INTRODUCTION

John Herschel (1792–1871) was angry. The young natural philosopher, son of the world's most famous astronomer, top of his class at Cambridge University, and rising star among the scientific elite of Regency London, was fed up with the state of mathematics in Britain in general and as taught and practiced at Cambridge in particular. His frustration had been simmering for years as he worked toward mathematical reform through his own research and publications, but in 1816 the publication of a second edition of *Principles of Fluxions* by the venerable Cambridge don William Dealtry (1775–1847) was the last straw.

It was not simply that Herschel had hoped his own textbook, published two years earlier, had made works like Dealtry's irrelevant. It was not that Dealtry's book was bad and contained, according to Herschel, "nothing like uniformity of method, no pervading principle." It was not even that the book was riddled with errors. For Herschel, the problem of Dealtry's work was deeper and more fundamental. By posing as a treatise written to "instruct the rising generation in the principles of the differential calculus—to teach the young philosopher the nature and use of that all powerful instrument of research which is to be his guide through every intricacy of nature," the book was actively harmful to students and to the British scientific endeavor.

Herschel recognized that advanced mathematics had become indispensable for investigating the physical world. Mathematics had been central to natural philosophy for centuries, but new tools and methods developed throughout the 1700s had pushed this relationship to deeper levels and higher complexity—and Britain was being left behind. Though England proudly claimed the heritage of Isaac Newton (1643–

1727), works like Dealtry's showed how badly the nation was neglecting the expansions, transformations, and developments of Newton's work being made on the Continent, especially in France. Dealtry's book was backward and antiquated, according to Herschel, ignoring the new approaches to calculus and algebra (known together during this period as *analysis*) that Herschel felt were necessary for natural philosophy to make true progress.

British mathematicians remained stuck in the past, using outdated formalism and notation. And the success of Dealtry's book—evidenced by the appearance of a second edition—dashed Herschel's "aspirations after better things" and convinced him "that the period is yet far distant when mathematical science in the state of perfection to which our continental neighbours have brought it, will cease to be exotic to the British soil." In other words, Britain still had a long way to go. Herschel believed he was fighting for the future of the scientific endeavor, and pedantic texts like Dealtry's that centered on disconnected series of mathematical applications were worse than useless. They were actively harmful. Their "cloud of consecrated puerilities," Herschel railed, kept students and readers "distracted by an impertinent detail of trivial applications" and completely missed the point of mathematical instruction.[1]

Herschel was in a position to judge. Though known today primarily to historians of science and photography, Herschel in his lifetime became Britain's best-known natural philosopher, a world celebrity and scientific polymath of the generation in which the term *scientist* was itself invented. The son of William Herschel (1738–1822), discoverer of Uranus and constructor of the world's largest telescopes, Herschel sailed through Cambridge taking highest honors, conducted groundbreaking work in chemistry and optics (as a photographic pioneer he discovered the fixing agent used by traditional photography for more than a century and coined the terms *negative* and *snapshot*), helped establish a mathematical revolution, extended his father's astronomical surveys to the entire sky, and wrote the popular texts by which a generation of readers learned what it meant to "do science." Along the way, John Herschel established the practices of this new approach to natural philosophy in a period where traditional, hierarchical approaches to knowledge were giving way to new forms based on gentility, dispassion, and social credibility. The practice of science, under Herschel's influence, was becoming highly organized yet individualistic, culturally relevant and government funded but free from political control, and abstractly mathematical while grounded on observation. In sum, Herschel helped give to natural philosophy the contours of modern science. This culminated in his publication in 1831 of the book that turned a generation of natural philosophers into scientists: *A Preliminary Discourse on the Study of Natural Philosophy*.

In his *Discourse*, Herschel offered an appeal for and outline of this new scientific life. Among other things, he provided a definition of scientific theories as "creatures of reason rather than of sense," of creations of thought built from natural laws just as laws in turn were built from sense observations of the physical world.[2] But on another level, the term *creatures of reason* could also refer to a new type of scientific practitioner: the natural philosopher beginning to transition into the modern scientist. Finally, in a deeper sense, Herschel had created himself to be an ideal "creature of reason," and his entire early career was the story of this self-fashioning, from his initial frustrated mathematical reforms to becoming the central figure of the nineteenth-century British scientific community.

The *Preliminary Discourse* has long been acknowledged as a seminal text in the history of science. It was critical in the transition from natural philosophy to modern science that took place in the 1830s with the beginnings of professionalization of science into disciplines, the spread of scientific ideals to the middle classes through popular literature, and the application of scientific principles to society. For philosophers of science, the *Discourse* offered the first modern treatment of the inductive method. The work, in which Herschel set out his rules of scientific reasoning and theory formation, has been taken as offering everything from a codification of induction to an appeal to radical hypothesis to the first account of epistemological surprise as sign of robust theory formation. The *Discourse* was important for initiating one of the major philosophical debates of the nineteenth century between John Stuart Mill (1806–1873), who argued that experience was all-important in forming knowledge, and William Whewell (1794–1866), who argued that discoveries were made by the structures of human thought.[3]

Historian James Secord has argued that the majority of contemporary readers of the *Discourse* would have read it not as a philosophical text but, considering the book's price and format when originally published, as a conduct manual, a guide for the rising middle class to accrue social credibility by learning to think and act more scientifically. In this light, the *Discourse* was a product of the London publishing industry, shaped by market forces to appeal to a specific audience. As the steam press reduced the cost of printed books and politicians built programs of social reform on educating the populace through literature, the *Discourse* was a product capitalizing on a growing market, and Herschel was the scientific star pegged to write what would become one of the first science best sellers. As such, the work had an undeniable inspirational influence, the most famous example being the role it played for Charles Darwin (1809–1882) in providing not only a model for scientific theory formation but for a scientific life.[4]

The *Discourse* is thus a central text to understanding the origins of modern science. But what of the origins of the *Discourse*? The immediate context of the *Preliminary Discourse* is its author's life: not only how Herschel came to write it but how he became the person to write it—the experiences, values, and influences that shaped him as a creature of reason from his childhood through his early career to become one of the most recognized scientific authorities of his age. Placing the *Discourse* in this narrative allows new aspects of the work to emerge, in particular how the *Discourse* formed a synthesis of Herschel's previous work, built on his experiences at the telescope, in the laboratory, and on the mountaintop.

A biographical context also reveals the *Discourse* as a *reforming* work. A theme through Herschel's early life was his desire to see natural philosophy pulled from its traditional moorings in outdated mathematical formalisms and elite institutions to become more dynamic, efficient, and meritorious. Herschel found his attempts in this direction continually stymied throughout his years in Cambridge and then London, even as Tory conservatives in Parliament resisted political reform on the national level. When marketing and publishing forces offered Herschel the opportunity to write a popular treatise on natural philosophy, he used this chance to bring his reforming view of science to the public at large. This served the rationalizing social ambitions of the period as well as provided a rebuke to partisans (including some of his closest friends) arguing questions of privilege and financial support within scientific society. The virtues of Herschel's ideal natural philosopher—patience, disinterest, dispassion—were his own lived ideals, not the bickering controversies engulfing the Royal Society, which was supposed to be the nation's leading scientific institution. Herschel has often been seen as content to avoid controversy and work within established institutions. In the context of his life and career, however, the *Discourse* became his most effective instrument of reform. By the close of 1830, after only a few breakneck months of writing, Herschel created what would become the definitive treatment of the scientific endeavor for a generation. Herschel set out to reform natural philosophy; along the way, he helped invent modern science.

Though written almost two centuries ago, at the close of the Romantic era, Herschel's vision of science offered in the *Discourse* is of enduring importance in the twenty-first century. The *Preliminary Discourse* defined the nature of scientific practice for the age in which science became modern: professionalized, divided into disciplines, and inextricably linked with mathematics. During Herschel's early career, the increasingly complex mathematics required for natural philosophy created a perceived hierarchy between individuals who were trained in those mathematical methods and "amateur" natural philosophers who made observations, a division within science that remains in some form today. Science, it is claimed, is open to all, yet to produce scientific theories—not simply observations—mastery of advanced mathematical methods is required. Many can grapple with the concepts of physics, for instance, but only a mathematical physicist can use the observations from particle colliders to create new theories. Science is a plutocracy, and mathematics remains the currency of the realm.

Rightly or wrongly, Herschel was among the first of his generation to make this distinction. Even as he worried Britain had lost the mathematical edge it needed to advance in science, he was concerned that this mathematical necessity would undermine the reforming, democratic aspects of the natural philosophical endeavor. Herschel wrote in a period in which society was beginning to be modeled along scientific principles. As industry, commerce, wealth, and literacy grew, so did the need for an understanding of the methods and practices of science. A good citizen was someone who understood how to think scientifically. But was this even possible if only those trained in mathematical analysis could create the products of natural philosophy? Herschel wrestled with these issues, and the answers he forged in his *Preliminary Discourse* have shaped dialogue and conceptions of science in society ever since.

Since at least the 1960s, traditional views of the history of science have placed the origins of modern science within the Scientific Revolution, exemplified in the application of mathematics to the study of nature in the works of Galileo Galilei (1564–1642) and Newton and the inductive processes of Francis Bacon (1561–1626). More recently historians have argued that this misconstrues these early methods of understanding the world and that prior to the late 1700s and early 1800s this work should be understood in terms the practitioners themselves used, as *natural philosophy*, a mode of thought and investigation quite different from what we would identify as science today. As William Lubenow emphasizes in his study on learned societies of the nineteenth century, during this earlier period there was quite simply "no such thing as 'science.'"[5]

It was only the 1830s that saw the invention of science as a new and distinct undertaking. Natural philosophy was the effort to understand the world as created by God, and its virtues were largely confined to the gentlemanly elite. It was a unified endeavor, encompassing the entire natural world. In the period of Herschel's *Discourse*, however, the virtues of natural philosophy were expanded to all classes. In Britain, new professional opportunities arose, allowing the chance to pursue study of the natural world independent of the established church or social position. Optics, electromagnetism, chemistry, mineralogy, and geology flourished, giving rise to new scientific disciplines. The process of investigating the natural world went hand-in-hand with the growth of empire as science became globalized, and a new generation of philosophers began to critically examine what natural science was and how it worked, even as the industrial revolution transformed society. Herschel and the *Preliminary Discourse* were central to this transition. Understanding the context of this work thus illuminates this transformation from natural philosophy to science.[6]

Herschel has been referred to as "the forgotten philosopher." No theories are attributed to him, though his work showed how scientific theorizing was done. No discovery or invention bears his name, though his fingerprints are everywhere, from the vocabulary of photography to the names of moons of the outer solar system to the general deep-sky catalog used by astronomers today. Often lost in his father's shadow, the son nonetheless made sidereal astronomy mainstream. Herschel lies buried in Westminster Abby near Newton (and beside Darwin), a testimony to his place at the center of the scientific community and a reminder of how much we understand as the nature of modern science was established by Herschel and his *Preliminary Discourse*. Herschel's *Discourse* became, in sum, the *apologia* for a scientific life by the century's foremost natural philosopher. As such, the story of the *Discourse* and its composition is the story of the development of a new kind of scientific practice, a key step in the transition from natural philosophy to modern science.

A focus on the *Preliminary Discourse* allows a biographical approach to Herschel himself. Herschel embodied the scientific ideals of the era, values he articulated in his own persona before writing them into the *Discourse*. Though Herschel features centrally in the historiography of nineteenth-century science, no extensive biography of his life has been written. One reason is the daunting scale of his long career, which included hundreds of publications; thousands of pieces of surviving correspondence; important contributions to chemistry, mathematics, photography, optics, and astronomy; extensive travels, including his four years at the Cape of Good Hope; and a period holding the important governmental post of master of the mint. Using the *Preliminary Discourse* as a frame for Herschel's early biography provides a useful chronological breakpoint—the book's publication—as well as a natural culmination of the influence and credibility he slowly and steadily built from his student years onward. The story of the *Preliminary Discourse* is thus the story of Herschel's early career, from his matriculation at Cambridge in 1808 to preparations for his departure for the Cape in 1833.[7]

To write the *Discourse*, Herschel had to first become the person who *could* write the *Discourse*. The story of Herschel and the invention of science is thus the story of his invention of himself as the ideal natural philosopher, moving from the shadow of the telescope to becoming a reforming force in British society, drawing on his travels lost on an Alpine glacier in the middle of the night or scaling the slopes of Mount Etna, the influence of his famous father and aunt, and ultimately his relationship and marriage to Margaret Brodie Stewart (1810–1884), the daughter of an evangelical minister. It is a story of his colleagues, the pugnacious and sometimes infuriating father of computing, Charles Babbage (1791–1871), and the idealistic barrister James Grahame (1790–1842), and of middle-class accountants threatening the hegemony of aristocratic privilege. And it is ultimately the story of Herschel's failure at the ballot box but success through a runaway best seller that took the reform of science to the streets, making the practice of the halls of Somerset House the thought and conversation of the working class.

Herschel did not simply write about natural philosophy; he was the Romantic ideal of its practice. Herschel's vision of science in the *Discourse* was successful because the scientific ideal he laid out within was one he steadfastly pursued in his own life. His early career is the story of a polymath with one foot in the traditional world of natural philosophy and the other in the new realm of modern science, but it is also the account of a young person trying to live up to a very large name in a changing world.

Fortunately for Dealtry and his mathematics textbook, Herschel never published his damning review. It exists only in a manuscript draft, at the top of which Herschel at some point added a begrudging note that though not printed, "it ought to have been. It is very severe but perfectly just & would have done much good." At the time, Herschel was a fellow of St John's College and thus part of the institution he was railing against. Throughout his life, Herschel favored gradual reform, politically, socially, and pedagogically. His unpublished review gives a rare glimpse of the passions below his usually equanimous surface. "The force and vigour of the Student's mind is squandered away," Herschel thundered, "his spirit of enquiry quashed, and his relish for mathematical speculations in general, destroyed, in running this unmeaning round which leads to nothing; while the vast expanse of attainable knowledge is studiously kept concealed from his view."

Though Dealtry and Cambridge were spared the published ravages of his pen, Herschel worked to open that "vast expanse" to students and society by effecting the changes he wished to see. His reform of science would begin with a mathematical assault on the conservative courts of the university. The esteem in which Herschel held the new mathematical developments coming out of France—against which the traditional mathematics of Dealtry compared so poorly—went back to Herschel's childhood. William Herschel had made sure his son's education included exposure to the new mathematical analysis, but the roots went even further than that, to when John accompanied his father to Paris as a child and there got his first glimpse of a new scientific world. For William, the Paris trip marked the culmination of his own rise from itinerate immigrant musician to renowned natural philosopher, and for young John, that trip would have a lasting influence.

PROLOGUE

THE ASTRONOMER AND THE AUTOCRAT

When John Herschel was ten years old, peace broke out in Europe. Since the French Revolution, Britain and its network of European allies had been at war with the armies of the new French Republic. For most of John's life, the French had soundly defeated the allied forces on land, conquering portions of Italy, southern Germany, and the Low Countries, in part due to the brilliant military campaigns of Napoleon Bonaparte (1769–1821). In Britain any initial sympathy for the revolutionaries had been quickly quelled by growing horror as France moved toward regicide, authoritative rule, and wars that seemed aimed to export their revolutionary ideals abroad. As the French armies triumphed, it looked to many observers that equality and liberty were on their way to toppling the conservative forces of monarchy and aristocratic privilege. In 1802, however, the conflict ground to a halt long enough for both sides to lick their wounds. The Peace of Amiens meant that for the first time in nearly a decade it was possible for the British to travel freely to Paris, the center of the scientific world.

William Herschel leaped at the opportunity, taking his wife, Mary Pitt Herschel (1750–1832), and their young son, John, with him. William had been to Paris only once before, as an unknown musician in 1772. This time, he would come as a renowned natural philosopher recognized, together with his sister Caroline, as having revolutionized astronomy. Beyond his fame among savants, William was an international celebrity, having done what no one in history had before by discovering an entirely new world in the heavens. Almost exactly eleven years before John was born, William, an immigrant to England from Hannover in what is now Germany, went from being an established musician, composer, and music instructor in the English resort town of Bath to a household name in Britain and abroad with the discovery of the planet that would eventually become known as Uranus. Up until then, the solar system had included five visible planets besides Earth: Mercury, Venus, Mars, Jupiter, and Saturn. Even the telescopic discoveries of Galileo more than a century before had only provided new details of or attendants for bodies already known in the solar system: the surface of the moon, satellites around Jupiter, the phases of Venus. With William's discovery of an entirely new world, the size of the solar system doubled. By the time of the Peace of Amiens, William Herschel was at the height of his fame.

John Herschel grew up in the shadow of his father's astronomical fame. In particular, he grew up in the shadow of the massive forty-foot reflecting telescope, the largest in the world, that his father had constructed outside their home in the village of Slough, near Windsor Castle, after William became personal astronomer to King George III (1738–1820). Though George had lost the British colonies in the New World with the American Revolution, the discovery of a new planet (which William called the Georgium Sidus, or George's Star) may have helped mitigate a measure of British shame at being expelled from North America by a band of rebels. George had lost a continent but gained a world, and he honored its discoverer by making William his personal astronomer and providing him an annual stipend to continue his observations. The massive telescope, and the other reflecting telescopes William constructed with his brother Alexander and exported throughout Europe, represented a new kind of power and prestige. They were the artillery with which to wage a campaign of discovery. William's goal extended far beyond the boundary of the solar system. He wanted telescopes that could peer to the very boundaries of the universe, and the surveys of nebulae, star clusters, and double stars he conducted with them revealed a new vision of the cosmos.

One person in Paris was especially interested in the dynamic universe that William's telescopes revealed: Pierre Simon Laplace (1749–1827), the most powerful and influential natural philosopher in France. Laplace had gained renown in scientific circles before the French Revolution and had the political savvy to survive the following Terror even as friends and colleagues such as the aristocratic chemist Antoine Lavoisier (1743–1794) were sent to the guillotine. In his role at the École Militaire, Laplace had examined and passed Napoleon upon Napoleon's graduation as an artillery officer, and as that officer rose through the ranks Laplace saw his own influence increase, first as minister of the interior and ultimately as president of the French Senate.

Laplace gained fame by applying the new mathematical tools developed in France over the previous century to the physical world. Since Isaac Newton had created calculus to apply the law of universal gravitation to the motion of objects in the solar system, mathematicians such as Leonhard Euler (1707–1783), Jean le Rond d'Alembert (1717–1783), Joseph-Louis Lagrange (1736–1813), and Laplace himself had formalized new more powerful mathematical approaches known collectively as analysis. This development reached its culmination in Laplace's magisterial *Mécanique céleste* (published in five volumes from 1799 to 1825), which offered a comprehensive mathematical explanation of the motion of the planets and completed the project Newton had begun of quantifying the past and future motions of the objects in the solar system. In particular, Laplace's work had bearing on the stability of the cosmos. As Laplace was able to show, variations in the motions of the planets caused by their gravitational influence on each other were periodic within specific boundaries. In other words, the solar system was and would remain stable over long periods of time.

This insight was more than idle scientific speculation. During this period of political transitions, astronomy came to be seen as having important implications for society at large. The revolutions in France and the British colonies of North America raised questions about the assumptions on which a stable society was erected. For thinkers in Britain, who looked askance on the excesses of the French Revolution—the execution of a king, civil unrest, political instability, the overthrow of the aristocracy—astronomy revealed the orderly functioning of a carefully designed universe. Radical upheavals were not part of the natural order, which instead showed a divine and stable hierarchy ordained by a creator.

Order was important in France as well, exhausted as the country was by revolutionary tumults and subsequent European conflict. But in France this was an order founded on mathematical reasoning, a cohesive program of physical research dominated by Laplace, and strong centralized government support. Laplace had become the leader of a school of natural philosophers working to unify scientific knowledge and explain all physical processes in terms of attractive and repulsive forces between particles. His disciples, supported by government funding or lucrative official postings, went on to apply this program to developing an understanding of heat, light, magnetism, and electricity. And because the deposed Bourbon monarchs had shown liberal support of the sciences, the new autocrat Napoleon felt the need to ensure that science flourished even more under his own rule.[1] The scientific scene that William, with John in tow, arrived in Paris to find was one of excitement, optimism, organization, and prestige.

William was quickly immersed in the scientific milieu. In Paris he attended meetings of the first class of the Institut de France, established after the revolution in 1795 to replace the Académie Royale des Sciences and to which he was elected as one of the few foreign members. At the Institut he met figures like René Just Haüy (1743–1822), father of modern crystallography, the astronomer Charles Messier (1730–1817), whose famous catalog of nebulae was a precursor to Herschel's own work, and the mathematician Sylvestre François Lacroix (1765–1843), whose textbooks were promulgating the new French mathematics. Unlike the Royal Society of London, of which William was also a fellow, membership in the Institut was strictly limited to active scientific contributors, with no room for aristocratic dilettantes. It was small, select, and highly professional. Members received government salaries, and the entire body functioned as a formal advisory body to the government on scientific matters. The Royal Society, by contrast, resembled a club for wealthy amateurs. Science in Britain was seen as the concern not of the state but of individuals and voluntary associations. The Royal Society was large and diffuse, with only an informal relationship to the British government. By the end of the eighteenth century, its membership had ballooned to close to five hundred.[2]

During his weeks in Paris, William dined regularly with Laplace. He also met chemist Claude Louis Berthollet (1748–1822), Laplace's colleague and close friend, and traveled to Berthollet's home in the picturesque village of Arcueil. Arcueil, just a few miles outside of Paris, would eventually become an important center for the Laplacian school of physics when Laplace purchased a house on property adjoining Berthollet's. Though John may not have accompanied his father on these visits, the younger Herschel would eventually return to those "avenues, parterres, and lawns, terraces and broad gravel walks" to discuss his father's work and his own contributions to analysis as a mathematician in his own right.[3]

The conversations between William Herschel and Laplace no doubt ranged far and wide, but there was one topic that the doyen of French physical science was especially keen to discuss with the British astronomer: the origin of the solar system. Laplace had developed a theory that the solar system developed from a rotating cloud of gas that collapsed to form the sun. The inclination and direction of the orbits of the planets around the sun (including William's new planet) and the fact that the moons of the planets had similar orbital features pointed, Laplace argued, to a common physical cause. It was statistically unlikely for chance to have arranged all the bodies in such a way. There must be a natural mechanism that could explain these characteristics of the solar system. Laplace's explanation was that if the sun indeed formed of a collapsing, rotating ball of gas, portions of that cloud could have become the planets. These portions would then orbit in the direction the sun rotated and be strung out along the plane of the sun's equator, just as observed. Nebulous, congealing stars like the sun would naturally form systems of orderly planets. Unfortunately, Laplace's theory lacked observational evidence; there was no way to observe this process in action.

By the time of William's visit to Paris, the British astronomer's observations provided hints of support for Laplace's theory. If the universe beyond the solar system was dynamic and changing and if William's observations indeed showed nebulae collapsing to form stars, this would be a powerful corroboration of Laplace's ideas on the origin of the sun and planets. Laplace had provided mathematical reasoning; William's observations could provide evidence of the process of planetary formation in the universe. The critical observation did not come, however, until almost a decade after their meeting: in 1811 William discovered a "nebulous star" that seemed to indicate stars condensed gravitationally from glowing clouds of gas in the heavens. When Laplace read about this observation, he took it as a confirmation of his own theory. Popular writers would ultimately combine William's theory with Laplace's theory to formulate the "nebular hypothesis" as the ultimate origin of planets and stars as well as a symbol of the progressive development of the cosmos.[4]

These developments were in the future, but the work of both Laplace and William Herschel had already begun to bring notions of deep time to the sidereal universe. While in Paris, William met someone doing the same for Earth itself: Georges Cuvier (1769–1832), a young naturalist considered the founder of modern paleontology. Cuvier had quickly risen to prominence in the scientific world with his studies of fossil remains and by the year after Herschel's visit had been named one of the two executive secretaries to the first class of the Institut. This role put him in personal contact with Napoleon, and his growing influence allowed Cuvier to establish a network gathering paper proxies of fossil specimens from collections across Europe. In particular, Cuvier collected evidence and argued in a series of popular works that species existed in the past that no longer existed on Earth; in other words, Cuvier claimed there had been cataclysms in the past that had markedly changed conditions on Earth's surface and driven certain species to extinction. Cuvier's work on fossils opened the door to a history of Earth as extended and dynamic as the celestial history William was building for the heavens.[5]

Much of Cuvier's work would come after William's visit, but while in Paris William likely glimpsed the beginnings of a debate that was to play out in geology, mirroring questions about the nature of the larger universe. In 1801 Jean-Baptiste Lamarck (1744–1829), another French naturalist and colleague of Cuvier, had published his influential work on invertebrates. In the work, Lamarck included an essay on fossils in which he refuted Cuvier's claims and argued instead that fossils were evidence of transmutations or changes in species. Instead of a geological history that included cataclysmic changes, Lamarck argued for a gradualist or even static view in which things ceaselessly and steadily changed but not through cataclysmic revolutions. This view was eventually associated in Britain with the work of James Hutton (1726–1797), a Scottish natural philosopher who had argued something similar for Earth's surface: that the continents were constantly being eroded away while new continents were uplifted from the sea. Both Lamarck in terms of fossils and Hutton in terms of surface processes came to represent a steady-state or even eternal view of Earth's surface opposed to Cuvier's stance. The year of William's trip to Paris, Hutton's views were made more accessible and widely known through the publication of *Illustrations of the Huttonian Theory of the Earth* by another Scottish mathematician, John Playfair (1748–1819). This debate brought Earth itself into questions of whether the universe was eternal or whether it progressed from distinct past states to new states. It was a conversation that John Herschel would find himself engaging when he returned to Paris years later.[6]

In Paris William was exposed to a community of natural philosophers far more organized and supported than in Britain. The learned societies in England were focused primarily on botany, natural history, and agricultural improvements, largely supported by aristocratic interest or patronage and pursued by amateurs haphazardly as their interests dictated or (rarely) by professors at the universities of Cambridge, Oxford, and Edinburgh. In contrast, the natural philosophers at the Institut were, like Laplace and Cuvier, professional civil servants, the most successful of whom were rewarded with government positions and generous salaries. Science in France was seen as a tool of republicanism, equality, humanism, and rationalism, and it was flourishing like never before under the sponsorship of Napoleon, technically still the first consul of France but in practice quickly becoming the nation's all-powerful dictator. Before he returned to England, William would have an opportunity to meet this new patron of science.

On 8 August, a Sunday, William dined with Jean-Antoine Chaptal (1756–1832), a chemist and the minister of the interior, who took the visiting astronomer along with Laplace and a few others to Malmaison, Napoleon's palace home. William was unsure what to expect meeting the man who had conquered much of Europe. The king's astronomer often interacted with the British monarch and his family, but Napoleon represented something new—a self-made ruler, military genius, and dictator. To his surprise, William and his French colleagues found the first consul in his gardens, supervising the digging of an irrigation system. Napoleon, William related in his journal of the trip, was civil and easy to talk with, showing a surprising depth of knowledge. They walked together for about half an hour, with Napoleon politely asking William questions on astronomy. Eventually the first consul invited the group inside to continue the conversation, which ranged from breeding horses in England to the creation of the universe. Napoleon sat and invited William to do the same, but when William noticed that no one else was offered a seat—including the second and third consuls—he remained standing for the entire conversation.[7]

Laplace had recently published the third volume of his *Mécanique*, which he dedicated to Napoleon. The conversation that played out between the mathematician and the dictator at this meeting on the contents of Laplace's work has become the stuff of historical legend. Napoleon is supposed to have remarked to Laplace that there was no mention of God anywhere in Laplace's physical explanation of the planetary system, to which Laplace answered that he had no need of such a hypothesis. Though there is no evidence for this exact exchange, William noted in his journal that Napoleon and Laplace indeed argued about whether the system of the world needed a creator to explain it. When the discussion turned to the extent of the universe, Napoleon asked "in a tone of exclamation or admiration . . . 'and who is the author of all this.'" Laplace, William recounted, tried to show in response that "a chain of natural causes would account for the construction and preservation of the wonderful system." Napoleon was not pleased. "This," the astronomer recorded wryly, "the First Consul rather opposed."

Eventually Napoleon was called to other duties, and his guests excused themselves. William concluded his account of the meeting by reflecting that the truth likely lay between Laplace's and Napoleon's positions: by uniting their arguments, he felt, one could be led to "Nature and Nature's God." William, who had converted from his native Lutheranism when he immigrated to England, had served as organist at the cathedral in Bath, and hosted bishops and clergymen at his home, seems to have been a person of reserved but genuine faith, not an enthusiastic churchgoer but a profound believer in God. Years after his father's death, John would emphasize this faith. "Let it be distinctly understood," he told a Continental correspondent, "that my Father . . . was a sincere believer in and worshipper of a benevolent intelligent and superintending Deity whose glory he conceived himself to be legitimately forwarding by investigating the magnificent structure of the universe." William's astronomy—in contrast with much of the consciously secular philosophy of his French colleagues—was situated firmly within the British tradition of the natural sciences generally and astronomy particularly, supporting a broad interpretation of Christianity.[8]

William and his family soon concluded their Parisian visit and returned to England, where the astronomer resumed his telescopic surveys of the heavens, eventually making the discoveries that Laplace would take as confirmation for the very theory that he had argued with Napoleon. Within two years of the Herschels' return, the first consul had crowned himself emperor, Britain and the new French Empire were again at war, and England itself was threatened with invasion. The military and political conflict that had dominated the national context throughout John Herschel's childhood would continue to his time at university. Laplace, however, would survive Napoleon's ultimate fall and retain his influence throughout the restoration of the Bourbon monarchy. Though William never returned to France, John would resume conversations on the structure of the universe with the elder statesman of French science when he returned as a young man.

At ten years old, John Herschel no doubt had a very different perspective on his time in Paris than his father, but William's experiences there colored his own. The organization of science, the overarching scientific program of Laplace and his colleagues, the professional meetings of the Institut, the bourgeoning geological debates—all these showed a pursuit of knowledge different from what John would experience in Britain. In addition, the trip allowed William to see firsthand the role that the new French mathematics played in making the scientific accomplishments of Laplace and his school possible, and he determined that whether or not such tools were widely available in England, they would become a feature of John Herschel's education. The mathematics of Laplace's France, nurtured under the autocracy of Napoleon, would ultimately be the first step in the younger Herschel's reform of British science.