

## **Memoir of Sir John William Herschel**

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About the year 1760, as Dr. Miller, the organist, better known, perhaps, as the historian of Doncaster, England, was dining at Pontefract with the officers of the Durham militia, one of them told him that they had a young German in their band who was an excellent performer on the violin, and if he would step into another room he might judge for himself. The invitation was gladly accepted, and Miller heard a solo of Giardini's executed in a manner that surprised him. Learning afterward that the engagement of the young musician was only from month to month, he invited him to leave the band and come and live with him. "I am a single man," he said, "and we doubtless shall be happy together beside, your merit will soon entitle you to a more eligible situation." The offer was accepted as frankly as it was made and the satisfaction with which the old organist always plumed himself upon this act of generous feeling is not surprising, since the German hautboy-player turned out at last to be Herschel the astronomer. Snetzler, a famous organ-builder a hundred years and more ago, was at his time setting up a new organ for the parish church of Halifax. Herschel, at Dr. Miller's advice, became one of the seven candidates for the place of organist. They drew lots how they were to perform in succession. Herschel drew the third. The second fell to Dr. Wainwright, of Manchester, whose rapid execution astonished the judges. "I was standing in the middle aisle with Herschel," wrote Dr. Miller, "and I said to him, What chance have you to follow this man? He replied, "I don't know I am sure fingers will not do." He ascended the organ-loft, however, and produced from the instrument so uncommon a fullness, such a volume of slow, solemn harmony, that I could not account for the effect. After a short extempore effusion, he finished with the old Hundredth Psalm tune, which he played better than his opponent. 'Ay, ay,' cried old Snetzler, 'tish is very goot; I vill luf tish man, for he gives my piphes room for to spheak.'" Having afterward asked Mr. Herschel by what means he produced so uncommon an effect, he replied, "I told you fingers would not do;" and taking two pieces of lead from his pocket, "One of these," he said, "I placed on the lowest key of the organ and the other on the octave above;

thus, by accommodating the harmony, I produced the effect of four hands instead of two." In 1780, twenty years after this, when Miller talked of his friend Herschel's great fame, and of his sister, Caroline Herschel, who, when her brother was asleep, amused herself in sweeping the sky with his twenty-feet reflector and searching for comets, the kind-hearted old man used to wish that the science of acoustics had been advanced in the same degree as the science of optics, "For," he said, "had William constructed auditory tubes of proportionate power to his great telescope, who knows but we might have been enabled to hear the music of the spheres!" From this date, fourscore and twelve years ago, until the present time, no name among modern scientific men has attained a higher rank than that of Herschel. Ninety volumes of the Philosophical Transactions of the Royal Society have been enriched with papers bearing the well-known signature. Genius, though often hereditary, is quite as often wayward. It not infrequently skips a generation. It descends sometimes to daughters. It reappears in other cases, after being dormant in children and grandchildren, in a fourth or fifth step of descent. But with the two Herschels the transmission was immediate. The original circumstances of the two great philosophers were indeed widely different. Sir William, the father, by genius and application succeeded in rising from obscurity to the proud position of the first astronomer of the age. His son, Sir John Herschel, had the advantage of the highest university training. But both were gifted with extraordinary talents, keen scientific tastes, and those great mathematical powers which so materially assist in abstruse inquiries. In the case of the subject of this memoir, the combination of high education with an extraordinary natural talent for communicating his thoughts in an attractive manner, has been one of the means of making him the most distinguished philosopher of the nineteenth century. John Frederick William Herschel was born at Slough, March 7, 1792. His father was already famous. People came from distant lands to see the great telescope. There are traditions about the wonder with which mail-travelers used to stare, in passing, at the mechanism by which the monster tube was used. A thousand stories of its revelations passed current among the vulgar. The astronomer let nobody use his forty-foot telescope, but the fame of it could not be hidden. It went through all the civilized world. And it was under the shadow of that mysterious erection that this only child of

the house-born when his father, then of twoscore and twelve years, was absorbed alike in the fame he had' achieved and the wonders he was every night discovering; reared in infancy with an uncle who spent his days in adjusting instruments, and an aunt whose nights were devoted to discovering new comets in the heavens; without a boy's associations and playmates, in a house kept quiet all the day that the star-watchers might sleep; and wandering through rooms whose silence no sports were permitted to disturb and no youthful buoyancy to interrupt-it was here that he passed his boyhood. Twelve years before the boy's birth the "Observations of the periodical star Mira Ceti," read before the Royal Society, had established his father's position among scientific men, and one year later his discovery of Uranus brought him into the foremost rank of astronomical observers. Amid such a childhood, separated from boy of his own age, suppressed in every demonstration which youthful spirits naturally give to feeling, without the school antagonisms that teach a lad his real worth, or the school rivalries that lead him to rate his fellow according to the plucky boyhood he exhibits, at the form or on the play-ground, in the dormitory or at the sparring-match, it is strange that the boy did not grow up full of eccentricities. His detractors-and even he, the gentlest of men, was not without them-say that he did. But there was in him, from first to last, no lack of manliness, no insincerity, no jealousy, no indifference even to rival merit. And then the man's life-long and conspicuous veneration for his father is perhaps the best proof or a happy childhood and youth. No want pinched the household; warm affection existed between the parents; the boy was the idol of a fond aunt and a fonder uncle; and it must have been from a happy home that he went to Eton. At the usual period of life young Herschel entered St. John's College, Cambridge, from which he graduated B. A. in 1813, as senior wrangler, having for his competitors the late Dr. Peacock, Dean of Ely, who was second wrangler, and the late Rev. Fearon Fallows, formerly astronomer at the Cape of Good Hope, as third wrangler. The names of several other men of mark appear in the honor-list as contemporary students, such as Professor Mill, Dr. Robinson, Master of the Temple, and Bishop Carr, of Bombay. Mr. Herschel had no sooner attained his degree than he forwarded a mathematical paper to the Royal Society, "On a remarkable application of Cotes's Theorem." This was published in the Philosophical Transactions. In

the same year he was elected a Fellow of the Royal Society, and though barely past his majority became at once an active member. The early researches of Herschel were confined to pure mathematics. For papers on this subject, published in the Philosophical Transactions, the Copley medal was awarded him in 1821. In 1822 he turned his attention to "observing " astronomy, that practical branch which descended to him as a hereditary duty. This occupation led him to associate with others in forming a special society for the general advancement of astronomical science. A few years previous to the death of his father, in consequence of the improvement in astronomical telescopes, amateur observers sprang up; who took great interest in the delineation of the heavens. It was considered an epoch favorable to the formation of a body that should be exclusively devoted to the encouragement of astronomy; and Mr. Herschel drew up an address which forms the first publication of the present Royal Astronomical Society. All the while, however, the imagination of the young philosopher was dwelling on the last discovery of his father-the binary stars. It was a secret, won from the unknown, that opened a new view into the universe. The boy was scarcely in adolescence, the father passing into old age, when the constitution of the nebulae was announced. It was the great achievement of the one; it was the first dictate to the young manhood of the other. Three years of conversation and thought passed away, when the son, then twenty-four, took from his father, then seventy-eight, the work of examining the double stars. The old man's end of life was gained. What of nobility was in him had descended right royally. In the space of five years the young astronomer had mapped 380 double and triple stars, obtained by above 10,000 separate measurements. The record of these observations was acknowledged by the French Academy of Sciences in bestowing their astronomical medal, and followed by a similar reward in England. This occurred in 1824. The old astronomer had foreseen the honors which his son would win, but did not live to rejoice in them. Sir William had died two years before. With his death came great changes to the pleasant family at Slough. The good mother survived, indeed, but the strange, ancient household was broken up. The aunt, who had watched the clock and catalogued the stars up to the last, returned to her old home in Germany. The cheerful old uncle had desisted from mechanical adjustments only when

apoplexy felled him at his work, and the young inheritor of all the honors was left to perform his task alone. To those who have had no experience in continuous astronomical observations there can be no conception of its anxious toil. Money cannot repay it, nor honors, nor fame. In the pursuit day must be turned into night, society abandoned, the round of home comforts broken in upon, intercourse with friends and neighbors discontinued; and the astronomical observer, quitting all the amenities of life, finds his compensation in the brotherhood of the stars. This self-sacrifice young Herschel made. The objects to observe required a calm atmosphere. The best time for this is between midnight and sun-rise. This continuous night-work requires health. Herschel felt the severity of it. "Should I be fortunate enough," he writes, when he was but thirty years old, "to bring this work to a conclusion, I shall then joyfully yield up a subject on which I have bestowed a large portion of my time, and expended much of my health and strength, to others who will hereafter, by the aid of those masterpieces of workmanship which modern art places at their disposal, pursue with comparative ease and convenience an inquiry which has presented to myself difficulties such as at one period had almost compelled me to abandon it in despair. In 1831 Mr. Herschel received the honor of knighthood from the hands of King William, in acknowledgment of his eminent scientific services. In 1833 he was awarded the royal medal of the Royal Society for his paper "On the investigation of the orbits of revolving double stars." The Duke of Sussex then said of him, "Sir John Herschel has devoted himself for many years, as much from filial piety, perhaps, as from inclination, to the examination of those remote regions of the universe into which his illustrious father first penetrated, and which he transmitted to his son as a hereditary possession, with which the name of Herschel must be associated for all ages. He has subjected the whole sphere of the heavens within his observation to repeated and systematic scrutiny. He has determined the position and described the character of the most remarkable of the nebulae. He has observed and registered many thousand distances and angles of position of double stars, and has shown, from comparison of his own with other observations, that many of them form systems whose variations of position are subject to invariable laws. He has succeeded, by a happy combination of graphical construction with numerical calculations, in determining the relative elements of the orbits

which some of them describe round each other, and in forming tables of their motions; and he has thus demonstrated that the laws of gravitation, which are exhibited, as it were, in miniature in our own planetary system, prevail also in the most distant regions of space—a memorable conclusion, justly entitled, by the generality of its character, to be considered as forming an epoch in the history of astronomy, and presenting one of the most magnificent examples of the simplicity and universality of those fundamental laws of nature by which their great Author has shown that he is the same to day and forever, here and everywhere." It is impossible to give any analysis of the results of the numerous researches which occupied the time of Sir John Herschel at the various periods of his life. From a rough and evidently incomplete list of his papers it would appear that out of seventy, twenty-eight are on astronomical subjects, thirteen on optics, ten on pure mathematics, eight on geology, and eleven on miscellaneous science. There are, however, two of his astronomical works to which we may fittingly refer here, since they furnish a key which unlocks much of Sir John's personal history. These are, first, his "Catalogue of nebulae J and clusters," published in the *Philosophical Transactions* for the year 1833, for which the gold medals of the Royal Society and the Astronomical Society were awarded; and, second, "Results deduced from observations made at the Cape of Good Hope." For this latter work he received the Copley medal for the second time from the Royal Society, and an honorary testimonial from the Astronomical Society. The interest which Sir John Herschel always exhibited in the minute details of nebulae and double stars must be considered as the result of his association with his illustrious father. M. Arago, in his admirable and exhaustive biographical notice of Sir William Herschel, translated from the French, and published recently in the report of the Smithsonian Institution, refers gracefully to this fact. Sir John's early familiarity with his father's instruments, in familiarity with which he may be said to have grown up, and with their necessary use in making observations, had its influence doubtless in the same direction. Hence, probably the reason why so long a period of his observing time was devoted to this section of astronomical research. One of his first communications to the memoirs of the Astronomical Society is an account of the great nebulae of Andromeda and Orion, accompanied by an admirable engraving

of the latter. From 1825 to 1833 nearly all his astronomical energies were given to this kind of observation. The catalogue of nebulae and clusters, previously mentioned, contains a list of more than twenty-five hundred of both; their right ascensions and declinations determined; the character of their general appearance recorded; and those which present an unusual constitution, or an extraordinary shape, (of which there are nearly one hundred,) are drawn with a precision, delicacy, and taste worthy of the most accomplished artist. The astronomer royal, on presenting the gold medal of the Astronomical Society to Captain Smyth on behalf of Sir John Herschel, who was then residing at the Cape of Good Hope, remarks: "That one of the most important parts of this work is the division containing the engraved representations of the most remarkable nebulae. The peculiarities they represent cannot be described by words nor by numerical expressions. These drawings contain that which is conspicuous and distinctive to the eye, and that which will enable the eyes of future observers to examine whether secular variation is perceptible. They are, in fact, the most distinct and most certain records of the state of a nebulae at a given time." The second series of investigations to which it is desired here to draw especial attention, is that described in the unique volume entitled "Results of Astronomical Observations made during the, years 1834--18381 at the Cape of Good Hope; being the completion of a telescopic survey of the whole surface of the visible heavens." After the publication of the catalogue of nebulae in 1833, Sir John Herschel determined to undertake a voyage to South Africa" for the purpose of continuing his researches in another hemisphere under a new heaven. He had the same plan in view and the same instruments. It had been irksome to his honored father, and was alike fretful to his own spirit, that the clouded sky of England allowed free sweep of the great telescope along the path of the stars at a rate so niggardly. Hardly more than thirty hours in thrice that number of nights were the mysteries of the great vault exposed to his search. He resolved, therefore, to seek a clearer atmosphere and a wider field of inquiry. The southern extremity of Africa, where was an English colony, in which seclusion could be found without loss of means of communication with the philosophic world, and an un-clouded sky bending above a healthy climate, seemed to offer the greatest advantages. He consequently fixed upon the Cape of Good Hope as the most fitting

place for a protracted residence away from England, and the broadest field for thorough researches. " Sir John Herschel embarked at Portsmouth, in company with his family, on the 15th of November, 1833, and arrived safely at Table Bay on the 18th of January, 1834, after a pleasant voyage, diversified by few nautical incidents. No one knew so well as the great astronomer of whom we write, even before, while recumbent on the deck of the vessel that was bearing him through the tropic zone, he watched for hours together the shifting panorama of the star-fretted vault, how the moon appeared brighter, fairer, and better defined through a more transparent atmosphere; how the planets seemed to be other orbs; how the stars, long watched in a northern sky, drooped toward the horizon, and were at length looked for in vain; how orbs, which, to his former vision, had modestly moved along the southern outskirts of visible creation, now marched majestically overhead, each "Walking the heavens like a thing of life," while new and strange bodies ascended high and higher, until the old earth had passed away and a new heaven was aloft; nor how the Via Lactea, in the neighborhood of the Centaur and the Cross, coupled with profuse collections of nebulae and asteroids, stars and constellations, makes the southern sky the most magnificent star-view from any part of earth. Like the sources of the Nile to the untraveled geographer, or the ice-cliffs of Greenland to the student of arctic voyages, he knew well what a personal inspection would place before him, and though the civilized world rang with applause at his sacrifice of home and its comforts, and country and its honors, for the sake of science, yet true philosophers knew that the compensation, present and future, far outweighed the loss. After a temporary residence at Wilterfreiden, he engaged a suitable mansion, bearing the name of Feldhausen, about four miles from Cape Town—a spot full of rural beauty, within sight of lofty bills, and situated on the last of the terraced slopes by which Table Mountain lets itself down to the lowlands and meadows near the sea. In this place, removed from all the noise of traffic and exposure to intrusion, surrounded on all sides by a grove of planted trees, he caused a suitable building to be erected for the equatorial, while the 20-foot reflector was mounted in the open air. The observatory at Feldhausen was situated in south latitude 33° 58' 55" 56, and longitude 22° 46' 9" 11 east from Greenwich. Its altitude was 142 feet above the level of the sea in Table Bay. During the erection of his

instruments, Sir John resided at Welterfreiden, and so quickly were his plans completed, that on the 22nd of February, 1834, he was enabled to gratify his curiosity by viewing, with his 20-foot reflector. 9 Crucis, the interesting nebula about n Argus, and on the evening of the 5th of March to begin a regular series of observations. After erecting his observatory and determining its geographical position, the attention of Sir John was directed to the fitting up of the telescope with which his observations were to be made. He had carried out with him three specula, one of which was made by his father, and used by him in his 20-foot sweeps; another was made by Sir John himself, under his father's inspection and instructions, and the other, of the very same metal as the last, was ground and figured by himself alone. They had each a clear diameter of 18.25 inches of polished surface, and were all equally reflective when freshly polished, and perfectly similar in their performance. The operation of re-polishing, which was more frequently required than in England, was performed by himself with the requisite apparatus, which he also brought from England. Although Sir John Herschel never exhibited-as indeed he had no occasion to do-the wonderful mechanical genius of his father, he nevertheless fully understood all the former's methods of preparing and treating specula. When it was stated at a meeting of the British Association in 1842, that Lord Ross had attained such skill in the treatment of metallic specula that he could dismount the mirror of his large telescope, repolish it, and replace it the same day, Sir John four years previously had written to Arago these words: "By following my father's rules minutely and using his apparatus, I have succeeded in a single day, without the least assistance, in polishing, completely three Newtonian mirrors of nineteen-inch aperture." In the use of reflecting specula of considerable weight, it is of the utmost importance that the metal should be supported in its case so as not to suffer any change of figure from its own weight. Sir John found that a speculum was totally useless by allowing it to rest horizontally on three metallic points at its circumference. The image of every considerable star became triangular, throwing out long flaming caustics at the angles. Having on one occasion supported the speculum simply against a flat board, inclined at an angle of about 45°, he found that its performance was tolerably good; but on stretching a thin pack- thread vertically down the middle of the board, so as to bring the weight of

the metal to rest upon the thread, the images of the stars were lengthened horizontally to a preposterous extent, and all distinct vision utterly destroyed by the division of the mirror into two lobes, each retaining something of its parabolic figure, separated by a vertical band in a state of distortion, and of no figure at all! The method which Sir John found the best was the following: Between the; mirror and the back of the case he interposed six or seven folds of thick woolen baize, of uniform thickness and texture, stitched together at their edges. The metal, when laid flat on this bed, was shaken so as to be concentric with the rim of the case, and two supports, composed of several strips of similar baize, were introduced so as to occupy about 30° each, and to leave an arc of about 40° unoccupied opposite the point which was to be lowermost in the tube. When the case is raised into an inclined position, and slightly shaken, the mirror takes its own free bearing on these supports, and preserves its figure. It is essential, however, to the successful application of this method that many thicknesses of the baize should be employed, by which only the effect of flexure in the wooden back of the case can be eliminated." This simple plan, adopted by Sir John Herschel, is mentioned to show how mechanical genius aided him, as it did his father before him, in overcoming what had seemed to be insurmountable difficulties. The ingenious method by which Lord Ross afforded an equable support to a large speculum, and which is now generally adopted, was then unknown to him. The labors of Sir John Herschel in South Africa were chiefly confined to different subjects of observation. Stellar astronomy, however, occupied his principal attention. Two of the most celebrated nebulae-that in the sword-handle of Orion and that surrounding the variable star Eta Argus, as well as portions of the Milky Way, he delineated with particular care. The published drawings of these objects are acknowledged by all astronomers to be the most perfect representations of these beautiful ornaments of the southern sky. The nebula of Orion, magnificent as it is north of the equator, comes out in much grander detail in the southern hemisphere, where its great elevation in the heavens renders it comparatively free from the ill effects of an impure atmosphere. During the cooler months at the Cape of Good Hope, from May to October inclusive, and more especially in June and July, the finest opportunities for delicate astronomical observation occurred, and were quite equal to the observer's most sanguine expectations. Sir John

remarks that the state of the atmosphere in these months was habitually good, and imperfect vision rather the exception than the rule. The best nights, when the stars were most steady, always occurred after the heavy rains had ceased for a day or two, when the tranquility of the images and sharpness of vision was such that hardly any limit was set to magnifying power, but what the aberrations of the specula necessitated. Upon occasions like these Sir John found that optical phenomena of extraordinary splendor were produced by viewing a bright star through diaphragms of card-board or zinc, pierced in regular patterns of circular holes by machinery. These phenomena, arising from the interferences of the intromitted rays, and produced less perfectly in a moderate state of the air, surprised and delighted everyone. A result of a more interesting kind was obtained when the aperture of the telescope had the form of an equilateral triangle, the center of which coincided with the center of the speculum. When close double stars, were viewed with the telescope, having a diaphragm of this form, the discs of the two stars, which are exact circles, are reduced to about a third of their size, and possess a clearness and perfection almost incredible. These discs, however, are accompanied with six luminous radiations running from them at angles of  $60^\circ$ , forming straight, delicate, and brilliant lines, like illuminated threads, reaching far beyond the sea of view, and capable of being followed like real appendages to the star, long after the orb -itself had left the field. Another optical phenomenon, arising from a peculiar condition of the atmosphere, is described as "nebulous haze." The effect of it was to encircle every star of the ninth magnitude and upward with a faint sphere of light of an extent proportioned to the brightness of the star. This phenomenon presented itself very suddenly in a perfectly clear sky, free from suspicion of mist or cloud; and disappeared as suddenly after the lapse of about a hundred seconds. Sir John Herschel stated that similar nebulons affections occurred in England, but with less frequency of coming and going. He at first suspected that the phenomena arose from dew upon the eye-piece; but repeated observations satisfied him that they were atmospheric. Under the favorable circumstances in which he was now placed, the opportunity of studying the grand nebulae in the sword-handle of Orion was eagerly embraced. He had himself delineated this remarkable object in 1824. Four representations of it, differing essentially from his, had been subsequently

published, and it therefore became of the deepest interest to discover the causes of these discrepancies, and to ascertain whether in form or light a change had taken place. The splendid drawing of this nebulae, twelve inches square, is viewed with mute admiration, The mysterious assemblage of suns and systems which it sets before the observer is at first almost overlooked in his wonder at the patience and skill of the artist astronomer, No fewer than one hundred and fifty stars are accurately depicted, and the faint luminosity shades away on the picture, as in the heavens, into the dark sky. That this marvelous thing of beauty, having no relation to the stars which bespangle it and no union with the stars themselves, has recently undergone or is undergoing great and rapid changes, Sir John did not believe, He writes: "Comparing my only drawings made at epochs (1824 and 1837) differing by thirteen years, the disagreements, though confessedly great, are not more so than I am disposed to attribute to inexperience in such delineations, (which are really difficult) at an early period; to the far greater care, pains and time, bestowed upon the later drawings; and, above all, to the advantage of local situation, and the very great superiority in respect both of light and defining power in the telescope at the latter, over what it possessed at the former epoch, the reasons of which I have already mentioned. These circumstances render it impossible to bring the figures into comparison, except in points which cannot be influenced by such causes. Now there is only one such, particular on which I am at all inclined to insist as evidence of change, viz: in respect of the situation and form of the 'nebula oblongata,' which my figure of 1824 represents as a tolerably regular oval. Comparing this with its present appearance, it seems hardly possible to avoid the conclusion of some sensible alteration having taken place. No observer now, I think, looking ever so cursorily at this point of detail, would represent the broken, curved, and unsymmetrical nebula in question as it is represented in the earlier of the two figures, and to suppose it seen as in 1837, and yet drawn in 1824, would argue more negligence than I can believe myself fairly chargeable with". The magnificent Catalogue of Nebulae and Clusters of Stars in the Southern Hemisphere, comprehending 4,015, was reduced, arranged, and executed by Sir John's own hands, and appears like the work of a lifetime. In treating of the Magellanic clouds, two fine eye-sketches are given, drawn without telescopic aid, when seated at a table in the open air, in the

absence of the moon, and with no more light than was absolutely necessary for executing a drawing at all. He was compelled to this method in consequence of his attempts to represent other than very small portions of the Nubecula Major in the telescope, having been completely baffled by the perplexity of its details. On the 25th of October, 1837, Sir John was fortunate enough to obtain a view of the anxiously expected comet of Dr. Halley. In the fifth chapter of the "Astronomical Observations" he has given the results of his notice of this singular member of our solar system. Thirteen drawings illustrate the comet. We have it as it appeared night after night. On the 1st of November he describes its nucleus as small, bright, and highly condensed, shielded on the side next the sun by a narrow crescent of vivid, nebulous light, the front presenting an outline nearly circular, and having an altitude of  $90^\circ$  from horn to horn. Four days afterward it had the common appearance of a comet, with its nucleus and slightly diverging tail; but on its return from the sun on the 26th of January it assumed a new and surprising appearance.- Its head was sharply terminated "like a ground-glass lamp-shade, and within this head was seen a vividly luminous nucleus, as if a miniature comet, perfect in itself, possessing head and tail, and considerably exceeding the surrounding head in intensity of light;" in fact, a comet within a comet. As the nights followed each other, and the stranger advanced across the heavens, its increase in dimensions was so rapid that it might be said it was almost seen to grow." On the 26th the nucleus appeared as a star of the tenth magnitude, furred and nebulous, and more than double in size within twenty-four hours. On the 28th, upon looking through the 20-foot reflector, Sir John exclaimed, "Most astonishing! The coma is all but gone, and there are long irregular tails everywhere." The nucleus was then a sharp point, like one of Jupiter's satellites in a thick fog of hazy light-no well defined disk could be raised upon it-and its body was clearly discernable from its coma. "I can hardly doubt," he writes, that this comet was fairly evaporated in perihelion by the sun's heat, resolved into transparent vapor, and is now in process of rapid condensation and reprecipitation on the nucleus. Sir John concludes his "astronomical observations" by notices of the solar spots, and conjectures of their causes. Thirteen figures, delineated from magnified images formed on a screen by means of a 7-foot achromatic refractor, are given in a single plate. One of these spots occupied an area equal to 3,786,000,000 square

miles. Of one huge spot he makes no measurement. Of another, not one tenth in size, he says, its black center would have allowed the globe of our earth to drop through it, leaving a thousand miles clear of contact on all sides of that tremendous gulf." Of his theories of the causes of these vast spots on the surface of the sun no mention need here be made. Galileo, Kepler, Huygens, Kant, Lambert, and others, each gave their views upon these recondite phenomena. Sir John Herschel gave his as his father, had done before him. Others are giving, and others still, perhaps as accurate observers and logical reasoners as either of the two, will give theirs. The world can afford to wait. Astronomy advances. It may be, in the distant future, that the mysterious center around which our sun and his worlds revolve may be detected and afford a solution for other mysteries as well as these. The greatest astronomer is equipped for no more than a Sabbath-day's journey. Mountain-tops rise to his view as he moves along, and peaks of precipices disappear beyond the horizon which he leaves behind, but the Canaan he seeks to explore is still a terra incognita. . The work from which we have taken the foregoing, entitled "Results of Astronomical Observations made during the years 1834, '35-'36-'37, and '38, at the Cape of Good Hope, being the completion of a telescopic survey of the whole surface of the visible heavens, commenced in 1825," which occupies seven chapters, extending over four hundred and fifty pages, and illustrated by seventeen beautifully executed plates, would doubtless have appeared in a series of unconnected memoirs among the transactions of the Royal or Astronomical Societies, had it not been for the munificence of the late Duke of Northumberland, who gave a large sum for its publication as a single and separate work. The following are the subjects which are treated in the volume: CHAPTER I. On the nebulae and clusters of stars in the southern hemisphere. CHAPTER II. On the double stars in the southern hemisphere. CHAPTER III. On astronomy, or the numerical expression of the apparent magnitude of stars. CHAPTER IV. Of the distribution of stars, and of the constitution of the galaxy or milky way in the southern hemisphere. CHAPTER V. Observations on Halley's comet, with remarks on its physical condition and that of comets in general. CHAPTER VI. Observations on the satellites of Saturn. CHAPTER VII. Observations on the solar spots. Here let us turn back for a moment to fix our attention upon the

author of these marvelous works. The father, Sir William Herschel, had been not only a great astronomer, but a fortunate man, He was fortunate in having George the Third for a patron. Again he was fortunate in having Arago for a biographer, who, while complete master of his subject, was superior to envy and a lover of true greatness. But thrice fortunate was he in transmitting his name and fame to one, who, with the amplest intellectual resources of an accomplished scholar and philosopher, cherished the characteristic boldness of his predecessor's spirit, and; upheld that liberty of conjecture which is the mainspring of sagacity. It is rare that the parent's purple of intellect falls upon the child. By no culture however skillful, and no anxieties however earnest, can we transmit to our successors the qualities or the capacities of the mind. In lofty destinies father and son are rarely associated; and in the few cases where a joint commission has issued to them, it has generally been to work in different spheres, or at different levels. In the universe of mind a double star is more rare than its prototype in the firmament; and when it does appear we watch its phases and mutations with corresponding interest. The case of the two Herschels is a remarkable one, and appears an exception to the general law. The father, however, was not called to the survey of the heavens, till he had passed the middle period of life, and it was but a just arrangement that the son, in his youth and manhood, should continue the labors of his sire. As has been eloquently said, "The records of astronomy do not emblazon a more glorious day than that in which the semi-diurnal arc of the father was succeeded by the semi-diurnal arc of the son. No sooner had the evening luminary disappeared, amid the gorgeous magnificence of the west, than the morning star arose bright and cloudless in its appointed course." When it is considered that these two men, father and son, have carefully examined the whole starry firmament with 20-foot telescopes-instruments of which, in their present state of perfection, the elder Herschel may be said to have been the inventor-and that they have made known to us thousands of the most interesting phenomena, it is hardly an exaggeration to say that the science of moderate sidereal astronomy rests chiefly on their labors. It is worthy of remark, in connection with Sir John Herschel's labors at the Cape of Good Hope, that his residence was productive of benefits to meteorology as well as to astronomy. While occupied there, he suggested a plan of having meteorological observations made

simultaneously at different places-a plan subsequently developed at greater length in his instructions for making and registering meteorological observations at various stations in Southern Africa, published under official authority in 1844. The result has been the almost universal adoption of a similar plan in Europe and the United States. The record of the site of the 20-foot reflector at Feldhausen, South Africa, has been preserved. No sooner had Sir John embarked for England, than his numerous friends at the Cape raised by subscription a sufficient sum to erect a granite obelisk on the spot. There, in the quiet dell, surrounded by trees, at the foot of Table Mountain, stands an enduring memorial, not only of "the pleasing and grateful recollections of years spent in agreeable society, cheerful occupations, and unalloyed happiness," as he gracefully expressed it, but of the discovery of thousands of nebulae and double stars in the remote regions of the sidereal firmament. Sir John Herschel returned to England in May 1838. London received him with enthusiasm. The whole scientific world joined in the acclamation. He was entertained at a great public dinner. At the meeting of the British Association, at Newcastle, he was honored as the principal guest. The Crown made him a baronet. Oxford conferred upon him the highest university honor; and Scotland, not to be behind, elected him lord rector of Marischal College at Aberdeen. Without doubt, the Duke of Sussex having vacated the office, he might have been elected president of the Royal Society, and the British Government proposed to reimburse all his four years' pecuniary outlays; but he declined them both. His motives for his long expatriation had not been money, nor pleasure, nor health, nor fame, but increase and diffusion of knowledge among men. That object he had gained the means of teaching, and his largest ambition was satisfied. Sir John was the author of the articles on "Isoperimetrical Problems," and of "Meteorology," and "Physical Geography," in the Encyclopedia, Britannica, the last two of which have been republished separately, and also of several articles on scientific subjects in the Edinburg and Quarterly Reviews, which were collected-and published in a separate form in 1857, together with some of his lectures. He contributed besides to "Good Words" some popular papers on the wonders of the universe; and, two or three years before he died, he gave to the world, in the pages of "Cornhill Magazine," a poetical version of part of the Inferno of Dante. He was also one of

the many sexegenarian translators of Homer's Iliad. Sir John Herschel was either an honorary or corresponding member of the academies of Vienna, St. Petersburg, Gottingen, Turin, Bologna, Bruxelles, Nuremberg, Copenhagen, Stockholm, Prague, Warsaw, and Naples, as well as of almost all other scientific associations existing in Europe and America, Asia, and the southern hemisphere. To his other honors was added that of "Chevalier of Merit"; founded by Frederick the Great, and given at the recommendation of the Academy of Sciences at Berlin. We have hitherto confined our remarks to the principal original researches of Sir John Herschel, which are doubtless the most striking to the man of science; but still there can be no question that his popular reputation has arisen chiefly from his two well-known works, "A preliminary discourse on the study of natural philosophy" and "Outlines of astronomy," both of which contain internal evidence of his great attainments in almost every department of human knowledge, and of his high powers as a philosophical writer. We give a short extract from each of these works as examples of his style. Upon their contents it is not possible to enter here. In the "Preliminary discourse," writing upon a subject with which he was more intimately acquainted than any man had ever been in the past, or was in the present, he says: "Among the most remarkable of the celestial objects are the revolving double stars, or stars which, to the naked eye, or to inferior telescopes, appear single, but if examined with high magnifying powers are found to consist of two individuals placed almost close together, and which, when carefully watched, are (many of them) found to revolve in regular elliptic orbits about each other, and, so far as we have yet been able to ascertain, to obey the same laws which regulate the planetary movements. There is nothing calculated to give a grander idea of the scale on which the sidereal heavens are constructed than these beautiful systems. When we see such magnificent bodies united in pairs, undoubtedly by the same bond of mutual gravitation which holds together our own system, and sweeping over their enormous orbits in periods comprehending many centuries, we admit at once that they must be accomplishing ends in creation which will remain forever unknown to man; and that we have here attained a point in science where the human intellect is compelled to acknowledge its weakness, and to feel that no conception the wildest imagination can form will bear the least comparison with the

intrinsic greatness of the subject." Eloquently and nobly said; and yet not more eloquent and noble are the thoughts themselves, or the language that clothes the thoughts, in the passages we have quoted, than are others to be found on almost every page of the volume. In the other volume alluded to, "The outlines of astronomy," a work clustered with brilliant thoughts thick as the stars which stud the midnight heavens, he writes: "There is no science which, more than astronomy, draws more largely on that intellectual liberality which is ready to adopt whatever is demonstrated, or concede whatever is rendered highly probable, however new and uncommon the points of view may be in which objects the most familiar may thereby become placed. Almost all its conclusions stand in open and striking contradiction with those of superficial and vulgar observations, and with what appears to everyone, until he has understood and weighed the proofs to the contrary, the most positive evidence of his senses. Thus the earth on which he stands, and which has served for ages as the unshaken foundation of the firmest structures, either of art or of nature, is divested by the astronomer of its attribute of fixity, and conceived by him as turning swiftly on its center, and at the same time moving onwards through space with great rapidity. The sun and the moon, which appear to untaught eyes round bodies of no very considerable size, become enlarged in his imagination into vast globes; the one approaching in magnitude to earth itself, the other immensely surpassing it. The planets, which appear only as stars somewhat brighter than the rest, are to him spacious, elaborate, and habitable worlds, several of them much greater, and far more curiously furnished, than the earth he inhabits, as there are also others less so; and the stars themselves, properly so called, which, to ordinary apprehension, present only lucid sparks or brilliant atoms, are to him suns of various and transcendent glory, effulgent centers of life and light to myriads of unseen worlds. So that when, after dilating his thoughts to comprehend the grandeur of those ideas his calculations have called up, and exhausting his imagination and the powers of his language to devise similes and metaphors illustrative of the immensity of the scale on which his universe is constructed, he shrinks back to his native sphere, he finds it in comparison a mere point; so lost, even in the minute system to which it belongs, as to be invisible and unsuspected from some of its principal and remoter members." In the year

1851 Sir John Herschel accepted the appointment of master of the mint. This office, once held by Sir Isaac Newton, had degenerated into a place for politicians. Irrespective of qualification, the existing ministry had been accustomed for more than a hundred years to give it to the member of the House of Commons who had served them best. From the date of Herschel's acceptance of the office its political character ceased. He brought to the duties of the position the same thorough search, conscientious dealing, and indefatigable industry that characterized his life. He abolished old charters, did away with antiquated indentures, and refused to renew contracts for meltings and coinages. His work was so thorough that it is still styled by the employees at the mint the "revolution of '51." Like all innovations, it caused alarm. A faction threw up in opposition. Members of Parliament and of the ministry took sides against his plans; but that firmness for the right which never yielded, and that gentleness toward opponents which never lost its equipoise, ultimately achieved success. The "trial plates"-he called them "fiducial pieces"-which had been used for centuries, were abandoned; standard tables for the qualities of the precious metals were prepared; the conventional purity of British coin- gold as 916.6 and silver as 925-was settled; and the mathematical coincidence of the result of the pyx with the legal standard, established the correct result of the assays. The subject of our memoir, however, was not made for office-work. Though present at his labors throughout every day, and with papers spread before him, revising and calculating his work far into the hours of every night, the toil was not congenial. Bodily infirmity followed. He was unable to work. His friends became alarmed. For himself he had not sought the place. Nature still needed his interpretations, and he desired to be at liberty to pass his last days in her domain. He therefore resigned his office as master of the mint in 1855, and betook himself to the well-earned repose of a veteran of science. His mind, upon the recovery of his health, resumed its wonted activity, and though passing his life in comparative retirement at Collingwood, he prepared and published his catalogue of nebulae and star-clusters. This splendid work was presented to the Royal Society on November 19, 1863, and contains all the nebulae and clusters which had been anywhere described, and identified in position sufficiently to warrant their inclusion. The number of objects comprised in it is 5,078, including all observed by Sir William Herschel,

Sir John Herschel, the Earl of Rosse, and others. This truly noble undertaking will ever remain a monument of the energy and perseverance of Sir John Herschel, who at an age past three score and ten years found time and inclination to arrange and republish the great astronomical work of the century. From the rank which Sir John Herschel held among scientific men, his services were in almost constant demand on committees, boards, and royal commissions, whose object was the attainment of information for the advancement of science. For many years he was one of the "visitors" to inspect annually the Royal Observatory. To him was made the annual report of the Astronomer-Royal on the efficiency of that establishment, and he was an important member of the royal commission appointed to prepare new standards of length and weight in lieu of those destroyed by fire in 1835. As member of the council, and one of the secretaries of the Royal Society, he was one of its leading members for years. In 1830, on the resignation of the presidency by the late Mr. Davis Gilbert, a strong effort was made to elect Sir John Herschel to the vacant chair, in opposition to the Duke of Sussex, on the ground that his appointment would be peculiarly acceptable to men of science in Europe. But a commoner, however great, has in England little chance of success when a royal duke is his rival. There were special reasons which influenced a large number of the fellows to support a member of the royal family, and the duke was elected. In the Royal Astronomical Society Sir John filled the office of president for six years, and in 1845 he presided over the meeting of the British Association. It was the peculiar privilege-let us say in the conclusion of this part of our memoir-of Sir John Herschel, or peculiar gift, if the phrase he preferred, to combine with his special studies a breadth of view and power of expression- that made him the Homer of science. Take, for example, what he has said of the vast practical importance of scientific knowledge, "As showing us how to avoid impossibilities, in securing us from important mistakes when attempting what is in itself possible by means either inadequate or actually opposed to the end in view; in enabling us to accomplish our ends in the easiest, shortest, most economical and most effectual manner; and in inducing us to attempt and enabling us to accomplish objects which, but for such knowledge, we would never have thought of undertaking." Or again, "The character of the true philosopher is to hope all things not impossible, and to believe all things

not unreasonable. When once embarked on any physical research, it is impossible for anyone to predict where it will ultimately lead him. The true answer of science is that which again is at once the parallel and the illustration of the language of the apostle, "The mysteries of knowledge, which in other ages were not made known unto the sons of men, are now revealed, and will be still more revealed to those whom God has chosen." Or still again, "The students of science are as messengers from Heaven to earth to make such stupendous announcements, that they may claim to be listened to when they repeat in every variety of urgent instance, that these are not the last announcements they have to communicate; that there are yet behind, to search out and to declare, not only secrets of nature which shall increase the wealth and power of men, but truths which shall ennoble the age and country in which they are divulged and, by dilating the intellect, react upon the moral character of man-kind." We have called Sir John Herschel the Homer of science because he was its highest poet. It is the poet's function to move the soul-rousing the emotions, animating the affections, and inspiring the imagination; and all this Herschel did on almost every page of his writings. It is true that he avoids all fanciful representations of the facts of nature just as he eschews the meagerness of literal narration, but he has drawn beautiful pictures of nature's doings-so beautiful that they have disposed two generations to find their recreation and joy in science. There is, besides, poetry of no mean order in such a life as that of Sir John Herschel-a life wholly given to lofty, unselfish aims-a life of labor, working, as he expresses it, "like a working-bee" to the very end, reserving his almost only indignation for that spirit of idleness and luxury which spends life but does not use it. There is a passage in one of Sir John's popular addresses that furnishes so admirable an insight to his own character, that it is worth transcribing. Speaking of the advantages of a taste for reading, he says: "Give a man this, and you place him in contact with the best society in every period of history-with the wisest, wittiest, tenderest, bravest, and purest of characters who have adorned humanity; you make him a penizen with all nations, a contemporary of all ages. It is hardly possible but the character should take a higher and better tone from the constant habit of associating with thinkers above the average of humanity. It is morally impossible but that the manners should take a tinge of good breeding from having before one's eyes the ways in which

the best bred and the; best informed men have talked and acted. "No word he ever spoke, no sentence he ever wrote, so exactly depicts himself. He was in the utmost degree a well-bred man, not from gentle birth and careful training, not from scholarly pursuits and polite society, not from association with persons of rank and intimacy with men of taste and thought, not even from his loving nature and noble aspirations-not from all these together, so much as from the lofty ideal he cherished from boyhood to old age of perfect manhood. The upright form grew bent with passing years, the firm footstep staggered, the hand that poised instruments so accurately that well-nigh impossible angles of space could be measured to a hair's breadth became tremulous, the lines of thought on his face deepened into wrinkles, the straggling, grizzled "hair turned to snow-like whiteness, and the absent expression of the eyes grew more thoughtful, but the air and manner, and bearing and address of the well-bred man never left him. He received criticisms upon his own speculations with the same equanimity that he pointed out the errors of his opponents. His action in discussion was never violent, nor his voice loud. He readily acknowledged a fault, and still more readily apologized for a wrong. To the capacity of the young, whether in May-day sports or Christmas gambols, even when past his fourthscore year, he was as yielding as he was stern against any inroad upon morals or violation of truth. He never lost his equipoise, was never betrayed into anger, shrank from injustice to others as if the pain to be endured were his own, looked beneath the rough exterior of many who approached him for honest motives, and, more than most of the best and wisest of our race, might have said truly:

"Write me as one who loves his fellow-men."

Sir John Herschel's life-long contemplation of the infinite in number and magnitude, exalting and hallowing his mind, was exhibited in its effects upon his character. The truths he had learned from the stars were converted into principles of action. Lofty thoughts promoted noble deeds. " Surely," he himself had said in a yet higher mood of the same vein of thought as that of the last passage quoted, "Surely, if the worst of men were transported to Paradise for only half an hour amongst the company of the great and good, he would come back converted." There is one feature in Sir John Herschel's character of which some delineation

cannot be omitted in any approximately correct picture of his long life. It is his filial piety. In a soul full of the gentlest feelings, his love for his father while the veteran lingered on the stage of life: and his reverence for the great and good man's memory after his departure, constituted the strongest sentiment. Perhaps there is no other instance in all history where filial affection became for so long a time the ruling motive of a life. The son was born for a successor in the line of chemistry to Sir Humphrey Davy and a rival to Michael Faraday; for his father's sake he became an astronomer. His tastes led him into discoveries of the properties of hyposulphate salts and the actinic relations of light; his reverence for his illustrious sire determined him to complete, to the abandonment of every favorite pursuit, what the latter had so nobly begun. The pursuit of astronomy was neither the voluntary choice nor the principal bias of his intellectual life. His inborn aptitude lay in another direction. Uncontrollable circumstances determined his career, and these were framed out of impressions of the happy home of his childhood. He became a great astronomer, not through the promptings of natural taste but by the dictates of filial piety. And no man was ever more emphatically, in thought and work, in hostility to error and search after truth, the son of his father. Over the two the eulogy of David over Saul and Jonathan might be fitly pronounced.

"They were lovely and pleasant in their lives,  
And in their death they were not divided:  
They were swifter than eagles;  
they were stronger than lions."

This deep reverence for his father's memory, and this high appreciation of the value of his discoveries—either undeserved nor overrated—possessed Sir John Herschel to the last. His "idolatry" of the great telescope by which the sidereal heavens had been first unveiled to human sight has been called "weak in sentiment and dubious in taste." Arago did not so regard the means by which its remains were preserved, nor do other philosophers who hold the heart to be ever superior to the intellect. On the 1st of January, 1840, Sir John Herschel and his family, the old servants among the number, assembled at Slough. The metal tube had been placed horizontally in the meridian. At noon they walked in procession around the instrument, entered the capacious cylinder, seated themselves on benches previously prepared, sung a requiem, and then, ranging themselves around

that—call it a piece of metal if you will—which had been the means of opening the star-world to human sight, witnessed its hermetical sealing. "I know not," says Arago, "whether those persons who can only appreciate things from the peculiar point of view from which they have been accustomed to look, may think there was something strange in several of the details of this ceremony; I affirm, however, that the whole world will applaud the pious feeling which actuated Sir John Herschel, and that the friends of science will thank him for having consecrated the humble garden where his father achieved such immortal labors by a monument more expressive in its simplicity than pyramids or statues. The true place of Sir John Herschel among the great lights of his age cannot be accurately fixed until this generation shall have passed away. The feelings, prejudices, and partialities of contemporaneous life warp correct judgment. Proximity is unfavorable to true appreciation. No one knew this better than Biot, when he replied, in answer to the question, "Whom of all the philosophers of Europe do you regard as the most worthy successor of Laplace?". "If I did not love him so much, I should unhesitatingly say Sir John Herschel." Indeed, through his long confinement and protracted old age, the seekers after scientific truth not only in the English universities, but over all Europe, in their difficulties, anticipations, and successes, betook themselves to the aged philosopher of Collingwood. Of the work done by the Herschels, father and son, during a period of almost one hundred years, it is fitting that something be said in the conclusion of this memoir. That work is not in general correctly understood. The labors of the elder Herschel are indeed associated in the public mind with those of his son, but the real end and aim of those labors, the qualities which characterized the labors of each, and the steps by which the two men moved on, each like a star in its orbit, "Making no haste and taking no rest," towards the grand consummation, it is only necessary to peruse the obituary notices which appeared upon his death to see are wholly misunderstood, even by men of intelligence. The real work of the Herschels, then, that to which all their labors were directed, was the survey of those regions of space which lie beyond the range of the unaided vision. Other work they did which well deserves attention. Sir William Herschel, in particular, left papers describing observations of the planets, careful studies of the sun's surface, and researches into a variety of

oilier subjects of interest. But all the work thus recorded was regarded by him rather as affording practice whereby he might acquire a mastery over his instruments than as a work to which he cared to devote his powers. Even the discovery of a planet traveling outside the path of Saturn—although, in popular estimation, this discovery is regarded as the most note-worthy achievement of Herschel's life—was in reality but an almost accidental result of his real work among the star-depths. It was, in truth, such an accident as he may be said to have rendered a certainty. No man can apply the powers of telescopes, larger than any before constructed, to scrutinize as he did every portion of the celestial depths, without being rewarded by some such discovery. He never swept the star-depths for an hour without meeting multitudes of hitherto unknown orbs far mightier than the massive bulk of Uranus. These discoveries pass unrecorded save numerically, but they tended to the solution of the noblest problem which men have yet attempted to master. It was the same with the sun. All discoveries, all studies, were subordinated to this one purpose, a knowledge of the construction of the heavens. In the pursuit of this single end it is not strange that the great pioneer of star-observers should have formed opinions from time to time which he afterwards abandoned as unsupported by facts. In his paper, printed in the Philosophical Transactions of 1785, Sir William Herschel had said, "I have now viewed and gauged the milky way in almost every direction, and find it composed of stars whose number constantly increases and decreases in proportion to its apparent brightness to the naked eye. That this shining zone is a most extensive stratum of stars of various sizes admits no longer of the least doubt, and that our sun is actually one of the heavenly bodies belonging to it is evident." In the plate accompanying this paper, our sun makes one of innumerable stars, all comparable with each other in magnitude, and distributed with approach to uniformity. In 1802, after his telescope had been asking seven years longer the secret of the skies, writing of our sun, magnificent as its system is, as only a single individual of the insulated stars, he says: "To this may be added that the stars we consider as insulated are also surrounded by a magnificent collection of innumerable stars called the milky way. For, though our sun and all the stars we see may truly be said to be in the plane of the milky way, yet I am now convinced by a long inspection that the milky way itself consists of stars differently scattered from those which are

immediately about us." Similar changes of opinion in regard to the nature of double stars, to the constitution of the vast star system, and to the nature of the nebulae, occurred, as he modified the principle of interpreting his observations. In 1811 he writes: "I find that by arranging the nebulae in certain successive, regular order, they may be viewed in a new light, which cannot be indifferent to an inquiring mind." He now expressed the opinion that these nebulae did not consist of multitudes of stars, but of some self-luminous substance of exceeding tenuity. He recognized the existence of this luminous vapor amidst large tracts of the heavens, and regarded it as lying within the limits of the galaxy. Nay more, he believed this vaporous matter to be the material from which the stars were made. According to this view, vast as has been the age of our galaxy, it has not completely formed itself into compact bodies. For many years he had held that all the nebulae are composed of stars. He now believed that some nebulae were not of a starry nature; that a luminous matter existed in the universe in an elemental state; that the globular nebulae were the earliest formed and most advanced in growth; and that this vaporous or luminous matter lay within the line of the milky way, and formed part and parcel of its constitution. This new view taken by Sir William Herschel of the construction of the heavens, whether as respects extension in space or duration in time, is singularly impressive. It implies indeed an enormous diminution of dimensions. It reduces the supposed countless millions of stars around Orion to chaotic vapor. It contracts distances, so far beyond our star-system as not to be separately discerned by the most powerful glass, into spaces midway only between us and our galaxy. In reducing these distances many hundred times, this theory reduced the vastness of the objects many million times. But, on the other hand, it showed the milky way to be a more wonderful scheme than had ever been supposed. Vast as has been the period of its existence it had not yet entirely shaped itself into stars; over the regions where it extends, enormous masses of nebulous matter are still condensing into suns, and it becomes to the imagination a stupendous laboratory where systems of worlds have been produced and countless suns have had their genesis. Despite the ingenuity of illustration and incontestable force of reasoning by which Sir William Herschel sought to establish this bold hypothesis, it has not won general favor since his day. Observation seems conclusively to show that the

greater the optical power of the telescope the more certain is the evidence that the nebulae are aggregations of stars. Sir John Herschel, too, with his usual reverential caution about controverting his father's dicta, seems to entertain this last opinion. "It may very reasonably be doubted," he wrote, "whether there is any essential physical distinction between clusters of stars and those nebulae which my father regarded as composed of a shining nebulous fluid, and whether such distinction as there is be anything else than one of degree, arising merely from the excessive minuteness and multitude of the stars of which the latter compared with the former consist." In the course of that stupendous work which has already been pointed out—the work of surveying those regions of space too distant to be seen by the naked eye—it would be a greater marvel than all their united discoveries had the Herschels never found occasion to change their views and remodel their theories. They did this, both father and son, once and again. "If it should be remarked," wrote Sir William Herschel in 1811, "that in this new arrangement I am not entirely consistent with what I have already in former papers said on the nature of some objects that have come under my observation, I must freely confess that, by continuing my sweeps of the heavens, my opinion of the arrangement of stars and their magnitudes, and of some other particulars, has undergone a gradual change; and, indeed, when the novelty of the subject is considered, we cannot be surprised that many things, formerly taken for granted, should on examination prove to be different from what they were generally but incautiously supposed to be. For instance, an equal scattering of the stars may be admitted in certain calculations; but when we examine the milky way, or the closely compressed clusters of stars, this supposed equality of scattering must be given up. We may also have surmised nebulae to be no other than clusters of stars disguised by their very great distance, but a longer experience and better acquaintance with the nature of nebulae will not allow a general admission of such a principle, although undoubtedly a cluster of stars may assume a nebulous appearance when it is too remote for us to discern the stars of which it is composed." In fact, M. Arago's memoir of Sir William Herschel, as well as the numerous papers of himself and Sir John Herschel, which appeared from time to time, during more than three-quarters of a century, in the Transactions of the Royal Society and the Astronomical Society, show not only that the

former modified his theories, gradually, indeed, but not infrequently, in accordance with newly-discovered facts, but also that Sir John Herschel's discoveries, though considerably in advance of the points reached by his father, but lying, nevertheless, strictly in the direction along which the elder had been progressing, led to the same result. Sir William modified his views about unequal double stars, concluding that the fainter orb is physically associated with the brighter one, instead of being far beyond it. He modified his views as to star-groups, regarding at last the masses of the milky way as aggregations of stars instead of depths extending into space. He had come to regard many star-clusters as part and parcel of the milky way; large numbers of nebulae as vaporous luminous masses; and galaxies external to our system, as he once believed, a portion of the heavens with which he was familiar. Neither father nor son ever regretted to see hypotheses, though never so dearly cherished, pass beyond the field of controversy into the domain of the known. Let us now turn to another consideration of Sir John Herschel—still necessarily but less closely, perhaps, connecting him with his father—the consideration of his character as a theorist in astronomy. As an astronomical observer he was undeniably facile princeps, not merely among the astronomers of his own country, but among all his astronomical contemporaries. His mastery extended over the widest range. In his general knowledge of the science of astronomy he was unapproached; in the mathematical department of the science he was proficient above most; in his knowledge of the details of observatory-work he was surpassed by none; and as a gauger of the heavens by the largest telescopes he dwarfs into insignificance all the observational work accomplished by astronomers living or dead. He went over the whole range of his father's work through the northern skies, and then completed the survey of the heavens that bend over the southern hemisphere. He alone could boast that no part of the celestial depths had escaped his scrutiny. As an interpreter of nature, he was unrivaled as an expounder of astronomical truths he had no living peer, and as a theorist he commanded universal attention and compelled large assent. In order to be clearly understood as to the meaning attached to the words "astronomical theorist," let us quote a passage from one of the papers of Sir William Herschel. It is taken from that noble essay contributed to the Transactions of the Royal Society, in which he first presented his ideas

respecting the constitution of the celestial depths. "First let, me mention," he says, " that if we should hope to make any progress in investigations of a delicate nature, we ought to avoid two opposite extremes, of which I can hardly say which is the most dangerous. If we indulge a fanciful imagination and build worlds of our own, we must not wonder at our going wide from the path of truth and nature; but these will vanish like the Cartesian vortices that soon gave way when better theories were offered. On the other hand, if we add observation to observation, without attempting to draw, not only certain conclusions, but also conjectural views from them, we offend against the very end for which only observations ought to be made." Sir. John Herschel has also described the quality primarily requisite in a theorist. "As a first preparation," the paper goes on to say, "he must loosen his hold on all crude and hastily-adopted notions, and must strengthen himself by something like an effort and a resolve for the unprejudiced admission of any conclusion which shall appear to be supported by careful observation and logical argument, even should it prove of a nature adverse to notions he may have previously formed for himself, or taken up, without examination, on the credit of others. Such an effort is, in fact, a commencement of that intellectual discipline which forms one of the most important ends of all science. It is the first movement of approach towards that state of mental purity which alone can fit us for a full and steady perception of moral beauty as well as physical adaptation. It is the 'euphrasy and rue' with which we must 'purge our sight' before we can receive and contemplate as they are the lineaments of truth and nature." These principles Sir John Herschel strictly observed. He approached every subject on which he proposed to theorize with "enforced mental purity." He divested himself of prejudice. Previous views, preconceived notions, pride of opinion were cast aside. Like a child, he went to Nature's school to learn what she had to teach. When he entered on his astronomical labors, double stars were supposed to be two stars seen accidentally in the same direction, and his father had propounded the grandest views respecting galaxies beyond our own. Sir John. Herschel must have regarded these two theories with great favor, for they were associated with the name of his father. Notwithstanding this, Sir John devoted twenty-one years-eight in resurveying the fields of space which had been swept by his father's telescope, four in observation of the southern heavens, and

nine in reducing his work to form -in order to confirm or overturn, as facts might warrant, these hypotheses of his father. From him we now know that double stars are not stars seen accidentally in the same direction, but are star-couples, associated by the mighty bond of common gravity. We also know that the second hypothesis did not bear the crucial test to which it was subjected. Other theories, indeed, of the elder Herschel, in their important features, were confirmed. It is not of that, however, that we speak, but of the conscientious honesty and philosophic spirit with which the son reviewed and continued his father's work, forever setting scientific truth higher than filial reverence. Sir John Herschel was most sagacious in the interpretation of facts. Take, for example, his examination of the Magellanic clouds, those two curious patches on the southern celestial vault. He mapped their outlines, pictured their minute stars, and colored and shaded their star-cloudlets. At this point others might have stopped. There was an array of interesting objects in certain regions of the heavens. What more could he say But Sir John Herschel was not thus satisfied. He reasoned from the globular shape of the Magellanic clouds to the distance of the star-cloudlets within them, thence to the scale on which they were formed, and thus deduced the most important conclusion, perhaps, ever arrived at in astronomy by abstract reasoning, to wit, that all the orders of star-cloudlets belong to our own system. Again, Sir John Herschel was deeply impressed with the existence of analogies throughout the whole range of creation. In a private letter written to Richard A. Procter, as late as 1869, we find him saying: "An opinion which the structure of the Magellanic clouds has often suggested to me, has been strongly recalled by what you say of the inclusion of every variety of nebulous form within our galaxy, viz, that if such be the case, that is, if these forms belong to the galactic system, is then that system includes within itself miniatures of itself on an almost infinitely reduced scale, and what evidence then have we that there exists a universe beyond, unless a sort of argument from analogy, that the galaxy, with all its contents, may be but one of these miniatures of that vast universe, and so on an infinitum, and that in that universe there may exist multitudes of other systems on a scale as vast as our galaxy, the analogues of those other nebulous and clustering forms which are not miniatures of our galaxy. As an illustration of his power of tracing the chain that binds cause and effect, we may refer to a passage in his Treatise

on Astronomy. Tracing the connection between the central luminary of our system and terrestrial phenomena, Sir John remarks that the sun's rays are the ultimate source of almost every motion that takes place on the surface of the earth. By its heat are produced the winds and those disturbances on the electric equilibrium of the atmosphere which give rise to the phenomena of lightning, and probably also to those of terrestrial magnetism and the aurora. By their vivifying action vegetables are enabled to draw support from inorganic matter, and become in their turn the support of animals and man, and the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata. By them the waters of the sea are made to circulate in vapors through the air and irrigate the land, producing springs and rivers. By them are produced all disturbances of the chemical equilibrium of the element of nature, which by a series of compositions and decompositions give rise to new products and originate transfers of material. Even the slow degradation of the solid constituents of the surface, in which its chief geological changes consist, is almost entirely due, on the one hand to the abrasion of wind and rain, and the alternation of heat and frost, and on the other hand to the continual beating, of sea-waves, the result of solar radiation." He was an admirable expounder of scientific principles. His style of writing is perhaps cumbrous, and his sentences are often long and involved. But the thought he would express, like a thread of silver running through a web of purple, is always clear. The popular taste for astronomical studies is due to his writings more than to those of all other men. He, of all others, held mastery over pride of self-opinion. His own errors he admitted instantly they were discovered. Upon theories of others he worked as fairly and patiently as upon his own. He never struggled for a known error nor declined to accept a proven truth. With untiring patience, observing skill, and ingenious device, he sought earnestly to detect falsehood in his own opinions, and to discover truth in the opinions of others. It is said that he had a feeble grasp upon facts; that while his father clung with vise like grip to the sure and the known, he at times allowed them to slip from his grasp. " If so, it were a grievous fault." But so few are the instances-not above two or three-cited by those who allege this, so unimportant are the facts named, so apparent is the motive, unconscious it may be to themselves, of the theorizers who urge the objection, that it would seem probable that his opinions upon the facts had been

misinterpreted or his statements of them misunderstood. Even if this blemish exists, it is but as a spot upon the sun. It argues no more than that in one particular the son was second to the father. But without more satisfactory evidence we prefer to range ourselves among the doubters, and to be among the number of those who believe that Sir John Herschel's reasoning was never in a single instance marred by a forgotten fact. In the contemplation of the work of the two Herschels, let us remark in conclusion, and what that work has revealed to us, the mind stands appalled. Reason shrinks before the specter of boundless creation. ..If our sun and all his planets, primary and secondary, are in rapid motion round an invisible focus-if from that mysterious center no ray of light has ever reached our globe, then the buried relics of primeval life have taught us less of man's brief tenure on this terrestrial paradise than we learn from the lesson of the stars. The one may date back unnumbered centuries, the other declares that from the origin of the human race to its far distant future the system to which it belongs will have described but an infinitesimal arc of an immeasurable circle in which it is destined to revolve. He married Margaret Brodie, daughter of Dr. Stewart, in 1829; she and a numerous family survive him. Two of his sons are already very favorably known in the realm of science, and their father lived to see one of them selected by the council for election to the Royal Society. Another son has an important professorship in the north of England. The eldest son, the present Sir William Herschel, occupies, with distinguished merit, a very important post in the civil service of Bengal. Herschel's whole life, like the lives of Newton and Faraday, confutes the assertion, and ought to remove the suspicion, that a profound study of nature is unfavorable to a sincere acceptance of the Christian faith. Surrounded by an affectionate family, of which he was long spared to be the pride, the guide, and the life, John Herschel died, as he had lived, in the unostentatious exercise of a devout, yet simple, faith.