an idea of the pecuniary help received from him by some of his fellow-workers. In local affairs his interest and benevolence in the educational and charitable institutions of the parish of Lewisham are now, alas! matters of history.

For more than two years before his death his friends noticed with concern that his health was visibly and seriously impaired. A severe attack of eczema was followed by chorea, and this by severe gastric disturbance. About a year ago, indications of cancer of the stomach showed themselves, and became more and more confirmed. His illness was painless, but the great weakness constantly increased, as did his inability to retain or assimilate nourishment, and he passed peacefully away, in full possession of his mental faculties to the last.

In 1846 he married Isabel, the youngest daughter of Thomas Dunn, Esq., of Sheffield, but had no family. She survives him, and was his constant companion in all his work, travels, and excursions, and his devoted attendant during his long illness.

R. McL.

Thomas Archer Hirst, the third and youngest son of Mr. Thomas Hirst, a wool-stapler, was born at Heckmondwike, in Yorkshire, on 22nd April, 1830. He was educated at the West Riding Proprietary School; and, in 1844 he became an articled pupil of a surveyor at Halifax. It was in this office that he made the acquaintance of John Tyndall, who became a life-long friend of Hirst, and exercised a deep influence on his scientific career; and, in particular, it was the example of Tyndall which led him to give up the pursuit of the profession at first chosen for him. Tyndall had left England to study chemistry, under Bunsen, at Marburg; and thither Hirst followed him, in 1849, to study mathematics, physics, and chemistry. After three years at that University he obtained the degree of Ph.D., on examination in his three subjects and an approved dissertation in analytical geometry. Subsequently, a short time was spent in Göttingen with Gauss and Weber, and then he went to Berlin where he attended lectures by Dirichlet, Steiner, and Joachimsthal. His intercourse with Steiner did much to determine the ultimate bent of his mathematical investigations; but some years elapsed before it was fully indicated, as the majority of his earlier papers are devoted to researches in mathematical physics.

He succeeded Tyndall, at Queenwood, in 1853, on the appointment of the latter at the Royal Institution; but this post was resigned in 1856 on account of the delicate health of his wife, whom he had married in 1854. The succeeding winter was spent at Biarritz and Pau, but without permanent good results, as Mrs. Hirst died in Paris, in 1857. Tyndall took him to Switzerland for six weeks,

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and, on their return, left him in Paris, where the next winter was occupied in attending lectures by Chasles, Lamé, and others, and in making the acquaintance of the leading French mathematicians. In the winter of 1858–59 he was in Rome; and subsequently he travelled in Italy, making the acquaintance of many mathematicians, especially of his friend Cremona.

Returning to England in 1860, he was appointed mathematical master at University College School; and he held this post for a period of five years, during which he made his first developments in teaching geometry. The experience of the results then attained led him to join the Association for the Improvement of Geometrical Teaching, when it was formed in 1871; and for the first seven years of its existence he was its President and took an active part in its work.

He had been elected a Fellow of the Royal Society in 1861, and it was from this date onwards that his researches are devoted to the various branches of pure geometry which proved of most absorbing interest to him. He was appointed Professor of Physics at University College in 1865, and, on the death of Professor De Morgan in 1867, he succeeded to the Professorship of Pure Mathematics; but the latter chair he resigned in 1870 to become Assistant Registrar in the University of London. In 1873, the date of the establishment of the Royal Naval College at Greenwich, he was appointed Director of Naval Studies; and he continued to discharge the duties of that office for ten years. The precarious condition of his health then compelled him to resign: and he subsequently lived in comparative retirement, spending most of his winters abroad, until his death on 16th February, 1892.

Hirst took a prominent part in the foundation of the London Mathematical Society in 1865, served as its President from 1872 to 1874, and was a member of its Council for over twenty years. His active co-operation with the Society did much to extend its influence: and it was largely to the pages of its Proceedings that his papers on pure geometry were contributed. These are the papers containing the particular researches for which a Royal Medal was awarded to him in 1883—the year which practically marks the termination of his public life. He had served on the Council of the Royal Society in the years 1864–66, 1871–73, 1880–82: after 1883, the only sign of activity was the production of several papers, one of which in continuation of his earlier researches is of considerable importance.

The amount of Hirst's published work is not great; but his work is valuable, and an appreciable portion of it has been translated into French and into Italian. His papers are singularly clear: and side issues, that might lead him away from the main line of development of his subjects, are severely excluded. It is evident that he

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bestowed great care not merely in carrying out his investigations, but in considering the form in which they are expressed: and his reluctance to premature publication of incomplete work may be gathered from the fact that, though, on quitting the Presidential Chair of the London Mathematical Society on 12th November, 1874, he made a brief statement of some results which he had obtained in the theory of Correlation of Space, the full exposition of his results was not communicated to the Society until 9th January, 1890.

The work with which his name as a mathematician will be most definitely associated is contained in his papers on the Correlation of Planes and the Correlation of Space. The simplest space of two dimensions is a plane, and the elements of such a space are a point and a straight line; a correspondence is established between two planes when all the elements of one plane are connected by a relation or relations with all the elements of the other. When the relations are such that, in general, one element of one plane is associated with one (and with only one) element of the other plane, and *vice versâ*, the correspondence is unique. If each point in one plane corresponds uniquely with a point in the other, and likewise each line in one plane uniquely with a line in the other, the correspondence is called a homography: the theory of homography is considered at length by Chasles in his 'Traité de Géométrie Supérieure.' If each point in one plane correspond uniquely with a line in the other, and likewise each line in the one plane with a point in the other, the correspondence is a correlation. A few properties of correlative planes are proved by Chasles in the treatise quoted: it is Hirst's distinction to have constructed the theory of correlation of planes and to have developed it to a great degree of perfection. The extension of the theory of correlation so that it may be applied to space of three dimensions was adverted to by Chasles in his 'Aperçu Historique'; the full extension was carried out by Hirst, whose investigations in this subject, together with those of his friends Rudolf Sturm, Cremona, and others, have resulted in important and substantial additions to the theory of pure geometry.

The following memoranda of Dr. Hirst are due to Professor Tyndall; the present state of his health is sufficient to account for their brevity.

A. R. F.

[*Memoranda concerning Dr. Hirst.*]

The "railway mania" was at its height, and profitable employment was in prospect for young men trained to the use of the theodolite, spirit-level, chain, and drawing-pen. Youths of well-to-do families were articled in numbers to a profession offering so many

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attractions. Under such circumstances, Thomas Archer Hirst was articled, in 1846, to Mr. Richard Carter, then resident in Halifax, in whose office, at the time, I happened to be principal assistant. He was then about sixteen years of age. His father had been engaged in the wool trade, his mother was a widow, and he was the youngest of a family of three sons.

The West Riding of Yorkshire was then the battle-field of two great rival railway companies—the West Riding Junction and the West Riding Union. Our duty at the time consisted in the preparation of plans and sections of the lines proposed by the latter company. Save in the office, I saw but little of Hirst at the commencement—he being told off in the field to a party different from mine. But an intimacy gradually grew up between us, and in due time, though I was ten years his senior, we became steadfast friends. Influenced by the writings of Carlyle, Emerson, Fichte, and other philosophers, I held, in those days, very serious views of human conduct and duty. After some time, I noticed that my conversations with Hirst were producing a similar shade of earnestness in his mind. In 1848, I quitted England for Germany, choosing the University of Marburg, in Hesse Cassel, where, in regard to science, Bunsen was then the leading star. Hirst, instead of pursuing the profession chosen for him, soon resolved to follow me to that University. He paid me a preliminary visit in the summer of 1849. It was associated with a pathetic incident. Prior to the examination for the Doctor's Degree, it was customary for the candidates to visit the Professors, and to invite them to be present at the examination. I was on my way to the rooms of one of the Professors, when the postman, meeting me in the street, placed a letter in my hands. It was from a young colleague of Hirst's, who worked in the same office with him in Halifax. I was stunned by the perusal of its first few lines. Hirst had left his mother in good health, and this letter informed me of her sudden death. The writer told me that he had also written to Hirst, but that knowing his strong attachment to his mother, he was afraid to let him know the worst. He trusted to my discretion to disclose it to him in the gentlest manner possible. On returning to our lodgings, I found that Hirst had received the letter announcing his mother's illness, and was making preparations for his immediate return to England. He was far from well. In those days he frequently suffered from a malady of the throat, which entirely quitted him in later years. Everything being prepared for the journey, he had his trunk taken to the coach office, where, after waiting some time, he entered the *Post Wagen*. I was in great perplexity; for, while shrinking from imparting to him the knowledge in my possession, I could not bear to allow him to return, cherishing the delusion that his mother still lived. On squeezing his hand for

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the last time, I said to him, "Dear Tom, prepare your mind for the worst." His reply was a startled, steadfast look, and, in a moment, he added, "John, my mother is dead. Tell me all; I can bear it." "Yes," I replied, "she is dead," and he drove away.

After my severance from Halifax, Hirst was accustomed to hold a little weekly symposium in his lodgings. A group of young fellows desiring intellectual intercourse used thus to meet, mainly for the discussion of questions touching upon religion. One of them, I remember, was the son of a Congregationalist minister; another a young author of considerable ability—at that time an ardent admirer of Carlyle, but who afterwards became an equally ardent Roman Catholic. Hirst had now grown into a tall man, with a singularly noble countenance. It was interesting, indeed, to observe how this nobility of expression increased as thought and aspiration mingled more and more with his physical conformation. His hair was dark, his forehead finely formed, his nose and general features well chiselled. The only exception that could be taken to the beauty of his countenance was a certain looseness of lip, which seemed to indicate a lack of firmness of character. But the indication was deceptive, for Hirst could be immovable when circumstances called forth the exercise of firmness.

There was, at that time, near Halifax, a tract of heath-land called Skircoat Moor, at one corner of which stood a little cottage called "The Birdcage." The widow who occupied this cottage eked out a livelihood by selling sweets to the children who came to the moor. She had one son, who had begun life as an errand boy in a printer's office, but who, by good conduct and intelligence, had risen to a highly respectable position in one of the mills. This youth, whose name was Booth, attended Hirst's symposium. His health began to fail, and Hirst observed with anxiety the increasing pallor of his countenance as he walked to and from his work. Medical advice was resorted to, and Booth's malady was pronounced to be consumption. His weakness increased, his usefulness as a clerk diminished, until at last Hirst insisted that he must cease working and direct the whole of his attention to the care of his health. As to his salary, he (Hirst) undertook to make that good. The poor youth lingered long. Hirst had followed me to Marburg, had quitted that University, and had become a favourite pupil of the illustrious Steiner at Berlin. The *Semester* had begun; its busiest time had set in. One morning, however, he made his appearance in London, and told me that Booth, who was obviously dying, had written, imploring his benefactor to visit him. In response to that letter, Hirst had quitted his studies and had come over to England. Travelling down to Halifax, he found that Booth's chief anxiety related to his mother. "What will become of her," he exclaimed, "when I am gone?" The means at

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Hirst's command at the time were very moderate. Through the accidents of trade, or the misconduct of individuals, the property left by his father had, in great part, disappeared. Still, without a moment's hesitation, he gave the dying youth the comforting assurance that his mother would be properly taken care of. For some years afterwards, while Hirst continued in Germany, I was myself the intermediary through whom the widow's allowance passed to her hands.

The sum paid when Hirst was articled to Mr. Carter, together with a professional education of five years, was naturally, on the part of his relatives, expected to produce some tangible result; and when they found that he had resolved to relinquish it all for the sake of the cultivation of his intellect, they thought his resolution a wild one. But he never wavered for a moment, and, except on occasions when his health caused me anxiety, I never wavered in the conviction that the step he had taken was a wise one. Throughout the winter and spring in Marburg, our days were spent in labour, attending lectures, working in the chemical laboratory, and studying at home. At 10 P.M., the stroke of a piano by Hirst gave notice that the work of the day was ended. We had music and light reading afterwards, the latter including the 'Essays of Montaigne,' which proved to us a source of strength as well as of delight. At 11 P.M. we went to bed. I was earliest up, for, soon observing that hard study was telling upon the younger and less vigorous constitution, I persuaded him to give more time to repose.

After I had quitted Marburg, leaving Hirst behind me, Dr. Simpson, a medical man with a passion for chemistry, afterwards Professor of Chemistry at Queen's College, Cork, came to the University to pursue his studies in Bunsen's laboratory. He brought with him his wife and family and a sister of his wife. They were both sisters of John Martin, the pure-minded Young Irelander. Acquaintance ripened into friendship between the young people, friendship into love, and, after Hirst had taken my place at Queenwood College in 1853, he married Miss Anna Martin. A few years of unalloyed happiness were wound up by an attack of tuberculosis, which ended in her death in 1857. He had taken her to Biarritz, thence to Pau, whence he had returned to Paris, where she died. I was on my way to Switzerland when intelligence of the calamity reached me. Ignorant of their address in Paris, I sought him in his old qnarters. Failing to find him there, and guided by a vague indication, I sought him in the Rue Marbœuf. Here, though baulked at first, I discovered where he lodged. On turning, afterwards, the corner of a street, I met him face to face, looking as white as marble. He was returning from ordering his wife's coffin.

I stood beside him in the cemetery of Père la Chaise when she was

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lowered into the grave, and afterwards carried him with me to the Alps. Prior to joining me at Chamounix, he had three days of lonely wandering; communing with himself under his changed conditions. We made the little *auberge* at the Montanvert, which was then a very small affair, our permanent residence. For six weeks his life was filled with healthy exercise, under conditions where constant attention was necessary to his personal safety. Nothing could have been better calculated to divert his mind from the grief which weighed upon it. A few days after our arrival, we were joined by Professor Huxley. As we assembled night after night round our pine-wood fire, life became to all of us more and more a thing to be enjoyed. We returned from the Alps, Hirst halting in Paris, where for some time he took up his abode. Here he made the acquaintance and secured the friendship of the foremost mathematicians. He went afterwards to Italy; and was at the village of Solferino, helping the wounded, on the day after the battle. In Italy he met Professor Cremona, who remained his friend in a very special sense to the end of his life. On his return to London, Hirst became mathematical master in University College School, then Professor of Applied Mathematics in University College. For the sake of his health, he afterwards accepted the Assistant Registrarship of the University. His final appointment was to the Post of Director of Studies in the Royal Naval College, Greenwich, under the presidency of Admiral Sir Cooper Key, who was succeeded by Admiral Fanshawe; Mr. Goschen was at the time of his appointment First Lord of the Admiralty. Hirst never forgot the Minister's high-minded sympathy with his mathematical studies, or his willingness so to arrange matters as to reconcile the prosecution of those studies with his duties as Director.

During his later years, the state of Hirst's health frequently caused his friends the gravest anxiety. He relinquished in succession the posts he had occupied, retiring finally from Greenwich with a Government pension. During the present calamitous year, he was smitten with influenza, to which he finally succumbed.

I have already given an example of Hirst's kindness of heart. To this it may be added that, apart from his scientific labours, his life throughout was one of wise beneficence.

J. T.

Edward Killwick Calver, born 1813, entered the Royal Navy in 1828, in the navigating branch, on board H.M.S. "Crocodile." After a further term of foreign service in the "Satellite," he in 1836 commenced his long period of service as a marine surveyor on the Home Station. For thirty-six years, with scarcely a break, he served in this capacity mainly on the south and east coasts of Great Britain.

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