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JAMES CLERK MAXWELL.*

THE life of James Clerk Maxwell, who, as his biographers state, "has enriched the inheritance left by Newton, consolidated the work of Faraday, and impelled the mind of Cambridge to a fresh course of real investigation;" and who, amid all the subtlety of speculation, the profundity of research, and the brilliance of discovery for which his career is so distinguished, retained the simplicity and fervor of the Christian faith, well deserves to be chronicled, and to hold a permanent place in human memory. Professors Campbell and Garnett have performed their task with great ability and fairness, and have conferred an invaluable boon upon what is after all the major portion of scientific students, those who are observers rather than theorizers, and who do not desire to drift away from the old moorings of religious conviction and sentiment. We have here presented to us the history of a man of eminent natural endowments, of keen penetration fitting him for the closest scrutiny, of calm, clear judgment without which genius is but a Phaeton holding the reins of the sun, who attained to scholarship in classics and English literature, who shone in mathematics and astronomy, and who spoke with unsurpassed authority in every branch of physical science. Such a man cannot be regarded as narrow and fossilized in his ideas when he ventures to tell out the deeper feelings of his mind, awakened by a contemplation of the soul's relationship to God. Those who have won celebrity by the brilliance of their theories, or the novelty of their speculations in one or two departments of science, but who with an almost scornful cynicism have turned aside from those realms of thought and study which border upon religion, or which are of a distinctly theological character, while they have not refrained from pronouncing dogmatically upon the vast problems concerned therein, ought not to be astonished if thoughtful men decline to give that deference to their opinions which they freely accord to others, who, like Clerk Maxwell, have attained to high rank among scholars and discoverers, and who have not shrunk from bringing their extraordinary powers of mind to bear upon the great subjects involved in the beliefs and doctrines of Christianity.

It is almost taken for granted in some quarters that there is a necessary and irreconcilable conflict between science and religion. The bolder spirits amongst the devotees of science, and the more timid of the adherents to Christianity, to whom perhaps science is almost a sealed book, have come to regard one another with feelings approaching to implacable hostility, as if the one class tended to the license of atheism, and the other dreaded anything like freedom of thought. These, however, are the extreme sections of the two encampments between which there is a vast phalanx of sober and devout men who love both science and religion, and see much in each to help the other. Scientific methods of the pursuit of truth give precision and accuracy to the visions of faith, while a wider sweep and loftier range are imparted to the inquiries of the mind by the aspirations of faith. Science might have grown ridiculous because of brilliant but false theories and unwarrantable generalizations had it not been for the moderating influence of Christian thought, and theology owes some of the most effective demonstrations of her reasonableness and truth to the principles and researches of scientific men. Earnest and painstaking study of the laws and phenomena of nature have not only a practical influence upon the material and social welfare of humanity, ameliorating sanitary conditions by the light of physiological researches, improving manufacturing industry by a better understanding of physical laws, or making agriculture more productive as the result of the chemist's skill and the observations of the botanist; but it also cultivates a true metaphysic by the discovery of cause and effect, and fosters those intellectual qualifications which are as indispensable to correct religious as to scientific thought.

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* *Life of James Clerk Maxwell.* By PROFESSOR LEWIS CAMPBELL, M.A., LL.D., and PROFESSOR WILLIAM GARNETT, M.A. London: Macmillan and Co. 1882.

And there ought to be no concern as to the fate of Christianity in consequence of the study of nature, when we call to mind that the most distinguished philosophers and scientists of every age have clung to it with fervent tenacity, and have attributed to its inspirations the noblest impulses of their minds. Copernicus, Tycho Brahé, Kepler, Galileo, Newton, and Descartes, all accepted a divine revelation. Pascal defended the faith, and Kant bent all his energies against sceptical modes of thought. Hamilton, Hugh Miller, Owen, Faraday, Agassiz, and Clerk Maxwell, princes among men, found a place in their beliefs for a direct communication of the Creator's will to mankind, and Francis Bacon, whom students of nature reverence as the high priest of their order, has said, "Slight tastes of philosophy may perchance move to atheism, but fuller draughts lead back to religion."

We shall have to refer again to what we regard as the most charming characteristic of this lamented man, too soon stricken down by death, the trustfulness and fervor with which he clung to the faith in which he had been nurtured; but we must now endeavor to outline the development of his mind, and sketch the growth of those intellectual tastes which led on to the splendid attainments of after years, and the permanent contributions to science which he has made.

James Clerk Maxwell was born at Edinburgh, in 1831. Being an only child, with the exception of a daughter who died in infancy, he was the object of great solicitude, and as his mother died when he was but nine years old, it was fortunate that his father was eminently qualified for the training of a young mind, and the moulding of a moral character. This important and congenial task he performed with the "judiciosity," to borrow a word from his Bradwardinean vocabulary, which characterized all he did. As a younger son he had received a portion of the old Middlebie estate, which by the conditions of entail could not go with the Penicuick estate of the Clerks, and to this he added by purchase the Glenlair farm. It was to Glenlair that he retired after his marriage, and here James lived till he was ten years of age. During this period the kindly and ingenious father exercised a deep and lasting influence on the susceptible nature of his son. Mr. Maxwell planned all the buildings and improvements on his estate, and superintended all domestic matters, even to the cutting of the last for his own square-toed shoes. And as James was his one companion and care, it is not an exaggeration to say that those mechanical and mathematical proclivities which he manifested at a quite juvenile age, and which found their consummation in the planning of the Cavendish Laboratory during his Cambridge professorship, were the direct products of his father's example and training. As his biographers say, "The Galloway boy was in many ways the father of the Cambridge man; and even the 'ploys' of his childhood contained the germ of his life work" (p. 429).

The necessities of education led to James being sent to Edinburgh Academy at the age of ten, his father taking up his abode again at Edinburgh, except during the summer season, when he repaired to Glenlair. He was thus enabled to take the oversight of his son's studies, and also, which was more important, of his recreation. Some slight oddities in dress and manners did not tend to make the boy's introduction to school-life smooth and agreeable. Tunics of hodden gray tweed, and shoes clasped and fashioned after the somewhat bucolic ideas of his father, were not likely to escape the keen observation of frolicsome schoolboys, to whom round jackets and shoestrings were *de rigueur*. But his fine natural gift of irony, combined with his geniality of disposition, saved him on many an occasion from provoking merriment, and established him eventually as a general favorite. The very first time he was questioned as to the maker of his shoes, he replied in broad Scotch *patois*: —

> Din ye ken, 'twas a man,
> And he lived in a house
> In whilk was a mouse.

At school, though at first he seems to have found more pleasure in watching "humble bees" than in the monotony of Latin grammar, yet he soon applied himself with vigor to his books, and placed himself in the first rank among his compeers. His ingenuity is evidenced by his framing a system of mnemonics based on the positions of the windows in the school, and by his humorous sketches and hieroglyphic letters to his father. He also displayed as a mere lad those versifying powers and imaginative faculties which through his whole life he occasionally exercised, and which, had he not been occupied with sterner pursuits, might have placed him among our principal poets. On leaving the Academy at the age of sixteen he was first in English, and only narrowly missed being first in classics, besides gaining the great distinction of the mathematical medal. Already he gave proof of that extraordinary capacity for physical investigations, and that skill in the application of mathematics to physical problems which afterwards raised him to the highest eminence in the scientific world. His attention was turned to magnetism and to optics, especially the phenomenon of "Newton's rings," the chromatic effect caused by pressing lenses together. He was also incited to the study of the polarization of light in consequence of a visit to Mr. Nicol, of Edinburgh, the inventor of the polarizing prism bearing his name. In 1846, while he was but fifteen, young Maxwell prepared a paper for the Royal Society of Edinburgh, on the description of oval curves and those having a plurality of foci, in which he presented the suggestion that the common theory of the foci of conic sections could be extended to curves of a higher degree of complication. Professor Forbes, in a letter to Maxwell's father, said of this paper, "I think it very ingenious, and certainly remarkable for his years, and I believe substantially new." James found out later on, what Professor Forbes seems not to have observed, that his ovals were the same as those of Descartes, and that his method of describing the curves by means of cords and pins was identical with that of the French philosopher; but his paper was clearly original. Professor P. G. Tait, with whom Maxwell commenced a friendship at this time, which lasted throughout his life, says of his schoolfellow's mathematical ability, when he first met him: "I still possess some of the MSS. we exchanged in 1846, and early in 1847. Those on the 'Conical Pendulum,' 'Descartes' Ovals,' 'Meloid and Apioid,' and 'Trifocal Curves,' are all drawn up in strict geometrical form and divided into consecutive propositions. At the time when these papers were written he had received no instruction in mathematics beyond a few books in Euclid and the merest elements of algebra."

In 1847 Maxwell entered Edinburgh University, where he remained for three years. He of course followed the usual curriculum, but the subjects on which his attention was most concentrated during this period were polarization, galvanism, rolling curves, and the compression of solids. There was no scientific problem, however, but was interesting to him. Biology was then rapidly acquiring that fascination and prominence which it now possesses, and Owen's hypothesis of types of creation, with its terminology and the problems it involved, was completely mastered by Maxwell. He was also led under Sir W. Hamilton through the abstract but to him intensely interesting fields of metaphysics, and from that able and learned philosopher he received impressions which remained with him through life. His mathematical bent made him responsive to the doctrine of natural realism, while his mystical tendency was appealed to by Hamilton's distinction between knowledge and belief in relation to perception. Hamilton's philosophy has received rude criticism from the more positive schools of later years, but no metaphysician has ever inspired in his disciples a more ardent love for abstract thought than that which has been manifested by many who listened to Hamilton's speculations on perception, his demonstration of the reality of an external world, and his masterly treatment of the unconditioned or infinite. Maxwell evidently took a great interest in those subjects dealt with by Hamilton which constitute the borderland of physics and metaphysics, for a paper which was found by Professor Baynes treasured in Hamilton's private drawer, and which had been written by Maxwell as an exercise, displays a profound acquaintance with the properties of matter, and the speculations of such men as Descartes and Leibnitz. It is true he spoke in 1870 at the Liverpool meeting of the British Association of "the barren metaphysics of past ages;" but he would have admitted without hesitation that his psychological studies had helped him to an accurate understanding of the problems concerned in vision on the one hand, as well as in molecular physics on the other, when he came to study experimental optics and the laws of matter and motion. He must also by this time have made some mark in the departments of electricity and chemistry, for Sir W. Thomson requested him to make some magne-crystalline preparations for Tyndall and Knoblauch, who were studying the origin of magne-crystal line forces.

Meanwhile he was prosecuting inquiries into color vision and color blindness. At the meeting of the British Association, in 1850, when a paper by Sir David Brewster had been read on "Haidinger's brushes," two conspicuous yellow appearances, with the complementary violet color filling up the space between them, which are seen by some persons when they look at a point in the sky at a distance of 90° from the sun, general surprise was created by the rising of Maxwell, a beardless youth, to dispute some point that had been urged. Although he was embarrassed by bashfulness, yet he succeeded in gaining the hearing and the confidence of his audience. Even in his adolescence, a period when most youths are led by authority, he had begun to think for himself. Some of his criticisms on men and books at this period reveal a maturity of intellectual vigor and independence rarely met with in young men not yet of age. Of Professor Wilson, the moral philosophy lecturer, he wrote: —

> Wilson, after having fully explained his own opinions, has proceeded to those of other great men: Plato, Aristotle, Stoics, Epicureans. He shows that Plato's proof of the immortality of the soul from its immateriality if it be a proof, proves its pre-existence, the immortality of beasts and vegetables, and why not transmigration? He quarrels with Aristotle's doctrine of the golden mean — a virtue is the mean between two vices — not properly understanding the saying. He chooses to consider it as a pocket rule to find virtue, which it is not meant to be, but an apophthegm or maxim or dark saying, signifying that as a hill falls away on both sides of the top, so a virtue at its maximum declines by excess or defect (not of virtue), but of some variable quantity at the disposal of the will . . . So that Wilson garbles Aristotle, but I bamboozle myself (p. 128).

Maxwell's father had supposed his son would follow in his own footsteps by embracing the legal profession, but it was clear by this time that, as James himself expressed it, he "was called to study another kind of law." This point was at length finally settled by Maxwell's entrance at Cambridge, first at Peterhouse, and afterwards, for the sake of the greater advantages presented by the larger establishment, at Trinity College.

When he went up to Cambridge there was a general expectation that he would distinguish himself in the mathematical and scientific studies which form so prominent a portion of the curriculum of that university. The "average undergraduate," accustomed to parsing and late rising, would no doubt feel considerable astonishment at beholding Maxwell's scraps of gelatine and unannealed glass, his bits of magnetized steel, and other similar objects which the odd young freshman took with him, and which were evidently of greater interest to him than some of the studies which have become venerable in our universities. His originality was somewhat pronounced too, in the curious modes of exercise and recreation which he occasionally adopted. One of his contemporaries says: "From 2 to 2.30 A.M. he took exercise by running along the upper corridor, down the stairs, along the lower corridor, then up the stairs, and so on, until the inhabitants of the rooms along his track got up and lay *perdus* behind their doors to have shots at him with boots and hairbrushes as he passed."

His geniality and social temperament, combined with wit which sparkled but rarely wounded, soon attached to him many sincere and valuable friends, among whom were C. Hope Robertson, Mackenzie, afterwards Bishop of Natal, Howard Elphinstone, and F. W. Farrar. His intellectual development rapidly progressed, and everything that had to do with experimental physics was more than ever fascinating to him. In 1851 he witnessed the pendulum experiment at Trinity, which Foucault had just introduced to the scientific world to prove the rotation of the earth. He also received a strong impulse towards the practical and utilitarian as the result of a careful inspection of the great exhibition held in this same year at the Crystal Palace. At Cambridge there was a "Select Essay Club," composed of the very cream of the university, the members of which, being limited in number to twelve, were familiarly known as "the apostles." Into this circle of the *élite* Maxwell was soon welcomed, and his contributions to this society which still remain show that he was busily investigating the first principles of all things. As an illustration of his speculative tendencies as well as of the activity of his intellect, and the fine irony which characterized his humor, the following extracts are taken from a paper on the "Nature of the Evidence of Design," which he read before this association, when he was most closely occupied with preparation for the approaching mathematical tripos, and which deals with subjects that were gradually becoming the main study of his life: —

> Design! the very word disturbs our quiet discussions about *how* things happen with restless questionings about the *why* of them all. We seem to have recklessly abandoned the railroad of phenomenology, and the black rocks of ontology stiffen their serried brows and frown inevitable destruction . . . The belief in design is a necessary consequence of the laws of thought acting on the phenomena of perception. The essentials then for true evidence of design are: (1) A phenomenon having significance to us. (2) Two ascertained chains of physical causes contingently connected and both having the same apparent terminations, viz., the phenomenon itself and some presupposed personality. If the discovery of a watch wakens my torpid intelligence, I perceive a significant end which the watch subserves. It goes, and considering its locality, it is going well. My young and growing reason points out two sets of phenomena: (*a*) the elasticity of springs, etc.; (*b*) the astronomical facts which render the mean solar day the unit of civil time combined with those social habits which require the cognisance of the time of day . . . It is the business of science to investigate these causal chains. If they are found not to be independent, but to meet in some ascertained point, we must transfer the evidence of design from the ultimate fact to the existence of the chain. Thus, suppose we ascertain that watches are now made by machinery . . . the machinery including the watch forms one more complicated and therefore more evident instance of design.

He then goes on to speculate upon the Neo-Platonic notion of Δημιουργοί, and almost intimates a belief that, if a plurality of intelligent creators were discovered, it would not weaken our conviction that there is an ultimate First Cause.

Mathematics, of course, in view of the tripos, now constituted his main study, and in this department he displayed wonderful power. At one of Hopkins's lectures, when the tutor had filled the blackboard three times with the investigation of some hard problem in geometry of three dimensions and was not at the end of it, Maxwell came up and said he thought it would come out geometrically, and thereupon he showed how, with a diagram and a few lines, the solution could be obtained at once.

At the end of his three years' course at Cambridge he obtained the second place in the mathematical tripos, Mr. Routh, the well-known tutor, being first wrangler, and in the still more difficult examination for Smith's Prize he was bracketed first with Routh. Soon afterwards he was elected fellow of Trinity, and was at once appointed to lecture on hydrostatics and optics. By this time it may be said that his path in life was determined, and the habitual bent of his mind, as well as his replete and varied scholarship, were speedily to find favorable opportunities and appropriate spheres for their display. His experiments with the color top and the color box for the purpose of studying the combinations of colors and the laws of color vision were continued with zest, and by these he was able to show that the common notion that blue and yellow make green is correct only in the case of pigments and not where light is concerned. He also constructed an instrument called the opthalmoscope, with which he could examine the retina of living animals, and he continued to seek for the principles of matter in motion. Magnetism and electricity were pursued with avidity, and at every favorable opportunity he would fascinate, while he often mystified his friends, with excited and voluble descriptions of the swift invisible motions by which galvanic and magnetic phenomena were to be explained. These studies led up to his mathematical treatment of Faraday's lines of force, one of the most profound as well as most useful of his achievements. The next sphere in which Maxwell was called upon to labor was at Aberdeen, where he was appointed to the chair of natural philosophy in Marischal College. Shortly before he entered upon his duties he experienced one of the greatest sorrows of his life in the death of his father. These two had been associated for years in the bonds of an affection which was inspired on the one hand by the wisdom, integrity, and paternal solicitude displayed by the father, and on the other hand by the filial reverence, the gentleness and purity of heart, which had ever characterized the son. Their letters to each other, interchanged every two or three days, and at some periods oftener, kept up the community of thoughts and pursuits during their absence from one another that had always marked their companionship. The grief caused by this bereavement was borne by Maxwell with a quiet spirit and uncomplaining resignation, which were the noble fruits of that faith whose germs had been fostered in his soul by him who was gone. A poem elicited by this sad event, from which the following lines are taken, reveals the depth of tender feeling which lay underneath the placid demeanor of the bereaved son: —

Yes, I know the forms that meet me are but phantoms of the brain,
For they walk in mortal bodies, and they have not ceased from pain,
Oh those signs of human weakness, left behind forever now,
Dearer far to me than glories round a fancied seraph's brow.
Oh the old familiar voices; oh the patient waiting eyes;
Let me live with them in dreamland while the world in slumber lies,
For by bonds of sacred honor will they guard my soul in sleep
From the spells of aimless fancies that around my senses creep.
They will link the past and present into one continuous life;
While I feel their hope, their patience, nerve me for the daily strife.
For it is not all a fancy that our lives and theirs are one,
And we know that all we see is but an endless work begun.
Part is left in nature's keeping, part has entered into rest;
Part remains to grow and ripen hidden in some living breast.

With chastened mind and a deepened sense of responsibility, Maxwell now entered upon the double work of carrying on the management of the Glenlair estate, which had been the object of so much care and interest to his departed father, and the still more engrossing duties of his Aberdeen professorship.

He now for the first time turned his attention to Saturn's rings, studying them as instances of the circular motion of fluids. The idea with which he set out was that the very forces which would tend of themselves to divide the ring into great drops or satellites are made by the motion to keep the fluid in a uniform ring. For more than a year he followed up this laborious task with a view to the writing of an essay on "The Structure of Saturn's Rings," the subject set by the examiners for the Adams Prize, given by St. John's College, in honor of the discoverer of Neptune. To draw up an hypothesis which should embrace all the conditions of the case, and stand every test to which it could possibly be put, was an undertaking of no ordinary difficulty, but it was one that completely fascinated him for a time, nor was it beyond his vast intellectual capacity and mathematical ingenuity. He constructed a very clever model by which the motions of a ring of satellites could be practically demonstrated. This model is preserved in the Cavendish Laboratory, at Cambridge, and consists essentially of two wheels turning on parallel parts of a cranked axle, and thirty-six small cranks equal in length between corresponding points of the circumferences of the wheels, each carrying a little ivory satellite. It is not astonishing that work done in this thorough manner should be rewarded by the highest success. The Adams prize was awarded to him, and after a minute revision the essay was published.

At Aberdeen he became acquainted with the family of Principal Dewar, to whose daughter, Katherine Mary, he was married, in June, 1858. It is impossible that there could be a deeper tenderness or a truer devotion than he manifested towards his wife as long as he lived. For more than twenty years he brought to her in the smallest domestic concerns, as well as in matters of greater moment, the most perfect sympathy and the most prudent counsel. Even when lying on his deathbed he regularly inquired into everything that concerned her comfort, and, so far as he could, supervised those household arrangements which from her invalid state of health she was prevented from attending to. And she, on her part, fully reciprocated his devotion, for she interested herself in all his labors, rendered him such assistance as she could in his experiments, and on several occasions when he was dangerously ill, once with a highly infectious disease, she nursed him with unwearying assiduity. His views of the married state had something almost mystical about them, and it seemed to him as if in spirit they were one, whether absent from each other or together. There is an exquisite touch of sentiment in the following lines, which he sent to his wife during an absence from home, revealing something of the depths of his manly heart: —

Oft in the night from this lone room
I long to fly o'er land and sea,
To pierce the dark dividing gloom,
And join myself to thee.

And thou to me would'st gladly fly,
I know thee well, my own true wife!
We feel that when we live not nigh,
We lose the crown of life.

Then, referring to their approaching meeting, he continues: —

Then shall the secret of the will,
That dares not enter into bliss;
That longs for love, yet lingers still,
Be solved in one long kiss.

I, drinking deep of thy rich love,
Thou, feeling all the strength of mine,
Our souls will rise in faith above
The cares which make us pine.

Till I give thee, thou giving me,
As that which either loves the best,
To Him that loved us both, that He
May take us to His rest.

Wandering and weak are all our prayers
And fleeting half the gifts we crave;
Love only, cleansed from sins and cares,
Shall live beyond the grave.

All powers of mind, all force of will,
May lie in dust when we are dead,
But love is ours, and shall be still,
When earth and seas are fled.

After only three sessions at Marischal, the professorship of natural philosophy lapsed, owing to the fusion of the Aberdeen Colleges. Maxwell therefore, in 1860, accepted a similar position in King's College, London. Here his duties were more burdensome than at Aberdeen. His course of lectures extended over nine months out of the twelve, and there were additional lectures in the evening to artisans. At the meeting of the British Association this year, at Oxford, he exhibited his box for mixing the colors of the spectrum. He also read a paper on Bernouilli's theory of gases, in which he showed that what is called the viscosity of gases, as well as their low conductivity for heat, and Graham's laws of diffusion, could all be accounted for by the supposition that gas consists of a number of independent particles in rapid and constant motion among themselves, and he calculated that in ordinary atmospheric air each particle undergoes more than eight billion collisions every second, and that the flying molecules repelled one another as the inverse fifth power of their distance.

The following year he delivered his first lecture at the Royal Institution, on the theory of the three primary colors. He also acted upon a committee with Balfour Stewart and Fleeming Jenkin to make experimental measurements in order to determine the electric ohm, the standard of electrical resistance, and the system of units then established was adopted by the Electric Congress, which met at Paris in 1881. Further investigations were also made by him while in London, on the subject of electric units for the purpose of making comparisons between electricity and the velocity of light.

Mainly in consequence of ill-health he resigned the professorship at King's College, in 1865, and for some half-dozen years lived in comparative retirement at Glenlair, hoping to bring to completion his great work on "Magnetism and Electricity," upon which he had already bestowed some labor; but which, amid the many calls upon his time in connection with his lectures in London, had not advanced so rapidly as he desired. It was during the period of his residence at Glenlair that he brought the book into something like a definite shape, although it was not published till 1873. His treatise on "Heat," published in 1870, was also undertaken during this season of leisure, and moreover he filled the office of examiner several times for the Cambridge Tripos, in which capacity he was mainly instrumental in introducing those changes which have since been admitted into the examination system of that university. It is probable that these few years at Glenlair were the happiest of his life. The day was occupied with correspondence, which was always voluminous, and with various scientific experiments, while in the evening he would often read aloud to his wife from Chaucer, Spenser, or Shakespeare. On Sundays he was regular in his attendance at the kirk, and on returning home he habitually devoted himself to the works of the old standard divines.

In 1870 he attended the meetings of the British Association, being elected to the presidency of the Mathematical and Physical Section, to which he delivered an address on the relation of mathematics and physics to each other. The few opening sentences of this address are worth quoting, not only because they indicate in a masterly way the nature and conditions of the problem, but also because they refer to some previous presidential addresses which dealt with important topics. He said: —

I have endeavored to follow Mr. Spottiswoode as with far reaching vision he distinguishes the systems of science into which phenomena, our knowledge of which is still in the nebulous stage, are growing. I have been carried by the penetrating insight and forcible expression of Dr. Tyndall into that sanctuary of minuteness and of power, where molecules obey the laws of their existence, clash together in fierce collision, or grapple in yet more fierce embrace, building up in secret the forms of visible things. I have been guided by Professor Sylvester towards those serene heights:

> Where never creeps a cloud or moves a wind,
> Nor ever falls the least white star of snow,
> Nor ever lowest roll of thunder moans,
> Nor sound of human sorrow mounts, to mar
> Their sacred everlasting calm.

But who will lead me into that still more hidden and dimmer region where thought weds fact, where the mental operation of the mathematician and the physical action of the molecules are seen in their true relation? Does not the way to it pass through the very den of the metaphysician, strewed with the remains of former explorers and abhorred by every man of science?

The most useful and influential period of Maxwell's career was that during which he filled the chair of experimental physics at Cambridge, from 1871 till the time of his death. Here he performed the main business of his life, inspiring the enthusiastic youths by whom he was surrounded with his own passionate love for scientific research, and achieving those magnificent results in the departments of electricity and molecular physics by which he rose to the very highest fame among the leaders of science. As this chair had but just been founded by the munificence of the Duke of Devonshire, the chancellor of the university, the principal work of the new professor for some time was necessarily that of designing and superintending the building of a laboratory. This he did with the utmost care and diligence, visiting the laboratories of Sir. W. Thomson at Edinburgh, and Professor Clifton at Oxford, in order that he might have the benefit of the most recent improvements. By the spring of 1874 all was ready for the commencement of work. With such spirit and energy did he throw himself into his duties that, as Sir W. Thomson declared, there was "nothing short of a revival of physical science at Cambridge" resulting from Maxwell's influence. His great delight now was to render all needful assistance to those who were studying science, and some who have since attained to great distinction owe their success largely to the enthusiasm which the experiments of Maxwell inspired.

He was now brought into pleasant association with many of the leading spirits of Cambridge, some of whom had formed a club called the Erănos (*ἀνδρῶν πρεσβυτέρων ἐταιρία*), differing from the "apostles" in the graver character of the discussions. Besides Maxwell, this select circle contained Dr. Lightfoot, and Professors Westcott and Hort.

One of the most remarkable productions of his later life, and one to which reference has often been made, owing to the intense scientific interest of the topics dealt with, is the famous "Discourse on Molecules," delivered before the British Association in 1873. Towards the end of the address he gave utterance to some weighty sentiments on the relation of physics to theology:—

> In the heavens we discover by their light, and by their light alone, stars so distant from each other that no material thing can ever have passed from one to another; and yet this light, which is to us the sole evidence of the existence of these distant worlds, tells us also that each of them is built up of molecules of the same kind as those which we find on earth. A molecule of hydrogen, for example, whether in Sirius or in Arcturus, executes its vibrations in precisely the same time. . . . No theory of evolution can be formed to account for the similarity of molecules, for evolution necessarily implies continuous change, and the molecule is incapable of growth or decay, of generation or destruction. None of the processes of nature, since the time when nature began, have produced the slightest difference in the properties of any molecule. We are therefore unable to ascribe either the existence of the molecules or the identity of their properties to any of the causes which we call natural. On the other hand, the exact equality of each molecule to all others of the same kind gives it, as Sir John Herschel has well said, the essential character of a manufactured article, and precludes the idea of its being eternal and self-existent. Though in the course of ages catastrophes have occurred, and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built—the foundation stones of the material universe—remain unbroken and unworn. They continue this day as they were created, perfect in number and measure and weight; and from the ineffaceable characters impressed on them we may learn that those aspirations after accuracy in measurement and justice in action, which we reckon among our noblest attributes as men, are ours because they are essential constituents of the image of Him who, in the beginning, created not only the heaven and the earth, but the materials of which heaven and earth consist (pp. 359, 360).

No apology need be made for this lengthy extract when it is reflected how important is its bearing upon the nebular hypothesis of Laplace, which, it is to be feared, is being too readily accepted by the world without giving due weight to the difficulties which beset it as regards the origin of matter and of force; as well as upon that extreme phase of evolutionism which some men of science prefer to the alternative belief in special and distinct creative acts by an intelligent First Cause. The greatest physicist of the present age has declared that the marks of skill and handicraft impressed upon the molecule are a fatal difficulty in the way of that theory which was dimly adumbrated by Kant and Laplace, and brought into definite expression by the labors of Darwin, Tyndall, and Huxley.

It is clear from the quotation just given that Maxwell was diametrically opposed to the views which were propounded by Professor Tyndall in his famous address which he delivered at Belfast, when president of the British Association in 1874. This was the last meeting of the Association that Maxwell attended. He read a paper on the "Application of Kirchhoff's Rules for Electric Circuits to the Solution of a Geometrical Problem," but he is associated with that meeting chiefly on account of his humorous paraphrase of Tyndall's startling address, which, together with a Greek translation of it by Mr. Shilleto, was published in *Blackwood's Magazine*. The whole of this witty production would be worth quoting, but only a few representative lines can be given: —

In the very beginnings of science, the parsons who managed things then
Being handy with hammer and chisel, made gods in the likeness of men,
Till commerce arose, and at length some men of exceptional power,
Supplanted both demons and gods by the atoms, which last to this hour.

. . . .

So treading a path all untrod, the poet philosopher sings
Of the seeds of the mighty world in the first beginnings of things;
How freely he scatters his atoms before the beginning of years;
For he clothes them with force as a garment, those small incompressible spheres.

. . . .

Thus in atoms a simple collision excites a sensational thrill,
Evolved through all sorts of emotion, as sense, understanding and will.

. . . .

Thus a pure elementary atom the unit of mass and of thought
By force of mere juxtaposition to life and sensation is brought;
So down through untold generations, transmission of structureless germs
Enables our race to inherit the thoughts of beasts, fishes and worms.
We honor our fathers and mothers, grandfathers and grandmothers too,
But how shall we honor the vista of ancestors now in our view?
First then let us honor the atom, so lively, so wise and so small,
The Atomists next let us praise, Epicurus, Lucretius and all;
Last, praise we the noble body to which for the time we belong,
Ere yet the swift whirl of the atoms has hurried us ruthless along,
The British Association.

While at Cambridge Maxwell wrote several articles for the ninth edition of the "Encyclopædia Britannica," the most valuable and interesting of which is the one on "Atom," in which he gives a full exposition of his doctrines and researches in connection with that subject. He also wrote a small treatise on "Matter and Motion" for the Society for Promoting Christian Knowledge series, wherein will be found an admirably concise expression of his ordinary teaching and habitual thoughts on molecular physics, dynamics, and kinematics. But the chief literary work of his later life was "An Account of the Electrical Researches of the Hon. Henry Cavendish," which was published in 1879. It may have been that he was impelled to this great task by a sense of the obligations under which the University of Cambridge was placed to the founder of the Cavendish Laboratory, but, valuable as the book is, those precious years might have been still more fruitful had he given them to continued study along his own lines.

The last few years of Maxwell's life were clouded by his wife's serious and protracted illness, and there can be no doubt that his unremitting attention to her, combined with his other enormous labors, undermined his strength and led to the premature breaking up of his constitution. He began to be much troubled with dyspepsia in 1877, and although he rarely referred to his health and retained his old youthful buoyancy of spirits, yet by the early part of 1879 it had become painfully evident to his friends that a great change had taken place in him, and in October he was told by his physician that he had not a month to live. He then left Glenlair for Cambridge, accompanied by his wife, in order to obtain more conveniently the best medical assistance. But he was now beyond the reach of human skill. During his last few weeks his sufferings were intense, but he bore them with the greatest fortitude and serenity. He was anxious for nothing save the welfare of his invalid wife whom he was to leave behind. His thoughts dwelt upon subjects of a moral and spiritual rather than of a scientific character. One day he repeated those lines in "The Merchant of Venice" in which occurs the noble passage: —

Look how the floor of heaven
Is thick inlaid with patines of bright gold;
There's not the smallest orb which thou behold'st
But in his motion like an angel sings,
Still quiring to the young-eyed cherubims:
Such harmony is in immortal souls;
But whilst this muddy vesture of decay
Doth grossly close it in, we cannot hear it.

He then said he had been wondering why Shakespeare had put such sublime language into the mouth of so frivolous a person as Lorenzo.

On another occasion he suddenly started up from a long reverie and repeated the verse, "Every good gift and every perfect gift is from above," and asked, "Do you know that that is a hexameter? *πᾶσα δόσις ἀγαθὴ κὰι πᾶν δώρημα τελειον.* I wonder who composed it!" He was very fond of quoting from Richard Baxter's hymn: —

Lord it belongs not to my care,
Whether I die or live;
To love and serve Thee is my share,
And this Thy grace must give.

Four days before his death he received the sacrament, and while the clergyman was putting on the surplice, Maxwell repeated aloud George Herbert's touching lines on the priest's vestments entitled "Aaron," one of the stanzas of which runs thus: —

Christ is my only head,
My only heart and breast,
My only music, striking me, e'en dead;
That to the old man I may rest,
And be in Him new drest.

The last time this clergyman saw Maxwell, he found him too weak and restless for conversation, but just as he was about to go, the dying man said to him, "My dear friend, you have been a true under-shepherd to me; read to me, before you leave, the beautiful prayer out of the Burial Service, 'Suffer me not at my last hour for any pains of death to fall from Thee.'"

A minute or two before he breathed his last, while being held up in bed, he said slowly and distinctly, "God help me! God help my wife!" Then to the friend who was holding him up he said, "Lay me down lower, for I am very low myself and it suits me to lie low;" after which, he fixed his eyes upon his wife, and with one long, tender look at her, he breathed his last. Thus died this truly great man, meekly trusting in the mercy of God, on November 5th, 1879.

A profound sorrow was universally felt at Cambridge when his death became known, for all who had come into contact with him had been impressed with his worth. He was not only eminent in science, but he was firm and tender in friendship, moving no envy by his success, and showing none at the honors paid to others. One of the physicians who was at his bedside when he expired, and who had known him intimately for years, said of him, "He was one of the best men I have ever met, and a greater merit than his scientific attainments is his being, so far as human judgment can discern, a most perfect example of a Christian gentleman."

Although we have endeavored in the foregoing biographical sketch to indicate the nature of Professor Maxwell's scientific work, and to show how prominent was the position he occupied among the great intellects of the time, yet in order to form anything like a true estimate of those contributions to science with which his name is most closely associated, it will be necessary to deal somewhat more fully with several matters to which a passing reference has already been made.

His earliest original investigations, which, however, were continued all through his life, were those which bear upon color vision. While the *extent* of light vibrations determines the intensity of the light produced, it is their *rapidity* which explains the sensation of color. An analogy may be instituted between light and sound, for loudness or intensity is caused by the extent of the sound waves, while pitch depends upon the number of vibrations required to produce a given note. It is estimated that the deep red of the spectrum corresponds to 400,000,000,000,000 vibrations per second, while the opposite end of the spectrum, the extreme violet, is produced by more than 700,000,000,000,000; the wave-lengths, which decrease as the number of vibrations increases, being respectively $\frac{1}{39000}$ and

$\frac{1}{68000}$ of an inch. White light, however, may be composed not only by the commingling of all the colors of Newton's spectrum, but also by various other combinations of colors, hence the *chromatic* effects of mixing different colors are not always identical with the *optical.* Dr. Thomas Young at the beginning of this century had turned his attention to this problem. He supposed that green, red, and violet were the three primary colors, and that all other hues were compounds of these. Maxwell followed along the lines laid down by Young. He constructed a top upon which could be placed circular discs of colored papers. By putting two or more discs on the spindle of the top, different combinations of colors could be effected, which, owing to the persistence of impressions on the retina, became blended together when the top was spinning. He also constructed an ingenious and elaborate apparatus called the "color box," for similar experiments. By these means he was able to discover that an ordinary eye possesses three independent color sensations, but that color-blind persons have only two. The missing sensation he found to be nearer the red than to any other color of the solar spectrum. This discovery led to the construction of a pair of spectacles having one glass red and the other green, by which a color-blind person could distinguish between red and green, a red object appearing brighter when seen through the red glass, while a green color would be brighter when looked at through the green glass. It was for these researches that the Rumford Medal was awarded to Maxwell in 1860. M. Frithiof Holmgren, of Upsala, has since shown by following Maxwell's methods that there are also cases of violet-blindness.

Many other optical contrivances were devised by Maxwell, among them being the zoetrope, or "wheel of life," and the more important real-image spectroscope. His most valuable contribution to optics was to show the relation between certain electrical units and the velocity of light. It is impossible here to enter fully into this intricate subject, which Maxwell fully explained in a paper published in the *Philosophical Transactions* for 1868. He first of all showed that the ratio of the electro-magnetic to the electro-static unit of electricity is proportional to the ratio of the square root of the elasticity of the medium to the square root of its density. Then, regarding the air as a dielectric (or insulator) he obtained, as the value of this ratio, a velocity of one hundred and seventy-nine thousand miles per second. Weber and others, by similar processes, have since given other slightly increased results, the mean of which agrees with tolerable exactness with Foucault's determination of the velocity of light. It follows, then, that the medium for light is the same as that for electro-magnetic phenomena, and that the propagation of light is of similar nature to an electro-magnetic disturbance.

Maxwell's studies and experiments in relation to Saturn's rings, were an important contribution to astronomical physics. Huyghens in 1659 first announced the discovery that Saturn was girdled with a thin flat ring inclined to the ecliptic. Hadley and Sir W. Herschel threw further light on the question of the plane of Saturn's revolution, and also settled the fact of a division in the ring. It has since been established that the planet is enveloped by two bright rings, the outer of which is divided into two concentric rings by a very narrow gap, and that when seen at certain angles of vision, each ring is perceived to be broken up into a number of thin rings. Within the two bright rings there has also been observed a darker ring which is of such extreme tenuity as to be transparent, so that the edge of the planet can be seen through it. The stability of Saturn's rings was for a long time a problem of intense interest and of great difficulty. If they were solids, and at rest, the attraction of Saturn would, as Maxwell remarked, cause iron to become semi-fluid, and yet if the outer rings rotated with the velocity which the planet's revolution on its axis seemed to require, it was thought they would fly off into space, while if the velocity of the outer rings were accommodated to that of the inner, the latter would be crushed down upon the planet's surface. Laplace supposed a very large number of concentric rings each revolving independently with its own velocity around the planet. In Maxwell's essay, which gained the Adams prize, he showed that Laplace's theory was correct in principle, but that the rings were far more numerous than he had supposed. He dismissed the theory of solid rings and showed that the assumption of a liquid ring did not meet all the necessities of the case, concluding that "the only system of rings which can exist is one composed of an indefinite number of unconnected particles revolving round the planet with different velocities according to their respective distances. These particles may be arranged in a series of narrow rings, or they may move through each other irregularly. In the first case the destruction of the system will be very slow, in the second case it will be more rapid, but there may be a tendency towards an arrangement in narrow rings which may retard the progress." The late astronomer royal declared that this paper was "one of the most remarkable applications of mathematics to physics" he had ever seen.

The electrical researches and experiments of Professor Maxwell have brought him a fame which has been eclipsed by none of the men of science who have made this century illustrious. After his graduation he took up Faraday's works, in which he discerned at once the connection between the theory of attractions as developed mathematically and the method pursued by Faraday. The science of electricity may be said to have been founded in the reign of Elizabeth, when Dr. Gilbert ascertained that many substances possessed the property which amber had been long known to have, of attracting light bodies when heated by friction. Then Coulomb devised the torsion balance, by which he determined the law that the attraction or repulsion between two small bodies charged with electricity varies with the charges and the distance. The mathematical theory of electricity was started by Cavendish a century ago, and it is to him that we are mainly indebted for the experimental evidence of electric laws. He demonstrated that attraction or repulsion between two charged bodies varies directly as the product of the charges, and inversely as the square of the distance between them. It is curious that Faraday was unacquainted with the views of Cavendish, and it is perhaps as well that the exposition of those views was left to one who possessed all Faraday's capacity for observation and experiment, as well as a mathematical skill which Faraday never claimed. Faraday thought that there must be some mode by which electric actions are conducted from point to point, and it was his great merit that he showed them to be transmitted in lines, straight or curved, and to exert pressure and tension wherever they occur. The supposition that Faraday's conception of electrical phenomena differed from that of the mathematicians, was shown by Maxwell to be unwarranted, for he perceived that Faraday's method was also capable of mathematical expression. "Faraday saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance. Faraday saw a medium where they saw nothing but distance. Faraday sought the seat of the phenomena in real actions going on in the medium; they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids." Such is Maxwell's explicit solution of the supposed difficulty.

Faraday in reality represents a magnetic field geometrically as a space traversed by lines which lie in the direction of the magnetic force at every point, and which are distributed in such a way that their frequency is everywhere proportional to the intensity of the field. Maxwell, in a paper read before the Cambridge Philosophical Society, showed that if at any part of the course of these lines, their number passing through a unit area of surface at right angles to the direction of the force is proportional to the magnitude of the force, the same proportion between the number of lines per unit of area crossed and the intensity will hold good in every part of the course of the lines. Faraday, moreover, pointed out that, besides the tension along each line of force, the lines exert a repulsion on one another, and Maxwell showed how equilibrium results from this tension and repulsion. When Faraday saw this paper he showed his appreciation of its value by addressing the following letter to Maxwell: —

> I received your paper and thank you very much for it. I do not say I venture to thank you for what you have said about "lines of force," because I know you have done it for the interests of philosophical truth; but you must suppose that it is work grateful to me, and gives me much encouragement to think on. I was at first almost frightened when I saw such mathematical force made to bear upon the subject, and then I wondered to see that the subject stood it so well.

Only one other branch of study in which Maxwell was of service to science can be glanced at, and that is molecular physics. In this, as indeed in all sciences, an atomic theory of some kind plays an important part. Democritus in very early times had framed such a theory, and on it the system of Epicurus was based. Lucretius, in ancient times, and Gassendi in the Cartesian age, embraced the doctrines of Epicurus. Descartes entered into controversy with Gassendi, and framed a material system, remarkable for its compactness and logical consistency, but it was vitiated by the fundamental error of regarding matter as being nothing more than extension. He says (Princip., ii. 4), "The nature of matter or of body, considered generally, does not consist in a thing being hard, or heavy, or colored, but only in its being extended in length, breadth, and depth." This is simply confounding the properties of matter with those of space, an error which runs through all Descartes's philosophy, and lies at the foundation of Spinoza's system.

Maxwell gives a concise account of the various older atomic theories in his article "Atom," which he wrote for the "Encyclopædia Britannica." Professor Clausius and Dr. Boltzmann, but especially Clerk Maxwell, have brought the molecular theory of gases to its present complete state, and have established it on a sound dynamical basis. According to the molecular theory all material substances are made up of molecules which are in motion relatively to each other. In solids the movement is nothing more than a vibration, in liquids there is less interference of the molecules with one another, but their freedom is much impeded, while in gases each molecule is quite free, except when one collides with another. Upon these principles is based the kinetic theory of gases. The momentum of a particle varies as the product of its mass and velocity (mv) and its kinetic energy as the product of mass and the square of velocity, being equal, as Maxwell explains in "Matter and Motion," to half mv^2 the *vis viva* of Leibnitz. The pressure of a gas is determined by its kinetic energy, and since this is the same for each gas at the same temperature, it follows that equal volumes of two gases at the same pressure and temperature contain the same number of molecules, and hence the density of a gas is proportional to the mass of a molecule. As the molecule is the combining weight, we have a demonstration of Gay Lussac's law of equivalent volumes.

The basis of the modern atomic theory is the union of bodies in fixed and multiple proportions, for though "atom," like the "first beginnings" of Lucretius, is a creature of the imagination, begotten for the purpose of satisfying man's intellectual need of something ultimate, yet its dimensions are determined by necessary conditions. If water be decomposed by an electric current, the proportion in volumes is unaltered, and similarly with nitrous oxide (N_2O) as well as with all other chemical combinations.

Molecules are groups of atoms held together by what chemists call affinity. A molecule of water consists of two atoms of hydrogen and one of oxygen (H_2O). Steam is precisely the same, except that the molecules are further apart. They are not broken up into atoms, for atoms are only ideal. It is probable that intense vibration may wreck some molecules; indeed, Professor Tyndall remarks that a photographer dare not use blue rays, lest they should wreck his salts of silver. There is an intimate relation between the atomic theory and light and sound, for the vibrations of the ether select those atoms whose periods of vibration synchronize with their own, and deliver up their motion to those atoms. This theory also explains why elementary gases are impervious to heat, and compound gases absorb it.

The only information we can possibly acquire about molecules is what Maxwell calls "statistical," implying that the motion of the centre of gravity of the group can be determined, but not that of any one of its members for the time being; because these members are continually passing from one group to another in a manner beyond our power to observe.

There are some allied questions to this of atoms and molecules of vast importance, which are referred to in the article "Atom." Referring to the dimensions of atoms, Maxwell declares that the physiologist

> is forbidden from imagining that structural details of infinitely small dimensions can furnish an explanation of the infinite variety which exists in the properties and functions of the most minute organisms. A microscopic germ is, we know, capable of development into a highly organized animal. Another germ equally microscopic, becomes when developed an animal of a totally different kind. Do all the differences, infinite in number, which distinguish one animal from another arise each from some difference in the structure of the respective germs? Even if we admit this as possible, we shall be called upon by the advocates of Pangenesis to admit still greater marvels. For the microscopic germ, according to this theory, is no mere individual but a representative body, containing members collected from every rank of the long-drawn ramification of the ancestral tree, the number of these members being amply sufficient not only to furnish the hereditary characteristics of every organ of the body, and every habit of the animal from birth to death, but also to afford

> a stock of latent gemmules to be passed on in an inactive state from germ to germ, till at last the ancestral peculiarity which it represents is revived in some remote descendant.
>
> Some of the opponents of this theory of heredity have attempted to elude the difficulty of placing a whole world of wonders within a body so small and so devoid of visible structure as a germ, by using the phrase structureless germs. Now, one material system can differ from another only in the configuration and motion which it has at a given instant. To explain differences of function and development of a germ without assuming differences of structure is therefore to admit that the properties of a germ are not those of a purely material system (p. 573).

The latter part of this article deals with a matter concerning which there had been much interest manifested, and which, in October, 1874, had been discussed in the pages of *Nature*, the designation of the molecule as "a manufactured article." The expression was first used by Sir J. F. Herschel in his "Preliminary Discourse on the Study of Natural Philosophy." To Bishop Ellicott Maxwell wrote: —

> What I thought of was not so much that uniformity of result which is due to uniformity in the process of formation, as a uniformity intended and accomplished by the same wisdom and power of which uniformity, accuracy, symmetry, consistency, and continuity of plan are as important attributes as the contrivance of the special utility of each individual thing (p. 393).

As was objected in *Nature* by Mr. C. J. Monro, in some cases the uniformity among manufactured articles is evidence of want of power in the manufacturer to adapt each article to its special use, but there is also a uniformity of plan, the choice of which is the highest proof and manifestation of intelligence, and that is the uniformity by which the Divine Artificer proceeds, because it is the absolutely best. Such, in substance, is the answer which Maxwell gave to the criticisms upon his use of Herschel's comparison.

These doctrines, the profound convictions of one of the best physicists of the age, arrived at not by brilliant generalizations to meet the momentary exigencies of public appearances with the aim of exciting popular sensation, but reached by the most thorough inquiry according to strictly scientific methods, are a distinct and sufficient rebuke of that materialistic tendency which is exhibited by some of his *confrères* in physical research. Professor Huxley has said, "Thought is the expression of molecular changes in that matter of life which is the source of our other vital phenomena." Du Bois Reymond tells us that not only our bodily but also our mental functions are performed by the motion of atoms, and the finite mind has a double aspect, on the one hand acting, yet unconscious, and on the other, conscious, but inactive; the former, as Maxwell remarks in his dry way, being nothing but the mechanics of atoms, and the latter lying outside of mechanics, and caring nothing for cause and effect.

By grave, strong reasoning, as well as with the keen weapon of his subtle irony, he was ever ready to do battle with all that was brought into contradiction with his intense belief that nature bore upon it the marks of perfect wisdom, and that the universe was everywhere stamped with the vestiges of an intelligent Creator. Although he was no controversialist, and, as he said, had no nose for heresy, yet he was continually bringing his powers of burlesque and satire to bear upon contemporary fallacies. Some of his writings of this kind appeared in *Nature*, and others were handed to some friend for perusal. Among his more weighty utterances on this subject was a remark he made during his last illness, "I have looked into most philosophical systems, and I have seen that none will work without a God." This is a testimony worth pondering. Some of the divine laws, it is true, are incomprehensible and transcendental, but, as Maxwell said, "It is an universal condition of the enjoyable, that mind must believe in the existence of a law, and yet have a mystery to move in." The belief in a personal deity was to him a mental necessity, but it was by no means a stagnant faith. "Nothing," wrote he in a letter, "is to be *holy ground* consecrated to stationary faith, whether positive or negative." Research "is never to be willingly suspended till nothing more remains to be done; *i.e.*, till A.D. $+ \infty$." Mystery there will ever be, therefore let there be unending research.

If the scientific world has reason to be grateful for Maxwell's noble labors, the Christian Church may also be thankful for such a life. Not in the spirit of a polemic, but with tender considerateness for the feelings and beliefs of others, he yet managed to convince many who would have otherwise looked coldly on his faith, that to him it was an intense reality and a sublime inspiration to purity and philanthropy. Through all his career he never forgot the entreaty which fell from his dying mother's lips, that he would "always look up through nature to nature's God."

As might be expected from one whose mother was a pious Episcopalian and whose father was a Presbyterian elder, Maxwell was ordinarily very reticent with regard to the deeper and more sacred instincts of his nature, but in his letters, especially to his wife, all the depths of his soul were revealed, and the strong, clinging love which he cherished for Christ was spoken of with such unobtrusive naturalness as leaves no doubt concerning the reality and intensity of his spiritual life. On one occasion he wrote: —

> I have been back at 1 Cor. xiii. I think the description of charity or divine love is another loadstone for our life — to show us that this is one thing which is not in parts, but perfect in its own nature, and so it shall never be done away. It is nothing negative, but a well-defined, living, almost acting, picture of goodness, that kind of it which is human, but also divine. Read along with it 1 John iv., ver. 7 to end; or if you like, the whole Epistle, and Mark xii. 28.

Again he writes to Mrs. Maxwell: —

> I am always with you in spirit, but there is One who is nearer to you and to me than we ever can be to each other, and it is only through Him and in Him that we can ever really get to know each other. Let us try to realize the great mystery in Ephes. v. and then we shall be in our right position with respect to the world outside, the men and women whom Christ came to save from their sins.

His religion was moreover of a practical kind. He gave largely and worked with much zeal and energy for the endowment of Corsock Church near his estate, and the building of the manse. He also set apart a site and got plans made out for a day-school in the neighborhood, to be built and supported at his own expense, a purpose which was interfered with by his illness and premature death.

We have not many men to lose like Professor Maxwell, and it is pardonable if those who long to see the thinking, throbbing world of science spiritualized by a living faith in God, and sobered by a reverence for revealed truth, should feel that his departure has left a gap which cannot easily be filled. But he lived nobly, and future generations will be the richer for his life.

From Macmillan's Magazine.

THE WIZARD'S SON.

CHAPTER XXII.

THE room was large with that air of bare and respectable shabbiness which is the right thing in a long-established private hotel — with large pieces of mahogany furniture, and an old-fashioned carpet worn, not bare exactly, but dim, the pattern half obliterated here and there, which is far more correct and *comme il faut* than the glaring newness and luxury of modern caravanseries. As Mr. Williamson, like a true Englishman (a Scotsman in this particular merely exaggerates the peculiarity), loved the costly all the better for making no show of being costly, it was naturally at one of these grimly expensive places that he was in the habit of staying in London. A large window, occupying almost one entire side of the room, filled it with dim evening light, and a view of roofs and chimneys, against which Katie's little figure showed as she came forward asking, "Is it any one I know?" It was not a commanding, or even very graceful figure, though round and plump, with the softened curves of youth. When the new comers advanced to meet her, and she saw behind her father's middle-aged form, the slimmer outlines of a young man, Katie made another step forward with an increase of interest. She had expected some contemporaries of papa's such as he was in the habit of bringing home with him to dinner, and not a personage on her own level. Mr. Williamson, in his good-humored cordiality, stepped forward, something like a, showman, with a new object which he feels will make a sensation.

"You will never guess who this is," he said, "so I will not keep ye in suspense, Katie. This is our new neighbor at Loch Houran, Lord Erradeen. Think of me meeting him just by chance on the pavey, as ye may say, of a London street, and us next door to each other, to use a vulgar expression, at home!"

"Which is the vulgar expression?" said Katie. She was very fond of her father, but yet liked people to see that she knew better. She held out her hand frankly to Walter, and though she was only a round-about, bread-and-butter little girl with nothing but money, she was far more at her ease than he was. "I am very glad to make your acquaintance, Lord Erradeen," she said. "We were just wondering whether we should meet you anywhere. We have only been a week in town."