*losopher, and Practical Citizen,"* in the *"American Men of Energy"* series (New York: G. P. Putnam's Sons, $1.50).

6. Another recent biography of Franklin is that entitled *"The True Benjamin Franklin,"* by Sydney George Fisher (Philadelphia: J. B. Lippincott Co., $2.00). This work is highly eulogized by some critics, and quite as strongly dispraised by others. No one, however, questions the author's honesty of purpose, or his painstakingness.

7. An account of Benjamin Franklin for boys, "a boy's book on a boy's own subject," is Henry Mayhew's *"Young Benjamin Franklin, or The Right Road Through Life"* (New York: Harper & Brothers, $1.25).

8. Popular accounts of Franklin—not whole books—are found numerously. In Philip G. Hubert's *"Inventors"* in the *"Men of Achievement"* series, the opening chapter is devoted to Franklin, the other chapters being devoted to other great American inventors from Fulton and Whitney to Edison and Bell (New York: Scribners, $1.50).

9. In Dr. William Garnett's *"Heroes of Science—Physicists"* (New York: E. & J. B. Young & Co.), Franklin has a place along with such other great physicists as Boyle, Cavendish, Rumford, Young, Faraday, and Clerk Maxwell—truly a noble company.

# Sir William Herschel

present. There has perhaps been never another like it—in its singleness of purpose, its unresting industry, and its successful overcoming of difficulties, combined with the charm of personality which accompanied it and the greatness of real achievement which it won. All this can be only hinted at here. Frederick William Herschel, known to fame as Sir William Herschel, was born at Hanover November 15, 1738. His father, who was an oboist in the

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band of the Hanoverian guard, was an accomplished musician and a man of native ability, with a keen intellectual interest in many matters beyond those of his immediate business. The mother was a skillful, practical housekeeper. From the father Herschel inherited genius and an unquenchable thirst for knowledge; from the mother an instinct for mechanical contrivance, an inborn dexterity



in the use of tools, constitutional strength, and unbounded energy. His formal education was meager and wholly obtained in the regimental school of the guards. But he had a natural talent for music, and with his father's assistance he became an accomplished violinist, familiar also with the organ and several other instruments. For awhile he was a member of the band his father belonged to. But when he was nineteen his parents determined that he should not continue a soldier's life and they sent him to England. England and Hanover were at that time in close connection and the electors of Hanover were the kings of England. For some years after his emigration to England Herschel's life is obscure; but it must have been both industrious and self-helpful, for when opportunities for advancement arose he was able to take the fullest advantage of them. For some time he was bandmaster of a militia regiment. In 1765 he won by his skillful playing the position of organist at Halifax, in Yorkshire. In 1767 he was appointed organist to a chapel in Bath. Bath was then in the very height of its fame as a place of resort for people of fashion and wealth, and Herschel's talents soon became known and his life exceedingly busy. He gave lessons to private pupils. He trained and led choirs and orchestras. He conducted concerts and oratorios. He composed songs, glees, catches, and choruses, for his concert performers, concerted music for his orchestras, and psalm tunes, anthems, and even more difficult pieces, for his choirs. He had to engage and train soloists for all his public engagements, and even compose pieces suited to their particular voices or instruments. In short, his life was apparently as full and as preoccupied with its regular work as it was possible for a life to be.

But Herschel's devotion to his profession was only one part of his life. Another part of it, quite as exhaustive of time and energy, was his devotion to self-improvement. At first he studied Latin and Greek and French. He then turned his attention to the higher branches of his profession and became interested in the science of harmony. This led him to the study of mathematics. From mathematics he was naturally led to optics. In optics he was fairly entranced; and it was thence but a step to astronomy. Once introduced to the science of the heavens his love for it became a fervid, burning passion, which no difficulty could daunt, no obstacle restrain. The study of astronomy with him was at first principally observational. But for his observation he needed a telescope, and as he could not afford to buy one he made one. Having made one he made another, and then another, each time increasing his instrument's size and power. He made his own castings for the specula, and he did his own polishing. It was not, however, all a matter of easy success with him. Before he had got a satisfactory speculum for his first telescope he had suffered no fewer than 200 failures. And when afterward he was producing telescopes of larger size, over and over again would a speculum break down in the casting, or crack in the cooling, or show some hitherto unnoticed flaw in the polishing, which would entail his going through the whole work again, and so cost him weeks and often months of precious time. The work of polishing was especially arduous. Once it was begun his hands could not be removed from the metal without injury to the success of the result. At times he was known to sustain sixteen hours of continuous labor at a speculum in order to secure its perfect completion, his sister in the



meantime keeping up his strength by putting bits of food in his mouth as he wrought at the work. But the result of it all was that he became the most skillful telescope maker in Europe, and, for that matter, the most skillful the world has ever known. The art of shaping and polishing specula by hand, which he was so skillful in, became at his death a lost art, and the great forty-foot telescope which he completed in 1789, was, after his death, dismounted, because no one else could polish its mirror.

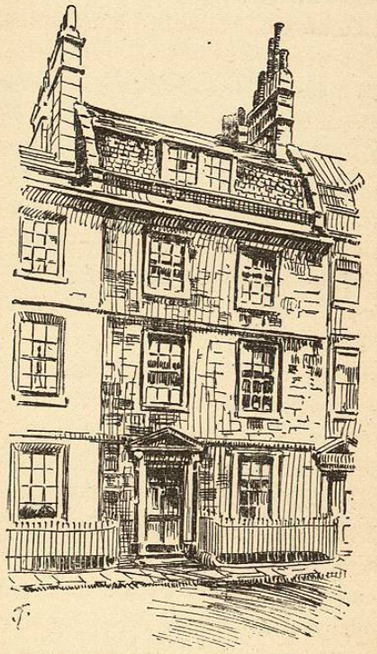
Herschel's first successful telescope was finished early in 1774, when he was in his 36th year. In March of that year he made his first important observation. Almost half a lifetime was already behind him when he began his new career, but never was a scientific career entered upon so late in life so gloriously blessed with rich achievement. His first task was to make a "review of the heavens;" that is, to bring under his telescope every part of the heavens visible in his latitude and to observe and carefully map down what he saw. This work, unattempted and unthought of previously, he performed no less than four times in his life, each time with instruments of greater power than before, and with increased skill and knowledge begotten of experience. On March 13, 1781, during the course of the second of these reviews, an event happened which at once made him famous throughout the civilized world. "A new planet swam into his ken." At first he was not certain that his discovery was a planet. Like the rest of mankind, he had supposed that all the planets had been known for ages. He therefore modestly gave his discovery to the world as "an account of a comet." It was not until a year and a half had elapsed that he felt sure enough of the planetary character of his

discovery to give it a name. Thus was Uranus found and admitted into the solar system. Herschel could no longer be a music master. Science claimed him wholly for her own. The Royal Society granted him a medal and elected him a fellow. Among opticians and astronomers nothing was talked of but the greatness of his discoveries. The king was desirous of seeing his telescope and asked him to bring it to London and show it to him. To London, therefore, Herschel went, taking his telescope with him. The king and the royal family looked through it and were enraptured. Herschel was made king's astronomer and royal telescope maker, and though the salary given him was not a large one it was enough to satisfy his simple needs. Besides, from the sale of his telescopes, which all the world wanted to buy, he soon had an income that was ample. The king bought four at $2,500 apiece, and ordered him to erect one for his own use at a cost of $20,000. In addition, he executed innumerable other commissions at prices varying from $1,000 to $15,000 each.

Herschel left Bath and removed to Datchet, near Windsor, in August, 1782, but his fame is principally identified with Slough, whither he removed in April, 1786. The house (now called "Observatory House") still stands in which he pursued his labors there, and no house in England has been the scene of more numerous or more renowned scientific achievements. The amount of work that Herschel accomplished is simply marvelous. For years he lost not a single hour of time suitable for astronomical observation. Calculations, the writing of his memoirs for publication, telescope making, business, the reception of visitors, eating, drinking, and sleeping, were all left to the daytime, or to be done at night-time when the



stars were invisible. His labor was incessant and no one not endowed with a constitution extraordinarily strong could have endured the strain of it. In all his work, however, he was assisted by his sister, Caroline Herschel, twelve years younger than himself, whom he brought over from Hanover to Bath to train for a concert singer, but



THE HERSCHEL HOUSE, BATH.

whom also he had trained to be an expert astronomer. Her labor and zeal were scarcely less incessant or remarkable than his; but they derived their inspiration from

her interest in him, but not from any real interest of her own in astronomical work. She discovered eight comets, however, and performed astronomical calculations that gained her the applause of astronomers the world over. But her real contribution to science was the work she did for her brother; for without her aid, which was as quick and accurate at the telescope as it was at the calculating table, he could have accomplished but a fraction of what he did.

Herschel's contributions to science were far too many and too complex to permit of summarization here. Besides the discovery of Uranus, and the "review of the heavens" four times repeated, he discovered two satellites of Uranus, and a fifth and sixth moon to Saturn. A great deal of his astronomical effort was spent in determining the nature of double stars. Of these he discovered and catalogued 806 pairs; and he proved that these star twins were not couples accidentally appearing so, due to a proximity of position in the visible firmament, but real twins, both in origin and constitution, that had a revolution about a common center. A second great department of his work was the identification and examination of star clouds, or nebulæ. Of these he catalogued no less than 2,500; and he proved conclusively that while many star clouds, or nebulæ, are in reality assemblages of stars whose tremendous distances make them appear dim and coalescent, there are many, many nebulæ which cannot be resolved into individual stars, but which are, in reality as in appearance, masses of luminous matter, gaseous, and without definite form. He was thus able to give physical demonstration, to give indeed ocular proof, of the reasonableness of certain parts of Laplace's "Nebular Hypothesis."



It is but right to state that the spectroscopic and photographic investigations of recent astronomers are wholly confirmatory of Herschel's conclusions in this matter. A third great department of Herschel's work was his star-gauging, or his endeavors to fix the relative distances of stars from the earth by means of comparisons of their relative brightnesses. Though his methods were imperfect, and his conclusions unsatisfactory (even to himself), yet they served to direct subsequent inquirers to the question, and lead to methods and results that are comparatively satisfactory. It must be remembered, too, that the question was first propounded by Herschel; and that it was, indeed, but a constituent part of the great problem of his life, namely the determination of the construction and organization of the universe as a whole. And though, of course, Herschel did not, and could not, reach a solution of his daring problem, yet, nevertheless, he deserves credit for propounding it, and for doing so much towards resolving it. The final achievement of Herschel's that may be mentioned, is one that bears on the same problem—namely the discovery of the motion of the sun (and, of course, with it, of the whole solar system) through space (at a rate now known to be probably 150,000,000 miles a year). This motion of the sun (which is but a star) is, of course, only the counterpart near by of similar motions to be observed in other stars, whose infinite distances, however, render their motion scarcely ascertainable. All this and much more did Herschel achieve, for his life was a long one, his industry untiring, his genius for his work unrivaled among the sons of men. He died August 25, 1822, in his 84th year. He had been made a knight in 1816.

# V. SIR WILLIAM HERSCHEL

1738-1822

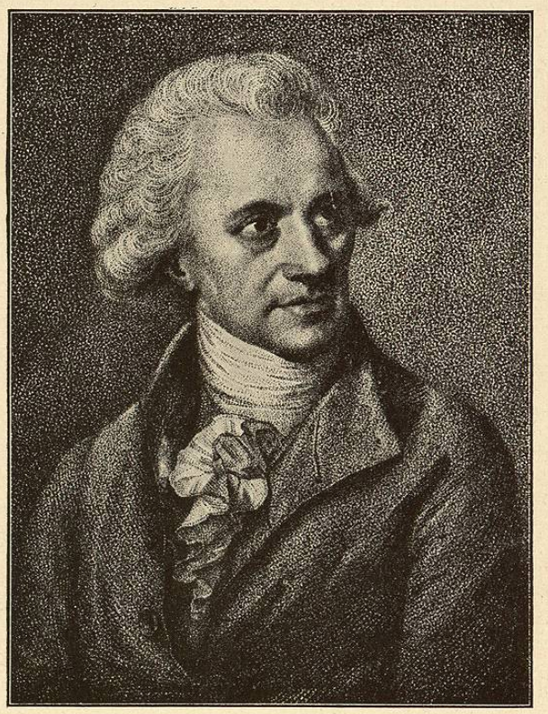
## *BIOGRAPHICAL STUDY*

BY JOHN EBENEZER BRYANT, M. A.

Herschel is the founder of the science of sidereal astronomy. That is to say, he was the first observer of the heavens who studied their unfathomable depths and tried to determine the order and motions of the stars as distinct from the planets. Since the beginning of the modern science of astronomy all previous observers of the firmament had been concerned principally with the motions of the planets. Copernicus had propounded the theory of the revolution of the planets around the sun. Tycho Brahë had mapped out the actual courses of the planets. Kepler had discovered the conditions which the planets observe in these courses. Galileo had with his telescope, and his splendid genius for physical demonstration, established innumerable proofs in confirmation of the Copernican theory. Newton, with his matchless insight into the harmonies of nature, had divined the law of gravitation, and, with his matchless powers of mathematical reasoning, had shown that that law was sufficient to account

for the motions of the planets, including the so-called "laws" of Kepler, and also for all perturbations from perfect regularity in their motions due to mutual inter-attractions, etc. Also, he had predicted that when the constitution of the heavens should be studied it would be found that the same law which held the planets in their courses would be operative in the infinite spaces in which the starry worlds are situated. Later on the two French scientists, Lagrange and Laplace, had taken Newton's law, and with wonderful patience, mathematical skill, and astronomical learning, had worked out all conceivable problems of planetary motions and perturbations, and had shown that the law needed no corrective, as had been supposed by some, but that despite its simplicity it explains every variation from normal regularity which the planets in their courses can possibly take. Moreover, they had shown that these variations are "periodic;" that is to say, that they are mutually corrective, and not accumulative, and that therefore the solar system is perfectly stable and in no danger of self-destruction, as had sometimes been feared. Finally Laplace (sometimes, and deservedly, called the French Newton), looking beyond the planetary world, looking, too, away from the present, peering into the infinite past, peering also into the infinite future, and trying to account for the construction of the universe—no less for its origin and development than for its present constitution—had propounded the theory now known as the "nebular hypothesis"—the theory which, with Newton's law assumed to be general, goes far to explain not merely the construction of the solar system, with all its revolving planets and satellites, but also, so far as can be tested, the construction of the entire universe.





SIR WILLIAM HERSCHEL

But neither Newton nor Laplace had any ocular knowledge of the heaven of stars beyond what other observers had obtained, and that had been almost wholly confined to the solar system. In fact all stars other than the stars of the solar system were called "fixed stars," and their fixedness had been taken by most astronomers to be so absolute that study of them had been considered unnecessary. Observers all the world over were engaged merely in problems connected with the motions of the planets, or with such obvious problems concerning the fixed stars, as their times of rising, meridian passing, and setting, as might be useful in navigation and surveying. But it happened that a new observer came into the astronomical world—one whose advent was as little to be expected, whose career was as much a matter for wonder and admiration, as ever were the advent and career of a comet in the world of stars. This was William Herschel, who, though favored neither with the education nor the training that an astronomer should have, and burdened also with the duties of another profession by which alone he could support himself, became one of the most technically learned and technically skilled astronomical observers the world has ever known; who enlarged the sphere of astronomical effort and made it include the whole universe; and who also by his discoveries and ocular demonstrations showed that the grand predictions of Newton and the even grander speculations of Laplace had the support of physical fact, and that the whole illimitable starry universe, no less than our own definite solar system, is under the domain of observable and determinate law.

Herschel's career was altogether too multifarious and brilliant to be adequately presented in a sketch like the