

Trinity Monday Memorial Discourse 2015

James MacCullagh (1809-47)

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Provost, Fellows, Scholars, Colleagues, Guests and Friends

Great, good, unhappy! For his country's fame
Too hard he toiled; from too unresting brain
His arachnean web of thought he wove
The planet-form he loved, the crystal's frame
Through which he taught to trace light's tremulous train,
Shall be his symbol in the cypress grove.

In these words, one of Ireland's greatest mathematicians, William Rowan Hamilton, responded to the shocking death and the all too short life of his friend, colleague and rival, James MacCullagh. It is an honour and pleasure for me, 168 years later, to try to respond in my turn to MacCullagh's achievements, by presenting the Trinity Monday Discourse on this gifted mathematical physicist in Trinity College Dublin in the first half of the 19th century. I want to thank the Provost for asking me to give the discourse this year, which is the UNESCO Year of Light. In preparing the discourse, and coming to understand this complex individual, I have been greatly helped by the work of several scholars, in particular Brendan Scaife and David Spearman from this College, Jim Bennett from Oxford, and Oliver Darrigol from Paris, who have all written on the life and work of James MacCullagh.

James MacCullagh was born in 1809 into a Protestant family, the eldest of twelve children of James and Margaret, in the townland of Landahussey in the parish of Upper Badoney in the valley of the Glenelly River in Co Tyrone. Five sons and three daughters survived early childhood. The Glenelly River runs westward from Landahussey in a steep-sided valley for about 2 miles to the small town of Plumbridge. It is a very scenic location that is now classified as an Area of Outstanding Natural Beauty. Though the surroundings were idyllic, winning a living from their hill farm was surely a challenge. Reverend William McGhee, who was the rector of Upper Badoney parish and the clergyman who baptised James MacCullagh described the area:

There is neither poverty nor riches, none that arrogate to themselves pre-eminence, the equality is uncommon... Their general food, oat bread, potatoes, milk and butter....They make a decent appearance on Sunday, mostly clothed in cloth of their own manufacture,... English and Irish are spoken in common by the Protestants and the Catholics. We all carry well together, no party business, we have neither orange or ribbon men.

Though the family circumstances were modest there was a strong interest in education. Two brothers of James were to follow him to Trinity. It seems that James MacCullagh commenced his education at the parish school at Castledamph on the Glenelly Road. While James was still young his father moved the family ten miles to Strabane, seemingly to access better education for him. In a presidential address to the Royal Society shortly after MacCullagh's death, The Marquis of Northampton, gives the following anecdote of his early education:

In Strabane he was, while very young, placed in the only respectable school in the town. Here his genius soon displayed itself. After school hours he was almost constantly employed in solving mathematical problems; yet, it is remembered that when Euclid was first put in his hands he was dissatisfied with the task. He was only required to get the solution to the problem by heart, like a copy of verses, and repeat it. There was no attempt made at explanation. This did not suit the character of his mind, which could not rest until it thoroughly understood the nature of everything that came before

it. For some days he was restless, unhappy and puzzled, wandering about with Euclid in his hand. In his perplexity he met a neighbour, a working carpenter, a man of cleverness and talent, who, seeing the boy evidently unhappy, was good enough to ask him what was the matter. He immediately told his good-natured friend that he was obliged to get by heart a set of strange words, the meaning of which he wanted to understand; at the same time showing him the proposition he was committing to memory for the next day's task. The carpenter sat down with the puzzled boy, and in a short time showed him what a proof was. This was the way in which Professor MacCullagh first learned to prove a proposition in Euclid.

Clearly the problem of rote learning is not new, particularly in mathematics.

James MacCullagh entered Trinity College Dublin in November 1824, aged fifteen, as a Pensioner, or fee-paying student, obtaining second place out of one hundred and thirty candidates. He was successful in the Sizarship examination in June 1825, and was second out of ninety-five candidates. The College Calendar defined sizars thus:

This rank is composed of young men whose means are generally much more limited than their talents; therefore, intellectually, their rank is a high one, as the number of very eminent men who have come from this class sufficiently testifies...

The sizars have their Commons, and often their chambers, free of expense; they are likewise exempt from all College and tutors' fees.

MacCullagh took up his rooms in College in June 1826 and resided in College for the rest of his life.

Up to the beginning of the 19th century Trinity College was essentially an ecclesiastical institution, where an important function was to train priests for the Anglican Church, which was then the established church in Ireland. In the 1820s and 30s Trinity introduced internal reform in order to take account of new trends in education and to avoid parliamentary interference. James MacCullagh benefitted from the revolution in mathematics in Trinity introduced by Bartholomew Lloyd, who

was Professor of Mathematics from 1813 to 1822, and then Professor of Natural Philosophy until 1831, when he was elected Provost. MacCullagh had a very distinguished undergraduate career and was elected to scholarship in June 1827. He took his degree examination in 1829. He was on the honours list, indicating that he had taken the medal examination in which gold medals were awarded to the top candidates in mathematics and classics. In mathematics students were expected to be well grounded in analytic geometry, calculus, mechanics and optics and to be familiar with the continental authors, such as Poisson, Laplace and Lagrange.

The next big academic test was examination for Fellowship. The examination was highly competitive. It was conducted in Latin, and in public, with all the candidates participating together. The examination included logic, mathematics, natural philosophy, ethics, classical literature and composition, though by 1828 mathematics and natural philosophy were the primary elements. Somewhat earlier Dionysius Lardner had poked fun at the Fellowship election:

Will it be credited abroad, that in the University of Dublin, at the election of Fellows, there is actually held an oral examination in physics and mathematics? The development of a function by the theorem of Taylor or Lagrange, or the introduction of a differential equation effected *viva voce*, and in Latin, are probably phenomena new to the learned world!

MacCullagh was unsuccessful in the Fellowship examinations in 1829 and 1831. He succeeded in 1832 and was elected to Fellowship in June of that year. Tenure was for life. The salary was modest, but he was entitled to rooms, and Commons at High Table, free of charge. In due course he could expect to become a Senior Fellow, which commanded a quite substantial salary and influence in the College. He was appointed junior assistant to Franc Sadlier, the Professor of Mathematics, and to the lecturer in Greek. In this time Fellows were forbidden to marry and nearly all had be ordained as priests in the Anglican Church. He chose not be ordained and requested to be elected to one of the three lay Fellowships; one in medicine and two in law. He was elected Jurista.

MacCullagh's first publications, when he was only 21, were communicated to The Royal Irish Academy in 1830. These were "Geometrical theorems on the rectification of the conic sections" and "On the double refraction of light in a crystallised medium according to the principles of Fresnel". Optics and geometry were the main themes of his scientific career, though it was his work in optics that was more significant.

When James MacCullagh commenced his career in Trinity College the wave theory of light had largely replaced the corpuscular theory that had been dominant until nearly the end of the 18th century. Natural philosophers asserted that some kind of medium was required to support the undulations of light, just as for other kinds of wave. To this mysterious supporting medium they gave the name ether, and many of the scholars of the time devoted much effort to try to discover the properties of this hypothetical substance. Because the velocity of light is so high, the elastic ether needed to have very low density, while at the same time be exceedingly strong; and it not present any hindrance to the passage of solid objects. It was supposed to pervade all space, including material bodies. It was believed that the propagation of light in transparent materials was governed by the way the matter particles interact with the ether. At first it was imagined that the vibrations of the ether were similar to sound waves in a gas where the particle vibration is longitudinal, to and fro along the direction of wave propagation. However, through experiments on double refraction in the mineral, Iceland spar, it became clear that the ether vibration had to be transverse, where the vibrations are perpendicular to the direction of propagation. Up to this time it was thought that all doubly-refracting materials were uniaxial and possessing two principal wave velocities, or refractive indices. However in 1813 David Brewster in Scotland discovered a new class of crystalline materials which are biaxial and possessed three principal refractive indices.

In 1821 Augustin Fresnel applied a transverse wave theory of light to find a description of double refraction. In this theory the interparticle forces, and thus the wave velocity, depend on the direction of vibration. He derived the shape of the ray surface, which defines the propagation of a pulse of light away from an imagined point source inside a biaxial crystal. The surface turned out to be quite complicated. It is double sheeted, and the two sheets interleave at 4 different

locations. To help you visualize this complex arrangement I have allowed myself just one visual aid. This elegant object is a wire model of the ray surface in a biaxial crystal. It was discovered by Professor Ian Sanders of the Department of Geology in 2006 when the College was commemorating the birth of William Rowan Hamilton.

One of MacCullagh's communications to the Royal Irish Academy in 1830 concerned the derivation of the biaxial wave normal and ray surfaces. Fresnel had determined the shape of these biaxial surfaces, though in the case of the ray surface he had used a "synthetic" method. Of this he said:

I followed this synthetic route because I thought it would be simpler than elimination, and yet the resulting calculations are so long and so fastidious that I do not think I should transcribe them here.

MacCullagh felt the derivation of these surfaces could be improved; he writes:

Judging from the simplicity and elegance of the results that there must be some simple method of arriving at them, I have been led to consider the subject with the attention which it merits, and have succeeded in discovering a method by which the whole may be explained with that simplicity which is characteristic of every theory that is founded in nature.

MacCullagh took advantage of his skill in geometry to find a more elegant method of deriving the biaxial wave-normal and ray surfaces. He made use of the concept of reciprocal surfaces, his own invention. The French scientist Emile Verdet praised MacCullagh's work, writing:

The most elegant and rapid procedure for arriving at the equation of the ray surface is undoubtedly the one used by MacCullagh"

William Rowan Hamilton also considered the wave normal and ray surfaces in biaxial crystals, and he identified a previously unnoticed feature. In Oct 1832 Hamilton read before the Royal Irish Academy a Supplement to his monumental "Theory of systems of rays" where he argued algebraically that the intersections of the two sheets should give rise to a new optical phenomenon, which he called conical refraction. It comes in two varieties, internal and external conical refraction. For the internal case

a narrow light beam directed along one of the optic axes spreads out as a cone of rays in the crystal and emerges as a cylinder of rays. Hamilton asked Humphrey Lloyd, the Professor of Natural Philosophy in Trinity to look for this new phenomenon. Within a few months Lloyd had procured a suitable crystal of aragonite and experimentally verified Hamilton's prediction, which of course was based on the wave theory of light.

The predication and observation of conical refraction was seen as powerful confirmation of the wave theory of light, and a personal triumph for Hamilton. In 1834 Hamilton was invited to present a review talk on Physical Optics at the meeting in Edinburgh of the British Association for the Advancement of Science. In this period the British Association was the primary forum for the presentation of new scientific results. In the following year Hamilton won the Royal Medal, and in 1835 he was knighted at the British Association meeting in Dublin. He was only 30 years old.

MacCullagh realised that he had narrowly missed an important discovery. In 1833, he published a "Note on the subject of conical refraction" in the Philosophical Magazine, where he claimed that this effect could be deduced from the theorems he had published three years earlier, and of which Hamilton "did not seem to have been aware"; in fact Hamilton had referred MacCullagh's paper. Hamilton was very annoyed by this challenge to his priority in discovering conical refraction. Humphrey Lloyd interceded between the two men and apparently convinced MacCullagh to write a second note to the Philosophical Magazine saying "The introductory part of my Note which appeared in your last number was written in haste, and I have reason to think it may not be rightly understood" He also states that though he had been aware of the existence of interesting special cases, and spoke of his intention to return to them, but admits that some of the details in his previous note had been deduced after hearing of Hamilton's result. David Spearman has commented on the uneasy relationship between MacCullagh and Hamilton:

Each man respected the other's ability. There was a certain bond of affection but there could not be the mutual trust which is a necessary element in a real friendship. Whether intentionally or not, Hamilton conveyed at least a hint of

condescension in his dealings with MacCullagh, whose proud spirit must have reacted with some bitterness.

Indeed Hamilton sometimes referred to his colleague as “poor MacCullagh”, though this may have been in sympathy for the mental anguish to which MacCullagh was prone.

The next challenge which MacCullagh set himself was to improve the Fresnel sine and tangent laws which govern the reflection and refraction of light at the surface of a transparent material. He also sought to extend these laws to optically anisotropic materials. In 1837 he read a major paper to the Academy where he made substantial progress on this complicated problem. In his model the propagation was described in terms of ether oscillations, but this ether motion was not calculated using the laws of dynamics. His results agreed with Brewster’s observations on the polarisation of the light reflected from crystals. The Academy awarded him the Cunningham medal for this paper and the presentation was made by Hamilton as President. In his comments on the paper Hamilton showed a very clear understanding of the direction which MacCullagh’s work was taking when he comments:

He has not sought to deduce, from any pre-supposed attraction or repulsions, and arrangements of the molecules of the ether, any conclusions respecting the vibrations in the interior or at the boundaries of a medium, as necessary consequences of those dynamical principles or assumptions. But he has sought to gather from phenomena a system of mathematical laws by which these phenomena might be expressed and grouped together...

Unfortunately MacCullagh soon learned that the Königsberg scientist Franz Neumann had read a very similar paper in the Berlin Academy in 1835 and published it in 1837. At the end of his paper MacCullagh generously acknowledges Neumann’s work:

...Mr Neumann’s paper is very elaborate, and supersedes, in a great measure, the design which I had formed of treating the subject more fully at my leisure; nor can I do better than recommend it to those who wish to pursue the investigation through all their details.

In 1823 Fresnel had introduced complex numbers in the mathematical description of total internal reflection in a transparent material. In 1836 MacCullagh sought a new theoretical description of how light is reflected at metal surfaces. He introduced the concept of complex refractive index, where the real part determines the wave propagation and the imaginary part the absorption. This formalism is still in use today, and is another example of MacCullagh's drive to find both elegant and efficient mathematical descriptions of optical phenomena.

In a paper in 1837 on crystalline reflection and refraction MacCullagh suggested that;

Perhaps the next step in physical optics would probably be to those higher and more elementary principles by which the laws of reflexion and the laws of propagation are linked together as parts of the same system.

In December 1839 in his paper "An essay towards a dynamical theory of crystalline reflexion and refraction" he proudly announced to the Royal Irish Academy:

This step has now been made, and these anticipations have been realised. In the present paper I propose to supply the link between the two sets of laws by means of a very simple theory, depending on certain assumptions, and employing the usual methods of analytical dynamics.

Drawing on his deep understanding of the propagation of light in crystalline materials, MacCullagh concluded that the perturbations of the ether induced by the passage of light had to be rotational in character. In deriving a potential energy function for these rotational distortions he invented a new differential operator for a vector field, which was later named the curl of a vector field by James Clerk Maxwell. MacCullagh then followed the Lagrangian methodology to derive a differential equation for light. When he applied this equation to the propagation of a light wave in a crystal he could account all the known optical behaviour. His paper was indeed a major breakthrough, though perhaps it was somewhat too abstract to be fully appreciated at the time. His peers found it hard to accept a theory based on ether motions which did not correspond to any known elastic wave. In writing to

John Herschel, a well-known English scientist and son of Sir William Herschel in 1846 MacCullagh says:

With respect to the question which you have put regarding my notions of the constitution of the ether, I must confess that I am not able to give any satisfaction – I have thought a good deal (as you may suppose) on the subject – but have not succeeded in acquiring any definite mechanical conception - i.e. such a conception that would lead directly to the form of my function V , and would of course include the actual laws of the phenomena. One thing only I am persuaded of, is that the constitution of the ether, if it would ever be discovered, will be found to be quite different from anything that we are in the habit of conceiving, though at the same time very simple and very beautiful. An elastic medium composed of points acting on each other in the way supposed by Poisson and others, will not answer.

Here we see the boldness of MacCullagh in giving priority to the constraints imposed by the mathematical description of the phenomenon over the inclination to imagine a physical model. At the end of the same letter he says: “I read Faraday’s late papers with great eagerness, I quite agree with your view of his experiments”. It is interesting to imagine how Faraday’s work might have inspired MacCullagh if he had lived longer.

In all MacCullagh published 23 papers in optics. One of these in 1843 was on the results of some experiments on reflection from metals he had done with help from Thomas Grubb in 1837.

MacCullagh did not live to see the breakthrough by James Clerk Maxwell in the theory of light in the 1860’s. Maxwell produced his great mathematical synthesis of the experiments of Michael Faraday on electromagnetic induction, which led to a wave equation for electromagnetic waves. The wave velocity predicted by the theory was equal to the measured velocity of light. Towards the end of the 19th century another Professor of Natural Philosophy at Trinity, George Francis Fitzgerald, who studied the works of MacCullagh for the Fellowship examination, showed that it

was possible to interpret MacCullagh's theory of light to bring it into harmony with Maxwell's approach.

Though MacCullagh's theory was soon eclipsed by Maxwell's achievement, it continues to feature in the history of the theory of light. Richard Feynman, who shared the Nobel Prize in 1965 for the development of quantum electrodynamics, makes reference to MacCullagh when he introduces the concept of electric and magnetic interactions in his "Lectures on Physics". Feynman writes:

The best way is to use the abstract field idea. That the field is abstract is unfortunate, but necessary. The attempts to try to represent the electric field as the motion of some kind of gear wheels, or in terms of lines, or of stresses in some kind of material have used up more effort of physicists than would have taken to simply to get the right answers about electrodynamics. It is interesting that the correct equations for the behaviour of light were worked out by MacCullagh in 1843. But people said to him "Yes, but there is no real material whose mechanical properties could possibly satisfy those equations, and since light is an oscillation that must vibrate in something, we cannot believe in this abstract equation business." If people had been more open-minded, they might have believed in the right equations for the behaviour of light much earlier than they did.

There are vestiges of MacCullagh's potential energy function even in the generalisation of quantum electrodynamics to a gauge theory that included the weak interaction, which is responsible for the light emitted by stars.

In a recent paper entitled *James MacCullagh's ether: An optical route to Maxwell's equation?* Olivier Darrigol summarises MacCullagh's achievement as follows:

In attempts to perfect Fresnel's theory of double refraction, MacCullagh discovered an elegant geometrical proof of the wave surface, the true boundary conditions at the limits of refracting crystals, and a simple Lagrangian for the whole theory. By renouncing mechanical modelling in favour of a more abstract dynamical method, he unveiled the structure which optics came to share with Maxwell's electrodynamics.

I will now turn to say something of James MacCullagh as a professor in Trinity and as a public figure. In 1835 Franc Sadlier became a Senior Fellow and was required to give up the Erasmus Smith's Professorship of Mathematics, and MacCullagh was appointed to that chair. The Erasmus Smith's endowment was supplemented to give him a salary of 700 pounds – a good salary for the time.

MacCullagh had a strong influence on the development of the School of Mathematics at Trinity. He gave lectures to candidates preparing for the Fellowship examination and was an examiner. Indeed some of his original theorems featured in the examination papers he set. He gave the School a strong inclination towards geometry. The renowned algebraic geometer George Salmon was one of the students he encouraged. An anonymous obituarist says of MacCullagh:

He trained up a school of geometers of whom their country may be proud, and who bid fair to wipe away for ever from their university the ignominious title of the “silent sister”.

Before MacCullagh's time critics accused Trinity of being the silent sister to Oxford and Cambridge in terms of scholarly output.

MacCullagh made several original contributions in geometry. He invented reciprocal surfaces, which he used in his work on the optics of crystalline materials. In 1843 he published a major paper “On surfaces of second order”. He derived a formula for the gravitational field around a spheroidal planet, which textbooks on geophysics still quote as MacCullagh's formula.

In April 1841 Humphrey Lloyd, Thomas Luby and James MacCullagh wrote to the Board of the College proposing the development of a School of Engineering, which was established later that same year. It is hard to imagine such rapid strategic development in modern times!

In 1842 MacCullagh was awarded the Copley medal of the Royal Society and in the following year was elected a Fellow of the Royal Society. The Board of the College tried to show its appreciation for “the credit he has done the College by his discoveries in science” by voting him an extra £100 a year for as long as he remain a

junior fellow. He declined the offer “on the ground that he would accept of nothing, which was not permanently attached to the Professorship, for the benefit of his successors”. In 1843 Humphrey Lloyd was co-opted as a Senior Fellow and resigned from the Chair of Natural Philosophy. He was replaced by James MacCullagh, who resigned from the Chair of Mathematics.

Jim Bennett has written on the institutional and cultural space for geometry and physics in Ireland at the time of MacCullagh, of which Trinity College, the University of the Protestant Ascendancy, was the major part. He states that “if Anglicanism represented one source of the values and practices of the College, mathematics was another”. Mathematics was promoted as part of a liberal education. David Attis in his recent book, *Mathematics and the Making of Modern Ireland*, suggests that:

...Trinity felt that rigorous scientific standards for both the students and professors offered the best strategy for strengthening the precarious position of the Irish Protestant University and the Protestant Ascendancy it existed to educate. Trinity’s reforms worked.

Hamilton and MacCullagh viewed their achievements as a contribution to the prestige of their university and the standing of Ireland as part of the Union. In this period there was strong representation from the Irish contingent, which included Hamilton, MacCullagh and Lloyd, at the meetings of the British Association for the Advancement of Science. The Association witnessed vigorous debate on the nature of light, and science in general. The “Cambridge-Dublin coterie”, as they were called, could point to Hamilton’s prediction of conical refraction in support of the wave theory of light and the deductive approach to science. The opposition was led by David Brewster, who was still committed to the corpuscular theory and favoured an inductive approach to science.

Though MacCullagh was mainly a theorist, he was a member of the Royal Dublin Society which emphasised the practical application of science. In 1841 he was drawn into a tricky political controversy when the RDS was challenged by the government to cease subscription to publications considered inappropriately political, namely newspapers, and not achieving objectives appropriate to the annual government

grant. The grant was to be suspended until the matter was resolved, and MacCullagh was asked to chair a commission of enquiry to find a solution. He managed to steer the commission to find a compromise acceptable to both parties; the Newspaper Room was closed.

Hamilton proposed MacCullagh for membership of the Royal Irish Academy. He was elected in 1833, and it became an important part of his life. He served as secretary to the Academy council and as secretary for foreign correspondence. Most of his papers were published in the *Transactions or Proceedings* of the Academy. In his relationship with the Academy, we see evidence of MacCullagh's patriotism and public spirit. In the 1830s public museums in Ireland were still in their infancy, and some members of the Academy were concerned that unique artefacts were being melted down or sold abroad. The archaeological community became aware of the magnificent 12th century Cross of Cong when George Petrie made his tour of Connaught in the early 1820s. He noted that the Cross was in the possession of Father Patrick Prendergast, the last Augustinian abbot of Cong. Using his own savings James MacCullagh purchased the cross in 1839 for 100 guineas from Dean Patrick Waldron at a time when funds were required to repair the church roof. He presented it to the Royal Irish Academy "to save it from the shameful process of destruction to which everything venerable in Ireland has been exposed, and to contribute to the formation of a national collection". He continued for the rest of his life to contribute generously to the purchase of material for the Academy. He led a subscription to purchase two Bronze Age gold torcs, which had been found at Tara, Co. Meath. The objects from the Academy Museum are now in the collection of the National Museum. Again at personal expense, he purchased important manuscripts for the Academy Library.

MacCullagh made three trips to the continent. In 1840 he was persuaded by Charles Babbage to join him at a meeting of the Italian Physical Society in Turin. Babbage was the English polymath who originated the concept of the programmable computer. MacCullagh took a keen interest in his friend's Analytical Engine. In 1842 Babbage supported MacCullagh's election to the Athenaeum Club in London. Jim Bennett has commented that the Athenaeum "would surely be an unusual place to

find the son of a hill farmer from Tyrone". In the same year MacCullagh confided to Babbage;

To talk of myself – I have grown very stupid of late, and regularly fail in everything I attempt. What the reason may be I cannot tell. But I begin to be of Newton's opinion, that after a certain age, a man may as well give up mathematics. Perhaps it would be better – at least for one's own happiness – to have some occupation or profession which would connect one immediately with his fellow men, and to make the pursuit of science a collateral object, rather than a direct one.

The government of Robert Peel fell in 1847 and James MacCullagh was proposed as a candidate for one of the two Dublin University seats at Westminster. The seats were held by Frederick Shaw and George Hamilton, who were both Oxford graduates and Tories. In an election address in June 1847 MacCullagh says;

.. a representative of the University ought to be really a member of it; a person educated within its walls, formed under its influence, and familiar with its work. I would add, that he ought also to be a person having some pretensions to represent the interests of science and learning, and capable of giving them something of their due weight in the public counsels.

He goes on to say that he will work to maintain the Anglican Church as the established church; perhaps, as a Fellow who was not in Holy Orders, affirming his religious orthodoxy.

He continues:

".. I would wish to see, and should endeavour to promote, such changes as would tend to raise my unhappy country from the almost desperate state into which it has fallen. As an Irishman, I should enter heart and hand into every well-devised plan for effecting what ought now to be the first of objects – the development of national resources, and the improvement of the habits and condition of the people."

Shaw and Hamilton were elected, MacCullagh got 374 votes out 2224. It must have been disappointing for him that more of the graduates of the University of Dublin were not prepared to support one of their own, but it was not a disgrace. Perhaps it was not surprising that, in this time of political uncertainty, the alumni chose not elect a patriotic idealist with little political experience.

On the evening of Sunday 24 October 1847 James MacCullagh took his own life. He was found in his College rooms by his housekeeper with his throat cut. At the inquest it was revealed that he had been unwell the previous week and was under the medical supervision of Dr Stokes. The doctor reported that MacCullagh was afraid that his friends might think him mad. The inquest verdict read that, "he died of wounds inflicted on himself while labouring under temporary insanity". A funeral service was held in College Chapel and the remains were buried in the family vault in the graveyard of the parish church of Upper Badoney, County Tyrone. Clearly his susceptibility to depression was a recurring problem. Thomas Romney Robinson, whom MacCullagh assisted in experiments on vibrations generated by railway trains, recalled "that only his intervention as a friend prevented a similar end some years previously". In an obituary notice in *The Nation* the Young Irelanders praised MacCullagh as a "warm and ardent nationalist", though it seems he had not expressed an opinion on constitutional issues. A wide range of important politicians and academics supported a petition to secure a Civil List pension for his three sisters and brother William, who were dependent on him at the time of his death.

He is remembered in College by a neoclassical bust by Christopher Moore, which stands above the door between the main Common Room and the Chess Room. There is also a blue plaque at the parish church in the Glenelly Valley. The National Gallery holds some sketches by Frederick William Burton, which show a handsome man with rather delicate features. He was remembered in 2009, the bicentenary of his birth, both here in Trinity and in Co. Tyrone. Rose Mary Murphy, who is with us today, led a project by Glenelly Historical Society to draw attention to one of their local heroes and to refurbish the MacCullagh family vault. Following a one-day academic symposium in the RIA, a large group travelled to the Glenelly Valley for a range of commemorative events organised by Rose Mary. I still have a

vivid memory of the group of distinguished professors of mathematics and physics making their way through the rushy fields in the lashing rain, in wellingtons provided by Rosemary, to see the little that remains of the MacCullagh homestead.

John Ralston, a theoretical physicist at University of Kansas, has taken a keen interest in the work of MacCullagh. On a research trip to Britain and Ireland in 1995 he visited the Glenelly Valley and asked an elderly local farmer, Cyril Houston, what he knew of James MacCullagh. He replied:

So you want to know about Professor James MacCullagh. I don't know much about what he was doing, but he was a-studying light. And as he got in deeper and deeper, he found there was more and more to it. But it got the better of him.

I will conclude by looking at some general comments on the man and his achievements. David Spearman draws attention to the complexity of MacCullagh's character:

Of his brilliance there is no question, but his genius was flawed by a lack of stability and a deep self-questioning insecurity, aggravated by a powerful urge towards achievement, which could manifest itself in mood introspection...[but] he was a man of the highest integrity, of great generosity and intense loyalty.

Brendan Scaife summarised MacCullagh's scientific achievements thus:

The outstanding accomplishment of MacCullagh in his work on light seems to be his extraordinarily deep analysis of the properties of light and his appreciation that the nature of the ether would involve concepts and ideas that were quite new. He was, in fact, extremely modern in his outlook, and had little faith in the possibility of building a mechanical model of the ether. He would have found it much easier to accept the developments of the 20th century than many of his contemporaries and successors.

One might say he was unlucky to have worked in the shadow of Hamilton, and that after his death his main contribution was eclipsed by the achievement of Maxwell.

However in his short life he made his way from the hill farm in County Tyrone to engage with work of the best mathematical minds of his age, to build on their achievements, and to be widely recognised for his contribution. Not only that, but he is remembered by scholars in other disciplines for his generosity and patriotic zeal. I would like to draw this discourse to a close by reading from the sonnet sequence on the life of Hamilton by my colleague Iggy McGovern. In this sonnet McGovern imagines James MacCullagh speaking from beyond the grave:

As long as mathematics still shall rule,
The lawyer's son and Talbot's graduate
The farmer's son and product of the hedge school,
They both may enter Trinity's Front Gate.

In reasoning we kept the paths we knew,
His floating with the clouds, my feet of clay,
Small wonder then that as his stature grew.
I claimed to have already passed that way.

In one respect alone I yield the floor:
For all that he appeared the mystic sage
He was the grafter, I the one to pour
My anguished doubts across the empty page

And so we tip the balance of a life,
The choice between the quill and pocket-knife.