therefore exist.

A *protegé* of Kepler's, of the name of Horky, wrote a volume against Galileo's discovery, after having declared, "that he would never concede his four new planets to that Italian from Padua, even if he should die for it." This resolute Aristotelian was at no loss for arguments. He asserted that he had examined the heavens *through Galileo's own glass*, and that no such thing as a satellite existed round Jupiter. He affirmed, that he did not more surely know that he had a soul in his body, than that reflected rays are the sole cause of Galileo's erroneous observations; and that the only use of the new planets was to gratify Galileo's thirst for gold, and afford to himself a subject of discussion.

When Horky first presented himself to Kepler, after the publication of this work, the opinion of his patron was announced to him by a burst of indignation which overwhelmed the astonished author. Horky supplicated mercy for his offence; and, as Kepler himself informed Galileo, he took him again into favour, on the condition that Kepler was to show him Jupiter's satellites, and that Horky was not only to see them, but to admit their existence.

When the spirit of philosophy had thus left the individuals who bore so unworthily her sacred name, it was fortunate for science that it found a refuge among princes. Notwithstanding the reiterated logic of his philosophical professor at Padua, Cosmo de Medici preferred the testimony of his senses to the syllogisms of his instructor. He observed the new planets several times, along with Galileo, at Pisa; and when he parted with him, he gave him a present worth more than 1000 florins, and concluded that liberal arrangement to which we have already referred.

As philosopher and principal mathematician to the Grand Duke of Tuscany, Galileo now took up his residence at Florence, with a salary of 1000 florins. No official duties, excepting that of lecturing occasionally to sovereign princes, were attached to this appointment; and it was expressly stipulated that he should enjoy the most perfect leisure to complete his treatises on the constitution of the universe, on mechanics, and on local motion. The resignation of his professorship in the university of Padua, which was the necessary consequence of his new appointment, created much dissatisfaction: but though many of his former friends refused at first to hold any communication with him, this excitement gradually subsided; and the Venetian senate at last appreciated the feelings, as well as the motives, which induced a stranger to accept of promotion in his native land.

While Galileo was enjoying the reward and the fame of his great discovery, a new species of enmity was roused against him. Simon Mayer, an astronomer of no character, pretended that he had discovered the satellites of Jupiter before Galileo, and that his first observation was made on the 29th of December, 1609. Other astronomers announced the discovery of new satellites: Scheiner reckoned five, Rheita nine, and others found even so many as twelve: these satellites, however, were found to be only fixed stars. The names of *Vladislavian*, *Agrippine*, *Uranodavian*, and *Ferdinandotertian*, which were hastily given to these common telescopic stars, soon disappeared from the page of science, and even the splendid telescopes of modern times have not been able to add another gem to the diadem of Jupiter.

A modern astronomer of no mean celebrity has, even in the present day, endeavoured to rob Galileo of this staple article of his reputation. From a careless examination of the papers of our celebrated countryman, Thomas Harriot, which Baron Zach had made in 1784, at Petworth, the seat of Lord Egremont, this astronomer has asserted[13] that Harriot first observed the satellites of Jupiter on the 16th of January, 1610; and continued his observations till the 25th of February, 1612. Baron Zach adds the following extraordinary conclusion:—"Galileo pretends to have discovered them on the 7th of January, 1610; so that it is not improbable that Harriot was likewise the first discoverer of these attendants of Jupiter." In a communication which I received from Dr Robertson, of Oxford, in 1822,[14] he informed me that he had examined a portion of Harriot's papers, entitled, "De Jovialibus Planetis;" and that it appears, from two pages of these papers, *that Harriot first observed Jupiter's satellites on the 17th of October, 1610*. These observations are accompanied with rough drawings of the positions of the satellites, and rough calculations of their periodical revolutions. My friend, Professor Rigaud,[15] who has very recently examined the Harriot MSS., has confirmed the accuracy of Dr Robertson's observations, and has thus restored to Galileo the honour of being the first and the sole discoverer of these secondary planets.

CHAPTER III.

Galileo announces his discoveries in Enigmas—Discovers the Crescent of Venus—the Ring of Saturn—the Spots on the Sun—Similar Observations made in England by Harriot—Claims of Fabricius and Scheiner to the discovery of the Solar Spots—Galileo's Letters to Velser on the claims of Scheiner—His residence at the Villa of Salviati—Composes his work on Floating Bodies, which involves him in new controversies.

The great success which attended the first telescopic observations of Galileo, induced him to apply his best instruments to the other planets of our system. The attempts which had been made to deprive him of the honour of some of his discoveries, combined, probably, with a desire to repeat his observations with better telescopes, led him to announce his discoveries under the veil of an enigma, and to invite astronomers to declare, within a given time, if they had observed any new phenomena in the heavens.

Before the close of 1610, Galileo excited the curiosity of astronomers by the publication of his first enigma. Kepler and others tried in vain to decipher it; but in consequence of the Emperor Rodolph requesting a solution of the puzzle, Galileo sent him the following clue:—

> "Altissimam planetam tergeminam observavi."
>
> I have observed that the most remote planet is triple.

In explaining more fully the nature of his observation, Galileo remarked that Saturn was not a single star, but three together, nearly touching one another. He described them as having no relative motion, and as having the form of three o's, namely, oOo, the central one being larger than those on each side of it.

Although Galileo had announced that nothing new appeared in the other planets, yet he soon communicated to the world another discovery of no slight interest. The enigmatical letters in which it was concealed formed the following sentence:—

> "Cynthiæ figuras æmulatur mater Amorum."
>
> Venus rivals the phases of the moon.

Hitherto, Galileo had observed Venus when her disc was largely illuminated; but having directed his telescope to her when she was not far removed from the sun, he saw her in the form of a crescent, resembling exactly the moon at the same elongation. He continued to observe her night after night, during the whole time that she could be seen in the course of her revolution round the sun, and he found that she exhibited the very same phases which resulted from her motion round that luminary.

Galileo had long contemplated a visit to the metropolis of Italy, and he accordingly carried his intentions into effect in the early part of the year 1611. Here he was received with that distinction which was due to his great talents and his extended reputation. Princes, Cardinals, and Prelates hastened to do him honour; and even those who discredited his discoveries, and dreaded their results, vied with the true friends of science in their anxiety to see the intellectual wonder of the age.

In order to show the new celestial phenomena to his friends at Rome, Galileo took with him his best telescope; and as he had discovered the spots on the sun's surface in October or November 1610, or even earlier,[16] he had the gratification of exhibiting them to his admiring disciples. He accordingly erected his telescope in the Quirinal garden, belonging to Cardinal Bandini; and in April 1611 he shewed them to his friends in many of their most interesting variations. From their change of position on the sun's disc, Galileo at first inferred, either that the sun revolved about an axis, or that other planets, like Venus and Mercury, revolved so near the sun as to appear like black spots when they were opposite to his disc. Upon continuing his observations, however, he saw reason to abandon this hasty opinion. He found that the spots must be in contact with the surface of the sun,—that their figures were irregular,—that they had different degrees of darkness,—that one spot would often divide itself into three or four,—that three or four spots would often unite themselves into one,—and that all the spots revolved regularly with the sun, which appeared to complete its revolution in about twenty-eight days.

Previous to the invention of the telescope, spots had been more than once seen on the sun's disc with the unassisted eye. But even if these were of the same character as those which Galileo and others observed, we cannot consider them as anticipations of their discovery by the telescope. As the telescope was now in the possession of several astronomers, Galileo began to have many rivals in discovery; but notwithstanding the claims of Harriot, Fabricius, and Scheiner, it is now placed beyond the reach of doubt that he was the first discoverer of the solar spots. From the communication which I received in 1822 from the late Dr Robertson, of Oxford,[17] it appeared that Thomas Harriot had observed the solar spots on the 8th of December 1610; but his manuscripts, in Lord Egremont's possession,[18] incontestably prove that his regular observations on the spots did not commence till December 1, 1611, although he had seen the spots at the date above mentioned, and that they were continued till the 18th of January 1613. The observations which he has recorded are 199 in number, and the accounts of them are accompanied with rough drawings representing the number, position, and magnitude of the spots.[19] In the observation of Harriot, made on the 8th December 1610, before he knew of Galileo's discovery, he saw three spots on the sun, which he has represented in a diagram. The sun was then 7° or 8° high, and there was a frost and a mist, which no doubt acted as a darkening glass. Harriot does not apply the name of spots to what he noticed in this observation, and he does not enumerate it among the 199 observations above mentioned. Professor Rigaud[20] considers it "a misapplication of terms to call such an observation a discovery;" but, with all the respect which we feel for the candour of this remark, we are disposed to confer on Harriot the merit of an original discoverer of the spots on the sun.

Another candidate for the honour of discovering the spots of the sun, was John Fabricius, who undoubtedly saw them previous to June 1611. The dedication of the work[21] in which he has recorded his observation, bears the date of the 13th of June 1611; and it is obvious, from the work itself, that he had seen the spots about the end of the year 1610; but as there is no proof that he saw them before October, we are compelled to assign the priority of the discovery to the Italian astronomer.

The claim of Scheiner, professor of mathematics at Ingolstadt, is more intimately connected with the history of Galileo. This learned astronomer having, early in 1611, turned his telescope to the sun, necessarily discovered the spots which at that time covered his disc. Light flying clouds happened, at the time, to weaken the intensity of his light, so that he was able to show the spots to his pupils. These observations were not published till January 1612; and they appeared in the form of three letters, addressed to Mark Velser, one of the magistrates of Augsburg, under the signature of *Appelles post Tabulam*. Scheiner, who, many years afterwards, published an elaborate work on the subject, adopted the same idea which had at first occurred to Galileo—that the spots were the dark sides of planets revolving round and near the sun.[22]

On the publication of Scheiner's letters, Velser transmitted a copy of them to his friend Galileo, with the request that he would favour him with his opinion of the new phenomena. After some delay, Galileo addressed three letters to Velser, in which he combated the opinions of Scheiner on the cause of the spots. The first of these letters was dated the 4th of May 1612;[23] but though the controversy was carried on in the language of mutual respect and esteem, it put an end to the friendship which had existed between the two astronomers. In these letters Galileo showed that the spots often dispersed like vapours or clouds; that they sometimes had a duration of only one or two days, and at other times of thirty or forty days; that they contracted in their breadth when they approached the sun's limb, without any diminution of their length; that they describe circles parallel to each other; that the monthly rotation of the sun again brings the same spots into view; and that they are seldom seen at a greater distance than 30° from the sun's equator. Galileo likewise discovered on the sun's disc *faculæ*, or *luculi*, as they were called, which differ in no respect from the common ones but in their being brighter than the rest of the sun's surface.[24]

In the last of the letters which our author addressed to Velser, and which was written in December 1612, he recurs to his former discovery of the elongated shape, or rather the triple structure, of Saturn. The singular figure which he had observed in this planet had entirely disappeared; and he evidently announces the fact to Velser, lest it should be used by his enemies to discredit the accuracy of his observations. "Looking on Saturn," says he, "within these few days, I found it solitary, without the assistance of its accustomed stars, and, in short, perfectly round and defined like Jupiter; and such it still remains. Now, what can be said of so strange a metamorphosis? Are the two smaller stars consumed like the spots on the sun? Have they suddenly vanished and fled? or has Saturn devoured his own children? or was the appearance indeed fraud and illusion, with which the glasses have for so long a time mocked me, and so many others who have often observed with me? Now, perhaps, the time is come to revive the withering hopes of those who, guided by more profound contemplations, have followed all the fallacies of the new observations, and recognised their impossibilities. I cannot resolve what to say in a chance so strange, so new, and so unexpected; the shortness of the time, the unexampled occurrence, the weakness of my intellect, and the terror of being mistaken, have greatly confounded me." Although Galileo struggled to obtain a solution of this mystery, yet he had not the good fortune to succeed. He imagined that the two smaller stars would reappear, in consequence of the supposed revolution of the planet round its axis; but the discovery of the ring of Saturn, and of the obliquity of its plane to the ecliptic, was necessary to explain the phenomena which were so perplexing to our author.

The ill health to which Galileo was occasionally subject, and the belief that the air of Florence was prejudicial to his complaints, induced him to spend much of his time at Selve, the villa of his friend Salviati. This eminent individual had ever been the warmest friend of Galileo, and seems to have delighted in drawing round him the scientific genius of the age. He was a member of the celebrated Lyncæan Society, founded by Prince Frederigo Cesi; and though he is not known as the author of any important discovery, yet he has earned, by his liberality to science, a glorious name, which will be indissolubly united with the immortal destiny of Galileo.

The subject of floating bridges having been discussed at one of the scientific parties which had assembled at the house of Salviati, a difference of opinion arose respecting the influence of the shape of bodies on their disposition to float or to sink in a fluid. Contrary to the general opinion, Galileo undertook to prove that it depended on other causes; and he was thus led to compose his discourse on floating bodies,[25] which was published in 1612, and dedicated to Cosmo de Medici. This work contains many ingenious experiments, and much acute reasoning in support of the true principles of hydrostatics; and it is now chiefly remarkable as a specimen of the sagacity and intellectual power of its author. Like all his other works, it encountered the most violent opposition; and Galileo was more than once summoned into the field to repel the aggressions of his ignorant and presumptuous opponents. The first attack upon it was made by Ptolemy Nozzolini, in a letter to Marzemedici, Archbishop of Florence;[26] and to this Galileo replied in a letter addressed to his antagonist.[27] A more elaborate examination of it was published by Lodovico delle Colombe, and another by M. Vincenzo di Grazia. To these attacks, a minute and overwhelming answer was printed in the name of Benedetti Castelli, the friend and pupil of Galileo; but it was discovered, some years after Galileo's death, that he was himself the author of this work.[28]

CHAPTER IV.

Galileo treats his opponents with severity and sarcasm—He is aided by the sceptics of the day—The Church party the most powerful—Galileo commences the attack, and is answered by Caccini, a Dominican—Galileo's Letter to the Grand Duchess of Tuscany, in support of the motion of the Earth and the stability of the Sun—- Galileo visits Rome —Is summoned before the Inquisition, and renounces his opinions as heretical—The Inquisition denounces the Copernican System—Galileo has an audience of the Pope, but still maintains his opinions in private society—Proposes to find out the Longitude at Sea by means of Jupiter's Satellites—His negociation on this subject with the Court of Spain—Its failure—He is unable to observe the three Comets of 1618, but is involved in the controversy to which they gave rise.

The current of Galileo's life had hitherto flowed in a smooth and unobstructed channel. He had now attained the highest objects of earthly ambition. His discoveries had placed him at the head of the great men of the age; he possessed a professional income far beyond his wants, and even beyond his anticipations; and, what is still dearer to a philosopher, he enjoyed the most perfect leisure for carrying on and completing his discoveries. The opposition which these discoveries encountered, was to him more a subject for triumph than for sorrow. Prejudice and ignorance were his only enemies; and if they succeeded for a while in harassing his march, it was only to lay a foundation for fresh achievements. He who contends for truths which he has himself been permitted to discover, may well sustain the conflict in which presumption and error are destined to fall. The public tribunal may neither be sufficiently pure nor enlightened to decide upon the issue; but he can appeal to posterity, and reckon with confidence on "its sure decree."

The ardour of Galileo's mind, the keenness of his temper, his clear perception of truth, and his inextinguishable love of it, combined to exasperate and prolong the hostility of his enemies. When argument failed to enlighten their judgment, and reason to dispel their prejudices, he wielded against them his powerful weapons of ridicule and sarcasm; and in this unrelenting warfare, he seems to have forgotten that Providence had withheld from his enemies those very gifts which he had so liberally received. He who is allowed to take the start of his species, and to penetrate the veil which conceals from common minds the mysteries of nature, must not expect that the world will be patiently dragged at the chariot wheels of his philosophy. Mind has its inertia as well as matter; and its progress to truth can only be insured by the gradual and patient removal of the obstructions which surround it.

The boldness—may we not say the recklessness—with which Galileo insisted upon making proselytes of his enemies, served but to alienate them from the truth. Errors thus assailed speedily entrench themselves in general feelings, and become embalmed in the virulence of the passions. The various classes of his opponents marshalled themselves for their mutual defence. The Aristotelian professors, the temporising Jesuits, the political churchmen, and that timid but respectable body who at all times dread innovation, whether it be in religion or in science, entered into an alliance against the philosophical tyrant who threatened them with the penalties of knowledge.

The party of Galileo, though weak in numbers, was not without power and influence. He had trained around him a devoted band, who idolised his genius and cherished his doctrines. His pupils had been appointed to several of the principal professorships in Italy.

The enemies of religion were on this occasion united with the Christian philosopher; and there were, even in these days, many princes and nobles who had felt the inconvenience of ecclesiastical jurisdiction, and who secretly abetted Galileo in his crusade against established errors.

Although these two parties had been long dreading each others power, and reconnoitring each others position, yet we cannot exactly determine which of them hoisted the first signal for war. The church party, particularly its highest dignitaries, were certainly disposed to rest on the defensive. Flanked on one side by the logic of the schools, and on the other by the popular interpretation of Scripture, and backed by the strong arm of the civil power, they were not disposed to interfere with the prosecution of science, however much they may have dreaded its influence. The philosophers, on the contrary, united the zeal of innovators with that firmness of purpose which truth alone can inspire. Victorious in every contest, they were flushed with success, and they panted for a struggle in which they knew they must triumph.

In this state of warlike preparation Galileo addressed a letter, in 1613, to his friend and pupil, the Abbé Castelli, the object of which was to prove that the Scriptures were not intended to teach us science and philosophy. Hence he inferred, that the language employed in the sacred volume in reference to such subjects should be interpreted only in its common acceptation; and that it was in reality as difficult to reconcile the Ptolemaic as the Copernican system to the expressions which occur in the Bible.

A demonstration was about this time made by the opposite party, in the person of Caccini, a Dominican friar, who made a personal attack upon Galileo from the pulpit. This violent ecclesiastic ridiculed the astronomer and his followers, by addressing them sarcastically in the sacred language of Scripture—“Ye men of *Galilee,* why stand ye here looking up into heaven?” But this species of warfare was disapproved of even by the church; and Luigi Maraffi, the general of the Dominicans, not only apologised to Galileo, who had transmitted to him a formal complaint against Caccini, but expressed the acuteness of his own feelings on being implicated in the “brutal conduct of thirty or forty thousand monks.”

From the character of Caccini, and the part which he afterwards played in the persecution of Galileo, we can scarcely avoid the opinion that his attack from the pulpit was intended as a snare for the unwary philosopher. It roused Galileo from his wonted caution; and stimulated, no doubt, by the nature of the answer which he received from Maraffi, he published a long letter of seventy pages, defending and illustrating his former views respecting the influence of scriptural language on the two contending systems. As if to give the impress of royal authority to this new appeal, he addressed it to Christian, Grand Duchess of Tuscany, the mother of Cosmo; and in this form it seems to have excited a new interest, as if it had expressed the opinion of the grand ducal family. These external circumstances gave additional weight to the powerful and unanswerable reasoning which this letter contains; and it was scarcely possible that any man, possessed of a sound mind, and willing to learn the truth, should refuse his assent to the judicious views of our author. He expresses his belief that the Scriptures were designed to instruct mankind respecting their salvation, and that the faculties of our minds were given us for the purpose of investigating the phenomena of nature. He considers Scripture and nature as proceeding from the same divine author, and, therefore, incapable of speaking a different language; and he points out the absurdity of supposing that professors of astronomy will shut their eyes to the phenomena which they discover in the heavens, or will refuse to believe those deductions of reason which appeal to their judgment with all the power of demonstration. He supports these views by quotations from the ancient fathers; and he refers to the dedication of Copernicus's own work to the Roman Pontiff, Paul III., as a proof that the Pope himself did not regard the new system of the world as hostile to the sacred writings. Copernicus, on the contrary, tells his Holiness, that the reason of inscribing to him his new system was, that the authority of the Pontiff might put to silence the calumnies of some individuals, who attacked it by arguments drawn from passages of Scripture twisted for their own purpose.

It was in vain to meet such reasoning by any other weapons than those of the civil power. The enemies of Galileo saw that they must either crush the dangerous innovation, or allow it the fullest scope; and they determined upon an appeal to the inquisition. Lorini, a monk of the Dominican order, had already denounced to this body Galileo's letter to Castelli; and Caccini, bribed by the mastership of the convent of St Mary of Minerva, was invited to settle at Rome for the purpose of embodying the evidence against Galileo.

Though these plans had been carried on in secret, yet Galileo's suspicions were excited; and he obtained leave from Cosmo to go to Rome about the end of 1615.[29] Here he was lodged in the palace of the Grand Duke's ambassador, and kept up a constant correspondence with the family of his patron at Florence; but, in the midst of this external splendour, he was summoned before the inquisition to answer for the heretical doctrines which he had published. He was charged with maintaining the motion of the earth, and the stability of the sun—with teaching this doctrine to his pupils—with corresponding on the subject with several German mathematicians—and with having published it, and attempted to reconcile it to Scripture, in his letters to Mark Velser in 1612. The inquisition assembled to consider these charges on the 25th of February 1615; and it was decreed that Galileo should be enjoined by Cardinal Bellarmine to renounce the obnoxious doctrines, and to pledge himself that he would neither teach, defend, nor publish them in future. In the event of his refusing to acquiesce in this sentence, it was decreed that he should be thrown into prison. Galileo did not hesitate to yield to this injunction. On the day following, the 26th of February, he appeared before Cardinal Bellarmine, to renounce his heretical opinions; and, having declared that he abandoned the doctrine of the earth's motion, and would neither defend nor teach it, in his conversation or in his writings, he was dismissed from the bar of the inquisition.

Having thus disposed of Galileo, the inquisition conceived the design of condemning the whole system of Copernicus as heretical. Galileo, with more hardihood than prudence, remained at Rome for the purpose of giving his assistance in frustrating this plan; but there is reason to think that he injured by his presence the very cause which he meant to support. The inquisitors had determined to put down the new opinions; and they now inserted among the prohibited books Galileo's letters to Castelli and the Grand Duchess, Kepler's epitome of the Copernican theory, and Copernicus's own work on the revolutions of the heavenly bodies.

Notwithstanding these proceedings, Galileo had an audience of the Pope, Paul V., in

March 1616. He was received very graciously, and spent nearly an hour with his Holiness. When they were about to part, the Pope assured Galileo, that the congregation were not disposed to receive upon light grounds any calumnies which might be propagated by his enemies, and that, as long as he occupied the papal chair, he might consider himself as safe.

These assurances were no doubt founded on the belief that Galileo would adhere to his pledges; but so bold and inconsiderate was he in the expression of his opinions, that even in Rome he was continually engaged in controversial discussions. The following very interesting account of these disputes is given by Querenghi, in a letter to the Cardinal D'Este:—

"Your eminence would be delighted with Galileo if you heard him holding forth, as he often does, in the midst of fifteen or twenty, all violently attacking him, sometimes in one house, sometimes in another. But he is armed after such fashion that he laughs all of them to scorn; and even if the novelty of his opinions prevents entire persuasion, he at least convicts of emptiness most of the arguments with which his adversaries endeavour to overwhelm him. He was particularly admirable on Monday last in the house of Signor Frederico Ghisilieri; and what especially pleased me was, that before replying to the contrary arguments, he amplified and enforced them with new grounds of great plausibility, so as to leave his adversaries in a more ridiculous plight, when he afterwards overturned them all."

The discovery of Jupiter's satellites suggested to Galileo a new method of finding the longitude at sea. Philip III. had encouraged astronomers to direct their attention to this problem, by offering a reward for its solution; and in those days, when new discoveries in science were sometimes rejected as injurious to mankind, it was no common event to see a powerful sovereign courting the assistance of astronomers in promoting the commercial interests of his empire. Galileo seems to have regarded the solution of this problem as an object worthy of his ambition; and he no doubt anticipated the triumph which he would obtain over his enemies, if the Medicean stars, which they had treated with such contempt, could be made subservient to the great interests of mankind. During his residence at Rome in 1615 and 1616, Galileo had communicated his views on this subject to the Comte di Lemos, the Viceroy of Naples, who had presided over the council of the Spanish Indies. This nobleman advised him to apply to the Spanish minister the Duke of Lerma; and, through the influence of the Grand Duke Cosmo, his ambassador at the court of Madrid was engaged to manage the affair. The anxiety of Galileo on this subject was singularly great. He assured the Tuscan ambassador that, in order to accomplish this object, "he was ready to leave all his comforts, his country, his friends, and his family, to cross over into Spain, and to stay as long as he might be wanted at Seville or at Lisbon, or wherever it might be convenient to communicate a knowledge of his method." The lethargy of the Spanish court seems to have increased with the enthusiasm of Galileo; and though the negotiations were occasionally revived for ten or twelve years, yet no steps were taken to bring them to a close. This strange procrastination has been generally ascribed to jealousy or indifference on the part of Spain; but Nelli, one of Galileo's biographers, declares, on the authority of Florentine records, that Cosmo had privately requested from the government the privilege of sending annually to the Spanish Indies two Leghorn merchantmen free of duty, as a compensation for the loss of Galileo!

The failure of this negotiation must have been a source of extreme mortification to the high spirit and sanguine temperament of Galileo. He had calculated, however, too securely on his means of putting the new method to a successful trial. The great imperfection of the time-keepers of that day, and the want of proper telescopes, would have baffled him in all his efforts, and he would have been subject to a more serious mortification from the failure and rejection of his plan, than that which he actually experienced from the avarice of his patron, or the indifference of Spain. Even in the present day, no telescope has been invented which is capable of observing at sea the eclipses of Jupiter’s satellites; and though this method of finding the longitude has great advantages on shore, yet it has been completely abandoned at sea, and superseded by easier and more correct methods.

In the year 1618, when no fewer than *three* comets visited our system, and attracted the attention of all the astronomers of Europe, Galileo was unfortunately confined to his bed by a severe illness; but, though he was unable to make a single observation upon these remarkable bodies, he contrived to involve himself in the controversies which they occasioned. Marco Guiducci, an astronomer of Florence, and a friend of Galileo, had delivered a discourse on comets before the Florentine Academy. The heads of this discourse, which was published in 1619,[30] were supposed to have been communicated to him by Galileo, and this seems to have been universally admitted during the controversy to which it gave rise. The opinion maintained in this treatise, that comets are nothing but meteors which occasionally appear in our atmosphere, like halos and rainbows, savours so little of the sagacity of Galileo that we should be disposed to question its paternity. His inability to partake in the general interest which these three comets excited, and to employ his powerful telescope in observing their phenomena, and their movements, might have had some slight share in the formation of an opinion which deprived them of their importance as celestial bodies. But, however this may have been, the treatise of Guiducci afforded a favourable point of attack to Galileo’s enemies, and the dangerous task was entrusted to Horatio Grassi, a learned Jesuit, who, in a work entitled *The Astronomical and Philosophical Balance*, criticised the discourse on comets, under the feigned name of Lotario Sarsi.

Galileo replied to this attack in a volume entitled *Il Saggiatore*, or *The Assayer*, which, owing to the state of his health, was not published till the autumn of 1623.[31] This work was written in the form of a letter to Virginio Cesarini, a member of the Lyncæan Academy, and master of the chamber to Urban VIII., who had just ascended the papal throne. It was dedicated to the Pontiff himself, and has been long celebrated among literary men for the beauty of its language, though it is doubtless one of the least important of Galileo’s writings.

CHAPTER V.

Urban VIII., Galileo's friend, raised to the Pontificate—Galileo goes to Rome to offer his congratulations—The Pope loads Galileo with presents, and promises a Pension to his Son—Galileo in pecuniary difficulties, owing to the death of his patron, Cosmo—Galileo again rashly attacks the Church, notwithstanding the Pope's kindness—He composes his System of the World, to demonstrate the Copernican System—Artfully obtains a license to print it—Nature of the work—Its influence on the public mind—The Pope resolves on suppressing it—Galileo summoned before the Inquisition—His Trial—His Defence—His formal abjuration of his opinions—Observations on his conduct—The Pope shews great indulgence to Galileo, who is allowed to return to his own house at Arcetri, as the place of his confinement.

The succession of the Cardinal Maffeo Barberini to the papal throne, under the name of Urban VIII., was hailed by Galileo and his friends as an event favourable to the promotion of science. Urban had not only been the personal friend of Galileo and of Prince Cesi, the founder of the Lyncæan Academy, but had been intimately connected with that able and liberal association; and it was therefore deemed prudent to secure his favour and attachment. If Paul III. had, nearly a century before, patronised Copernicus, and accepted of the dedication of his great work, it was not unreasonable to expect that, in more enlightened times, another Pontiff might exhibit the same liberality to science.

The plan of securing to Galileo the patronage of Urban VIII. seems to have been devised by Prince Cesi. Although Galileo had not been able for some years to travel, excepting in a litter, yet he was urged by the Prince to perform a journey to Rome, for the express purpose of congratulating his friend upon his elevation to the papal chair. This request was made in October 1623; and though Galileo's health was not such as to authorise him to undergo so much fatigue, yet he felt the importance of the advice, and, after visiting Cesi at Acqua Sparta, he arrived at Rome in the spring of 1624. The reception which he here experienced far exceeded his most sanguine expectations. During the two months which he spent in the capital he was permitted to have no fewer than six long and gratifying audiences of the Pope. The kindness of his Holiness was of the most marked description. He not only loaded Galileo with presents,[32] and promised him a pension for his son Vincenzo, but he wrote a letter to Ferdinand, who had just succeeded Cosmo as Grand Duke of Tuscany, recommending Galileo to his particular patronage. "For we find in him," says he, "not only literary distinction, but the love of piety; and he is strong in those qualities by which Pontifical good-will is easily obtained. And now, when he has been brought to this city to congratulate us on our elevation, we have very lovingly embraced him; nor can we suffer him to return to the country whither your liberality recalls him, without an ample provision of Pontifical love. And that you may know how dear he is to us, we have willed to give him this honourable testimonial of virtue and piety. And we further signify, that every benefit which you shall confer upon him, imitating or even surpassing your father's liberality, will conduce to our gratification."

Not content with thus securing the friendship of the Pope, Galileo endeavoured to bespeak the good-will of the Cardinals towards the Copernican system. He had, accordingly, many interviews with several of these dignitaries; and he was assured, by Cardinal Hohenzoller, that in a representation which he had made to the Pope on the subject of Copernicus, he stated to his Holiness, "that as all the heretics considered that system as undoubted, it would be necessary to be very circumspect in coming to any resolution on the subject.” To this remark his Holiness replied—“that the church had not condemned this system; and that it should not be condemned as heretical, but only as rash;” and he added, “that there was no fear of any person undertaking to prove that it must necessarily be true.”

The recent appointment of the Abbé Castelli, the friend and pupil of Galileo, to be mathematician to the Pope, was an event of a most gratifying nature; and when we recollect that it was to Castelli that he addressed the famous letter which was pronounced heretical by the Inquisition, we must regard it also as an event indicative of a new and favourable feeling towards the friends of science. The opinions of Urban, indeed, had suffered no change. He was one of the few Cardinals who had opposed the inquisitorial decree of 1616, and his subsequent demeanour was in every respect conformable to the liberality of his early views. The sincerity of his conduct was still further evinced by the grant of a pension of one hundred crowns to Galileo, a few years after his visit to Rome; though there is reason to think that this allowance was not regularly paid.

The death of Cosmo, whose liberality had given him both affluence and leisure, threatened Galileo with pecuniary difficulties. He had been involved in a “great load of debt,” owing to the circumstances of his brother’s family; and, in order to relieve himself, he had requested Castelli to dispose of the pension of his son Vincenzo. In addition to this calamity he was now alarmed at the prospect of losing his salary as an extraordinary professor at Pisa. The great youth of Ferdinand, who was scarcely of age, induced Galileo’s enemies, in 1629, to raise doubts respecting the payment of a salary to a professor who neither resided nor lectured in the university; but the question was decided in his favour, and we have no doubt that the decision was facilitated by the friendly recommendation of the Pope, to which we have already referred.

Although Galileo had made a narrow escape from the grasp of the Inquisition, yet he was never sufficiently sensible of the lenity which he experienced. When he left Rome in 1616, under the solemn pledge of never again teaching the obnoxious doctrine, it was with a hostility against the church, suppressed but deeply cherished; and his resolution to propagate the heresy seems to have been coeval with the vow by which he renounced it. In the year 1618, when he communicated his theory of the tides to the Archduke Leopold, he alludes in the most sarcastic manner to the conduct of the church. The same hostile tone, more or less, pervaded all his writings, and, while he laboured to sharpen the edge of his satire, he endeavoured to guard himself against its effects, by an affectation of the humblest deference to the decisions of theology. Had Galileo stood alone, his devotion to science might have withdrawn him from so hopeless a contest; but he was spurred on by the violence of a party. The Lyncæan Academy never scrupled to summon him from his researches. They placed him in the forlorn hope of their combat, and he at last fell a victim to the rashness of his friends.

But whatever allowance we may make for the ardour of Galileo’s temper, and the peculiarity of his position; and however we may justify and even approve of his past conduct, his visit to Urban VIII., in 1624, placed him in a new relation to the church, which demanded on his part a new and corresponding demeanour. The noble and generous reception which he met with from Urban, and the liberal declaration of Cardinal Hohenzoller on the subject of the Copernican system, should have been regarded as expressions of regret for the past, and offers of conciliation for the future. Thus honoured by the head of the church, and befriended by its dignitaries, Galileo must have felt himself secure against the indignities of its lesser functionaries, and in the possession of the fullest license to prosecute his researches and publish his discoveries, provided he avoided that dogma of the church which, even in the present day, it has not ventured to renounce. But Galileo was bound to the Romish hierarchy by even stronger ties. His son and himself were pensioners of the church, and, having accepted of its alms, they owed to it, at least, a decent and respectful allegiance. The pension thus given by Urban was not a remuneration which sovereigns sometimes award to the services of their subjects. Galileo was a foreigner at Rome. The sovereign of the papal state owed him no obligation; and hence we must regard the pension of Galileo as a donation from the Roman Pontiff to science itself, and as a declaration to the Christian world that religion was not jealous of philosophy, and that the church of Rome was willing to respect and foster even the genius of its enemies.

Galileo viewed all these circumstances in a different light. He resolved to compose a work in which the Copernican system should be demonstrated; but he had not the courage to do this in a direct and open manner. He adopted the plan of discussing the subject in a dialogue between three speakers, in the hope of eluding by this artifice the censure of the church. This work was completed in 1630, but, owing to some difficulties in obtaining a license to print it, it was not published till 1632.

In obtaining this license, Galileo exhibited considerable address, and his memory has not escaped from the imputation of having acted unfairly, and of having involved his personal friends in the consequences of his imprudence.

The situation of master of the palace was, fortunately for Galileo’s designs, filled by Nicolo Riccardi, a friend and pupil of his own. This officer was a sort of censor of new publications, and when he was applied to on the subject of printing his work, Galileo soon found that attempts had previously been made to thwart his views. He instantly set off for Rome, and had an interview with his friend, who was in every respect anxious to oblige him. Riccardi examined the manuscript, pointed out some incautious expressions which he considered it necessary to erase, and returned it with his written approbation, on the understanding that the alterations he suggested would be made. Dreading to remain in Rome during the unhealthy season, which was fast approaching, Galileo returned to Florence, with the intention of completing the index and dedication, and of sending the MS. to Rome, to be printed under the care of Prince Cesi. The death of that distinguished individual, in August 1630, frustrated Galileo’s plan, and he applied for leave to have the book printed in Florence. Riccardi was at first desirous to examine the MS. again, but, after inspecting only the beginning and the end of it, he gave Galileo leave to print it wherever he chose, providing it bore the license of the Inquisitor-General of Florence, and one or two other persons whom he named.

Having overcome all these difficulties, Galileo’s work was published in 1632, under the title of “*The System of the World of Galileo Galilei*, &c., in which, in four dialogues concerning the two principal systems of the world—the Ptolemaic and the Copernican—he discusses, indeterminately and firmly, the arguments proposed on both sides.” It is dedicated to Ferdinand, Grand Duke of Tuscany, and is prefaced by an “Address to the prudent reader,” which is itself characterised by the utmost imprudence. He refers to the decree of the Inquisition in the most insulting and ironical language. He attributes it to passion and to ignorance, not by direct assertion, but by insinuations ascribed to others; and he announces his intention to defend the Copernican system, as a pure mathematical hypothesis, and not as an opinion having an advantage over that of the stability of the earth absolutely. The dialogue is conducted by three persons, Salviati, Sagredo, and Simplicio. Salviati, who is the true philosopher in the dialogue, was the real name of a nobleman whom we have already had occasion to mention. Sagredo, the name of another noble friend of Galileo's, performs a secondary part under Salviati. He proposes doubts, suggests difficulties, and enlivens the gravity of the dialogue with his wit and pleasantry. Simplicio is a resolute follower of Ptolemy and Aristotle, and, with a proper degree of candour and modesty, he brings forward all the common arguments in favour of the Ptolemaic system. Between the wit of Sagredo, and the powerful philosophy of Salviati, the peripatetic sage is baffled in every discussion; and there can be no doubt that Galileo aimed a more fatal blow at the Ptolemaic system by this mode of discussing it, than if he had endeavoured to overturn it by direct arguments.

The influence of this work on the public mind was such as might have been anticipated. The obnoxious doctrines which it upheld were eagerly received, and widely disseminated; and the church of Rome became sensible of the shock which was thus given to its intellectual supremacy. Pope Urban VIII., attached though he had been to Galileo, never once hesitated respecting the line of conduct which he felt himself bound to pursue. His mind was, nevertheless, agitated with conflicting sentiments. He entertained a sincere affection for science and literature, and yet he was placed in the position of their enemy. He had been the personal friend of Galileo, and yet his duty compelled him to become his accuser. Embarrassing as these feelings were, other considerations contributed to soothe him. He had, in his capacity of a Cardinal, opposed the first persecution of Galileo. He had, since his elevation to the pontificate, traced an open path for the march of Galileo's discoveries; and he had finally endeavoured to bind the recusant philosopher by the chains of kindness and gratitude. All these means, however, had proved abortive, and he was now called upon to support the doctrine which he had subscribed, and administer the law of which he was the guardian.

It has been supposed, without any satisfactory evidence, that Urban may have been influenced by less creditable motives. Salviati and Sagredo being well-known personages, it was inferred that Simplicio must also have a representative. The enemies of Galileo are said to have convinced his Holiness that Simplicio was intended as a portraiture of himself; and this opinion received some probability from the fact, that the peripatetic disputant had employed many of the arguments which Urban had himself used in his discussions with Galileo. The latest biographer of Galileo[33] regards this motive as necessary to account for "the otherwise inexplicable change which took place in the conduct of Urban to his old friend;"—but we cannot admit the truth of this supposition. The church had been placed in hostility to a powerful and liberal party, which was adverse to its interests. The dogmas of the Catholic faith had been brought into direct collision with the deductions of science. The leader of the philosophic band had broken the most solemn armistice with the Inquisition: he had renounced the ties of gratitude which bound him to the Pontiff; and Urban was thus compelled to entrench himself in a position to which he had been driven by his opponents.

The design of summoning Galileo before the Inquisition, seems to have been formed almost immediately after the publication of his book; for even in August 1632, the preliminary proceedings had reached the ears of the Grand Duke Ferdinand. The Tuscan ambassador at Rome was speedily acquainted with the dissatisfaction which his Sovereign felt at these proceedings; and he was instructed to forward to Florence a written statement of the charges against Galileo, in order to enable him to prepare for his defence. Although this request was denied, Ferdinand again interposed, and transmitted a letter to his ambassador, recommending the admission of Campanella and Castelli into the congregation of ecclesiastics by whom Galileo was to be judged. Circumstances, however, rendered it prudent to withhold this letter. Castelli was sent away from Rome, and Scipio Chiaramonte, a bigotted ecclesiastic, was summoned from Pisa to complete the number of the judges.

It appears from a despatch of the Tuscan minister, that Ferdinand was enraged at the transaction; and he instructed his ambassador, Niccolini, to make the strongest representations to the Pope. Niccolini had several interviews with his Holiness; but all his expostulations were fruitless. He found Urban highly incensed against Galileo; and his Holiness begged Niccolini to advise the Archduke not to interfere any farther, as he would not "get through it with honour." On the 15th of September the Pope caused it to be intimated to Niccolini, as a mark of his especial esteem for the Grand Duke, that he was obliged to refer the work to the Inquisition; but both the prince and his ambassador were declared liable to the usual censures if they divulged the secret.

From the measures which this tribunal had formerly pursued, it was not difficult to foresee the result of their present deliberations. They summoned Galileo to appear before them at Rome, to answer in person the charges under which he lay. The Tuscan ambassador expostulated warmly with the court of Rome on the inhumanity of this proceeding. He urged his advanced age, his infirm health, the discomforts of the journey, and the miseries of the quarantine,[34] as motives for reconsidering their decision: But the Pope was inexorable, and though it was agreed to relax the quarantine as much as possible in his favour, yet it was declared indispensable that he should appear in person before the Inquisition.

Worn out with age and infirmities, and exhausted with the fatigues of his journey, Galileo arrived at Rome on the 14th of February, 1633. The Tuscan ambassador announced his arrival in an official form to the commissary of the holy office, and Galileo awaited in calm dignity the approach of his trial. Among those who proffered their advice in this distressing emergency, we must enumerate the Cardinal Barberino, the Pope's nephew, who, though he may have felt the necessity of an interference on the part of the church, was yet desirous that it should be effected with the least injury to Galileo and to science. He accordingly visited Galileo, and advised him to remain as much at home as possible, to keep aloof from general society, and to see only his most intimate friends. The same advice was given from different quarters; and Galileo, feeling its propriety, remained in strict seclusion in the palace of the Tuscan ambassador.

During the whole of the trial which had now commenced, Galileo was treated with the most marked indulgence. Abhorring, as we must do, the principles and practice of this odious tribunal, and reprobating its interference with the cautious deductions of science, we must yet admit that, on this occasion, its deliberations were not dictated by passion, nor its power directed by vengeance. Though placed at their judgment-seat as a heretic, Galileo stood there with the recognised attributes of a sage; and though an offender against the laws of which they were the guardian, yet the highest respect was yielded to his genius, and the kindest commiseration to his infirmities.

In the beginning of April, when his examination in person was to commence, it became necessary that he should be removed to the holy office; but instead of committing him, as was the practice, to solitary confinement, he was provided with apartments in the house of the fiscal of the Inquisition. His table was provided by the Tuscan ambassador, and his servant was allowed to attend him at his pleasure, and to sleep in an adjoining apartment. Even this nominal confinement, however, Galileo's high spirit was unable to brook. An attack of the disease to which he was constitutionally subject contributed to fret and irritate him, and he became impatient for a release from his anxiety as well as from his bondage. Cardinal Barberino seems to have received notice of the state of Galileo's feelings, and, with a magnanimity which posterity will ever honour, he liberated the philosopher on his own responsibility; and in ten days after his first examination, and on the last day of April, he was restored to the hospitable roof of the Tuscan ambassador.

Though this favour was granted on the condition of his remaining in strict seclusion, Galileo recovered his health, and to a certain degree his usual hilarity, amid the kind attentions of Niccolini and his family; and when the want of exercise had begun to produce symptoms of indisposition, the Tuscan minister obtained for him leave to go into the public gardens in a half-closed carriage.

After the Inquisition had examined Galileo personally, they allowed him a reasonable time for preparing his defence. He felt the difficulty of adducing any thing like a plausible justification of his conduct; and he resorted to an ingenious, though a shallow artifice, which was regarded by the court as an aggravation of the crime. After his first appearance before the Inquisition in 1616, he was publicly and falsely charged by his enemies with having then abjured his opinions; and he was taunted as a criminal who had been actually punished for his offences. As a refutation of these calumnies, Cardinal Bellarmine had given him a certificate in his own handwriting, declaring that he neither abjured his opinions, nor suffered punishment for them; and that the doctrine of the earth's motion, and the sun's stability, was only denounced to him as contrary to Scripture, and as one which could not be defended. To this certificate the Cardinal did not add, because he was not called upon to do it, that Galileo was enjoined not *to teach in any manner* the doctrine thus denounced; and Galileo ingeniously avails himself of this supposed omission, to account for his having, in the lapse of fourteen or sixteen years, forgotten the injunction. He assigned the same excuse for his having omitted to mention this injunction to Riccardi, and to the Inquisitor-General at Florence, when he obtained the licence to print his Dialogues. The court held the production of this certificate to be at once a proof and an aggravation of his offence, because the certificate itself declared that the obnoxious doctrines had been pronounced contrary to the Holy Scriptures.

Having duly weighed the confessions and excuses of their prisoner, and considered the general merits of the case, the Inquisition came to an agreement upon the sentence which they were to pronounce, and appointed the 22d of June as the day on which it was to be delivered. Two days previous to this, Galileo was summoned to appear at the holy office; and on the morning of the 21st, he obeyed the summons. On the 22d of June he was clothed in a penitential dress, and conducted to the convent of Minerva, where the Inquisition was assembled to give judgment. A long and elaborate sentence was pronounced, detailing the former proceedings of the Inquisition, and specifying the offences which he had committed in teaching heretical doctrines, in violating his former pledges, and in obtaining by improper means a license for the printing of his Dialogues. After an invocation of the name of our Saviour, and of the Holy Virgin, Galileo is declared to have brought himself under strong suspicions of heresy, and to have incurred all the censures and penalties which are enjoined against delinquents of this kind; but from all these consequences he is to be held absolved, provided that with a sincere heart, and a faith unfeigned, he abjures and curses the heresies he has cherished, as well as every other heresy against the Catholic church. In order that his offence might not go altogether unpunished, that he might be more cautious in future, and be a warning to others to abstain from similar delinquencies, it was also decreed that his Dialogues should be prohibited by public edict; that he himself should be condemned to the prison of the Inquisition during their pleasure, and that, in the course of the next three years, he should recite once a week the seven penitential psalms.

The ceremony of Galileo's abjuration was one of exciting interest, and of awful formality. Clothed in the sackcloth of a repentant criminal, the venerable sage fell upon his knees before the assembled Cardinals; and laying his hands upon the Holy Evangelists, he invoked the Divine aid in abjuring and detesting, and vowing never again to teach, the doctrine of the earth's motion, and of the sun's stability. He pledged himself that he would never again, either in words or in writing, propagate such heresies; and he swore that he would fulfil and observe the penances which had been inflicted upon him.[35] At the conclusion of this ceremony, in which he recited his abjuration word for word, and then signed it, he was conveyed, in conformity with his sentence, to the prison of the Inquisition.

The account which we have now given of the trial and the sentence of Galileo, is pregnant with the deepest interest and instruction. Human nature is here drawn in its darkest colouring; and in surveying the melancholy picture, it is difficult to decide whether religion or philosophy has been most degraded. While we witness the presumptuous priest pronouncing infallible the decrees of his own erring judgment, we see the high-minded philosopher abjuring the eternal and immutable truths which he had himself the glory of establishing. In the ignorance and prejudices of the age—in a too literal interpretation of the language of Scripture—in a mistaken respect for the errors that had become venerable from their antiquity—and in the peculiar position which Galileo had taken among the avowed enemies of the church, we may find the elements of an apology, poor though it be, for the conduct of the Inquisition. But what excuse can we devise for the humiliating confession and abjuration of Galileo? Why did this master-spirit of the age—this high-priest of the stars—this representative of science—this hoary sage, whose career of glory was near its consummation—why did he reject the crown of martyrdom which he had himself coveted, and which, plaited with immortal laurels, was about to descend upon his head? If, in place of disavowing the laws of Nature, and surrendering in his own person the intellectual dignity of his species, he had boldly asserted the truth of his opinions, and confided his character to posterity, and his cause to an all-ruling Providence, he would have strung up the hair-suspended sabre, and disarmed for ever the hostility which threatened to overwhelm him. The philosopher, however, was supported only by philosophy; and in the love of truth he found a miserable substitute for the hopes of the martyr. Galileo cowered under the fear of man, and his submission was the salvation of the church. The sword of the Inquisition descended on his prostrate neck; and though its stroke was not physical, yet it fell with a moral influence fatal to the character of its victim, and to the dignity of science.

In studying with attention this portion of scientific history, the reader will not fail to perceive that the Church of Rome was driven into a dilemma, from which the submission and abjuration of Galileo could alone extricate it. He who confesses a crime and denounces its atrocity, not only sanctions but inflicts the punishment which is annexed to it. Had Galileo declared his innocence, and avowed his sentiments, and had he appealed to the past conduct of the Church itself, to the acknowledged opinions of its dignitaries, and even to the acts of its pontiffs, he would have at once confounded his accusers, and escaped from their toils. After Copernicus, himself a catholic priest, had *openly* maintained the motion of the earth, and the stability of the sun:—after he had dedicated the work which advocated these opinions to Pope Paul III., on the express ground that the *authority of the pontiff* might silence the calumnies of those who attacked these opinions by arguments drawn from Scripture:—after the Cardinal Schonberg and the Bishop of Culm had urged Copernicus to publish the new doctrines;—and after the Bishop of Ermeland had erected a monument to commemorate his great discoveries;—how could the Church of Rome have appealed to its pontifical decrees as the ground of persecuting and punishing Galileo? Even in later times, the same doctrines had been propagated with entire toleration: Nay, in the very year of Galileo’s first persecution, Paul Anthony Foscarinus, a learned Carmelite monk, wrote a pamphlet, in which he illustrates and defends the mobility of the earth, and endeavours to reconcile to this new doctrine the passages of Scripture which had been employed to subvert it. This very singular production was dated from the Carmelite convent at Naples; was dedicated to the very reverend Sebastian Fantoni, general of the Carmelite order; and, sanctioned by the ecclesiastical authorities, it was published at Naples in 1615, the very year of the first persecution of Galileo.

Nor was this the only defence of the Copernican system which issued from the bosom of the Church. Thomas Campanella, a Calabrian monk, published, in 1622, “*An Apology for Galileo*,” and he even dedicates it to D. Boniface, Cardinal of Cajeta. Nay, it appears from the dedication, that he undertook the work at the command of the Cardinal, and that the examination of the question had been entrusted to the Cardinal by the Holy Senate. After an able defence of his friend, Campanella refers, at the conclusion of his apology, to the suppression of Galileo’s writings, and justly observes, that the effect of such a measure would be to make them more generally read, and more highly esteemed. The boldness of the apologist, however, is wisely tempered with the humility of the ecclesiastic, and he concludes his work with the declaration, that in all his opinions, whether written or to be written, he submits himself to the opinions of the Holy Mother Church of Rome and to the judgment of his superiors.

By these proceedings of the dignitaries, as well as the clergy of the Church of Rome, which had been tolerated for more than a century, the decrees of the pontiffs against the doctrine of the earth’s motion were virtually repealed; and Galileo might have pleaded them with success in arrest of judgment. Unfortunately, however, for himself and for science, he acted otherwise. By admitting their authority, he revived in fresh force these obsolete and obnoxious enactments; and, by yielding to their power, he riveted for another century the almost broken chains of spiritual despotism.

It is a curious fact in the annals of heresy and sedition, that opinions maintained with impunity by one individual, have, in the same age, brought others to the stake or to the scaffold. The results of deep research or extravagant speculation seldom provoke hostility, when meekly announced as the deductions of reason or the convictions of conscience. As the dreams of a recluse or of an enthusiast, they may excite pity or call forth contempt; but, like seed quietly cast into the earth, they will rot and germinate according to the vitality with which they are endowed. But, if new and startling opinions are thrown in the face of the community—if they are uttered in triumph or in insult—in contempt of public opinion, or in derision of cherished errors, they lose the comeliness of truth in the rancour of their propagation; and they are like seed scattered in a hurricane, which only irritates and blinds the husbandman. Had Galileo concluded his *System of the World* with the quiet peroration of his apologist Campanella, and dedicated it to the Pope, it might have stood in the library of the Vatican, beside the cherished though equally heretical volume of Copernicus.

In the abjuration of his opinions by Galileo, Pope Urban VII. did not fail to observe the full extent of his triumph; and he exhibited the utmost sagacity in the means which he employed to secure it. While he endeavoured to overawe the enemies of the church by the formal promulgation of Galileo’s sentence and abjuration, and by punishing the officials who had assisted in obtaining the license to print his work, he treated Galileo with the utmost lenity, and yielded to every request that was made to diminish, and almost suspend, the constraint under which he lay. The sentence of abjuration was ordered to be publicly read at several universities. At Florence the ceremonial was performed in the church of Santa Croce, and the friends and disciples of Galileo were especially summoned to witness the public degradation of their master. The inquisitor at Florence was ordered to be reprimanded for his conduct; and Riccardi, the master of the sacred palace, and Ciampoli, the secretary of Pope Urban himself, were dismissed from their situations.

Galileo had remained only four days in the prison of the Inquisition, when, on the application of Niccolini, the Tuscan ambassador, he was allowed to reside with him in his palace. As Florence still suffered under the contagious disease which we have already mentioned, it was proposed that Sienna should be the place of Galileo’s confinement, and that his residence should be in one of the convents of that city. Niccolini, however, recommended the palace of the Archbishop Piccolomoni as a more suitable residence; and though the Archbishop was one of Galileo’s best friends, the Pope agreed to the arrangement, and in the beginning of July Galileo quitted Rome for Sienna.

After having spent nearly six months under the hospitable roof of his friend, with no other restraint than that of being confined to the limits of the palace, Galileo was permitted to return to his villa near Florence under the same restrictions; and as the contagious disease had disappeared in Tuscany, he was able in the month of December to re-enter his own house at Arcetri, where he spent the remainder of his days.

CHAPTER VI.

Galileo loses his favourite Daughter—He falls into a state of melancholy and ill health—Is allowed to go to Florence for its recovery in 1638—But is prevented from leaving his House or receiving his Friends—His friend Castelli permitted to visit him in the presence of an Officer of the Inquisition—He composes his celebrated Dialogues on Local Motion—Discovers the Moon's Libration—Loses the sight of one Eye—The other Eye attacked by the same Disease—Is struck blind—Negociates with the Dutch Government respecting his Method of finding the Longitude—He is allowed free intercourse with his Friends—His Illness and Death in 1642—His Epitaph—His Social, Moral, and Scientific Character.

Although Galileo had now the happiness of rejoining his family under their paternal roof, yet, like all sublunary blessings, it was but of short duration. His favourite daughter Maria, who along with her sister had joined the convent of St Matthew in the neighbourhood of Arcetri, had looked forward to the arrival of her father with the most affectionate anticipations. She hoped that her filial devotion might form some compensation for the malignity of his enemies, and she eagerly assumed the labour of reciting weekly the seven penitentiary psalms which formed part of her father's sentence. These sacred duties, however, were destined to terminate almost at the moment they were begun. She was seized with a fatal illness in the same month in which she rejoined her parent, and before the month of April she was no more. This heavy blow, so suddenly struck, overwhelmed Galileo in the deepest agony. Owing to the decline of his health, and the recurrence of his old complaints, he was unable to oppose to this mental suffering the constitutional energy of his mind. The bulwarks of his heart broke down, and a flood of grief desolated his manly and powerful mind. He felt, as he expressed it, that he was incessantly called by his daughter—his pulse intermitted—his heart was agitated with unceasing palpitations—his appetite entirely left him, and he considered his dissolution so near at hand, that he would not permit his son Vicenzo to set out upon a journey which he had contemplated.

From this state of melancholy and indisposition, Galileo slowly, though partially, recovered, and, with the view of obtaining medical assistance, he requested leave to go to Florence. His enemies, however, refused this application, and he was given to understand that any additional importunities would be visited with a more vigilant surveillance. He remained, therefore, five years at Arcetri, from 1634 to 1638, without any remission of his confinement, and pursuing his studies under the influence of a continued and general indisposition.

There is no reason to think that Galileo or his friends renewed their application to the Church of Rome; but, in 1638, the Pope transmitted, through the Inquisitor Fariano, his permission that he might remove to Florence for the recovery of his health, on the condition that he should present himself at the office of the Inquisitor to learn the terms upon which this indulgence was granted. Galileo accepted of the kindness thus unexpectedly proffered. But the conditions upon which it was given were more severe than he expected. He was prohibited from leaving his house or admitting his friends; and so sternly was this system pursued, that he required a special order for attending mass during passion week.

The severity of this order was keenly felt by Galileo. While he remained at Arcetri, his seclusion from the world would have been an object of choice, if it had not been the decree of a tribunal; but to be debarred from the conversation of his friends in Florence—in that city where his genius had been idolised, and where his fame had become immortal, was an aggravation of punishment which he was unable to bear. With his accustomed kindness, the Grand Duke made a strong representation on the subject to his ambassador at the Court of Rome. He stated that, from his great age and infirmities, Galileo's career was near its close; that he possessed many valuable ideas, which the world might lose if they were not matured and conveyed to his friends; and that Galileo was anxious to make these communications to Father Castelli, who was then a stipendiary of the Court of Rome. The Grand Duke commanded his ambassador to see Castelli on the subject—to urge him to obtain leave from the Pope to spend a few months in Florence—and to supply him with money and every thing that was necessary for his journey. Influenced by this kind and liberal message, Castelli obtained an audience of the Pope, and requested leave to pay a visit to Florence. Urban instantly suspected the object of his journey; and, upon Castelli's acknowledging that he could not possibly refrain from seeing Galileo, he received permission to visit him in the company of an officer of the Inquisition. Castelli accordingly went to Florence, and, a few months afterwards, Galileo was ordered to return to Arcetri.

During Galileo's confinement at Sienna and Arcetri, between 1633 and 1638, his time was principally occupied in the composition of his "Dialogues on Local Motion," in which he treats of the strength and cohesion of solid bodies, of the laws of uniform and accelerated motions, of the motion of projectiles, and of the centre of gravity of solids. This remarkable work, which was considered by its author as the best of his productions, was printed by Louis Elzevir, at Amsterdam, and dedicated to the Count de Noailles, the French ambassador at Rome. Various attempts to have it printed in Germany had failed; and, in order to save himself from the malignity of his enemies, he was obliged to pretend that the edition published in Holland had been printed from a MS. entrusted to the French ambassador.

Although Galileo had for a long time abandoned his astronomical studies, yet his attention was directed, about the year 1636, to a curious appearance in the lunar disc, which is known by the name of the moon's libration. When we examine with a telescope the outline of the moon, we observe that certain parts of her disc, which are seen at one time, are invisible at another. This change or libration is of four different kinds, viz. the diurnal libration, the libration in longitude, the libration in latitude, and the spheroidal libration. Galileo discovered the first of these kinds of libration, and appears to have had some knowledge of the second; but the third was discovered by Hevelius, and the fourth by Lagrange.

This curious discovery was the result of the last telescopic observations of Galileo. Although his right eye had for some years lost its power, yet his general vision was sufficiently perfect to enable him to carry on his usual researches. In 1636, however, this affection of his eye became more serious; and, in 1637, his left eye was attacked with the same disease. His medical friends at first supposed that cataracts were formed in the crystalline lens, and anticipated a cure from the operation of couching. These hopes were fallacious. The disease turned out to be in the cornea, and every attempt to restore its transparency was fruitless. In a few months the white cloud covered the whole aperture of the pupil, and Galileo became totally blind. This sudden and unexpected calamity had almost overwhelmed Galileo and his friends. In writing to a correspondent he exclaims, “Alas! your dear friend and servant has become totally and irreparably blind. These heavens, this earth, this universe, which by wonderful observation I had enlarged a thousand times beyond the belief of past ages, are henceforth shrunk into the narrow space which I myself occupy. So it pleases God; it shall, therefore, please me also.” His friend, Father Castelli, deplores the calamity in the same tone of pathetic sublimity:—“The noblest eye,” says he, “which nature ever made, is darkened; an eye so privileged, and gifted with such rare powers, that it may truly be said to have seen more than the eyes of all that are gone, and to have opened the eyes of all that are to come.”

Although Galileo had been thwarted in his attempt to introduce into the Spanish marine his new method of finding the longitude at sea, yet he never lost sight of an object to which he attached the highest importance. As the formation of correct tables of the motion of Jupiter’s satellites was a necessary preliminary to its introduction, he had occupied himself for twenty-four years in observations for this purpose, and he had made considerable progress in this laborious task. After the publication of his “Dialogues on Motion,” in 1636, he renewed his attempts to bring his method into actual use. For this purpose he addressed himself to Lorenzo Real, who had been the Dutch Governor-General in India, and offered the free use of his method to the States-General of Holland.[36] The Dutch government received this proposal with an anxious desire to have it carried into effect. At the instigation of Constantine Huygens, the father of the illustrious Huygens, and the secretary to the Prince of Orange, they appointed commissioners to communicate with Galileo; and while they transmitted him a gold chain as a mark of their esteem, they at the same time assured him, that if his plan should prove successful it should not pass unrewarded. The commissioners entered into an active correspondence with Galileo, and had even appointed one of their number to communicate personally with him in Italy. Lest this, however, should excite the jealousy of the court of Rome, Galileo objected to the arrangement, so that the negociation was carried on solely by correspondence.

It was at this time that Galileo was struck with blindness. His friend and pupil, Renieri, undertook in this emergency to arrange and complete his observations and calculations; but before he had made much progress in the arduous task, each of the four commissioners died in succession, and it was with great difficulty that Constantine Huygens succeeded in renewing the scheme. It was again obstructed, however, by the death of Galileo; and when Renieri was about to publish, by the order of the Grand Duke, the “Ephemeris,” and “Tables of the Jovian Planets,” he was attacked with a mortal disease, and the manuscripts of Galileo, which he was on the eve of publishing, were never more heard of. By such a series of misfortunes were the plans of Galileo and of the States-General completely overthrown. It is some consolation, however, to know that neither science nor navigation suffered any severe loss. Notwithstanding the perfection of our present tables of Jupiter’s satellites, and of the astronomical instruments by which their eclipses may be observed, the method of Galileo is still impracticable at sea.

In consequence of the strict seclusion to which Galileo had been subjected, he was in the practice of dating his letters from his prison at Arcetri; but after he had lost the use of his eyes, the Inquisition seems to have relaxed its severity, and to have allowed him the freest intercourse with his friends. The Grand Duke of Tuscany paid him frequent visits; and among the celebrated strangers who came from distant lands to see the ornament of Italy, were Gassendi, Deodati, and our illustrious countryman Milton. During the last three years of his life, his eminent pupil Viviani formed one of his family; and in October 1641, the celebrated Torricelli, another of his pupils, was admitted to the same distinction.

Though the powerful mind of Galileo still retained its vigour, yet his debilitated frame was exhausted with mental labour. He often complained that his head was too busy for his body; and the continuity of his studies was frequently broken with attacks of hypochondria, want of sleep, and acute rheumatic pains. Along with these calamities, he was afflicted with another still more severe—with deafness almost total; but though he was now excluded from all communication with the external world, yet his mind still grappled with the material universe, and while he was studying the force of percussion, and preparing for a continuation of his "Dialogues on Motion," he was attacked with fever and palpitation of the heart, which, after continuing two months, terminated fatally on the 8th of January 1642, in the 78th year of his age.

Having died in the character of a prisoner of the Inquisition, this odious tribunal disputed his right of making a will, and of being buried in consecrated ground. These objections, however, were withdrawn; but though a large sum was subscribed for erecting a monument to him in the church of Santa Croce, in Florence, the Pope would not permit the design to be carried into execution. His sacred remains were, therefore, deposited in an obscure corner of the church, and remained for more than thirty years unmarked with any monumental tablet. The following epitaph, given without any remark in the Leyden edition of his Dialogues, is, we presume, the one which was inscribed on a tablet in the church of Santa Croce:—

Galilæo Galilæi Florentino,
Philosopho et Geometræ vere lynceo,
Naturæ Œdipo,
Mirabilium semper inventorum machinatori,
Qui inconcessa adhuc mortalibus gloria
Cælorum provincias auxit
Et universo dedit incrementum:
Non enim vitreos spherarum orbes
Fragilesque stellas conflavit:
Sed æterna mundi corpore
Mediceæ beneficentiæ dedicavit,
Cujus inextincta gloriæ cupiditas
Ut oculos nationum
Sæculorumque omnium
Videre doceret,
Proprios impendit oculos.
Cum jam nil amplius haberet natura
Quod ipse videret.
Cujus inventa vix intra rerum limites comprehensa
Firmamentum ipsum non solum continet,
Sed etiam recipit.

Qui relictis tot scientiarum monumentis
Plura secum tulit, quam reliquit.
Gravi enim
Sed nondum affecta senectute,
Novis contemplationibus
Majorem gloriam affectans
Inexplebilem sapientiæ animam
Immaturo nobis obitu
Exhalavit
Anno Domini
MCXLII.
Ætatis suæ
LXXVIII.

At his death, in 1703, Viviani purchased his property, with the charge of erecting a monument over Galileo's remains and his own. This design was not carried into effect till 1737, at the expense of the family of Nelli, when both their bodies were disinterred, and removed to the site of the splendid monument which now covers them. This monument contains the bust of Galileo, with figures of Geometry and Astronomy. It was designed by Giulio Foggini. Galileo's bust was executed by Giovanni Battista Foggini; the figure of Astronomy by Vincenzio Foggini, his son; and that of Geometry by Girolamo Ticciati.

Galileo's house at Arcetri still remains. In 1821 it belonged to one Signor Alimari, having been preserved in the state in which it was left by Galileo; it stands very near the convent of St Matthew, and about a mile to the S. E. of Florence. An inscription by Nelli, over the door of the house, still remains.

The character of Galileo, whether we view him as a member of the social circle, or as a man of science, presents many interesting and instructive points of contemplation. Unfortunate, and to a certain extent immoral, in his domestic relations, he did not derive from that hallowed source all the enjoyments which it generally yields; and it was owing to this cause, perhaps, that he was more fond of society than might have been expected from his studious habits. His habitual cheerfulness and gaiety, and his affability and frankness of manner, rendered him an universal favourite among his friends. Without any of the pedantry of exclusive talent, and without any of that ostentation which often marks the man of limited though profound acquirements, Galileo never conversed upon scientific or philosophical subjects except among those who were capable of understanding them. The extent of his general information, indeed, his great literary knowledge, but, above all, his retentive memory, stored with the legends and the poetry of ancient times, saved him from the necessity of drawing upon his own peculiar studies for the topics of his conversation.

Galileo was not less distinguished for his hospitality and benevolence; he was liberal to the poor, and generous in the aid which he administered to men of genius and talent, who often found a comfortable asylum under his roof. In his domestic economy he was frugal without being parsimonious. His hospitable board was ever ready for the reception of his friends; and, though he was himself abstemious in his diet, he seems to have been a lover of good wines, of which he received always the choicest varieties out of the Grand

Duke's cellar. This peculiar taste, together with his attachment to a country life, rendered him fond of agricultural pursuits, and induced him to devote his leisure hours to the cultivation of his vineyards.

In his personal appearance Galileo was about the middle size, and of a square-built, but well-proportioned, frame. His complexion was fair, his eyes penetrating, and his hair of a reddish hue. His expression was cheerful and animated, and though his temper was easily ruffled, yet the excitement was transient, and the cause of it speedily forgotten.

One of the most prominent traits in the character of Galileo was his invincible love of truth, and his abhorrence of that spiritual despotism which had so long brooded over Europe. His views, however, were too liberal, and too far in advance of the age which he adorned; and however much we may admire the noble spirit which he evinced, and the personal sacrifices which he made, in his struggle for truth, we must yet lament the hotness of his zeal and the temerity of his onset. In his contest with the Church of Rome, he fell under her victorious banner; and though his cause was that of truth, and hers that of superstition, yet the sympathy of Europe was not roused by his misfortunes. Under the sagacious and peaceful sway of Copernicus, astronomy had effected a glorious triumph over the dogmas of the Church; but under the bold and uncompromising sceptre of Galileo all her conquests were irrecoverably lost.

The scientific character of Galileo, and his method of investigating truth, demand our warmest admiration. The number and ingenuity of his inventions, the brilliant discoveries which he made in the heavens, and the depth and beauty of his researches respecting the laws of motion, have gained him the admiration of every succeeding age, and have placed him next to Newton in the lists of original and inventive genius. To this high rank he was doubtless elevated by the inductive processes which he followed in all his inquiries. Under the sure guidance of observation and experiment, he advanced to general laws; and if Bacon had never lived, the student of nature Would have found, in the writings and labours of Galileo, not only the boasted principles of the inductive philosophy, but also their practical application to the highest efforts of invention and discovery.

LIFE OF TYCHO BRAHE.

CHAPTER I.

Tycho's Birth, Family, and Education—An Eclipse of the Sun turns his attention to Astronomy—Studies Law at Leipsic—But pursues Astronomy by stealth—His Uncle's Death—He returns to Copenhagen, and resumes his Observations—Revisits Germany—Fights a Duel, and loses his Nose—Visits Augsburg, and meets Hainzel—Who assists him in making a large Quadrant—Revisits Denmark—And is warmly received by the King—He settles at his Uncle's Castle of Herritzvold—His Observatory and Laboratory—Discovers the new Star in Cassiopeia—Account of this remarkable Body—Tycho's Marriage with a Peasant Girl—Which irritates his Friends—His Lectures on Astronomy—He visits the Prince of Hesse—Attends the Coronation of the Emperor Rudolph at Ratisbon—He returns to Denmark.

Among the distinguished men who were destined to revive the sciences, and to establish the true system of the universe, Tycho Brahe holds a conspicuous place. He was born on the 14th December 1546, at Knudstorp, the estate of his ancestors, which is situated near Helsingborg, in Scania, and was the eldest son and the second child of a family of five sons and five daughters. His father, Otto Brahe, who was descended from a noble Swedish family, was in such straitened circumstances, that he resolved to educate his sons for the military profession; but Tycho seems to have disliked the choice that was made for him; and his next brother, Steno, who appears to have had a similar feeling, exchanged the sword for the more peaceful occupation of Privy Councillor to the King. The rest of his brothers, though of senatorial rank, do not seem to have extended the renown of their family; but their youngest sister, Sophia, is represented as an accomplished mathematician, and is said to have devoted her mind to astronomy as well as to the astrological reveries of the age.

George Brahe, the brother of Otto, having no children of his own, resolved to adopt and to educate one of his nephews. On the birth of Tycho, accordingly, he was desirous of having him placed under his wife's care; but his parents could not be prevailed upon to part with their child till after the birth of Steno, their second son.

Having been instructed in reading and writing under proper masters, Tycho began the study of Latin in his seventh year; and, in opposition to his father's views, he prosecuted it for five years under private teachers, from whom he received also occasional instruction in poetry and the belles lettres.

In April 1559, about three years after his father's death, Tycho was sent to the University of Copenhagen, to study rhetoric and philosophy, with the view of preparing for the study of the law, and qualifying himself for some of those political offices which his rank entitled him to expect. In this situation he contracted no fondness for any particular study; but after he had been sixteen months at college, an event occurred which directed all the powers of his mind to the science of astronomy. The attention of the public had been long fixed on a great eclipse of the sun, which was to happen on the 21st August 1560; and as in those days a phenomenon of this kind was linked with the destinies of nations as well as of individuals, the interest which it excited was as intense as it was general. Tycho watched its arrival with peculiar anxiety. He read the astrological diaries of the day, in which its phases and its consequences were described; and when he saw the sun darkened at the very moment that had been predicted, and to the very extent that had been delineated, he resolved to make himself master of a science which was capable of predicting future events, and especially that branch of it which connected these events with the fortunes and destinies of man. With this view he purchased the *Tabulæ Bergenses*, calculated by John Stadius, and began with ardour the study of the planetary motions.

When Tycho had completed his course at Copenhagen, he was sent, in February 1562, under the charge of a tutor to study jurisprudence at Leipsic. Astronomy, however, engrossed all his thoughts; and he had no sooner escaped from the daily surveillance of his master, than he rushed with headlong impetuosity into his favourite pursuits. With his pocket money he purchased astronomical books, which he read in secret; and by means of a celestial globe, the size of his fist, he made himself acquainted with the stars, and followed them night after night through the heavens, when sleep had lulled the vigilance of his preceptor. By means of the Ephemerides of Stadius, he learned to distinguish the planets, and to trace them through their direct and retrograde movements; and having obtained the Alphonsine and Prutenic Tables, and compared his own calculations and observations with those of Stadius, he observed great differences in the results, and from that moment he seems to have conceived the design of devoting his life to the accurate construction of tables, which he justly regarded as the basis of astronomy.

With this view, he applied himself secretly to the study of arithmetic and geometry; and, without the assistance of a master, he acquired that mathematical knowledge which enabled him to realise these early aspirations. His ardour for astronomy was still farther inflamed, and the resolution which it inspired still farther strengthened, by the great conjunction of Jupiter and Saturn, which took place in August 1563. The calculated time of this phenomenon differed considerably from the true time which was observed; and in determining the instant of conjunction Tycho felt in the strongest manner the imperfection of the instruments which he used. For this purpose he employed a sort of compass, one leg of which was directed to one planet and the second to the other planet or fixed star; and, by measuring the angular opening between them, he determined the distance of the two celestial bodies. By this rude contrivance he found that the Alphonsine Tables erred a whole month in the time of conjunction, while the Copernican ones were at least several days in error. To this celebrated conjunction Tycho ascribed the great plague which in subsequent years desolated Europe, because it took place in the beginning of *Leo*, and not far from the nebulous stars of *Cancer*, two of the zodiacal signs which are reckoned by Ptolemy “suffocating and pestilent!”

There dwelt at this time at Leipsic an ingenious artisan named Scultetus, who was employed by Homelius, the professor of mathematics in that city, to assist him in the construction of his instruments. Having become acquainted with this young man, Tycho put into his hand a wooden radius, such as was recommended by Gemma Frisius, for the purpose of having it divided in the manner adopted by Homelius; and with this improved instrument he made a great number of astronomical observations out of his window, without ever exciting the suspicions of his tutor.

Having spent three years at Leipsic, he was about to make the tour of Germany, when, in consequence of his uncle’s death, he was summoned to his native country to inherit the fortune which had been left him. He accordingly quitted Leipsic about the middle of May 1565, and after having arranged his domestic concerns in Denmark, he continued his astronomical observations with the radius constructed for him by Scultetus. The ardour with which he pursued his studies gave great umbrage to his friends as well as to his relations. He was reproached for having abandoned the profession of the law; his astronomical observations were ridiculed as not only useless but degrading, and, among his numerous connexions, his maternal uncle, Steno Bille, was the only one who applauded him for following the bent of his genius. Under these uncomfortable circumstances he resolved to quit his country, and pay a visit to the most interesting cities of Germany.

At Wittemberg, where he arrived in April 1566, he resumed his astronomical observations; but, in consequence of the plague having broken out in that city, he removed to Rostoch in the following autumn. Here an accident occurred which had nearly deprived him of his life. On the 10th December he was invited to a wedding feast; and, among other guests, there was present a noble countryman of his own, Manderupius Pasbergius. Some difference having arisen between them on this occasion, they parted with feelings of mutual displeasure. On the 27th of the same month they met again at some festive games, and having revived their former quarrel, they agreed to settle their differences by the sword. They accordingly met at 7 o’clock in the evening of the 29th, and fought in total darkness. In this blind combat, Manderupius cut off the whole of the front of Tycho’s nose, and it was fortunate for astronomy that his more valuable organs were defended by so faithful an outpost. The quarrel, which is said to have originated in a difference of opinion respecting their mathematical acquirements, terminated here; and Tycho repaired his loss by cementing upon his face a nose of gold and silver, which is said to have formed a good imitation of the original.

During the years 1567 and 1568, Tycho continued to reside at Rostoch, with the exception of a few months, during which he made a rapid journey into Denmark. He lived in a house in the college of the Jesuits, which he had rented on account of its fitness for celestial observations; but, though he intended to spend the winter under its roof, he had made no arrangement respecting his future life, leaving it, as he said, in the hands of Providence. A desire, however, to visit the south of Germany induced him to quit Rostoch, and having crossed the Danube, he paid a visit to Augsburg.

Upon entering this ancient city, Tycho was particularly struck with the grandeur of its fortifications, the splendour of its private houses, and the beauty of its fountains; and, after a short residence within its walls, he was still more delighted with the industry of the people, the refinement of the higher classes, and the love of literature and science which was cherished by its wealthy citizens. Among the interesting acquaintances which he formed at Augsburg, were two brothers, John and Paul Hainzel, the one a septemvir, and the other the consul or burgomaster. They were both distinguished by their learning, and both of them, particularly Paul, were ardent lovers of astronomy. Tycho had hitherto no other astronomical instrument than the coarse radius which was made for him by Scultetus, and he waited only for a proper occasion to have a larger and better instrument constructed for his use. Having now the command of workmen who could execute his plans, he conceived the bold design of making a divided instrument which should distinctly exhibit single minutes of a degree. While he was transferring the first rude conception of his instrument to paper, Paul Hainzel entered his study, and was so struck with the grandeur of the plan, that he instantly undertook to have it executed at his own expense. The projected instrument was a quadrant of fourteen cubits radius! and Tycho and his friend entered upon its construction with that intense ardour which is ever crowned with success.

In the village of Gegginga, about half a mile to the south of the city, Paul Hainzel had a country house, the garden of which was chosen as the spot where the quadrant was to be fixed. The best artists in Augsburg, clockmakers, jewellers, smiths, and carpenters, were engaged to execute the work, and from the zeal which so novel an instrument inspired, the quadrant was completed in less than a month. Its size was so great that twenty men could with difficulty transport it to its place of fixture. The two principal rectangular radii were beams of oak; the arch which lay between their extremities was made of solid wood of a particular kind, and the whole was bound together by twelve beams. It received additional strength from several iron bands, and the arch was covered with plates of brass, for the purpose of receiving the 5400 divisions into which it was to be subdivided. A large and strong pillar of oak, shod with iron, was driven into the ground, and kept in its place by solid mason work. To this pillar the quadrant was fixed in a vertical plane, and steps were prepared to elevate the observer, when stars of a low altitude required his attention. As the instrument could not be conveniently covered with a roof, it was protected from the weather by a covering made of skins, but notwithstanding this and other precautions, it was broken to pieces by a violent storm, after having remained uninjured for the space of five years.

As this quadrant was fitted only to determine the altitudes of the celestial bodies, Tycho constructed a large sextant for the purpose of measuring their distances. It consisted of two radii, which opened and shut round a centre, and which were nearly four cubits long, and also of two arches, one of which was graduated, while the other served to keep the radii in the same plane. After the radii had been opened or shut till they nearly comprehended the angle between the stars to be observed, the adjustment was completed by means of a very fine tangent screw. With this instrument Tycho made many excellent observations during his stay at Augsburg. He began also the construction of a wooden globe about six feet in diameter. Its outer surface was turned with great accuracy into a sphere, and kept from warping by interior bars of wood supported at its centre.

After receiving a visit from the celebrated Peter Ramus, who subsequently fell a victim at the massacre of St Bartholomew, Tycho left Augsburg, having received a promise from his friend Hainzel that he would communicate to him the observations made with his large quadrant, and with the sextant which he had given him in a present. He paid a visit to Philip Appian in passing through Ingolstadt, and returned to his native country about the end of 1571.

The fame which he had acquired as an astronomer procured for him a warmer reception than that which he had formerly experienced. The King invited him to court, and his friends and admirers loaded him with kindness. His uncle, Steno Bille, who now lived at the ancient convent of Herritzvold, and who had always taken a deep interest in the scientific character of his nephew, not only invited him to his house, but assigned to him for an observatory the part of it which was best adapted for that purpose. Tycho cheerfully accepted of this liberal offer. The immediate proximity of Herritzvold to Knudstorp, rendered this arrangement peculiarly convenient, and in the house of his uncle he experienced all that kindness and consideration which natural affection and a love of science combined to cherish. When Steno learned that the study of chemistry was one of the pursuits of his nephew, he granted him a spacious house, a few yards distant from the convent, for his laboratory. Tycho lost no time in fitting up his observatory, and in providing his furnaces; and regarding gold and silver and the other metals as the stars of the earth, he used to represent his two opposite pursuits as forming only one science, namely, celestial and terrestrial astronomy.

In the hopes of enriching himself by the pursuits of alchemy, Tycho devoted most of his attention to those satellites of gold and silver which now constituted his own system, and which disturbed by their powerful action the hitherto uniform movements of their primary. His affections were ever turning to Germany, where astronomers of kindred views, and artists of surpassing talent were to be found in almost every city. The want of money alone prevented him from realizing his wishes; and it was in the hope of attaining the means of travelling, that he in a great measure forsook his sextants for his crucibles. In order, however, that he might have one good instrument in his observatory, he constructed a sextant similar to, but somewhat larger than, that which he had presented to Hainzel. Its limb was made of solid brass, and was exquisitely divided into single minutes of a degree. Its radii were strengthened with plates of brass, and the apparatus for opening and shutting them was made with great accuracy.

The possession of this instrument was peculiarly fortunate for Tycho, for an event now occurred which roused him from his golden visions, and directed all his faculties into their earlier and purer current. On the 11th November 1572, when he was returning to supper from his laboratory, the clearness of the sky inspired him with the desire of completing some particular observations. On looking up to the starry firmament he was surprised to see an extraordinary light in the constellation of Cassiopeia, which was then above his head. He felt confident that he had never before observed such a star in that constellation, and distrusting the evidence of his own senses, he called out the servants and the peasants, and having received their testimony that it was a huge star such as they had never seen before, he was satisfied of the correctness of his own vision. Regarding it as a new and unusual phenomenon, he hastened to his observatory, adjusted his sextant, and measured its distances from the nearest stars in Cassiopeia. He noted also its form, its magnitude, its light, and its colour, and he waited with great anxiety for the next night that he might determine the important point whether it was a fixed star, or a body within, or near to, our own system.

For several years Tycho had been in the practice of calculating, at the beginning of each year, a sort of almanac for his own use, and in this he inserted all the observations which he had made on the new star, and the conclusions which he had drawn from them. Having gone to Copenhagen in the course of the ensuing spring, he shewed this manuscript to John Pratensis, a Professor, in whose house he was always hospitably received. Charles Danzeus, the French ambassador, and a person of great learning, having heard of Tycho’s arrival, invited himself to dine with him at the house of Pratensis. The conversation soon turned upon the new star, and Tycho found his companion very sceptical about its existence. Danzeus was particularly jocular on the subject, and attacked the Danes for their inattention to so important a science as astronomy. Tycho received this lecture in good temper, and with the anxious expectation that a clear sky would enable him to give a practical refutation of the attack which was made upon his country. The night turned out serene, and the whole party saw with astonishment the new star under the most favourable circumstances. Pratensis conceived that it was similar to the one observed by Hipparchus, and urged Tycho to publish the observations which he had made upon it. Tycho refused to accede to this request, on the pretext that his work was not sufficiently perfect; but the true reason, as he afterwards acknowledged, was, that he considered it would be a disgrace for a nobleman, either to study such subjects, or to communicate them to the public. This absurd notion was with some difficulty overcome, and through the earnest entreaties and assistance of Pratensis, his work on the new star was published in 1573.

This remarkable body presents to us one of the most interesting phenomena in astronomy. The date of its first appearance has not been exactly ascertained. Tycho saw it on the 11th November, but Cornelius Gemma had seen it on the 9th, Paul Hainzel saw it on the 7th of August at Augsburg, and Wolfgangus Schulerus observed it at Wittenberg on the 6th. Tycho conjectures that it was first seen on the 5th, and Hieronymus Munosius asserts that at Valentia, in Spain, it was not seen on the 2d, when he was shewing that part of the heavens to his pupils. This singular body continued to be seen during 16 months, and did not disappear till March 1574. In its appearance it was exactly like a star, having none of the distinctive marks of a comet. It twinkled strongly, and grew larger than *Lyra* or *Sirius*, or any other fixed star. It seemed to be somewhat larger than *Jupiter*, when he is nearest the earth, and rivalled *Venus* in her greatest brightness. In the *first* month of its appearance it was less than Jupiter; in the *second* it equalled him; in the *third* it surpassed him in splendour; in the *fourth* it was equal to *Sirius*; in the *fifth* to *Lyra*; in the *sixth* and *seventh* to stars of the *second* magnitude; in the *eighth*, *ninth*, and *tenth*, to stars of the *third* magnitude; in the *eleventh*, *twelfth*, and *thirteenth*, to stars of the *fourth* magnitude; in the *fourteenth* and *fifteenth* to stars of the *fifth* magnitude; and in the *sixteenth* month to stars of the *sixth* magnitude. After this it became so small that it at last disappeared. Its colour changed also with its size. At first it was white and bright; in the third month it began to become yellowish; in the fifth it became reddish like Aldebaran; and in the seventh and eighth it became bluish like Saturn; growing afterwards duller and duller. Its place in the heavens was invariable. Its longitude was in the 6th degree and 54th minute of Taurus; and its latitude 53° 45′ north. Its right ascension was 0° 26⅖′ and its declination 61° 46¾′. It had no parallax, and was unquestionably situated in the region of the fixed stars.

After Tycho had published his book, he proposed to travel into Germany and Italy, but he was seized with a fever, and he had no sooner recovered from it, than he became involved in a love affair, which frustrated all his schemes. Although Tycho was afraid of casting a stain upon his nobility by publishing his observations on the new star, yet he did not scruple to debase his lineage by marrying a peasant girl of the village of Knudstorp. This event took place in 1573, and in 1574 his wife gave birth to his daughter Magdalene. Tycho’s noble relations were deeply offended at this imprudent step; and so far did the mutual animosity of the parties extend, that the King himself was obliged to effect a reconciliation.

The fame of our author as an astronomer and mathematician was now so high, that several young Danish nobles requested him to deliver a course of lectures upon these interesting subjects. This application was seconded by Pratensis, Danzeus, and all his best friends; but their solicitations were vain. The King at last made the request in a way which ensured its being granted, and Tycho delivered a course of lectures, in which he not only gave a full view of the science of astronomy, but defended and explained all the reveries of astrology.

Having finished his lectures, and arranged his domestic affairs, he set out on his projected journey about the beginning of the spring of 1575, leaving behind him his wife and daughter, till he should fix upon a place of permanent residence. The first town which he visited was Hesse-Cassel, the residence of William, Landgrave of Hesse, whose patronage of astronomy, and whose skill in making celestial observations, have immortalized his name. Here Tycho spent eight or ten delightful days, during which the two astronomers were occupied one half of the day in scientific conversation, and the other half in astronomical observations; and he would have prolonged a visit which gave him so much pleasure, had not the death of one of the Landgrave's daughters interrupted their labours. Passing through Frankfort, Tycho went into Switzerland; and, after visiting many cities on his way, he fixed upon Basle as a place of residence, not only from its centrical position, but from the salubrity of the air, and the cheapness of living. From Switzerland he went to Venice, and, in returning through Germany, he came to Ratisbon, at the time of the congress, which had been called together on the 1st of November, for the coronation of the Emperor Rudolph. On this occasion he met with several distinguished individuals, who were not only skilled in astronomy, but who were among its warmest patrons. From Ratisbon he passed to Saalfeld, and thence to Wittemburg, where he saw the parallactic instruments and the wooden quadrant which had been used by John Pratensis in determining the latitude of the city, and in measuring the altitudes of the new star.

Tycho was now impatient for home, and he lost no time in returning to Denmark, where events were awaiting him which frustrated all his schemes, by placing him in the most favourable situation for promoting his own happiness, and advancing the interests of astronomy.

CHAPTER II.

Frederick II. patronises Tycho—And resolves to establish him in Denmark—Grants him the Island of Huen for Life—And Builds the splendid Observatory of Uraniburg—Description of the Island, and of the Observatory—Account of its Astronomical Instruments—Tycho begins his Observations—His Pupils—Tycho is made Canon of Rothschild, and receives a large Pension—His Hospitality to his Visitors—Ingratitude of Witichius—Tycho sends an Assistant to take the Latitude of Frauenburg and Konigsberg—Is visited by Ulric, Duke of Mecklenburg—Change in Tycho's fortunes.

The patronage which had been extended to astronomers by several of the reigning princes of Germany, especially by the Landgrave of Hesse, and Augustus, Elector of Saxony, had begun to excite a love of science in the minds of other sovereigns. The King of Denmark seems to have felt it as a stain upon his character, that the only astronomer in his dominions should carry on his observations in distant kingdoms and adorn by his discoveries other courts than his own. With this feeling he sent ambassadors to Hesse-Cassel to inquire after Tycho, and to intimate to him his wish that he should return to Denmark, and his anxiety to promote the advancement of astronomy in his own dominions. Tycho had left Cassel when these messengers arrived, and had heard nothing of the King's intentions till he was about to quit Knudstorp with his family for Basle. At this time he was surprised at the arrival of a noble messenger, who brought a letter requesting him to meet the King as soon as possible at Copenhagen. Tycho lost no time in obeying the royal summons. The King received him with the most flattering kindness. He offered to give him a grant for life of the island of Huen, between Denmark and Sweden, and to construct and furnish with instruments, at his own expense, an observatory, as well as a house for the accommodation of his family, together with a laboratory for carrying on his chemical inquiries. Tycho, who truly loved his country, was deeply affected with the munificence of the royal offer. He accepted of it with that warmth of gratitude which it was calculated to inspire; and he particularly rejoiced in the thought that if any success should attend his future labours, the glory of it would belong to his native land.

The island of Huen is about sxix miles from the coast of Zealand, three from that of Sweden, and fourteen from Copenhagen. It is six miles in circumference, and rises into the form of a mountain, which, though very high, terminates in a plain. It is nowhere rocky, and even in the time of Tycho it produced the best kinds of grain, afforded excellent pasturage for horses, cattle, and sheep, and possessed deer, hares, rabbits, and partridges in abundance. It contained at that time only one village, with about forty inhabitants.

Having surveyed his new territory, Tycho resolved to build a magnificent tower in the centre of the elevated plain, which he resolved to call Uraniburg, or *The City of the Heavens*. Having made the necessary arrangements, he repaired to the island on the 8th of August, and his friend Charles Danzeus laid the foundation stone of the new observatory, which consisted of a slab of porphyry, with the following inscription:—

> Regnante in Dania Frederico II., Carolus Danzæus Aquitanus R. G. I. D. L.,[37] Domui huic Philosophiæ, imprimisque Astrorum contemplationi, Regis decreto a nobili viro Tychone Brahe de Knudstrup extructæ votivum hunc lapidem memoriæ et felicis auspicii ergo P. Anno CIC.IC.LXXVI. VI Id. Augusti.

This ceremony was performed early in the morning of a splendid day, in which the rising sun threw its blessing upon Frederick, and upon the party of noblemen and philosophers who had assembled to testify their love of science. An entertainment was provided for the occasion, and copious libations of a variety of wines were offered for the success of the undertaking.

The observatory was surrounded by a rampart, each face of which was three hundred feet long. About the middle of each face the rampart became a semicircle, the inner diameter of which was ninety feet. The height of the rampart was twenty-two feet, and its thickness at the base twenty. Its four angles corresponded exactly with the four cardinal points, and at the north and south angles were erected turrets, of which one was a printing-house, and the other the residence of the servants. Gates were erected at the east and west angles, and above them were apartments for the reception of strangers. Within the rampart was a shrubbery with about three hundred varieties of trees; and at the centre of each semicircular part of the rampart was a bower or summer-house. This shrubbery surrounded the flower-garden, which was terminated within by a circular wall about forty-five feet high, which enclosed a more elevated area, in the centre of which stood the principal building in the observatory, and from which four paths led to the above-mentioned angles, with as many doors for entering the garden.

The principal building was about sixty feet square. The doors were placed on the east and west sides; and to the north and south fronts were attached two round towers, whose inner diameter was about thirty-two feet, and which formed the observatories which had windows in their roof, that could be opened towards any part of the heavens. The accommodations for the family were numerous and splendid. Under the observatory, in the south tower, was the museum and library, and below this again was the laboratory in a subterraneous crypt, containing sixteen furnaces of various kinds. Beneath this was a well forty feet deep, from which water was distributed by syphons to every part of the building.

Besides the principal building there were other two situated without the rampart, one to the north, containing a workshop for the construction of astronomical and other instruments, and the other to the south, which was occupied as a sort of farm-house. These buildings cost the King of Denmark 100,000 rix-dollars (£20,000), and Tycho is said to have expended upon them a similar sum.

As the two towers could not accommodate the instruments which Tycho required for his observations, he found it necessary to erect, on the hill about sixty paces to the south of Uraniburg, a subterranean observatory, in which he might place his larger instruments, which required to be firmly fixed, and to be protected from the wind and the weather. This observatory, which he called Stiern-berg, or the mountain, of the stars, consisted of several crypts, separated by solid walls, and to these there was a subterranean passage from the laboratory in Uraniburg. The various buildings which Tycho erected were built in a regular style of architecture, and were highly ornamented, not only with external decorations, but with the statues and pictures of the most distinguished astronomers, from Hipparchus and Ptolemy down to Copernicus, and with inscriptions and poems in honour of astronomers.

While these buildings were erecting, and after their completion, Tycho was busily occupied in preparing instruments for observation. These were of the most splendid description, and the reader will form some notion of their grandeur and their expense from the following list:—

In the south and greater Observatory.

1. A semicircle of solid iron, covered with brass, four cubits radius.
2. A sextant of the same materials and size.
3. A quadrant of one and a half cubits radius, and an azimuth circle of three cubits.
4. Ptolemy’s parallactic rules, covered with brass, four cubits in the side.
5. The sextant already described in page 134.
6. Another quadrant, like No. 3.
7. Zodiacal armillaries of melted brass, and turned out of the solid, of three cubits in diameter.

Near this observatory was a large clock, with one wheel two cubits in diameter, and two smaller ones, which, like it, indicated hours, minutes, and seconds.

In the south and lesser Observatory.

8. An armillary sphere of brass, with a steel meridian, whose diameter was about 4 cubits.

In the north Observatory.

9. Brass parallactic rules, which revolved in azimuth above a brass horizon, twelve feet in diameter.
10. A half sextant, of four cubits radius.
11. A steel sextant.
12. Another half sextant, with steel limb, four cubits radius.
13. The parallactic rules of Copernicus.
14. Equatorial armillaries.
15. A quadrant of a solid plate of brass, five cubits in radius, shewing every ten seconds.
16. In the museum was the large globe made at Augsburg, see p. 134.

In the Stiern-berg Observatory.

17. In the central part, a large semicircle, with a brass limb, and three clocks, shewing hours, minutes, and seconds.
18. Equatorial armillaries of seven cubits, with semi-armillaries of nine cubits.
19. A sextant of four cubits radius.
20. A geometrical square of iron, with an intercepted quadrant of five cubits, and divided into fifteen seconds.
21. A quadrant of four cubits radius, shewing ten seconds, with an azimuth circle.
22. Zodiacal armillaries of brass, with steel meridians, three cubits in diameter.
23. A sextant of brass, kept together by screws, and capable of being taken to pieces for travelling with. Its radius was four cubits.
24. A moveable armillary sphere, three cubits in diameter.
25. A quadrant of solid brass, one cubit radius, and divided into minutes by Nonian circles.
26. An astronomical radius of solid brass, three cubits long.
27. An astronomical ring of brass, a cubit in diameter.
28. A small brass astrolabe.

In almost all the instruments now enumerated, the limb was subdivided by diagonal lines, a method which Tycho first brought into use, but which, in modern times, has been superseded by the inventions of Nonius and Vernier.

When Tycho had thus furnished his observatory, he devoted himself to the examination of the stars; and during the twenty-one years which he spent in this delightful occupation, he made vast additions to astronomical science. In order to instruct the young in the art of observation, and educate assistants for his observatory, he had sometimes under his roof from six to twelve pupils, whom he boarded and educated. Some of these were named by the King, and educated at his expense. Others were sent by different academies and cities; and several, who had presented themselves of their own accord, were liberally admitted by the generous astronomer.

As Tycho had spent nearly a ton of gold (about 100,000 dollars) in his outlay at Uraniburg, his own income was reduced to very narrow limits. To supply this defect, Frederick gave him an annual pension of 2000 dollars, beside an estate in Norway, and made him Canon of the Episcopal Church of Rothschild, or Prebend of St Laurence,[38] which had an annual income of 1000 dollars, and which was burdened only with the expense of keeping up the chapel containing the Mausolea of the Kings of the family of Oldenburg.

It would be an unprofitable task, and one by no means interesting to the general reader, to give a detailed history of the various astronomical observations and discoveries which were made by Tycho during the twenty years that he spent at Uraniburg. Every phenomenon that appeared in the heavens, he observed with the greatest care; while he at the same time carried on regular series of observations for determining the places of the fixed stars, and for improving the tables of the sun, moon, and planets. Though almost wholly devoted to these noble pursuits, yet he kept an open house, and received, with unbounded hospitality, the crowds of philosophers, nobles, and princes who came to be introduced to the first astronomer of the age, and to admire the splendid temple which the Danish Sovereign had consecrated to science.

Among the strangers whom he received under his roof, there were some who returned his kindness with ingratitude. Among these was Paul Witichius, a mathematician; who, under the pretence of devoting his whole life to astronomy, insinuated himself into the utmost familiarity with Tycho. The unsuspecting astronomer explained to his guest all his inventions, described all his methods, and even made him acquainted with those views which he had not realised, and with instruments which he had not yet executed. When Witichius had thus obtained possession of the methods, and inventions, and views of Tycho, and had enjoyed his hospitality for three months, he pretended that he was obliged to return to Germany to receive an inheritance to which he had succeeded. After quitting Uraniburg, this ungrateful mathematician neither returned to see Tycho, nor kept up any correspondence with him; and it was not till five years after his departure that Tycho learned, from the letters of the Prince of Hesse to Ranzau, that Witichius had passed through Hesse, and had described, as his own, the various inventions and methods which had been shewn to him in Huen.

Being unable to reconcile his own observations with those of Copernicus, and with the Prutenic Tables, Tycho resolved to obtain new determinations of the latitude of Frauenburg, in Prussia, where Copernicus made his observations, and of Konigsberg, to the meridian of which Rheinhold had adapted his Prutenic Tables. For these purposes he sent one of his assistants, Elias Morsianus, with a proper instrument, under the protection of Bylovius, Ambassador of the Margrave of Anspach, to the King of Denmark, who was returning by sea to Germany; and after receiving the greatest attention and assistance from the noble Canons of Ermeland, he determined, from nearly a month’s observations on the sun and stars, that the latitude of Frauenburg was 54° 22½´, in place of 54° 19½´, as given by Copernicus. In like manner he determined that the latitude of Konigsberg was 54° 43´, in place of 54° 17´, as adopted by Rheinhold. When Morsianus returned to Huen in July, he brought with him, as a present to Tycho, from John Hannovius, one of the Canons of

Ermeland, the Ptolemaic Rules, or the Parallactic Instrument which Copernicus had used and made with his own hands. It consisted of two equal wooden rules, five cubits long, and divided into 1414 parts. Tycho preserved this gift as one peculiarly dear to him, and, on the day of his receiving it, he composed a set of verses in honour of the great astronomer to whom it belonged.

Among the distinguished visits which were paid to Tycho, we must enumerate that of Ulric, Duke of Mecklenburg, in 1586. Although his daughter, Sophia, Queen of Denmark, had already paid two visits to Uraniburg in the same year, yet such was her love of astronomy, that she accompanied her father and his wife Elizabeth on this occasion. Ulric was not only fond of science in general, but had for many years devoted himself to chemical pursuits, and he was therefore peculiarly gratified in examining the splendid laboratory and extensive apparatus which Tycho possessed. It has been said by some of the biographers of Tycho, that the Landgrave of Hesse visited Uraniburg about this period; but this opinion is not correct, as it was only his astronomer and optician, Rothman, who made a journey to Huen in 1591 for the recovery of his health. Tycho had long carried on a correspondence with this able astronomer respecting the observations made at the observatory of Hesse-Cassel, and, during the few months which they now spent together, they discussed in the amplest manner all the questions which had previously been agitated. Rothman was astonished at the wonderful apparatus which he saw at Uraniburg, and returned to his native country charmed with the hospitality of the Danish astronomer.

Hitherto we have followed Tycho through a career of almost unexampled prosperity. When he had scarcely reached his thirtieth year he was established, by the kindness and liberality of his sovereign, in the most splendid observatory that had ever been erected in Europe; and a thriving family, an ample income, and a widely extended reputation were added to his blessings. Of the value of these gifts he was deeply sensible, and he enjoyed them the more that he received them with a grateful heart. Tycho was a christian as well as a philosopher. The powers of his gifted mind have been amply displayed in his astronomical labours; but we shall now have occasion to witness his piety and resignation in submitting to an unexpected and an adverse destiny.

CHAPTER III.

Tycho's Labours do honour to his Country—Death of Frederick II.—James VI. of Scotland visits Tycho at Uraniburg—Christian IV. visits Tycho—The Duke of Brunswick's visit to Tycho—The Danish Nobility, jealous of his fame, conspire against him—He is compelled to quit Uraniburg—And to abandon his Studies—Cruelty of the Minister Walchendorp—Tycho quits Denmark with his Family and Instruments—Is hospitably received by Count Rantzau—Who introduces him to the Emperor Rudolph—The Emperor invites him to Prague—He gives him a Pension of 3000 Crowns—And the Castle of Benach as a Residence and an Observatory—Kepler visits Tycho—Who obtains for him the Appointment of Mathematician to Rudolph.

The love of astronomy which had been so unequivocally exhibited by Frederick II. and his Royal Consort, inspired their courtiers with at least an outward respect for science; and among the ministers and advisers of the King, Tycho reckoned many ardent friends. It was every where felt that Denmark had elevated herself among the nations of Europe by her liberality to Tycho; and the peaceful glory which he had in return conferred upon his country was not of a kind to dissatisfy even rival nations. In the conquests of science no widow's or orphan's tears are shed, no captives are dragged from their homes, and no devoted victims are yoked to the chariot wheels of the triumphant philosopher. The newly acquired domains of knowledge belong, in right of conquest, to all nations, and Denmark had now earned the gratitude of Europe by the magnitude as well as the success of her contingent.

An event, however, now occurred which threatened with destruction the interests of Danish science. In the beginning of April 1588, Frederick II. died in the 54th year of his age, and the 29th of his reign. His remains were conveyed to Rothschild, and deposited in the chapel under Tycho's care, where a finely executed bust of him was afterwards placed. His son and successor, Christian IV., was only in the 11th year of his age, and though his temper and disposition were good, yet Tycho had reason to be alarmed at the possibility of his discontinuing the patronage of astronomy. The taste for science, however, which had sprung up in the Danish Court had extended itself no wider than the influence of the reigning sovereign. The parasites of royalty saw themselves eclipsed in the bright renown which Tycho had acquired, and every new visit to Uraniburg by a foreign prince supplied fresh fuel to the rancour which had long been smothering in their breasts. The accession of a youthful king held out to his enemies an opportunity of destroying the influence of Tycho; and though no adverse step was taken, yet he had the sagacity to foresee, in "trifles light as air," the approaching confirmation of his fears. Hope, however, still cheered him amid his labours, but that hope was founded chiefly on the learning and character of Nicolas Caasius, the Chancellor of the Kingdom, from whom he had experienced the warmest attentions.

Among the princes who visited Uraniburg, there were none who conducted themselves with more condescension and generosity than our own sovereign, James VI. In the year 1590, when the Scottish King repaired to Denmark to celebrate his marriage with the Princess Anne, the King's sister, he paid a visit to Tycho, attended by his councillors and a large suite of nobility. During the eight days which he spent at Uraniburg, James carried on long discussions with Tycho on various subjects, but chiefly on the motion which Copernicus had ascribed to the earth. He examined narrowly all the astronomical instruments, and made himself acquainted with the principles of their construction and the method of using them. He inspected the busts and pictures in the museum, and when he perceived the portrait of George Buchanan, his own preceptor, he could not refrain from the strongest expressions of delight. Upon quitting the hospitable roof of Tycho, James not only presented him with a magnificent donation, but afterwards gave him his royal license to publish his works in England during seventy years. This license was accompanied with the following high eulogium on his abilities and learning:—"Nor have I become acquainted with these things only from the relation of others, or from a bare inspection of your works, but I have seen then before my own eyes, and have heard them with my own ears, in your residence at Uraniburg, and have drawn them from the various learned and agreeable conversations which I there held with you, and which even now affect my mind to such a degree, that it is difficult to determine whether I recollect them with greater pleasure or admiration; as I now willingly testify, by this license, to present and to future generations," &c.

At the request of Tycho, the King also composed and wrote in his own hand some Latin verses, which were more complimentary than classical. His Chancellor had also composed some verses of a similar character during his visit to Tycho. A short specimen of these will be deemed sufficient by the classical reader:—

> "Vidit et obstupuit Rex Huennum Scoticus almam;
> Miratus clari tot monumenta viri."

In the year 1591, when Christian IV. had reached his 14th year, he expressed a desire to pay a visit to Uraniburg. He accordingly set out with a large party, consisting of his three principal senators, and other councillors and noblemen; and having examined the various instruments in the observatories and laboratory, he proposed to Tycho various questions on mechanics and mathematics, but particularly on the principles of fortification and ship building. Having observed that he particularly admired a brass globe, which, by means of internal wheelwork, imitated the diurnal motion of the heavens, the rising and setting of the sun, and the phases of the moon, Tycho made him a present of it, and received in return an elegant gold chain, with his Majesty's picture, with an assurance of his unalterable attachment and protection.

Notwithstanding this assurance, Tycho had already, as we have stated, begun to suspect the designs of his enemies; and in a letter addressed to the Landgrave of Hesse, early in 1591, he throws out some hints which indicated the anxieties that agitated his mind. The Landgrave of Hesse, as if he had heard some rumours unfavourable to the prospects of Tycho, requested him to write him respecting the state of the Kingdom, and concerning his own private affairs. To this letter, which was dated early in February, Tycho replied about the beginning of April. He informed the Landgrave that he led a private life in his own island, exempt from all official functions, and never willingly taking a part in public affairs. He was desirous of leaving the ambition of public honours to others, and of devoting himself wholly to the study of philosophy and astronomy; and he expressed a hope that if he should be involved in the tumults and troubles of life, either by his own destiny or by evil counsels, he might be able, by the blessing of God, to extricate himself by the force of his mind and the integrity of his life. He comforted himself with the idea that every soil was the country of a great man, and that wherever he went the blue sky would still be over his head;[39] and he distinctly states at the close of his letter, that he had thought of transferring his residence to some other place, as there were some of the King’s councillors who had already begun to calumniate his studies, and to grudge him his pension from the treasury.

The causes which led to this change of feeling on the part of Christian IV.’s advisers have not been explained by the biographers of Tycho. It has been stated, in general terms, that he had made many enemies, by the keenness of his temper and the severity of his satire; but I have not been able to discover any distinct examples of these peculiarities of his mind. In an event, indeed, which occurred about this time, he slightly resented a piece of marked incivility on the part of Henry Julius, Duke of Brunswick, who had married the Princess Eliza of Denmark; but it is not likely that so trivial an affair, if it were known at court, could have called down upon him the hostility of the King’s advisers.

The Duke of Brunswick had, in 1590, paid a visit to Uraniburg, and had particularly admired an antique brass statue of Mercury, about a cubit long, which Tycho had placed in the roof of the hypocaust or central crypt of the Stiern-berg observatory. By means of a concealed mechanism, it moved round in a circular orbit. The Duke requested the statue and its machinery, which Tycho gave him, on the condition that he should obtain a model of it, for the purpose of having another executed by a skilful workman. The Duke not only forgot his promise, but paid no attention to the letters which were addressed to him. Tycho was justly irritated at this unprincely conduct, and ordered this anecdote to be inserted in the description of Uraniburg which he was now preparing for publication.

In the year 1592, Tycho lost his distinguished friend and correspondent the Prince of Hesse, and astronomy one of its most active and intelligent cultivators. His grief on this occasion was deep and sincere, and he gave utterance to his feelings in an impassioned elegy, in which he recorded the virtues and talents of his friend. Prince Maurice, the son and successor of the Landgrave, continued, with the assistance of able observers, to keep up the reputation of the observatory of Hesse-Cassel; and the observations which were there made were afterwards published by Snellius. The extensive and valuable correspondence between Tycho and the Landgrave was prepared for publication about the beginning of 1593, and contains also the letters of Rothman and Rantzau.

For several years the studies of Tycho had been treated with an unwilling toleration by the Danish Court. Many of the nobles envied the munificent establishment which he had received from Frederick, and the liberal pension which he drew from his treasury. But among his most active enemies were some physicians, who envied his reputation as a successful and a gratuitous practitioner of the healing art. Numbers of invalids flocked to Huen, and diseases, which resisted all other methods of cure, are said to have yielded to the panaceal prescription of the astrologer. Under the influence of such motives, these individuals succeeded in exciting against Tycho the hostility of the court. They drew the public attention to the exhausted state of the treasury. They maintained that he had possessed too long the estate in Norway, which might be given to men who laboured more usefully for the commonwealth; and they accused him of allowing the chapel at Rothschild to fall into decay. The President of the Council, Christopher Walchendorp, and the King’s Chancellor, were the most active of the enemies of Tycho; and, having poisoned the mind of their sovereign against the most meritorious of his subjects, Tycho was deprived of his canonry, his estate in Norway, and his pension.

Being no longer able to bear the expenses of his establishment in Huen, and dreading that the feelings which had been excited against him might be still further roused, so as to deprive him of the Island of Huen itself, he resolved to transfer his instruments to some other situation. Notwithstanding this resolution, he remained with his family in the island, and continued his observations till the spring of 1597, when he took a house in Copenhagen, and removed to it all his smaller and more portable instruments, leaving those which were large or fixed in the crypts of Stiern-berg. His first plan was to remove every thing from Huen as a measure of security; but the public feeling began to turn in his favour, and there were many good men in Copenhagen who did not scruple to reprobate the conduct of the government. The President of the Council, Walchendorp—a name which, while the heavens revolve, will be pronounced with horror by astronomers—saw the change of sentiment which his injustice had produced, and adopted an artful method of sheltering himself from public odium. In consequence of a quarrel with Tycho, the recollection of which had rankled in his breast, he dreaded to be the prime mover in his persecution. He therefore appointed a committee of two persons, one of whom was Thomas Feuchius, to report to the government on the nature and utility of the studies of Tycho. These two individuals were entirely ignorant of astronomy and the use of instruments; and even if they had not, they would have been equally subservient to the views of the minister. They reported that the studies of Tycho were of no value, and that they were not only useless, but noxious. Armed with this report, Walchendorp prohibited Tycho, in the King's name, from continuing his chemical experiments; and instigated, no doubt, by this wicked minister, an attack was made upon himself, and his shepherd or his steward was injured in the affray. Tycho was provoked to revenge himself upon his enemies, and the judge was commanded not to interfere in the matter.

Thus persecuted by his enemies, Tycho resolved to remain no longer in an ungrateful country. He carried from Huen every thing that was moveable, and having packed up his instruments, his crucibles, and his books, he hired a ship to convey them to some foreign land. His wife, his five sons and four daughters, his male and his female servants, and many of his pupils and assistants, among whom were Tengnagel, his future son-in-law, and the celebrated Longomontanus, embarked at Copenhagen, to seek the hospitality of some better country than their own.

Freighted with the glory of Denmark, this interesting bark made the best of its way across the Baltic, and arrived safely at Rostoch. Here the exiled patriarch found many of his early friends, particularly Henry Bruce, an able astronomer, to whom he had formerly presented one of his brass quadrants. The approach of the plague, however, prevented Tycho from making any arrangements for a permanent residence; and, having received a warm invitation from Count Henry Rantzau, who lived in Holstein at the Castle of Wandesberg, near Hamburg, he went with all his family, about the end of 1597, to enjoy the hospitality of his friend.

Though Tycho derived the highest pleasure from the kindness and conversation of Count Rantzau, yet a cloud overshadowed the future, and he had yet to seek for a patron and a home. His hopes were fixed on the Emperor Rudolph, who was not only fond of science, but who was especially addicted to alchemy and astrology, and his friend Rantzau promised to have him introduced to the Emperor by proper letters. When Tycho learned that Rudolph was particularly fond of mechanical instruments and of chemistry, he resolved to complete and to dedicate to him his work on the mechanics of astronomy, and to add to it an account of his chemical labours. This task he soon performed, and his work appeared in 1598 under the title of *Tychonis Brahe, Astronomiæ instauratæ Mechanica*. Along with this work he transmitted to the Emperor a copy of his MS. catalogue of 1000 fixed stars.

With these proofs of his services to science, and instigated by various letters in his favour, the Emperor Rudolph desired his Vice-Chancellor to send for Tycho, and to assure him that he would be received according to his great merits, and that nothing should be wanting to promote his scientific studies. Leaving his wife and daughters at Wandesberg, and taking with him his sons and his pupils, Tycho went to Wittemberg; but having learned that the plague had broken out at Prague, and that the Emperor had gone to Pilsen, he deferred for a while his journey into Bohemia.

Early in the spring of 1599, when the pestilence had ceased at Prague, and the Emperor had returned to his capital, Tycho set out for Bohemia. On his arrival at Prague, he found a splendid house ready for his reception, and a kind message from the Emperor, prohibiting him from paying his respects to him till he had recovered from the fatigues of his journey. On his presentation to Rudolph, the generous Emperor received him with the most distinguished kindness. He announced to him that he was to receive an annual pension of 3000 crowns; that an estate would as soon as possible be settled upon him and his family and their successors; that a town house would be provided for him; and that he might have his choice of various castles and houses in the country as the site of his observatory and laboratory. The Emperor had also taken care to provide every thing that was necessary for Tycho’s immediate wants; and so overwhelmed was he with such unexpected kindness, that he remarked that, as he could not find words to express his gratitude, the whole heavens would speak for him, and posterity should know what a refuge his great and good Sovereign had been to the Queen of the Arts.

Among the numerous friends whom Tycho found at Prague, were his correspondents Coroducius and Hagecius, and his benefactor Barrovitius, the Emperor’s secretary. He was congratulated by them all on his distinguished reception at court, and was regarded as the Æneas of science, who had been driven from his peaceful home, and who had carried with him to the Latium of Germany his wife, his children, and his household gods. If external circumstances could remove the sorrows of the past, Tycho must now have been supremely happy. In his spacious mansion, which had belonged to his friend Curtius, he found a position for one of his best instruments, and having covered with poetical inscriptions the four sides of the pedestal on which it stood, in honour of his benefactors, as well as of former astronomers, he resumed with diligence his examination of the stars.

When Rudolph saw the magnificent instruments which Tycho had brought along with him, and had acquired some knowledge of their use, he pressed him to send to Denmark for the still larger ones which he had left at Stiern-berg. In the meantime, he gave him the choice of the castles of Brandisium, Lyssa, and Benach as his country residence; and after visiting them about the end of May, Tycho gave the preference to Benach, which was situated upon a rising ground, and commanded an extensive horizon. It contained splendid and commodious buildings, and was almost, as he calls it, a small city, situated on the stream Lisor, near its confluence with the Albis. It stood a little to the east and north of

Prague, and was distant from that city only five German miles, or about six hours' journey.

On the 20th of August, the Prefect of Brandisium gave Tycho possession of his new residence. His gratitude to his royal patron was copiously displayed, not only in a Latin poem written on the occasion, but in Latin inscriptions which he placed above the doors of his observatory and his laboratory. In order that he might establish an astronomical school at Prague, he wrote to Longomontanus, Kepler, Muller, David Fabricius, and two students at Wittemberg, who were good calculators, requesting them to reside with him at Benach, as his assistants and pupils: He at the same time dispatched his destined son-in-law, Tengnagel, accompanied by Pascal Muleus, to bring home his wife and daughters from Wandesberg, and his instruments from Huen; and he begged that Longomontanus would accompany them to Denmark, and return in the same carriage with them to Bohemia.

Kepler arrived at Prague in January 1600, and, after spending three or four months at Benach, in carrying on his inquiries and in making astronomical observations, he returned to Gratz. Tycho had undertaken to obtain for him the appointment of his assistant. It was arranged that the Emperor should allow him a hundred florins, on the condition that the states of Styria would permit him to retain his salary for two years. This scheme, however, failed, and Kepler was about to study medicine, and offer himself for a professorship of medicine at Tubingen, when Tycho undertook to obtain him a permanent appointment from the Emperor. Kepler, accordingly, returned in September 1601, and, on the recommendation of his friend, he was named imperial mathematician, on the condition of assisting Tycho in his observations.

Tycho had experienced much inconvenience in his residence at Benach, from his ignorance of the language and customs of the country, as well as from other causes. He was therefore anxious to transfer his instruments to Prague; and no sooner were his wishes conveyed to the Emperor than he gave him leave to send them to the royal gardens and the adjacent buildings. His family and his larger instruments having now arrived from Huen, the astronomer with his family and his property were safely lodged in the royal edifice. Having found that there was no house in Prague more suited for his purposes than that of his late friend Curtius, the Emperor purchased it from his widow, and Tycho removed into it on the 25th February 1601.

CHAPTER IV.

Tycho resumes his Astronomical Observations—Is attacked with a Painful Disease—His Sufferings and Death in 1601—His Funeral—His Temper—His Turn for Satire and Raillery—His Piety—Account of his Astronomical Discoveries—His Love of Astrology and Alchymy—Observations on the Character of the Alchymists—Tycho's Elixir—His Fondness for the Marvellous—His Automata and Invisible Bells—Account of the Idiot, called Lep, whom he kept as a Prophet—History of Tycho's Instruments—His great Brass Globe preserved at Copenhagen—Present state of the Island of Huen.

Although Tycho continued in this new position to observe the planets with his usual assiduity, yet the recollection of his sufferings, and the inconveniences and disappointments which he had experienced, began to prey upon his mind, and to affect his health. Notwithstanding the continued liberality of the Emperor, and the kindness of his friends and pupils, he was yet a stranger in a distant land. Misfortune was unable to subdue that love of country which was one of the most powerful of his affections; and, though its ingratitude might have broken the chain which bound him to the land of his nativity, it seems only to have rivetted it more firmly. His imagination, thus influenced, acquired an undue predominance over his judgment. He viewed the most trifling occurrences as supernatural indications; and in those azure moments when the clouds broke from his mind, and when he displayed his usual wit and pleasantry, he frequently turned the conversation to the subject of his latter end.

This state of mind was the forerunner, though probably the effect, of a painful disease, which had, doubtless, its origin in the severity and continuity of his studies. On the 13th October, when he was supping at the house of a nobleman called Rosenberg, he was seized with a retention of urine, which forced him to leave the party.

This attack continued with little intermission for more than a week, and, during this period, he suffered great pain, attended with want of sleep and temporary delirium, during which, he frequently exclaimed, *Ne frustra vixisse videor*. On the 24th he recovered from this painful situation, and became perfectly tranquil. His strength, however, was gone, and he saw that he had not many hours to live. He expressed an anxious wish that his labours would redound to the glory of his Maker, to whom he offered up the most ardent prayers. He enjoined his sons and his son-in-law not to allow them to be lost. He encouraged his pupils not to abandon their pursuits, he requested Kepler to complete the Rudolphine Tables, and to his family he recommended piety and resignation to the Divine will. Among those who never quitted Tycho in his illness, was Erick Brahe, Count Wittehorn, a Swede, and a relation of his own, and Counsellor to the King of Poland. This amiable individual never left the bedside of his friend, and administered to him all those attentions which his situation required. Tycho, turning to him, thanked him for his affectionate kindness, and requested him to maintain the relationship with his family. He then expired without pain, amid the consolations, the prayers, and the tears of his friends. This event took place on the 24th of October 1601, when he was only fifty-four years and ten months old.

The Emperor Rudolph evinced the greatest sorrow when he was informed of the death of his friend, and he gave orders that he should be buried in the most honourable manner, in the principal church of the ancient city.[40] The funeral took place on the 4th November, and he was interred in the dress of a nobleman, and with the ceremonies of his order. The funeral oration was pronounced by Jessenius, before a distinguished assemblage, and many elegies were written on his death.

Tycho was a little above the middle size, and in the last years of his life he was slightly corpulent. He had reddish yellow hair and a ruddy complexion. He was of a sanguine temperament, and is said to have been sometimes irritable, and even obstinate. This failing, however, if he did possess it, was not exhibited towards his pupils or his scientific friends, who ever entertained for him the warmest affection and esteem. Some of his pupils had remained in his house more than twenty years; and in the quarrel which arose between him and Kepler,[41] and which is allowed to have originated entirely in the temper of the latter, he conducted himself with the greatest patience and forbearance. There is reason to think that the irritability with which he has been charged was less an affection of his mind than the effect of that noble independence of character which belonged to him, and that it has been inferred chiefly from his conduct to some of those high personages with whom he was brought in contact. When Walchendorp, the President of the Council, kicked his favourite hound, it was no proof of irritability of character that Tycho expressed in strong terms his disapprobation of the deed.

It was, doubtless, a greater weakness in his character that he indulged his turn for satire, without being able to bear retaliation. His jocular habits, too, sometimes led him into disagreeable positions. When the Duke of Brunswick was dining with him at Uraniburg, the Duke said, towards the end of the dinner, that, as it was late, he must be going. Tycho jocularly remarked that this could not be done without his permission; upon which the Duke rose and left the party, without taking leave of his host. Tycho became indignant in his turn, and continued to sit at table; but, as if repenting of what he had done, he followed the Duke, who was on his way to the ship, and, calling upon him, displayed the cup in his hand, as if he had washed out his offence by a draught of wine.

Tycho was a man of true piety, and cherished the deepest veneration for the Sacred Scriptures, and for the great truths which they reveal. Their principles regulated his conduct, and their promises animated his hopes. His familiarity with the wonders of the heavens increased, instead of diminishing, his admiration of Divine wisdom, and his daily conversation was elevated by a constant reference to a superintending Providence.

As a practical astronomer, Tycho has not been surpassed by any observer of ancient or of modern times. The splendour and number of his instruments, the ingenuity which he exhibited in inventing new ones and in improving and adding to those which were formerly known, and his skill and assiduity as an observer, have given a character to his labours, and a value to his observations, which will be appreciated to the latest posterity. The appearance of the new star in 1572 led him to form a catalogue of 777 stars, vastly superior in accuracy to those of Hipparchus and Ulugh Beig. His improvements on the lunar theory were still more valuable. He discovered the important inequality called the *variation*, and also the annual inequality which depends on the position of the earth in its orbit. He discovered, also, the inequality in the inclination of the moon’s orbit, and in the motion of her nodes. He determined with new accuracy the astronomical refractions from an altitude of 45° down to the horizon, where he found it to be 34´; and he made a vast collection of observations on the planets, which formed the groundwork of Kepler’s discoveries and the basis of the Rudolphine Tables. Tycho's powers of observation were not equalled by his capacity for general views. It was, perhaps, owing more to his veneration for the Scriptures than to the vanity of giving his name to a new system that he rejected the Copernican hypothesis. Hence he was led to propose a new system, called the Tychonic, in which the earth is stationary in the centre of the universe, while the sun, with all the other planets and comets revolving round him, performs his daily revolution about the earth. This arrangement of the planets afforded a sufficient explanation of the various phenomena of the heavens; and as it was consistent with the language of Scripture, and conformable to the indications of the senses, it found many supporters, notwithstanding the physical absurdity of making the whole system revolve round one of the smallest of the planets.

It is a painful transition to pass from the astronomical labours of Tycho to his astrological and chemical pursuits. That Tycho studied and practised astrology has been universally admitted. He calculated the nativity of the Emperor Rudolph, and foretold that his relations would make some attempts upon his life. The credulous Emperor confided in the prediction, and when the conduct of his brother seemed to justify his belief, he confined himself to his palace, and fell a prey to the fear which it inspired. Tycho, however, seems to have entirely renounced his astrological faith in his latter days; and Kepler states,[42] in the most pointed manner, that Tycho carried on his astronomical labours with his mind entirely free from the superstitions of astrology; that he derided and detested the vanity and knavery of astrologers, and was convinced that the stars exercised no influence on the destinies of men.

Although Tycho informed Rothman that he devoted as much labour and expense to the study of terrestrial (chemistry) as he did to that of celestial astronomy, yet it is a singular fact that he never published any account of his experiments, nor has he left among his writings any trace of his chemical inquiries. He pretended, however, to have made discoveries in the science, and we should have been disposed to reprobate the apology which he makes for not publishing them, did we not know that it had been frequently given by the other alchemists of the age—"On consideration," says he, "and by the advice of the most learned men, I thought it improper to unfold the secrets of the art (of alchemy) to the vulgar, as few persons were capable of using its mysteries to advantage and without detriment."

Admitting then, as we must do, that Tycho was not only a professed alchemist, but that he was practically occupied with its pursuits, and continually misled by its delusions, it may not be uninteresting to the reader to consider how far a belief in alchemy, and a practice of its arts, have a foundation in the weakness of human nature; and to what extent they are compatible with the piety and elevated moral feeling by which our author was distinguished.

In the history of human errors two classes of impostors, of very different characters, present themselves to our notice—those who wilfully deluded their species, and those who permitted their species to delude themselves. The first of those classes consisted of the selfish tyrants who upheld an unjust supremacy by systematic delusions, and of grovelling mountebanks who quenched their avaricious thirst at the fountains of credulity and ignorance. The second class comprehended spirits of a nobler mould: It embraced the speculative enthusiasts, whom the love of fame and of truth urged onward, in a fruitless research, and those great lights of knowledge and of virtue, who, while they stood forward as the landmarks of the age which they adorned, had neither the intellectual nor the moral courage to divest themselves of the supernatural radiance with which the ignorance of the vulgar had encircled them.

The thrones and shrines, which delusion once sustained even in the civilized quarter of the globe, are for ever fallen, and that civil and religious liberty, which in past ages was kept down by the marvellous exhibitions of science to the senses, is now maintained by its application to the reason of man. The charlatans, whether they deal in moral or in physical wonders, form a race which is never extinct. They migrate to the different zones of the social system, and though they change their place, and their purposes, and their victims, yet their character and motives remain the same. The philosophical mind, therefore, is not disposed to study either of these varieties of impostors; but the other two families which compose the second class are objects of paramount interest. The eccentricities and even the obliquities of great minds merit the scrutiny of the metaphysician and the moralist, and they derive a peculiar interest from the state of society in which they are exhibited. Had Cardan and Cornelius Agrippa lived in modern times, their vanity and self-importance would have been checked by the forms of society, and even if their harmless pretensions had been displayed, they would have disappeared in the blaze of their genius and knowledge. But nursed in superstition, and educated in dark and turbulent times, when every thing intellectual was in a state of restless transition, the genius and character of great men necessarily reflected the peculiarities of the age in which they lived.

Had history transmitted to us correct details of the leading alchemists and scientific magicians of the dark ages, we should have been able to analyse their actions and their opinions, and trace them, probably, to the ordinary principles by which the human mind is in every age influenced and directed. But when a great man has once become an object either of interest or of wonder, and still more when he is considered as the possessor of knowledge and skill which transcend the capacity of the age, he is soon transformed into the hero of romance. His powers are overrated, his deeds exaggerated, and he becomes the subject of idle legends, which acquire a firmer hold on credulity from the slight sprinkling of truth with which they are seasoned. To disclaim the possession of lofty attributes thus ascribed to great men is a degree of humility which is not often exercised. But even when this species of modesty is displayed, it never fails to defeat its object. It but calls forth a deeper homage, and fixes the demigod more firmly in his shrine.

The history of learning furnishes us with many examples of that species of delusion in which a great mind submits itself to vulgar adulation, and renounces unwillingly, if it renounces at all, the unenviable reputation of supernatural agency. In cases where self-interest and ambition are the basis of this peculiarity of temperament, and in an age when the conjuror and the alchemist were the companions and even the idols of princes, it is easy to trace the steps by which a gifted sage retains his ascendancy among the ignorant. The hecatomb which is sacrificed to the magician, he receives as an oblation to his science, and conscious of possessing real endowments, the idol devours the meats that are offered to him without analysing the motives and expectations under which he is fed. But even when the idolater and his god are not placed in this transverse relation, the love of power or of notoriety is sufficient to induce good men to lend a too willing ear to vulgar testimony in favour of themselves; and in our own times it is not common to repudiate the unmerited cheers of a popular assembly, or to offer a contradiction to fictitious tales which record our talents or our courage, our charity or our piety.

The conduct of the scientific alchemists of the thirteenth, fourteenth, and fifteenth centuries presents a problem of very difficult solution. When we consider that a gas, a fluid, and a solid may consist of the very same ingredients in different proportions; that a virulent poison may differ from the most wholesome food only in the difference of quantity of the very same elements; that gold and silver, and lead and mercury, and indeed all the metals, may be extracted from transparent crystals, which scarcely differ in their appearance from a piece of common salt or a bit of sugarcandy; and that diamond is nothing more than charcoal,—we need not greatly wonder at the extravagant expectation that the precious metals and the noblest gems might be procured from the basest materials. These expectations, too, must have been often excited by the startling results of their daily experiments. The most ignorant compounder of simples could not fail to witness the magical transformations of chemical action; and every new product must have added to the probability that the tempting doublets of gold and silver might be thrown from the dice-box with which he was gambling.

But when the precious metals were found in lead and copper by the action of powerful re-agents, it was natural to suppose that they had been actually formed during the process; and men of well-regulated minds even might have thus been led to embark in new adventures to procure a more copious supply, without any insult being offered to sober reason, or any injury inflicted on sound morality.

When an ardent and ambitious mind is once dazzled with the fascination of some lofty pursuit, where gold is the object, or fame the impulse, it is difficult to pause in a doubtful career, and to make a voluntary shipwreck of the reputation which has been staked. Hope still cheers the aspirant from failure to failure, till the loss of fortune and the decay of credit disturb the serenity of his mind, and hurry him on to the last resource of baffled ingenuity and disappointed ambition. The philosopher thus becomes an impostor; and by the pretended transmutation of the baser metals into gold, or the discovery of the philosopher’s stone, he attempts to sustain his sinking reputation, and recover the fortune he has lost. The communication of the great secret is now the staple commodity with which he is to barter, and the grand talisman with which he is to conjure. It can be imparted only to a chosen few—to those among the opulent who merit it by their virtues, and can acquire it by their diligence, and the divine vengeance is threatened against its disclosure. A process commencing in fraud and terminating in mysticism is conveyed to the wealthy aspirant, or instilled into the young enthusiast, and the grand mystery passes current for a season, till some cautious professor of the art, like Tycho, denounces its publication as detrimental to society.

Among the extravagant pretensions of the alchemists, that of forming a universal medicine was perhaps not the most irrational. It was only when they pretended to cure every disease, and to confer longevity, that they did violence to reason. The success of the Arabian physicians in the use of mercurial preparations naturally led to the belief that other medicines, still more general in their application, and efficacious in their healing powers, might yet be brought to light; and we have no doubt that many substantial discoveries were the result of such overstrained expectations. Tycho was not merely a believer in the medical dogmas of the alchemists, he was actually the discoverer of a new *elixir*, which went by his name, and which was sold in every apothecary's shop as a specific against the epidemic diseases which were then ravaging Germany. The Emperor Rudolph having heard of this celebrated medicine, obtained a small portion of it from Tycho by the hands of the Governor of Brandisium; but, not satisfied with the gift, he seems to have applied to Tycho for an account of the method of preparing it. Tycho accordingly addressed to the Emperor a long letter, dated September 7, 1599, containing a minute account of the process. The base of this remarkable medicine is Venetian treacle, which undergoes an infinity of chemical operations and admixtures before it is ready for the patient. When properly prepared he assures the Emperor that it is better than gold, and that it may be made still more valuable by mixing with it a single scruple either of the tincture of corals, or sapphire, or hyacinth, or a solution of pearls, or of potable gold, if it can be obtained free of all corrosive matter! In order to render the medicine *universal* for all diseases which can be cured by perspiration, and which, he says, form a third of those which attack the human frame, he combines it with antimony, a well known sudorific in the present practice of physic. Tycho concludes his letter by humbly beseeching the Emperor to keep the process secret, and reserve the medicine for himself alone!

The same disposition of mind which made Tycho an astrologer and an alchemist, inspired him with a singular love of the marvellous.

He had various automata with which he delighted to astonish the peasants; and by means of invisible bells, which communicated with every part of his establishment, and which rung with the gentlest touch, he had great pleasure in bringing any of his pupils suddenly before strangers, muttering at a particular time the words "Come hither, Peter," as if he had commanded their presence by some supernatural agency. If, on leaving home, he met with an old woman or a hare, he returned immediately to his house: But the most extraordinary of all his peculiarities remains to be noticed. When he lived at Uraniburg he maintained an idiot of the name of Lep, who lay at his feet whenever he sat down to dinner, and whom he fed with his own hand. Persuaded that his mind, when moved, was capable of foretelling future events, Tycho carefully marked every thing he said. Lest it should be supposed that this was done to no purpose, Longomontanus relates that when any person in the island was sick, Lep never, when interrogated, failed to predict whether the patient would live or die. It is stated also in the letters of Wormius, both to Gassendi and Peyter, that when Tycho was absent, and his pupils became very noisy and merry in consequence of not expecting him soon home, the idiot, who was present, exclaimed, *Juncher xaa laudit*, "Your master has arrived." On another occasion, when Tycho had sent two of his pupils to Copenhagen on business, and had fixed the day of their return, Lep surprised him on that day while he was at dinner, by exclaiming, "Behold your pupils are bathing in the sea." Tycho, suspecting that they were shipwrecked, sent some person to the observatory to look for their boat. The messenger brought back word that he saw some persons wet on the shore, and in distress, with a boat upset at a great distance. These stories have been given by Gassendi, and may be viewed as specimens of the superstition of the age.

Tycho left behind him a wife and six children, but even in the time of Gassendi nothing was known of their history, excepting that Tengnagel, who married one of the daughters, gave up his scientific pursuits, and, having been admitted among the Emperor’s counsellors, was employed in several of his embassies.

The instruments of Tycho were purchased from his heirs, by the Emperor, for 22,000 crowns. They were shut up in the house of Curtius, and were treated with such veneration, that no astronomer, not even Kepler himself, was permitted to see or to use them.

Here they remained till the death of the Emperor Matthias, in 1619, when the troubles in Bohemia took place. When Prague was taken by the forces of the Elector Palatine, the instruments were carried off, and some were destroyed, and others converted to different purposes. The great brass globe, however, was saved. It was first carried to Niessa, the episcopal city of Silesia; and having been presented to the College of Jesuits, it was preserved in their museum, till Udalric, the son of Christian, King of Denmark, took Niessa in 1632. The globe was recognized as having belonged to Tycho, and it was carried in triumph to Denmark. An inscription was written upon it by Longomontanus, and it was deposited with some pomp in the Library of the Academy of Sciences.

After Tycho left Huen, the island was transferred to some of the Danish nobility, and the following brief but melancholy description of it was given by Wormius. “There is, in the island, a field where Uraniburg was.” The scientific antiquities of Huen, have been more recently described by Mr Cox, in his travels through Denmark.

“We landed,” says he, “on the south west part in a small bay, just below the place where a stream, supplied by numerous pools and fish ponds, falls into the sea. We ascended the shore, which is clothed with short herbage, crossed the stream, and passed over a gently waving surface, gradually sloping towards the sea, and walked a mile to a farm house, standing in the middle of the island, inhabited by Mr Schaw, a Swedish gentleman, to whom the greater part of the island belongs. He lives here in summer, but in winter resides at Landscrona. This dwelling is the same as existed in Tycho Brahe’s time, and was the farm house belonging to his estate. A guide, whom we obtained from Mr Schaw, conducted us to the remains of Tycho’s mansion, which are near the house, and consist of little more than a mound of earth which enclosed the garden, and two pits, the sites of his mansion and observatory.”[43]

LIFE

OF

JOHN KEPLER.

CHAPTER I.

Kepler's Birth in 1571—His Family—And early Education—The Distresses and Poverty of his Family—He enters the Monastic School of Maulbronn—And is admitted into the University of Tubingen, where he distinguishes himself, and takes his Degrees—He is appointed Professor of Astronomy and Greek in 1594—His first speculations on the Orbits of the Planets—Account of their Progress and Failure—His "Cosmographical Mystery" published—He Marries a Widow in 1597—Religious troubles at Gratz—He retires from thence to Hungary—Visits Tycho at Prague in 1600—Returns to Gratz, which he again quits for Prague—He is taken Ill on the road—Is appointed Tycho's Assistant in 1601—Succeeds Tycho as Imperial Mathematician—His Work on the New Star of 1604—Singular specimen of it.

It is a remarkable circumstance in the history of science, that astronomy should have been cultivated at the same time by three such distinguished men as Tycho, Kepler, and Galileo. While Tycho, in the 54th year of his age, was observing the heavens at Prague, Kepler, only 30 years old, was applying his wild genius to the determination of the orbit of Mars, and Galileo, at the age of 36, was about to direct the telescope to the unexplored regions of space. The diversity of gifts which Providence assigned to these three philosophers was no less remarkable. Tycho was destined to lay the foundation of modern astronomy, by a vast series of accurate observations made with the largest and the finest instruments; it was the proud lot of Kepler to deduce the laws of the planetary orbits from the observations of his predecessors; while Galileo enjoyed the more dazzling honour of discovering by the telescope new celestial bodies, and new systems of worlds.

John Kepler, the youngest of this illustrious band, was born at the imperial city of Weil, in the duchy of Wirtemberg, on the 21st December 1571. His parents, Henry Kepler and Catherine Guldenmann, were both of noble family, but had been reduced to indigence by their own bad conduct. Henry Kepler had been long in the service of the Duke of Wirtemberg as a petty officer, and in that capacity had wasted his fortune. Upon setting out for the army, he left his wife in a state of pregnancy; and, at the end of seven months, she gave premature birth to John Kepler, who was, from this cause, a sickly child during the first years of his life. Being obliged to join the army in the Netherlands, his wife followed him into the field, and left her son, then five years old, under the charge of his grandfather at Limberg. Sometime afterwards he was attacked with the smallpox, and having with difficulty recovered from this severe malady, he was sent to school in 1577.

Having become security for one of his friends, who absconded from his creditors, Henry Kepler was obliged to sell his house and all his property, and was driven to the necessity of keeping a tavern at Elmendingen. Owing to these misfortunes, young Kepler was taken from school about two years afterwards, and was obliged to perform the functions of a servant in his father's house. In 1585, he was again placed in the school of Elmendingen; but his father and mother having been both attacked with the smallpox, and he himself having been seized with a violent illness in 1585, his education had been much neglected, and he was prohibited from all mental application.

In the year 1586, on the 26th of November, Kepler was admitted into the school at the Monastery of Maulbronn, which had been established at the Reformation, and which was maintained at the expense of the Duke of Wirtemberg, as a preparatory seminary for the University of Tubingen. After remaining a year at the upper classes, the scholars presented themselves for examination at the College for the degree of Bachelor; and having received this, they returned to the school with the title of Veterans. Here they completed the usual course of study; and being admitted as resident students at Tubingen, they took their degree of Master. In prosecuting this course of study, Kepler was sadly interrupted, not only by periodical returns of his former complaints, but by family quarrels of the most serious import. These dissensions, arising greatly from the perverseness of his mother, drove his father to a foreign land, where he soon died; and his mother having quarrelled with all her relations, the affairs of the family were involved in inextricable disorder. Notwithstanding these calamities, Kepler took his degree of Bachelor on the 15th September 1588, and his degree of Master in August 1591, on which occasion he held the second place at the annual examination.

In his early studies, Kepler devoted himself with intense pleasure to philosophy in general, but he entertained no peculiar affection for astronomy. Being well grounded in arithmetic and geometry, he had no difficulty in making himself master of the geometrical and astronomical theorems which occurred in the course of his studies. While attending the lectures of Mœstlin, professor of mathematics, who had distinguished himself by an oration in favour of the Copernican system, Kepler not only became a convert to the opinions of his master, but defended them in the physical disputations of the students, and even wrote an essay on the primary motion, in order to prove that it was produced by the daily rotation of the earth.

In 1594, the astronomical chair at Gratz, in Styria, fell vacant by the death of George Stadt, and, according to Kepler's own statement, he was forced to accept this situation by the authority of his professional tutors, who recommended him to the nobles of Styria. Though Kepler had little knowledge of the science, and no passion for it whatever, yet the nature of his office forced him to attend to astronomy; and, in the year 1595, when he enjoyed some leisure from his lectures, he directed the whole energy of his mind to the three important topics of the number, the size, and the motion of the orbits of the planets. He first tried if the size of the planets' orbits, or the difference of their sizes, had any regular proportion to each other. Finding no proof of this, he inserted a new planet between Mars and Jupiter, and another between Venus and Mercury, which he supposed might be invisible from their smallness; but even with these assumptions the distances of the planets exhibited no regular progression. Kepler next tried if these distances varied as the cosines of the quadrant, and if their motion varied as the sun's, the sine of 90 representing the motion at the sun, and the sine of 0° that at the fixed stars; but in this trial he was also disappointed.

Having spent the whole summer in these fruitless speculations, and praying constantly to his Maker for success, he was accidentally drawing a diagram in his lecture-room, in July 1595, when he observed the relation between the circle inscribed in a triangle, and that described round it; and the ratio of these circles, which was that of 1 to 2, appeared to his eye to be identical with that of Jupiter's and Saturn's orbits. Hence he was led to compare the orbits of the other planets' circles described in pentagons and hexagons. As this hypothesis was as inapplicable to the heavens as its predecessors, Kepler asked himself in despair, "What have *plane* figures to do with *solid* orbits? Solid bodies ought to be used for solid orbits." On the strength of this conceit, he supposed that the distances of the planets were regulated by the sizes of the five regular solids described within one another. “The Earth is the circle, the measurer of all. Round it describe a dodecahedron; the circle including this will be Mars. Round Mars describe a tetrahedron; the circle including this will be Jupiter. Describe a cube round Jupiter; the circle including this will be Saturn. Then inscribe in the Earth an icosahedron; the circle described in it will be Venus. Inscribe an octohedron in Venus; the circle inscribed in it will be Mercury.”

This discovery, as he considered it, harmonized in a very rude way with the measures of the planetary orbits given by Copernicus; but Kepler was so enamoured with it, that he ascribed the differences to errors of observation, and declared that he would not renounce the glory of having made it for the whole Electorate of Saxony.

In his attempt to discover the relation between the periodic times of the planets and their distances from the sun, he was not more successful; but as this relation had a real existence, he made some slight approach to its determination. These extraordinary researches, which indicate the wildness and irregularity of Kepler’s genius, were published in 1596, in a work entitled, “Prodromus of Cosmographical Dissertations; containing the cosmographical mystery respecting the admirable proportion of the celestial orbits, and the genuine and real causes of the number, magnitude, and periods of the planets demonstrated by the five regular geometrical solids.”

Notwithstanding the speculative character of this volume, it obtained for its author a high name among astronomers. Galileo and Tycho, whose opinions of it he requested, spoke of it with some commendation. The former praised the ingenuity and good faith which it displayed; and Tycho, though he requested him to try to adapt something of the same nature to the Tychonic system, saw the speculative character of his mind, and advised him “to lay a solid foundation for his views by actual observation, and then, by ascending from these, to strive to reach the causes of things.”

In 1592, before Kepler had quitted Tubingen, he was on the eve of entering into the married state. Though the foolish scheme was fortunately broken off, yet he resumed it again in 1596, when he paid his addresses to Barbara Millar of Muleckh, who was a widow for the second time, though only twenty-three years of age. Her parents, however, would not consent to the match till Kepler proved his nobility; and, owing to the delay which arose from this circumstance, the marriage did not take place till 1597. The income which Kepler derived from his professorship was very small, and as his wife’s fortune turned out much less than he had been led to expect, he not only was annoyed with pecuniary difficulties, but was involved in disputes with his wife’s relations. These evils were greatly increased by the religious troubles which took place in Styria. The Catholics at Gratz rose against the Protestants, and threatened to expell them from the city. Kepler, who openly professed the Protestant religion, saw the risks to which he was exposed, and retired with his wife into Hungary. Here he continued nearly a year, during which he composed and transmitted to his friend Zehentmaier, at Tubingen, several small treatises, “On the Magnet,” “On the cause of the Obliquity of the Ecliptic,” and “On the Divine Wisdom, as shewn in the Creation”—all of which seem to have been lost. In 1599, Kepler was recalled to Gratz by the States of Styria, and resumed his professorship; but the city was still divided into two factions, and Kepler, who was a lover of peace, found his situation very uncomfortable. Having learned from Tycho that he had been able to determine more accurately than had been done the eccentricities of the orbits of the planets, Kepler was anxious to avail himself of these observations, and set out on a visit to Tycho at Prague, where he arrived in January 1600. Tycho received him with great kindness, notwithstanding the part which he had taken against him along with Raimar, and he spent three or four months with him at Benach. It was then arranged that Kepler should be appointed Tycho's assistant in the observatory, with a salary of 100 florins, provided the States of Styria should, on the Emperor's application, allow him to be absent for two years and retain his salary. Kepler had returned to Gratz before this arrangement was completed, and new troubles having broke out in that city, he resigned his professorship. Dreading lest this step would frustrate his scheme of joining Tycho, he resolved to ask the patronage of the Duke of Wirtemberg for the professorship of medicine at Tubingen; and with this view he corresponded with Mœstlin and his other friends in that University. When Tycho heard of this plan, he pressed him to abandon it, and promised his best exertions to procure a permanent situation for him from the Emperor.

Encouraged by these promises, Kepler and his wife set off for Prague, but he was unfortunately attacked on the road with a quartan ague, which lasted seven months; and having exhausted the little money which he had along with him, he was obliged to apply to Tycho for a supply. After his arrival at Prague he was supported entirely by the bounty of his friend, and he endeavoured to make some return for this kindness by attacking in a controversial pamphlet two of the scientific opponents of Tycho. Kepler's total dependence on the generosity of his friend had made him suspicious of his sincerity. He imagined that Tycho had not freely communicated to him all his observations, and that he had not been sufficiently liberal in supplying his wife with money in his absence. While absent a second time from Prague, and influenced by these feelings, he addressed a violent letter to Tycho, filled with reproaches. On the plea of being occupied with his daughter's marriage, Tycho requested Ericksen, one of his assistants, to reply to Kepler's letter; and he did this with so much effect, that Kepler saw his mistake, and in the noblest and most generous manner supplicated the forgiveness of his friend. Tycho exhibited the same good feeling; and the kindness of Hoffman, President of the States of Styria, completed the reconciliation of the two astronomers.

On his return to Prague in 1601, he was presented by Tycho to the Emperor, who conferred upon him the title of Imperial Mathematician, on the condition that he would assist Tycho in his calculations. This connexion was peculiarly valuable to Kepler, as the observations of his colleague were the only ones made in the world which could enable him to carry on his own theoretical inquiries. These two astronomers now undertook to compute, from Tycho's observations, a new set of astronomical tables, to be called the Rudolphine Tables, in honour of the Emperor. This scheme flattered the vanity of their master, and he pledged himself to pay all the expenses of the work. Longomontanus, Tycho's principal assistant, took upon himself the labour of arranging and discussing the observations on the stars, while Kepler devoted himself to the more congenial task of examining those on the planet Mars, with which Tycho was at that time particularly occupied. The appointment of Longomontanus to a professorship in Denmark, and the death of Tycho in October 1601, put a stop to these important schemes.

Kepler succeeded Tycho as principal mathematician to the Emperor, and was provided with a handsome salary, which was partly charged on the imperial treasury, and partly on the States of Silesia, and the first instalment of which was to be paid in March 1602. The generosity of the Emperor did not fail to excite the jealousy of ignorant individuals, who were not aware of the value of science to the state; but the increasing fame of Kepler, and the valuable works which he published, soon silenced their opposition.

In September 1604, astronomers were surprised with the appearance of a new star in the foot of Serpentarius. It was not seen before the 29th of September, and Mœstlin informs us that, on account of clouds, he did not obtain a good view of it till the 6th of October. Like that of 1572,[44] it at first surpassed Jupiter in brightness, and rivalled even Venus, but it afterwards became as small as Regulus, and as dull as Saturn, and disappeared at the end of a few months. It constantly changed its colour, and was at first tawny, then yellow, then purple and red, and often white at great altitudes. It had no parallax, and therefore was a fixed star. Kepler wrote a short account of this remarkable body, and maintained its superiority to that of 1572, as this last came in an ordinary year, while the other appeared in the year of the *fiery trigon*, or that in which Saturn, Jupiter, and Mars, are in the three fiery signs, Aries, Leo, and Sagittarius, an event which occurs only every 800 years. After discussing a great variety of topics, but little connected with his subject, and in a style of absurd jocularity, he attacks the opinions of the Epicureans, that the star was a fortuitous concourse of atoms, in the following remarkable paragraph, which is a good specimen of the work:—"When I was a youth with plenty of idle time on my hands, I was much taken with the vanity, of which some grown men are not ashamed, of making anagrams by transposing the letters of my name, written in Latin. Out of *Joannes Keplerus* came *Serpens in Akuleo* (a serpent in his sting); but not being satisfied with the meaning of these words, and being unable to make another, I trusted the thing to chance, and taking out of a pack of playing cards as many as there were letters in the name, I wrote one upon each, and then began to shuffle them, and at each shuffle to read them in the order they came, to see if any meaning came of it. Now, may all the Epicurean gods and goddesses confound this same chance, which, although I have spent a good deal of time over it, never shewed me anything like sense even from a distance. So I gave up my cards to the Epicurean eternity, to be carried away into infinity; and, it is said, they are still flying about there in the utmost confusion among the atoms, and have never yet come to any meaning. I will tell those disputants, my opponents, not my own opinion, but my wife's. Yesterday, when weary with writing, and my mind quite dusty with considering these atoms, I was called to supper, and a salad I had asked for was set before me. 'It seems then,' said I, aloud, 'that if pewter dishes, leaves of lettuce, grains of salt, drops of water, vinegar, and oil, and slices of egg, had been flying about in the air from all eternity, it might at last happen by chance that there would come a salad.' 'Yes,' says my wife, 'but not so nice and well dressed as this of mine is.'"

CHAPTER II.

Kepler's Pecuniary Embarrassments—His Inquiries respecting the Law of Refraction—His Supplement to Vitellio—His Researches on Vision—His Treatise on Dioptrics—His Commentaries on Mars—He discovers that the orbit of Mars is an Ellipse, with the Sun in one focus—And extends this discovery to all the other Planets—He establishes the two first laws of Physical Astronomy—His Family Distresses—Death of his Wife—He is appointed Professor of Mathematics at Linz—His Method of Choosing a Second Wife—Her Character, as given by Himself—Origin of his Treatise on Gauging—He goes to Ratisbon to give his Opinion to the Diet on the change of Style—He refuses the Mathematical Chair at Bologna.

Although Kepler now filled one of the most honourable situations to which a philosopher could aspire, and possessed a large salary fitted to supply his most reasonable wants, yet, as the imperial treasury was drained by the demands of an expensive war, his salary was always in arrear. Owing to this cause he was constantly involved in pecuniary difficulties, and, as he himself described his situation, he was perpetually begging his bread from the Emperor at Prague. His increasing family rendered the want of money still more distressing, and he was driven to the painful alternative of drawing his income from casting nativities. From the same cause he was obliged to abandon his plan of publishing the Rudolphine Tables, and to devote himself to works of a less expensive kind, and which were more likely to yield some pecuniary advantages.

In spite of these embarrassments, and the occupation of his time in the practice of astrology, Kepler found leisure for his favourite pursuits. No adverse circumstances were capable of extinguishing his scientific ardour, and whenever he directed his vigorous mind to the investigation of phenomena, he never failed to obtain interesting and original results. Since the death of Tycho, his attention had been much occupied with the subject of refraction and vision; and, in 1606, he published the result of his researches in a work, entitled "A Supplement to Vitellio, in which the optical part of astronomy is treated, but chiefly on the artificial observation and estimation of diameters, and of the eclipses of the Sun and Moon." Astronomers had long been perplexed with the refraction of the atmosphere, and so little was known of the general subject, as well as of this branch of it, that Tycho believed the refraction of the atmosphere to cease at 45° of altitude. Even at the beginning of the second century, Claudius Ptolemy of Alexandria had unravelled its principal mysteries, and had given in his Optics a theory of astronomical refraction more complete than that of any astronomer before the time of Cassini;[45] but the MSS. had unfortunately been mislaid, and Alhazen and Vitellio and Kepler were obliged to take up the subject from its commencement. Ptolemy had not only determined that the refraction of the atmosphere had gradually increased from the zenith to the horizon, but he had measured with singular accuracy the angles of refraction for water and glass, from a perpendicular incidence to a horizontal one.

Kepler treated this branch of science in his own peculiar way, "hunting down," as he expressed it, every hypothesis which his fertile imagination had successively presented to him. In his various attempts to discover the law of refraction, or a measure of it, as varying with the density of the body and the angle of incidence of the light, he was nearer the goal, in his first speculation, than in any of the rest; and he seems to have failed in consequence of his not separating the question as it related to density from the question as it related to incidence. “I did not leave untried,” says he, “whether, by assuming a horizontal refraction according to the density of the medium, the rest would correspond to the sines of the distances from a vertical direction, but calculation proved that it was not so: and, indeed, there was no occasion to have tried it, for thus the *refraction would increase according to the same law in all mediums, which is contradicted by experiment*.”

Although completely foiled in his search after the law of refraction, which was subsequently discovered by Willebrord Snell, and sometime afterwards by James Gregory, he was, singularly successful in his inquiries respecting vision. Regarding the eye as analogous in its structure with the camera obscura of Baptista Porta, he discovered that the images of external objects were painted in an inverted position on the retina, by the union of the pencils of rays which issued from every point of the object. He ascribed an erect vision to an operation of the mind, by which it traces the rays back to the pupil, where they cross one another, and thus refers the lower parts of the image to the higher parts of the object. He also explained the cause of long-sighted and short-sighted vision, and shewed how convex and concave lenses enabled those who possessed these peculiarities of vision to see distinctly, by accurately converging the pencils of rays to a focus on the retina. Kepler likewise observed the power of accommodating the eye to different distances, and he ascribed it to the contraction of the ciliary processes, which drew the sides of the eyeball towards the crystalline lens, and thus elongated the eye so as to produce an adjustment of it for near objects. Kepler wisely declined to inquire into the way in which the mind perceives the images painted on the retina, and he blames Vitellio for attempting to determine a question which he considered as not belonging to optics.

The work of Kepler, now under consideration, contains the method of calculating eclipses which is now in use at the present day.

The only other optical treatise written by Kepler, was his *Dioptrics*, with an appendix on the use of optics in philosophy. This admirable work, which laid the foundation of the science, was published at Augsburg in 1611, and reprinted at London in 1653. Although Maurolycus had made some slight progress in studying the passage of light through different media, yet it is to Kepler that we owe the methods of tracing the progress of rays through transparent bodies with convex and concave surfaces, and of determining the foci of lenses, and of the relative positions of the images which they form, and the objects from which the rays proceed. He was thus led to explain the *rationale* of the telescope, and to invent the astronomical telescope, which consists of two convex lenses, by which objects are seen inverted. Kepler also discovered the important fact, that spherical surfaces were not capable of converging rays to a single focus, and he conjectured, what Descartes afterwards proved, that this property might be possessed by lenses having the figure of some of the sections of the cone. The total reflection of light at the second surface of bodies was likewise studied by Kepler, and he determined that the total reflection commenced when the angle of incidence was equal to the angle of refraction, which corresponded to an incidence of 90.

Two years before the publication of his Dioptrics, viz. in 1609, Kepler had given to the world his great work, entitled “The New Astronomy, or Commentaries on the Motions of Mars.” The discoveries which this volume records form the basis of physical astronomy. The inquiries by which he was led to them began in that memorable year 1601, when he became the colleague or assistant of Tycho. The powers of original genius were then for the first time associated with inventive skill and patient observation; and though the astronomical data provided by Tycho were sure of finding their application in some future age, yet without them Kepler's speculations would have been vain, and the laws which they enabled him to determine would have adorned the history of another century. Having tried in vain to represent the motion of Mars by an uniform motion in a circular orbit, and by the cycles and epicycles with which Copernicus had endeavoured to explain the planetary inequalities, Kepler was led, after many fruitless speculations,[46] to suppose the orbit of the planet to be oval; and, from his knowledge of the conic sections, he afterwards determined it to be an ellipse, with the sun placed in one of its foci. He then ascertained the dimensions of the orbit; and, by a comparison of the times employed by the planet to complete a whole revolution or any part of one, he discovered that the time in which Mars describes any arches of his elliptic orbit, were always to one another as the areas contained by lines drawn from the focus or the centre of the sun to the extremities of the respective arches; or, in other words, that the radius vector, or the line joining the Sun and Mars described equal areas in equal times. By examining the inequalities of the other planets he found that they all moved in elliptic orbits, and that the radius vector of each described areas proportional to the times. These two great results are known by the name of the first and second laws of Kepler. The third law, or that which relates to the connexion between the periodic times and the distances of the planets, was not discovered till a later period of his life.

When Kepler presented to Rudolph the volume which contained these fine discoveries, he reminded him jocularly of his requiring the sinews of war to make similar attacks upon the other planets. The Emperor, however, had more formidable enemies than Jupiter and Saturn, and from the treasury, which war had exhausted, he found it difficult to supply the wants of science. While Kepler was thus involved in the miseries of poverty, misfortunes of every kind filled up the cup of his adversity. His wife, who had long been the victim of low spirits, was seized, towards the end of 1610, with fever, epilepsy, and phrenitis, and before she had completely recovered, all his three children were simultaneously attacked with the smallpox. His favourite son fell a victim to this malady, and at the same time Prague was partially occupied by the troops of Leopold. The part of the city where Kepler resided was harassed by the Bohemian levies, and, to crown this list of evils, the Austrian troops introduced the plague into the city.

Sometime afterwards Kepler set out for Austria with the view of obtaining the professorship of mathematics at Linz, which was now vacant; but, upon his return in June, he found his wife in a decline, brought on by grief for the loss of her son, and she was sometime afterwards seized with an infectious fever, of which she died.

The Emperor Rudolph was unwilling to allow Kepler to quit Prague. He encouraged him with hopes that the arrears of his salary would be paid from Saxony; but these hopes were fallacious, and it was not till the death of Rudolph, in 1612, that Kepler was freed from these distressing embarrassments.

On the accession of Mathias, Rudolph's brother, Kepler was re-appointed imperial mathematician, and was allowed to accept the professorship at Linz. His family now consisted of two children—a daughter, Susannah, born in 1602, and a son, Louis, born in

1607. His own time was so completely occupied by his new professorial duties, as well as by his private studies, that he found it necessary to seek another parent for his children. For this purpose, he gave a commission to his friends to look out for him a suitable wife, and, in a long and jocular letter to Baron Strahlendorf, he has given an amusing account of the different negotiations which preceded his marriage. The substance of this letter is so well given by Mr Drinkwater Bethune, that we shall follow his account of it.

The first of the eleven ladies among whom his inclinations wavered, "was a widow, an intimate friend of his first wife; and who, on many accounts, appeared a most eligible match. At first," says Kepler, "she seemed favourably inclined to the proposal; it is certain that she took time to consider it, but at last she very quietly excused herself." It must have been from a recollection of this lady's good qualities, that Kepler was induced to make his offer; for we learn rather unexpectedly, after being informed of her decision, that when he soon afterwards paid his respects to her, it was the first time that he had seen her during the last six years; and he found, to his great relief, that "there was no single pleasing part about her." The truth seems to be, that he was nettled by her answer, and he is at greater pains than appears necessary, considering this last discovery, to determine why she would not accept his offered hand. Among other reasons, he suggested her children, among whom were two marriageable daughters; and it is diverting afterwards to find them also in the catalogue, which Kepler appeared to be making, of all his female acquaintance…. Of the other ladies, one was too old, another in bad health, another too proud of her birth and quarterings, a fourth had learned nothing but shewy accomplishments, "not at all suitable to the sort of life she would have to lead with me," another grew impatient, and married a more decided admirer, whilst he was hesitating. "The mischief," says he, "in all these attachments was, that whilst I was delaying, comparing and balancing conflicting reasons, every day saw me inflamed with a new passion." By the time he reached the 8th, he found his match in this respect. "Fortune at length has avenged herself on my doubtful inclinations. At first she was quite complying, and her friends also; presently, whether she did or did not consent, not only I, but she herself did not know. After the lapse of a few days came a renewed promise, which, however, had to be confirmed a third time; and four days after that, she again repeated her confirmation, and begged to be excused from it. Upon this I gave her up, and this time all my counsellors were of one opinion." This was the longest courtship in the list, having lasted three whole months; and, quite disheartened by its bad success, Kepler's next attempt was of a more timid complexion. His advances to No. 9 were made by confiding to her the whole story of his recent disappointment, prudently determining to be guided in his behaviour, by observing whether the treatment he had experienced met with a proper degree of sympathy. Apparently the experiment did not succeed; and, almost reduced to despair, Kepler betook himself to the advice of a friend, who had for some time past complained that she was not consulted in this difficult negotiation. When she produced No. 10, and the first visit was paid, the report upon her was as follows:—"She has, undoubtedly, a good fortune, is of good family, and of economical habits: but her physiognomy is most horribly ugly; she would be stared at in the streets, not to mention the striking disproportion in our figures. I am lank, lean, and spare; she short and thick: in a family notorious for fulness, she is considered superfluously fat." The only objection to No. 11 seems to have been her excessive youth; and when this treaty was broken off on that account, Kepler turned his back upon all his advisers, and chose for himself one who had figured as No. 5 in the list, to whom he professes to have felt attached throughout, but from whom the representations of his friends had hitherto detained him, probably on account of her humble station.

The following is Kepler's summary of her character:—"Her name is Susannah, the daughter of John Reuthinger and Barbara, citizens of the town of Eferdingen. The father was by trade a cabinetmaker, but both her parents are dead. She has received an education well worth the largest dowry, by favour of the Lady of Stahrenberg, the strictness of whose household is famous throughout the province. Her person and manners are suitable to mine—no pride, no extravagance. She can bear to work; she has a tolerable knowledge how to manage a family; middle-aged, and of a disposition and capability to acquire what she still wants. Her I shall marry, by favour of the noble Baron of Stahrenberg, at 12 o'clock on the 30th of next October, with all Eferdingen assembled to meet us, and we shall eat the marriage dinner at Maurice's at the Golden Lion."[47]

Kepler's marriage seems to have taken place at the time here mentioned; for, in his book on gauging, published at Linz in 1615, he informs us that he took home his new wife in November, on which occasion he found it necessary to stock his cellar with a few casks of wine. When the wine-merchant came to measure the casks, Kepler objected to his method, as he made no allowance for the different sizes of the bulging parts of the cask. From this accident, Kepler was led to study the subject of gauging, and to write the book which we have mentioned, and which contains the earliest specimens of the modern analysis.

About this period, Kepler was summoned to the Diet at Ratisbon, to give his opinion on the reformation of the kalendar, and he published a short essay on the subject; but though the Government did not scruple to avail themselves of his services, yet his pension was allowed to fall in arrear, and, in order to support his family, he was obliged to publish an Almanac, suited to the taste of the age. "In order," says he, "to defray the expense of the Ephemeris for two years,[48] I have been obliged to compose *a vile prophesying Almanac, which is scarcely more respectable than begging,* unless from its saving the Emperor's credit, who abandons me entirely, and would suffer me to perish with hunger."

Although Kepler's residence at Linz was rendered uncomfortable by the Roman Catholics, who had excommunicated him on account of his refusing to subscribe to some opinions respecting the ubiquity of our Saviour, or, as others maintain, on account of some opinions which he had expressed respecting transubstantiation, yet he refused, in 1617, to accept of an invitation to fill the mathematical chair at Bologna. The prospect of his fortune being bettered by such a change could not reconcile him to live in a country where his freedom of speech and manners might expose him to suspicion; and he accordingly declined, in the most respectful manner, the offer which was made him.

CHAPTER III.

Kepler's continued Embarrassments—Death of Mathias—Liberality of Ferdinand—Kepler's "Harmonies of the World"—The Epitome of the Copernican Astronomy—It is prohibited by the Inquisition—Sir Henry Wotton, the British Ambassador, invites Kepler to England—He declines the Invitation—Neglect of Genius by the English Government—Trial of Kepler's Mother—Her final Acquittal—And Death at the age of Seventy-five—The States of Styria burn publicly Kepler's Calendar—He receives his Arrears of Salary from Ferdinand—The Rudolphine Tables published in 1628—He receives a Gold Chain from the Grand Dulce of Tuscany—He is Patronised by the Duke of Friedland—He removes to Sagan, in Silesia—Is appointed Professor of Mathematics at Rostoch—Goes to Ratisbon to receive his Arrears—His Death, Funeral, and Epitaph—Monument Erected to his Memory in 1803—His Family —His Posthumous Volume, entitled "The Dream, or Lunar Astronomy."

Kepler was kept in a state of constant anxiety from the delay in the Government to pay up the arrears of his pension, while their repeated promises prevented him from accepting of other employments. He had hoped that the affair of the Bolognese chair would rouse the imperial treasury to a sense of its duty, and enable him to publish the Rudolphine Tables, —that great work which he owed to the memory both of Tycho and of Rudolph. But though he was disappointed in this expectation, an event now occurred which at least held out the prospect of a favourable change in his circumstances. The Emperor Mathias died in 1619, and was succeeded by Ferdinand III., who not only continued him in the situation of his principal mathematician, with his former pension, but promised to pay up the arrears of it, and to furnish the means for publishing the Rudolphine Tables.

The year 1619, so favourable to Kepler's prospects in life, was distinguished also by the publication, at Linz, of one of his most remarkable productions, entitled "The Harmonies of the World." It is dedicated to James I. of England, and will be for ever memorable in the history of science, as containing the celebrated law that the squares of the periodic times of the planets are to one another as the cubes of their distances. This singular volume, which is marked with all the peculiarities which distinguish his Cosmographical Mystery, is divided into five books. The two first books are principally geometrical, and relate to regular polygons inscribed in a circle; the third book is a treatise on music, in which musical proportions are derived from figures; the fourth book is astrological, and treats of the harmony of rays emanating on the earth from the heavenly bodies, and on their influence over the sublunary or human soul; the fifth book is astronomical and metaphysical, and treats of the exquisite harmonies of the celestial motions, and of the celebrated third law of the universe, which we have already referred to.

This law, as he himself informs us, first entered his mind on the 8th March 1618; but, having made an erroneous calculation, he was obliged to reject it. He resumed the subject on the 15th May; and having discovered his former error, he recognised with transport the absolute truth of a principle which for seventeen years had been the object of his incessant labours. The delight which this grand discovery gave him had no bounds. "Nothing holds me," says he; "I will indulge in my sacred fury; I will triumph over mankind by the honest confession, that I have stolen the golden vases of the Egyptians, to build up a tabernacle for my God, far away from the confines of Egypt. If you forgive me, I rejoice; if you are angry, I can bear it. The die is cast; the book is written, to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited six thousand years for an observer."

About the same time, in 1618, Kepler published, at Linz, the *three* first books of his "Epitome of the Copernican Astronomy," of which the *fourth* was published at the same place in 1622, and the *fifth*, *sixth*, and *seventh* at Frankfort in the same year. This interesting work is a kind of summary of all his astronomical views, drawn up in the form of a dialogue for the perusal of general readers. Immediately after its publication, it was placed by the Inquisition in the list of prohibited books; and the moment Kepler learned this from his correspondent Remus, he was thrown into great alarm, and requested from him some information respecting the terms and consequences of the censure which was then pronounced against him. He was afraid that it might compromise his personal safety if he went to Italy; that he would be compelled to retract his opinions; that the censure might extend to Austria; that the sale of his work would be ruined; and that he must either abandon his country or his opinions.

The reply of his friend Remus calmed his agitated mind, by explaining to him the true nature of the prohibition; and he concluded his letter with a piece of seasonable exhortation, "There is no ground for your alarm either in Italy or in Austria, only keep yourself within bounds, and put a guard upon your own passions."

In the year 1620, Sir Henry Wotton, the English ambassador at Venice, paid a visit to Kepler on his way through Germany. It does not appear whether or not this visit was paid at the desire of James I., to whom Kepler had dedicated one of his works, but from the nature of the communication which was made to him by the ambassador, there are strong reasons to think that this was the case. Sir Henry Wotton urged Kepler to take up his residence in England, where he could assure him of a welcome and an honourable reception; but, notwithstanding the pecuniary difficulties in which he was then involved, he did not accept of the invitation. In referring to this offer in one of his letters, written a year after it was made, he thus balances the difficulties of the question—"The fires of civil war," says he, "are raging in Germany. Shall I then cross the sea whither Wotton invites me? I, a German, a lover of firm land, who dread the confinement of an island, who presage its dangers, and must drag along with me my little wife and flock of children?" As Kepler seems to have entertained no doubt of his being well provided for in England, it is the more probable that the British Sovereign had made him a distinct offer through his ambassador. A welcome and an honourable reception, in the ordinary sense of these terms, could not have supplied the wants of a starving astronomer, who was called upon to renounce a large though an ill-paid salary in his native land; and Kepler had experienced too deeply the faithlessness of royal pledges to trust his fortune to so vague an assurance as that which is implied in the language of the English ambassador. During the two centuries which have elapsed since this invitation was given to Kepler, there has been no reign during which the most illustrious foreigner could hope for pecuniary support, either from the Sovereign or the Government of England. What English science has never been able to command for her indigenous talent, was not likely to be proffered to foreign merit. The generous hearts of individual Englishmen, indeed, are always open to the claims of intellectual pre-eminence, and ever ready to welcome the stranger whom it adorns; but through the frozen life-blood of a British minister such sympathies have seldom vibrated; and, amid the struggles of faction and the anxieties of personal and family ambition, he has turned a deaf ear to the demands of genius, whether she appeared in the humble posture of a suppliant, or in the prouder attitude of a national benefactor.

If the imperial mathematician, therefore, had no other assurance of a comfortable home in England than that of Sir Henry Wotton, he acted a wise part in distrusting it; and we rejoice that the sacred name of Kepler was thus withheld from the long list of distinguished characters whom England has starved and dishonoured.

In the year 1620, Kepler was exposed to a severe calamity, which continued to harass him for some time. His mother, Catherine Kepler, to whose peculiarities of temper we have already referred, was arrested on the 5th April, upon a charge of a very serious nature. One of her friends having some years before suffered a miscarriage, was subsequently attacked with violent headaches, and Catherine was charged with having administered poison to her friend. This accusation was indignantly repelled, and a young doctor of the law, whom she consulted, advised her to raise an action against her calumniator. From professional reasons, or probably pecuniary ones, this zealous practitioner continued to delay the lawsuit for five years. The judge who tried it happened to be displaced, and was succeeded by another, who had a personal quarrel with the prosecutor. The defender, who was aware of this favourable change in her case, became the accuser, and, in July 1620, Catherine Kepler was sent to prison, and condemned to the torture. The moment this event reached the ears of her son, he quitted Linz, and arrived in time to save her from punishment. He found that the evidence upon which she was condemned had no other foundation but her own intemperate conduct; and, though his interference was successful, yet she was not finally released from prison till the 4th November 1621. Convinced of her innocence, this bold woman, now in the 79th year of her age, raised a new action for damages against her opponent; but her death, in April 1622, put an end to her own miseries, as well as to the anxiety of her son. Among the virtues of this singular woman, we must number that of generosity. Mœstlin, the old preceptor of Kepler, had generously declined any compensation for his instructions. Kepler never forgot this act of kindness, and, in the midst of his poverty, he found means to send to Mœstlin a handsome silver cup in token of his gratitude. In acknowledging this gift, Mœstlin remarks, “Your mother had taken it into her head that you owed me 200 florins, and had brought 15 florins and a chandelier towards reducing the debt, which I advised her to send to you. I asked her to stay to dinner, which she refused. However, we hanselled your cup, as you know she is of a thirsty temperament.”

In the same year in which his mother was arrested, the States of Styria ordered all the copies of the Kalendar for 1624 to be publicly burnt. There does not seem to be any reason for supposing that this insult proceeded from his old enemies the Catholics. They would, no doubt, take an active share in carrying it into effect; but it would appear that his former patrons were affronted at Kepler’s giving the precedence in his title page to the States of Upper Ens, where he then resided, above the States of Styria.

In 1622, the Emperor Ferdinand, notwithstanding his own pecuniary difficulties, ordered the whole of Kepler’s arrears to be paid, even those which had been due by Rudolph and Mathias; and so great was his anxiety to have the Rudolphine Tables published, that he supplied the means for their immediate completion. New difficulties, however, sprung up to retard still longer the appearance of this most important work. The wars of the reformation, which were then agitating the whole of Germany, interfered with every peaceful pursuit. The library of Kepler was sealed up by order of the Jesuits, and it was only his position as imperial mathematician that saved him from personal inconvenience. A popular insurrection followed in the train of these disasters. The peasantry blockaded Linz, the place of Kepler's residence, and it was not till the year 1627, as the title page bears, or 1628, as Kepler elsewhere states, that these celebrated Tables were given to the world.

The Rudolphine Tables were published at Ulm in one volume folio. These Tables were calculated by Kepler from the Observations of Tycho, and are founded on his own great discovery of the ellipticity of the planetary orbits. The *first* and *third* parts of the work contain logarithmic and other auxiliary tables, for the purpose of facilitating astronomical calculations. The *second* part contains tables of the sun, moon, and planets; and the *fourth* a catalogue of 1000 stars, as determined by Tycho. A nautical map is prefixed to some copies of the tables, and the description of it contains the first notice of the method of determining the longitude by means of occultations.

A short time after the publication of these tables, the Grand Duke of Tuscany, instigated no doubt by Galileo, sent Kepler a gold chain in testimony of his approbation of the great service which he had rendered to astronomy.

About this time Albert Wallenstein, Duke of Friedland, a great patron of astrology, and one of the most distinguished men of the age, made the most munificent offers to Kepler, and invited him to take up his residence at Sagan in Silesia. The religious dissensions which agitated Linz, the love of tranquillity which Kepler had so little enjoyed, and the publication of his great work, induced him to accept of this offer. He accordingly removed his family from Linz to Ratisbon in 1629, and he himself set out for Prague, with the double object of presenting the Rudolphine Tables to the Emperor, and of soliciting his permission to go into the service of the Duke of Friedland. The Emperor did not hesitate to grant this request; and would have gladly transferred Kepler's arrears as well as himself to the charge of a foreign prince. Kepler accordingly set out with his wife and family for Sagan, where he arrived in 1629. The Duke Albert treated him with liberality and distinction. He supplied him with an assistant for his calculations, and also with a printing press; and, by his influence with the Duke of Mecklenburg, he obtained for him a professorship in the University of Rostoch.

In this remote situation, Kepler found it extremely difficult to obtain payment of the imperial pension which he still retained. The arrears had accumulated to 8000 crowns, and he resolved to go to the Imperial Assembly at Ratisbon to make a final effort to obtain them. His attempts, however, were fruitless. The vexation which this occasioned, and the great fatigue which he had undergone, threw him into a violent fever, which is said to have been one of cold, and to have been accompanied with an imposthume in his brain, occasioned by too much study. This disease baffled the skill of his physicians, and carried him off on the 5th November, O.S. 1630, in the sixtieth year of his age.

The remains of this great man were interred in St Peter's Churchyard at Ratisbon, and the following inscription, embodying an epitaph which he had written for himself, was engraven on his tombstone.

In hoc quiescit vir nobilissimus, doctissimus et celeberrimus Dom. Johannes Keplerus, trium Imperatorum Rudolphi II., Mathiæ, et Ferdinandi II., per annos XXX, antea vero procerum Styriæ ab anno 1594 usque 1600, postea quoque astriacorum ordinum ab anno 1612 usque ad annum 1628, Mathematicus toti orbi Christiani, per monumenta publica cognitus, ab omnibus doctis, inter Principes Astronomiæ numeratus, qui propria manu assignatum post se reliquit tale Epitaphium.

Mensus eram cœlos, nunc terræ metior umbras:
Mens cœlestis erat, corporis umbra jacet.

In Christo pie obiit anno Salutis 1630, die 5 Novembris, ætatis suæ sexagesimo.

This monument was not long preserved. It was destroyed during the wars which desolated Germany; and no attempt was made till 1786 to mark with honour the spot which contained such venerable remains. This attempt, however, failed, and it was not till 1803 that this great duty was paid to the memory of Kepler, by the Prince Bishop of Constance, who erected a handsome monumental temple near the place of his interment, and in the Botanical Garden of the city. The temple is surmounted by a sphere, and in the centre is a bust of Kepler in Carrara marble.

Kepler left behind him a wife and seven children—two by his first wife, Susanna and Louis; and three sons and two daughters by his second wife, viz.—Sebald, Cordelia, Friedman, Hildebert, and Anna Maria. The eldest of these, Susanna, was married a few months before her father’s death to Jacob Bartschius, his pupil, who was educated as a physician; and his son Louis died in 1663, while practising medicine at Konigsberg. The children by his second wife are said to have died young. They were left in very narrow circumstances; and though 24,000 florins were due to Kepler by the Emperor, yet only a part of this sum was received by Susanna, in consequence of her refusing to give up Tycho’s Observations till the debt was paid. Kepler composed a little work entitled “The Dream of John Kepler, or Lunar Astronomy,” the object of which was to describe the phenomena seen from the moon; but he died while he and Bartschius were engaged in its publication, and Bartschius having resumed the task, died also before its completion. Louis Kepler dreaded to meddle with a work which had proved so fatal to his father and his brother-in-law, but this superstitious feeling was overcome, and the work was published at Frankfort in 1636.

CHAPTER IV.

Number of Kepler's published Works—His numerous Manuscripts in 22 folio volumes—Purchased by Hevelius, and afterwards by Hansch—Who publishes Kepler's Life and Correspondence at the expense of Charles VI.—The History of the rest of his Manuscripts, which are deposited in the Library of the Academy of Sciences at St Petersburg—General Character of Kepler—His Candour in acknowledging his Errors—His Moral and Religious Character—His Astrological Writings and Opinions considered—His Character as an Astronomer and a Philosopher—The Splendour of his Discoveries—Account of his Methods of Investigating Truth.

Although the labours of Kepler were frequently interrupted by severe and long-continued indisposition, as well as by the pecuniary embarrassments in which he was constantly involved, yet the ardour and power of his mind enabled him to surmount all the difficulties of his position. Not only did he bring to a successful completion the leading inquiries which he had begun, but he found leisure for composing an immense number of works more or less connected with the subject of his studies. Between 1594, when he published his Kalendar at Gratz, and 1630, the year of his death, he published no fewer than *thirty-three* separate works; and he left behind him *twenty-two* volumes of manuscripts, *seven* of which contain his epistolary correspondence.

The celebrated astronomer Hevelius, who was a cotemporary of Louis Kepler, purchased all these manuscripts from Kepler's representatives. At the death of Hevelius they were bought by M. Gottlieb Hansch, a zealous mathematician, who was desirous of giving them to the world. For this purpose he issued a prospectus in 1714 for publishing them by subscription, in 22 volumes folio; but this plan having failed, he was introduced to Charles VI., who liberally obtained for him 1000 ducats to defray the expense of the publication, and an annual pension of 300 florins. With such encouragement, Hansch published in 1718, in one volume folio, the correspondence of Kepler, entitled "*Epistolæ ad Joannem Keplerum, insertis ad easdem responsionibus Keplerianis, quidquid hactenus reperiri potuerunt, opus novum, et cum Jo. Kepleri vita.*"

The expenses of this volume unfortunately exhausted the 1000 ducats which had been granted by the Emperor, and, instead of being able to publish the rest of the MSS., Hansch was under the necessity of pledging them for 828 florins. Under these difficulties he addressed himself in vain to the celebrated Wolfius, to the Royal Society of London, and to other bodies that were likely to interest themselves in such a subject. In 1761, when M. De Murr of Nuremberg was in London, he made great exertions to obtain the MSS., and Dr Bradley is said to have been on the eve of purchasing them. The competition probably raised the demands of the proprietor, in whose hands they continued for many years. In 1773 they were offered for 4000 francs, and sometime afterwards M. De Murr purchased them for the Imperial Academy of Sciences at St Petersburg, in whose library they still remain. Euler, Lexell, and Kraft undertook the task of examining them, and selecting those that were best fitted for publication, but we believe that no steps have yet been taken for executing this task, nor are we aware that science would derive any advantage from its completion.

Although, in drawing his own character, Kepler describes himself as "troublesome and choleric in politics and domestic matters," yet the general events of his life indicate a more peaceful disposition than might have been expected from the peculiarities of his mind and the ardour of his temperament. On one occasion, indeed, he wrote a violent and reproachful letter to Tycho, who had given him no just ground of offence; but the state of Kepler's health at that moment, and the necessitous circumstances in which he had been placed, present some palliation of his conduct. But, independent of this apology, his subsequent conduct was so truly noble as to reconcile even Tycho to his penitent friend. Kepler quickly saw the error which he committed; he lamented it with genuine contrition, and was anxious to remove any unfavourable impression which he might have given of his friend, by the most public confession of his error, and by the warmest acknowledgments of the kindness of Tycho.

In his relations with the scientific men of his own times, Kepler conducted himself with that candour and love of truth which should always distinguish the philosopher. He was never actuated by any mean jealousy of his rivals. He never scrupled to acknowledge their high merits; and when the discoveries made by the telescope established beyond a doubt the errors of some of Kepler's views, he willingly avowed his mistake, and never joined in the opposition which was made by many of his friends to the discoveries of Galileo. A striking example of this was exhibited in reference to his supposed discovery of Mercury on the sun's disc. In the year 1607,[49] Kepler observed upon the face of the sun a dark spot, which he mistook for Mercury; but the day proving cloudy, he had not the means of determining by subsequent observations whether or not this opinion was well founded. As spots on the sun were at that time unknown, Kepler did not hesitate to publish the fact in 1607, in his *Mercurius in Sole visus*; but when Galileo, a few years afterwards, discovered a great number of similar spots with the telescope, Kepler retracted his opinions, and acknowledged that Galileo's discovery afforded an explanation, also, of many similar observations in old writers, which he had found it difficult to reconcile with the actual motions of Mercury.

Kepler was not one of those cold-hearted men who, though continually occupied in the study of the material world, and ambitious of the distinction which a successful examination of it confers, are yet insensible to the goodness and greatness of the Being who made and sustains it. His mind was cast in a better mould. The magnificence and harmony of the divine works excited in him not only admiration but love. He felt his own humility the farther he was allowed to penetrate into the mysteries of the universe; and sensible of the incompetency of his unaided powers for such transcendent researches, and recognising himself as but the instrument which the Almighty employed to make known his wonders, he never entered upon his inquiries without praying for assistance from above. This frame of mind was by no means inconsistent with that high spirit of delight and triumph with which Kepler surveyed his discoveries. His was the unpretending ovation of success, not the ostentatious triumph of ambition; and if a noble pride did occasionally mingle itself with his feelings, it was the pride of being the chosen messenger of physical truth, not that of being the favoured possessor of superior genius. With such a frame of mind, Kepler was necessarily a Christian. The afflictions with which he was beset confirmed his faith and brightened his hopes: he bore them in all their variety and severity with Christian patience; and though he knew that this world was to be the theatre of his intellectual glory, yet he felt that his rest and his reward could be found only in another.

It is difficult to form any very intelligible idea of the nature and extent of Kepler's astrological opinions, and of the degree of credit which he himself placed in the opinions that he did avow. In his Principles of Astrology, published in 1602, and in other works, he rails against the vanity and worthlessness of the ordinary astrology. He regards those who professed it as knaves and charlatans; and maintains that the planets and stars exercise no influence whatever over human affairs. He conceives, however, that certain harmonious configurations of suitable planets, like the spur to a horse, or a speech to an audience, have the power of exciting the minds of men to certain general actions or impulses; so that the only effect of these configurations is to operate along with the vital soul in producing results which would not otherwise have taken place. As an example of this, he states that those who are born when many aspects of the planets occur, *generally* turn out busy and industrious, whether they be occupied in amassing wealth, managing public affairs, or prosecuting scientific studies. Kepler himself was born under a triple configuration, and hence, in his opinion, his ardour and activity in study; and he informs us that he knew a lady born under nearly the same configurations, "who not only makes no progress in literature, but troubles her whole family and occasions deplorable misery to herself." This excitement of the faculties of sublunary natures, as he expresses it, by the colours and aspects and conjunctions of the planets, is regarded by Kepler as a fact, which he had deduced from observation, and which has "compelled his unwilling belief." "I have been driven to this," says he, "not by studying or admiring Plato, but singly and solely by observing seasons, and noting the aspects by which they are produced. I have seen the state of the atmosphere almost uniformly disturbed as often as the planets are in conjunction, or in the other configurations so celebrated among astrologers. I have noticed its tranquil state either when there are none or few such aspects, or when they are transitory and of short duration." Had Kepler been able to examine these hasty and erroneous deductions by long continued observation, he would soon have found that the coincidence which he did observe was merely accidental, and he would have cheerfully acknowledged it. Speculations of this kind, however, are, from their very nature, less subject to a rigorous scrutiny; and a long series of observations is necessary either to establish or to overturn them. The industry of modern observers has now supplied this defect, and there is no point in science more certain than that the sun, moon, and planets do not exercise any influence on the general state of our atmosphere.

The philosophers in Kepler's day, who had studied the phenomena of the tides, without having any idea of their cause, and who observed that they were clearly related to the daily motions of the two great luminaries, may be excused for the extravagance of their belief in supposing that the planets exercised other influences over "sublunary nature." Although Kepler, in his Commentaries on Mars, had considered it probable that the waters of our ocean are attracted by the moon, as iron is by a loadstone, yet this opinion seems to have been a very transient one, as he long afterwards, in his System of Harmonies, stated his firm belief that the earth is an enormous living animal, and enumerates even the analogies between its habits and those of known animated beings. He considered the tides as waves produced by the spouting out of water through its gills, and he explains their relation to the solar and lunar motions by supposing that the terrene monster has, like other animals, its daily and nightly alternations of sleeping and waking.

From the consideration of Kepler's astrological opinions, it is an agreeable transition to proceed to the examination of his high merits as an astronomer and a philosopher. As an experimental philosopher, or as an astronomical observer, Kepler does not lay claim to our admiration. He himself acknowledges, “that for observations his sight was dull, and for mechanical operations his hand was awkward.” He suffered much from weak eyes, and the delicacy of his constitution did not permit him to expose himself to the night air. Notwithstanding these hindrances, however, he added several observations to those of Tycho, which he made with two instruments that were presented to him by his friend Hoffman, the President of the States of Styria. These instruments were an iron sextant, 2½ feet in diameter, and a brass azimuthal quadrant 3½ feet in diameter, both of which were divided into single minutes of a degree. They were very seldom used, and we must regard the circumstances which disqualified Kepler for an observer, as highly favourable to the developement of those great powers which he directed with undivided energy to physical astronomy.

Even if Kepler had never turned his attention to the heavens, his optical labours would have given him a high rank among the original inquirers of his age; but when we consider him also as the discoverer of the three great laws which bear his name, we must assign him a rank next to that of Newton. The history of science does not present us with any discoveries more truly original, or which required for their establishment a more powerful and vigorous mind. The speculations of his predecessors afforded him no assistance. From the cumbrous machinery adopted by Copernicus, Kepler passed, at one step, to an elliptical orbit, with the sun in one of its foci, and from that moment astronomy became a demonstrative science. The splendid discoveries of Newton sprung immediately from those of Kepler, and completed the great chain of truths which constitute the laws of the planetary system. The eccentricity and boldness of Kepler’s powers form a striking contrast with the calm intellect and the enduring patience of Newton. The bright spark which the genius of the one elicited, was fostered by the sagacity of the other into a steady and a permanent flame.

Kepler has fortunately left behind him a full account of the methods by which he arrived at his great discoveries. What other philosophers have studiously concealed, Kepler has openly avowed, and minutely detailed; and we have no hesitation in considering these details as the most valuable present that has ever been given to science, and as deserving the careful study of all who seek to emulate his immortal achievements. It has been asserted that Newton made his discoveries by following a different method; but this is a mere assumption, as Newton has never favoured the world with any account of the erroneous speculations and the frequent failures which must have preceded his ultimate success. Had Kepler done the same, by recording only the final steps of his inquiries, his method of investigation would have obtained the highest celebrity, and would have been held up to future ages as a pattern for their imitation. But such was the candour of his mind, and such his inordinate love of truth, that he not only recorded his wildest fancies, but emblazoned even his greatest errors. If Newton had indulged us with the same insight into his physical inquiries, we should have witnessed the same processes which were employed by Kepler, modified only by the different characters and intensities of their imaginative powers.

When Kepler directed his mind to the discovery of a general principle, he set distinctly before him, and never once lost sight of, the explicit object of his search. His imagination, now unreined, indulged itself in the creation and invention of various hypotheses. The most plausible, or perhaps the most fascinating, of these was then submitted to a rigorous scrutiny; and the moment it was found to be incompatible with the results of observation and experiment, it was willingly abandoned, and another hypothesis submitted to the same severe ordeal. By thus gradually excluding erroneous views and assumptions, Kepler not only made a decided approximation to the object of his pursuit, but in the trials to which his opinions were submitted, and in the observations or experiments which they called forth, he discovered new facts and arrived at new views which directed his subsequent inquiries. By pursuing this method, he succeeded in his most difficult researches, and discovered those beautiful and profound laws which have been the admiration of succeeding ages. In tracing the route which he followed, it is easy for those who live under the light of modern science to say that his fancies were often wild, and his labour often wasted; but, in judging of Kepler's methods, we ought to place ourselves in his times, and invest ourselves with the opinions and the knowledge of his contemporaries.

In the infancy of a science there is no speculation so absurd as not to merit examination. The most remote and fanciful explanations of facts have often been found the true ones; and opinions which have in one century been objects of ridicule, have in the next been admitted among the elements of our knowledge. The physical world teems with wonders, and the various forms of matter exhibit to us properties and relations far more extraordinary than the wildest fancy could have conceived. Human reason stands appalled before this magnificent display of creative power, and they who have drunk deepest of its wisdom will be the least disposed to limit the excursions of physical speculation.

The influence of the imagination as an instrument of research, has, we think, been much overlooked by those who have ventured to give laws to philosophy. This faculty is of the greatest value in physical inquiries. If we use it as a guide, and confide in its indications, it will infallibly deceive us; but if we employ it as an auxiliary, it will afford us the most invaluable aid. Its operation is like that of the light troops which are sent out to ascertain the strength and position of an enemy. When the struggle commences, their services terminate; and it is by the solid phalanx of the judgment that the battle must be fought and won.

G. S. TULLIS, PRINTER, CUPAN.

FOOTNOTES

[1] Childe Harold, canto iv. stanza liv.

[2] Life of Galileo, Library of Useful Knowledge, p. 1.

[3] De Insidentibus in Fluido.

[4] Opere di Galileo. Milano, 1810, vol. iv. p. 248-257.

[5] Life of Galileo, in Library of Useful Knowledge, p. 9.

[6] Systema Cosmicum, Dial. ii. p. 121.

[7] The authenticity of this work has been doubted. It was printed at Rome, in 1656, from a MS. in the library of Somaschi, at Venice. See Opere di Galileo, tom. vii. p. 427.

[8] On the First Invention of Telescopes.—*Journ. R. Instit.*, 1831., vol i., p. 496.

[9] Viviani *Vita del' Galileo*, p. 69.

[10] De Telescopio.

[11] Incredibili animi jucunditate.

[12] Nescio quo fato ductus.

[13] Berlin Ephemeris, 1788.

[14] Edin. Phil. Journ. vol. vi. p. 313.

[15] Life and Correspondence of Dr Bradley, Oxford, 1832, p. 533, See also his Supplement. Oxford, 1833, p. 17.

[16] Professor Rigaud is of opinion that Galileo had discovered the solar spots at an earlier period than eighteen months before May 1612.

[17] See page 40.

[18] These interesting MSS. I have had the good fortune of seeing in the possession of my much valued friend, the late Professor Rigaud of Oxford.

[19] Edin. Phil. Journ. 1822, vol. vi. p. 317. See Rigaud's Life of Bradley, Supplement, p. 31.

[20] Id. It., p. 37, 38.

[21] Joh. Fabricii Phrysii de Maculis in Sole observatis, et apparente earum cum Sole conversione, Narratio. Wittemb. 1611.

[22] It does not appear from the history of solar observations at what time, and by whom, coloured glasses were first introduced for permitting the eye to look at the sun with impunity. Fabricius was obviously quite ignorant of the use of coloured glasses. He observed the sun when he was in the horizon, and when his brilliancy was impaired by the interposition of thin clouds and floating vapours; and he advises those who may repeat his observations to admit at first to the eye a small portion of the sun's light, till it is gradually accustomed to its full splendour. When the sun's altitude became considerable, Fabricius gave up his observations, which he often continued so long that he was scarcely able, for two days together, to see objects with their usual distinctness. Fabricius speaks of observing the sun by admitting his rays through a small *hole* into a dark room, and receiving his image on paper; but he says nothing about a lens or a telescope being applied to the hole; and he does not say that he saw the spots of the sun in this way. Harriot also viewed the solar spots when the sun was near the horizon, or was visible through "thick layer and thin cloudes," or through thin mist. On December 21, 1611, at a quarter past 2 P.M., he observed the spots when the sky was perfectly clear, but his "sight was after dim for an houre."

Scheiner, in his "Appelles post Tabulam," describes four different ways of viewing the spots; one of which is by the *interposition of blue or green glasses*. His first method was to observe the sun near the horizon; the second was to view him through a transparent cloud; the third was to look at him through his telescope with a blue or a green glass of a proper thickness, and plane on both sides, or to use a thin blue glass when the sun was covered with a thin vapour or cloud; and the fourth method was to begin and observe the sun at his margin, till the eye gradually reached the middle of his disc.

[23] The original of this letter is in the British Museum.

[24] See Istoria e Dimonstrazioni, intorno alle macchie solare. *Roma*, 1616. See Opere di Galileo, vol, v., p. 131-293.

[25] Discorso intorno alle cose che stanno in su l'acqua, o che in quella si muovono. Opere di Galileo, vol. ii. pp. 165-311.

[26] Opere di Galileo, vol. ii. pp. 355-367.

[27] Ibid. 367-390.

[28] These three treatises occupy the whole of the third volume of the Opere di Galileo.

[29] It is said that Galileo was cited to appear at Rome on this occasion; and the opinion is not without foundation.

[30] Discorso delle Comete. Printed in the Opere di Galileo, vol. vi., pp. 117-191.

[31] Printed in the Opere di Galileo, vol. vi., pp. 191-571.

[32] A fine painting in gold, and a silver medal, and “a good quantity of agnus dei.”

[33] Library of Useful Knowledge, Life of Galileo, chap. viii.

[34] The communication between Florence and Rome was at this time interrupted by a contagious disease which had broken out in Tuscany.

[35] It has been said, but upon what authority we cannot state, that when Galileo rose from his knees, he stamped on the ground, and said in a whisper to one of his friends, “*E pur si muove*.” “It does move, though.”—Life of Galileo, Lib. Useful Knowledge, part ii. p. 63.

[36] It is a curious fact that Morin had about this time proposed to determine the longitude by the moon’s distance from a fixed star, and that the commissioners assembled in Paris to examine it requested Galileo’s opinion of its value and practicability. Galileo’s opinion was highly unfavourable. He saw clearly, and explained distinctly, the objection to Morin’s method, arising from the imperfection of the lunar tables, and the inadequacy of astronomical instruments; but he seemed not to be conscious that the very same objections applied with even greater force to his own method, which has since been supplanted by that of the French savant. See Life of Galileo, Library of Useful Knowledge, p. 94.

[37] Regis Gallorum in Dania Legatus.

[38] This office had been usually conferred on the King’s Chancellor.

[39] Omne solum forti patria, et cœlum undique supra est.

[40] The church of Tiers, where a monument has been erected to his memory.

[41] See the Life of Kepler.

[42] In his Preface to the Rudolphine Tables.

[43] Cox’s Travels in Poland, &c., vol. v., p. 189, 190.

[44] See the Life of Tycho, page 137.

[45] Cassini was born in 1625, and died in 1712.

[46] An interesting account of the steps by which Kepler proceeded will be found in Mr Drinkwater Bethune’s admirable Life of Kepler, in the Library of Useful Knowledge.

[47] Life of Kepler, chap. vi.

[48] These Ephemerides, from 1617 to 1620, were published at Linz in 1616. The one for 1620 was dedicated to Baron Napier of Merchiston.

[49] It is said that Kepler saw this dark spot *while looking at the sun in a camera obscura*. As a camera obscura is actually a telescope, magnifying objects in proportion to the focal length of the lens employed, he may be said to have first seen these spots with the aid of an optical instrument.

Transcriber’s Notes and Errata

The following typographical errors were corrected:

Page	Error	Coorection
50	betwen	between
71	his his	his
100	secretry	secretary
143	there sidence	the residence

234	guaging	gauging

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