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George Gordon: the Scot who refuted Aristotle

Tom McInally

George Gordon was born at Coffurach near Fochabers in Morayshire on 15 June 1712. The Gordons of Coffurach were gentry and a cadet branch of the ducal house of that name. Like their cousin, Alexander second Duke of Gordon, they were Catholic and in order to receive a higher education it was necessary for them to go abroad. George's elder brother, Alexander, attended the Scots College in Paris and in 1724 at the age of twelve George was sent to the *Schottenkloster* in Regensburg. In the late sixteenth and early seventeenth centuries Scottish Catholics had founded four colleges on the continent–Douai (in the Spanish Netherlands), Rome, Paris and Madrid–to allow young men to be educated in the Catholic tradition when the Penal Laws forbade such education in Scotland. At the beginning of the eighteenth century the Scots Benedictine monastery in Regensburg was also designated a college and seminary. The Regensburg monastery was one of three Scottish Benedictine houses in Southern Germany–the others were in Würzburg and Erfurt–which were known as *Schottenkloster*. During the seventeenth and eighteenth centuries when the Penal Laws against Catholics were being applied more than 2000 Scots were educated at the colleges and *Schottenkloster*.[1]

When George Gordon arrived in Regensburg the abbot, Bernard Baillie, was so impressed with the young boy's abilities that he organized a special educational programme for him. He was sent to study at colleges in Austria, Italy and France[2] where he received a fuller education than would have been possible at the monastic school. He returned to Regensburg in 1732 to start his Benedictine novitiate taking as his given name Andreas, the name

[1] In addition to the facilities abroad the Church attempted to maintain small junior colleges in isolated parts of the highlands. Harassment by State authorities meant that frequently they had to close or move location. The most successful one at Scalan in upper Glenlivet was burnt to the ground in 1746 as part of the reprisals in the aftermath of the Jacobite rising. The college was reopened in 1750 and functioned until the opening of the legal college at Aquhorties in 1799.

[2] In Paris he met up with his brother, Alexander, who was still studying at the Scots college. In 1735 Alexander became prefect of studies at the college in Paris before being appointed as rector in 1738 of the illegal seminary at Scalan.

by which he became famous. There he studied under Gallus Lieth who had recently resigned his professorship at the University of Erfurt. Lieth taught the scholastic tradition of philosophy which must have been frustrating for Gordon. The young man had already been exposed to the ideas of the German philosopher, Christian Wolff, who had rejected Aristotelian strictures and any other received wisdom which could not be verified by practical experiment. Wolff's views had caused much controversy and led to attacks by his co-religionists. He had been ousted from his professorship at Halle, in Prussia, in1723 by ultra-Lutheran Pietist professors of that university and had been forced to flee to the University of Marburg in Hesse-Kassel. Despite being a renowned scholar Wolff needed both academic allies and political protection to continue to teach until he was able to return to Halle in 1740. His experience was not unique. Enlightenment movements throughout Europe had to deal with entrenched conservative interests. Orthodox Lutheran and Jesuit universities espoused Aristotelian Humanism and adhered to debating theory in preference to engaging in scientific enquiry through practical experiment. When Andreas Gordon later in 1743 rejected this strict Scholasticism he too came under severe criticism. However while studying with Lieth in Regensburg he conformed to the conventional thinking of his teacher.

Andreas completed his formal education by taking a degree in law at the University of Salzburg gaining distinction and on graduation in 1737 he was appointed at the age of 25 to a chair of philosophy at the University of Erfurt. His appointment was possible because of the degree of control which the Scots Benedictines had gained over that university's senate. Over four decades prior to Gordon's arrival the Scots of the Erfurt *Schottenkloster* had worked with the senate of the university to mutual advantage. The Scots had provided financial assistance, significantly improved the library and allowed the university the use of a number of the monastery buildings. In return the Scots had by right two chairs reserved exclusively for them with membership of the senate. At the time of Gordon's appointment, the prior of the *Schottenkloster*, Hieronymus Panton was university principal and the Scots had a firm hold on the activities of the senate.

On arrival Gordon would have found that the monastery buildings housed the university's "Cabinet of Physics".[3] This appears to have stimulated Gordon's

[3] The "Cabinet of Physics" was a collection of scientific instruments used in experimentation and demonstrations. Pradel Johan, 'Studium und wissenschaftliches Streben', Erfurt, 1924. (A copy of this pamphlet which describes the conditions at the *Schottenkloster* in Erfurt at this time and the work of the Scots is in *Scottish Catholic*

interest in investigating practical problems.[4] Although there is no direct proof, the "Cabinet of Physics" probably contained an electrostatic globe of the type developed by Otto von Güricke in the previous century. Whatever provided the stimulus Gordon devoted his energies to the nascent science of electricity which he turned into his lifetime's work making an international reputation in the process. The science, such as it was, had scarcely progressed beyond the work of von Güricke and Isaac Newton.[5] The globe which von Güricke had devised was made of sulphur and was capable of being electrically charged through friction. The charge generated was only strong enough to create electrostatic attraction for small particles. Von Güricke claimed that he had demonstrated a force of gravity. This claim appears to have aroused Newton's interest and he made suggestions as to how von Güricke's device could be improved. The Newton/Hauksbee globe which resulted was made of glass and had similar limitations but was capable of generating more powerful discharges in the form of sparks. Gordon showed his practical ingenuity by improving on these early devices. He designed and built a machine capable of developing and sustaining enough of an electrostatic potential to produce continuous discharges. His friction generator consisted of a glass cylinder measuring 4 inches in diameter and 8 inches in height which was rotated on an axle suspended on a frame and driven by a flywheel of much larger size thus allowing the glass cylinder to be spun at very high speeds. As the cylinder attained its maximum speed of 680 rpm brushing against a spring

Archives, KC 42–3)

[4] Initially Gordon worked on the "Florentine Thermometer". This instrument which had been developed in Florence in the 1650s used alcohol to measure temperature and was unreliable due to the fact that alcohol's coefficient of expansion is not constant, thereby giving variable readings particularly at low temperatures. Gordon had done little more than describe the problem (his work on this was published posthumously in 1753) before Gabriel Daniel Fahrenheit, a German glass-blower and instrument maker working in Holland, had produced a reliable mercury based thermometer. This experience helped Gordon to appreciate that practical problems required practical approaches to achieve solutions.

[5] Güricke had produced static electrical charges on a revolving sulphur globe. He believed he was demonstrating how gravity worked when small particles were attracted to the globe. Newton conducted no experiments although he suggested an improvement in von Güricke's equipment by making the globe of glass. Francis Hauksbee improved on Newton's ideas in 1709. Newton's interest was aroused by electricity being another example of a "force acting at a distance" which he had espoused in the case of gravity but had been unable to explain. When Gordon first became interested there had been little progress on these matters and critics claimed that electricity was no more than a philosopher's toy. The challenge was to develop a deeper understanding of the nature of electricity through practical experimentation.

loaded leather pad it became electrically charged and produced a continuous discharge along a copper wire. Gordon's friction machine had the additional advantage of being portable and therefore could be set up in lecture rooms as well as in the laboratory.

With this equipment, which he had devised by the time of his first university session at Erfurt in 1737–38, Gordon created a whole series of experiments illustrating a number of aspects of the nature of electricity. He organized his lectures to include demonstrations and invited his audience to participate. One of his earliest experiments was to form a chain of people holding hands. He then electrified the chain such that its participants could not free themselves. This not only astounded everyone but also caused great amusement among the onlookers. A second early experiment consisted of attaching a cable to small animals or birds and electrocuting them. His generator was powerful enough to kill the animal even when the cable was more that 150 metres long. These experiments were highly popular and attracted greatly increased numbers of students. This was financially beneficial to the university and Gordon's standing in the senate grew. He reinforced his success by publishing detailed accounts of his friction machine and the experiments he was conducting using it. In this he followed Wolff's strictures by publishing in Latin for scholars and again in German for "a further readership". His fame spread internationally and he was invited to repeat his demonstrations at the courts of Gotha and Weimar. Gordon's experiments were studied and copied by many who were not privileged to witness his demonstrations. The books in which he described in detail his apparatus, methodology and findings were written specifically so that others would be able to replicate his results and were widely distributed and ran to several editions.

Philosophers interested in developing knowledge in the phenomena of electricity engaged him in correspondence. Abbé Jean Antoine Nollet, a member of the French Academy of Sciences, befriended Gordon and replicated a number of the young Scot's experiments.[6] Other scientists were copying extensively from Gordon's published work. Public demonstrations were financially profitable and Gordon's experiments were repeated for that reason alone. However at the opening conference of the Academy of

[6] In 1746 he made his own electric machine which adapted Gordon's design to accommodate a range of larger glass spheres generating even stronger discharges. Nollet repeated the human chain experiment with 200 Carthusian monks holding hands. However his machine did not displace Gordon's design as it was extremely cumbersome and could not be easily transported.

Sciences in Berlin in 1744 Christian Friedrich Ludolff gave a demonstration of an earlier experiment of Gordon's in which he used a spark to ignite the fumes from a bowl of warmed alcohol. Ludolff claimed that this proved that electricity was a form of fire.[7] In making this claim he was asserting that electricity conformed to Aristotle's categorisation of the four elements. Gordon rejected this claim and set out to show that it was wrong. He refined his original experiment by electrically charging a fine jet of water and aiming it at the bowl of alcohol. The fumes again caught fire but in Aristotelian terms this was a paradox since water could not be an agent of fire. Andreas Gordon published his experimental findings in his book *Oratio de philosophia nova veteri praeferenda* in 1745. In presenting them he stressed that advances in knowledge of natural philosophy could only be gained by the application of mathematics to experimentation.

The same year he followed this volume with another book of experiments, *Versuch einer Erklärung der Electricität*, (Erfurt, 1745). In this work he renewed his attack on Aristotelianism in a brilliantly devised experiment in which he pushed the boundaries of what was possible in the study of electricity while confounding Scholastic ideas. He had constructed an apparatus in which two bells were given opposite electrical charges. Between them was suspended a metal clapper insulated on a silken cord. On contact with the first bell the clapper took on its charge and simultaneously was repelled by the first bell and attracted to the oppositely charged second bell. On contact with it the clapper took on its charge and returned to strike the first bell again. The clapper was thereby being attracted to each bell in turn. The bells rang continuously for as long as the current was applied. This device which came to be known as "German Chimes" and later "Franklin's Bells" was the first device which could convert electrical energy into mechanical energy. Although this was a spectacular demonstration in itself Gordon's principal purpose was to show an application of "a force acting at a distance" which could not be explained away in Aristotelian terms. Aristotle's philosophy had denied the existence of such a force. Aristotelians claimed that all actions were explicable by the inherent nature of matter itself and manifestations of gravity, such as a falling apple, were caused by the object possessing the quality of gravity. (Similarly a piece of wood floated in water because it possessed the quality of levity.)

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[7] His fellow German scientist and great rival, Professor Georg M Bose of Leipzig University, made the same claim and stated that he had discovered this before Ludolff through having set his laboratory on fire on a number of occasions by accidental electrical discharges.

The object, therefore, had the potential to move without any external force being placed upon it and it was unnecessary to postulate that the cause was a force acting on it from a distance. Gordon's experiment of the ringing bells in which the metal clapper continuously changed position many times per second reduced the Aristotelian explanation to nonsense.

This rejection of Scholasticism aroused the hostility of members of the Society of Jesus[8] whose antagonism to Gordon was based as much on being made to look foolish as on having their philosophy refuted.[9] In 1747 a Jesuit professor of philosophy at the University of Würzburg, Petrus Eisentraut, attacked Gordon's ideas in his book *Dissertationes Philosophicae Quator de Electricitate*. A public dispute developed the following year when Gordon replied with his publication *Epistola ad Amicum Wirceburgi*. Gordon had made dangerous enemies who continued to attack him but he had also received international recognition for his work. In 1745 he was made a member of the Academy of Perugia and in 1748 he was appointed a member of the French Academy; Nollet having proposed him for this accolade.[10] However, the Jesuits persisted in their attacks. Another Würzburg professor, Lucas Opfermann, went as far as accusing Gordon of heresy.[11] Fortunately, Gordon had friends who stood by him. The senate of his university both Catholic and Lutheran fully supported him and he also had influential allies in those of his Benedictine brethren both Scottish and German who formed the Disputation College of academics (headquartered in St Emmeram's college in Regensburg)

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8 The hostility was restricted to members of the German Province of the Society. French and Italian Jesuits took a more relaxed view of this experimentation.

9 There is little doubt that Gordon took pleasure in making fun of his critics. A story is told of an observer at one of Gordon's lectures who questioned the value of studying electricity; claiming that it was no more than entertainment. Gordon responded that one of its benefits was to greatly improve one's sense of smell and that he could demonstrate such to him. The critic accepted the offer and Gordon poured some brandy into a spoon which he then held for him to smell. The spoon was electrified while Gordon was standing on an insulating pad. When the heckler breathed in the fumes the current discharged through his nose with chastening results. It is clear from this example that Gordon could be merciless with his critics. J. J. Heilbron *Electricity in the 17th and 18th Centuries,* (Berkeley, 1979), 273.

10 Fischer Ernst Ludwig, *The Scots in Germany* (Edinburgh, 1974; 1902), 218. The French Academy by law was prohibited from appointing more than six non-French nationals at any one time. In light of this Gordon's appointment was extremely prestigious.

11 In *Philosophia scholasticorum defense contra oratorem academicum Erfordiensem*. The accusation was that in disputing inherent qualities of matter he was attacking the doctrine of transubstantiation. He was being accused of the same heresy as Galileo had been a century earlier.

which was a forerunner of the Royal Bavarian Academy of Sciences. Gordon had been a founding member of this organisation. His most effective defence, however, came from the Pope. Benedict XIV was personally interested in science and the arts and was an acknowledged liberal in Enlightenment terms. As a young man he had been befriended by the eminent scholar, Bernard de Montfauçon, who encouraged him in Enlightenment thought, and when the new philosophers in Germany were attacked by the Jesuits, Benedict sided with the philosophers. In 1747 he wrote in defence of Johann Adam von Ickstatt, professor of philosophy at the University of Ingolstadt, saying that his teaching was irreproachable and entirely correct in faith. This defence was extended by argument to all like minded *philosophes* including Gordon.

Even in the face of this opposition the German Jesuits did not give up the fight. The matter generated a considerable amount of rancour and was almost out of control when the archbishop of Mainz, exerted his authority and imposed an interdict on all the parties to the dispute from issuing any further public communications on the subject. But in 1749 Josef Pfriemb, the Jesuit professor of Ethics and Physics at the University of Mainz, went public with another attack on Gordon. Immediately Pfriemb was removed from his post and transferred to the University of Bamberg. From that point onwards Gordon was free to continue research, teaching and publication of his findings for the remainder of his short life.

As well as researching the phenomenon of "action at a distance" Gordon was interested in another scientific preoccupation of the time, that of developing a "perpetual motion machine". In the same book as he published his experiment of "Gordon's Bells" he captured the imagination of the scientific community by describing an experiment involving a device known as "the electric whirl". This consisted of a metal wheel, like a star, with several points around its circumference which came into contact with an electrically charged conductor. As each point in turn touched the conductor it received an electrical discharge which caused the wheel to rotate and brought the next point on its circumference into contact with the conductor thus causing the wheel to spin continuously. This apparatus is the earliest example ever of an electric motor; specifically it was an electrostatic reduction motor. The forces were too weak to do much more than turn the wheel itself and therefore the device could not be put to practical use.[12] A better understanding of

[12] Paradoxically, reduction motors are now used in highly sophisticated control systems in a number of complex electrical devices including transformers and missile guidance systems. The inherent weakness of the low current produced is an advantage in

electromagnetism and particularly the invention of the induction coil were needed before a more powerful electric motor could be built. This was achieved by Faraday a century after Gordon's experiment. Nevertheless, the invention considerably enhanced Gordon's reputation.[13]

Other experimenters took advantage of Gordon's pioneering work but many did not follow his openness in publishing full details of their work. Professional vanity together with the financial benefit of devising new demonstrations led them to keep significant aspects secret so that others could not copy their experiments. Bose, Musschenbroek and von Kleist were among those guilty of such actions. While following one of Gordon's experiments each of these researchers independently discovered an effect which led to what is arguably the greatest advance in electrical science in the eighteenth century. In 1746 Peter Musschenbroek, a Dutch physicist at the University of Leiden, demonstrated to a friend, Andreas Cunneus, Gordon's experiment in which he electrified water in a jar which then was capable of generating sparks. Afterwards, while alone, Cunneus tried to copy the experiment and mistakenly held the jar in his hand. He received an enormous electric shock. When he told his friend, Musschenbroek realized that the jar itself could store electricity. Recognising the significance of this fact he published his discovery and was given credit as the inventor. The device, named a Leyden Jar by Nollet in honour of Musschenbroek's university, was the first condenser/capacitor to be developed. Ewald Georg von Kleist and Professor Bose belatedly claimed making the same discovery earlier than Musschenbroek, again by repeating Gordon's experiment, but in keeping with the secrecy which prevailed they had not disclosed it to anyone. It appears clear that Gordon's openness with his findings inspired a number of fellow philosophers to work on similar lines of research.

Andreas Gordon did not spend much time following up Musschenbroek's work. Progress in the better comprehension of the nature of electricity was thereby delayed. It was to take researchers many years through trial and error before a full understanding of the working of the Leyden Jar was made and its

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these circumstances. The current does not create an electromagnetic field capable of interfering with the signals being measured. Gordon had invented a solution for which there was no problem in his lifetime.

13 Prior to being made a member of the Academy of Perugia and the French Academy of Sciences other honours had been proposed to Gordon. In 1742 he was offered the position of librarian by the archbishop of Krakow and in 1743 on the death of Abbot Baillie his brother Benedictines asked him to become abbot of Regensburg. He declined each of these preferring to continue his researches at Erfurt.

effectiveness as a condenser achieved. A series of failures to understand the processes that were being observed hampered developments. Even as late as the 1770s Benjamin Franklin was still making suggestions for improvement. Gordon's limited work on the new discovery is not difficult to understand. His energies were being engaged in the dispute with his Jesuit critics and in addition, he was suffering from failing health. By 1750 he was showing clear signs of the tuberculosis which eventually killed him and he had ceased research into electricity altogether. He confined his efforts to writing up the scientific investigations he had already undertaken but when he died in 1751 at the age of 39 he had not finished his final book. His fellow Benedictine and professor at Erfurt, Bernard Grant, completed and published *Elementa Physica Experimentalis* in 1753. At the same time his former pupil, Ildephonse Kennedy, wrote that his friend's death had been hastened by the attacks of the Jesuits.[14]

Gordon's contribution to the early development of the science of electricity was undoubtedly substantial and groundbreaking. How then can one account for his relative obscurity today. A number of factors played a part. After his death Gordon's work continued to be copied but few gave credit to the Scotsman. Despite the fact that his experiments were all published, few researchers acknowledged any of his contributions to the science which they used. Only Nollet appears to have tried to give appropriate recognition to his friend. Franklin used Gordon's Bells as part of his experimentation into lightning referring to them only as "German Chimes". Subsequently they have become known as "Franklin's Bells" without any acknowledgement of their true inventor. It is perhaps easy to understand why intellectual rivalries among his contemporaries and successors contributed to Gordon's being ignored but lack of recognition in Scotland probably has more to do with the fact that he was a Scottish Benedictine monk working in Germany at a time when Catholicism was outlawed in his own country and Catholics were subject to penal laws.[15] Nevertheless acknowledgement of Gordon's contributions

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[14] Hammermeyer Ludwig, 'Aufklärung in Katholischen Deutschland des 18 Jahunderts', *Jahrbuch- Instituts für Deutsche Geschichte,* Vol. IV (1975), 102.

[15] Joseph Priestley's *The History and Present State of Electricity, with original experiments* (London, 1767), was the standard history of electricity for over a century after its publication. In it Priestley mentions Gordon's role in developing the friction machine and his earliest experiments with animals and electrification of water in jars but makes no mention of how his experiments influenced other researchers. This was possibly due to lack of information since he was writing twenty years after Gordon's great experiments when competing claims for prominence in the advancement of

could be expected in his adopted country of Germany but even here it has been limited. The University of Efurt was rightly proud of its distinguished professor but in 1803 Prussia annexed Erfurt and the surrounding Thuringian state. The Prussians closed the three hundred year old university and it was not re-founded until the 1990s after the fall of Communism and the re-unification of Germany. The new institution is still engaged in re-establishing itself as a fully functioning university. Nevertheless Erfurt has honoured Gordon. In 1900 the city commemorated its famous Scotsman by naming its new technical college the Andreas Gordon Schule. The college continues to prosper today, running degree level courses in a wide range of subjects including, appropriately, electrical and electronic engineering.

An eponymous college in the city of his triumphs is a deserved but limited reward for Gordon's significant contributions to the Enlightenment in general and science in particular. His legacy includes three specific achievements which deserve better recognition. First is the major contribution which he made to the science of electricity. Unlike a number of his contemporaries he did not simply seek to entertain with diverting displays of electrical effect – although he certainly did that. He also sought to explain what he saw. In this, like everyone else prior to James Clerk Maxwell a century and a half later, he was unsuccessful except that he argued passionately that Aristotle's philosophy could not accommodate the new science. By the time he died he had won that argument.

Secondly Gordon helped grow a tradition in which Scottish Catholics played major roles in education in Germany. This involvement did not begin with Gordon but he ushered in its most important period. By training and inspiring a group of young Scotsmen his influence lasted beyond throughout the rest of the eighteenth and even into the nineteenth century. In the 1750s his pupils Ildephonse Kennedy and Benedict Arbuthnot helped found the Bavarian Academy of Sciences and contributed to science with their researches into chemistry, mathematics, anthropology and genetics.[16] Kennedy was appointed the academy's secretary and held the post for forty years. Apart from continuing his old mentor's practice of public lectures and demonstrations he also translated scientific papers written by British scientists such as Joseph

the science were being made by many. Priestley himself was also heavily engaged in experimentation into electricity.

16 Hammermeyer Ludwig, 'Academiae Scientiarum Boicae Secreterius Perpetuus: Ildephons Kennedy O.S.B. (1722 – 1804)', Kuhn Ortwin Ed., *Grossbritannien und Deutschland* (Munich, 1974) 197.

Black and published them in order to ensure that German scientists were kept informed of the latest developments in commercially important technologies.[17] Scottish Benedictine involvement in German academic life was reduced when religious institutions were secularized in the first decade of the nineteenth century but it did not end immediately. Its last great flowering came with the Scots astronomer, John Lamont, who studied at the Regensburg *Schottenkloster*. Lamont went on to be appointed Bavarian Astronomer Royal in 1852 and was created a count by the king of Bavaria, dying in his adopted country in 1879. Scottish contributions could be said to have continued even afterwards with Lamont's bequest of his considerable wealth to found scholarships in science.

Andreas Gordon's third contribution to the Enlightenment and arguably his finest was the manner in which he conducted his research and disseminated his findings. His complete candour and willingness to inform others is impressive: his work was shared with the wider community of philosophers; his observations were from practical experiment; measurements and detailed notes were taken; all experiments were repeatable resulting in replication of the same findings. All this was achieved at a time when most of his contemporaries acted out of personal gain and professional hubris. This marks Gordon as a philosopher in a new mould dedicated to the advancement of science in a spirit of cooperation.

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[17] Eric Forbes, 'Ildephonse Kennedy, O.S.B. (1722–1804) and the Bavarian Academy of Sciences', *Innes Review,* Vol. 32, p. 93.