When Baden Baden-Powell (1860–1937), president of the Aëronautical Society of Great Britain (ASGB), invited the eminent physicist William Thomson, Baron Kelvin (1824–1907) to join the society in 1896, Kelvin declined stating, “I am afraid I am not in the flight for ‘aerial navigation’. I was greatly interested in your work with kites; but I have not the smallest molecule of faith in aerial navigation … you will understand that I would not care to be a member of the aëronautical society” (quoted in Hallion 2003, 167). Within a decade the Wright brothers accomplished the world’s first successful human flight in a machine, decidedly bringing aerial navigation into a new age. Why was Kelvin so pessimistic about aerial navigation? The answer lies in the overlapping space of Victorian aeronautics and ornithology.

With the first flight taking place in Paris in 1783 ballooning had long become an established form of aerial travel and entertainment within Europe (Hallion 2003, ch. 2; Holmes 2013). As Caitlín Doherty (2017) has documented in her study on early balloon voyages, at its inception “ballooning represented a utopian vision that promised a new social order and forecast man’s control over nature from his new position in the upper atmosphere” (247). But with increasing ascents and descents its limitations quickly became apparent. Most men and women had no means to participate in balloon flights in person and so their only experience was as observers. And even for balloonists such as John Jeffries (1744-1819), an American born physician, the lack of steering capability was a challenge which threatened to devalue the scientific potential of ballooning (Doherty 2017, 234). Issues as such which carried over into the nineteenth century lent to the image of ballooning as chiefly a public spectacle. On the other hand, aerial *navigation*, or the ability to control flight speed and direction at will, was a wholly different enterprise (although not unconnected) which began to gain some, although very little, interest at the turn of the century. It held the promise of pushing beyond the limitations of ballooning yet its pursuit by men of science and engineers required that they advance their contemporaries’ limited understandings of the atmosphere, wind dynamics, and, most critically, principles of bird flight. Because these problems seemed legion, Victorians largely ignored the study of aerial navigation altogether in favour of other more promising areas of science and technology such as steam power and telegraphy as evidenced by Kelvin’s scepticism. However, not all Victorians were content with the idea of simply leaving the territory of the birds unexamined. In the eyes of a young and enthusiastic boy, George Douglas Campbell, afterwards 8th Duke of Argyll (1823–1900), it was “a simple matter of obvious fact” that we could attain aerial navigation in the future, or at least come to fully understand its principles (Argyll 1906, I: 77).

In this paper I use Argyll as a case study in order to weave together connections between ornithology, aerial navigation, and country house science. In so doing, I argue that Argyll's case reveals yet another instance of Victorian country house science within a broader tradition in which aristocratic town and country houses hosted private laboratories (Opitz 2006). Moreover, Argyll's contributions to ornithological and aerial navigation studies constituted a significant turning point in the progress of aeronautics, both in terms of its theoretical basis and its transatlantic respectability, hitherto unappreciated in the standard histories (Hallion, 2003; Reese 2014). As we will see, Argyll's ultimate claim was that the laws of flight were embedded in nature and accessible to humans as a result of God's design. It was therefore up to up to humans to move beyond mere aesthetic observations, and well-worn ballooning feats, to apprehend the underlying principles of bird flight. Only then could humans have any hope of achieving mechanical flight. This emphasis, infused with aristocratic respectability, underlay Argyll's position in the advancement of aeronautics through the efforts of the ASGB, an organization he helped to found and sustain, and whose proceedings shaped the progress of the nascent field of aerial navigation on both sides of the Atlantic.

Ornithology in the domestic context: Ardencaple Castle

George Douglas Campbell was born at Ardencaple Castle, Dunbartonshire, on the 30th April 1823. He had an older brother and two younger sisters, the youngest dying barely before the age of one. His uncle, the 6th Duke of Argyll, died in 1839 without a son, and so George's father, John Henry Campbell (1777–1847), inherited the dukedom as the eldest surviving male next-of-kin, becoming the 7th Duke of Argyll. Because George's older brother had also died a couple of years earlier, George assumed the courtesy title Marquess of Lorne and succeeded his father as the 8th Duke of Argyll upon his father's death in 1847. Politically, and as a member of the Liberal party, Argyll engaged in a career of public service distinguished by high government appointments (Lord Privy Seal, Postmaster General, Secretary of State for India). His perspectives were marked by his inquiry into Scottish schooling leading to the 1872 Education Act, and such questions as the Disestablishment of the Church of Scotland, which he opposed. Born into a deeply religious Presbyterian aristocratic context, his pursuits into the study of nature were encouraged by a home education grounded in Christian teachings, and by the influence of a father who was avidly interested in science and the mechanical arts.

Home-schooled by private tutors as a teenager, Campbell had the privilege of growing up on a large country estate with ample opportunities upon which to observe creatures in their natural habitats.[1] Although interested in natural history, ornithology became his main love. Before she died, Argyll's mother Joan Glassel (1775–1828) had made it her mission to cultivate a Christian ethos within her children by asking them to read the scriptures to her every night and morning. John Campbell, on the other hand was never one to open up much about faith, but as a man dedicated to the sciences he sought to cultivate a spirit of natural enquiry in his children. He gave a telescope to young George with which it was his delight to observe birds from a distance and listen to their distinguishing songs (Argyll 1906, I: 60, 70). In his autobiography, George mentioned that "at a very early age, how early I cannot quite remember, I began to write careful notes of ever day's observations on my favourite pursuit [ornithology]" (Argyll 1906, I: 60, 70). His earliest observations are documented in diary notes he made from 1835 to 1836, at the age of twelve.[2] His Dunbartonshire family house and grounds provided Campbell with a form of private laboratory in which to observe natural phenomena and theorise upon them. So much so that by the time he was only sixteen we can already perceive a striking sense of confidence regarding his theoretical knowledge. In a response to Sir James Stewart of Allanbank, a Scottish painter who Campbell had developed a strong connection with over the years, Campbell proceeded to challenge his deduction about the flying speed of the frigate bird (a family of seabird):

> I was amused with your description of the frigate bird, but you have drawn a deduction from the length of its wings and smallness of its body which I am afraid will not hold good. You seem to think that its flight must in consequence be very quick, or to use your own words, "prodigious." Now a bird's flight is in the inverse ratio to the size of its wing in proportion to the weight of its body, as you may see by comparing the flight of the heron (whose wings are enormous in proportion to the weight of her body) with that of the red-throated diver (whose wings are so small that it requires the bird to make them go like a fly-wheel to keep her up at all). You will find that the latter goes at a tremendous rate while the former goes in a slow and laboured manner; the greater the bird's downward tendency in proportion to its supporting power, the quicker the bird flies, because the greater is

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[1] Inveraray Castle Archives (hereafter ICA), Bundle 2639, contract written by 7th Duke of Argyll assigning George and his sister Emma new tutors in 1839.
[2] ICA, Bundle 919.

> the impetus which the wings have merely to direct and support (Argyll 1906, II: 563).

Here young Campbell underlined a difference, which he presumably deciphered based on his observations, that birds with smaller bodies and larger wings tended to fly slower compared to birds with bigger bodies and yet smaller wings. Suggesting that flight speed depended on an inverse relationship between a bird's wing size to its body weight. As we shall see, Campbell's studies on bird flight continued into adulthood and resulted in various publications, most importantly a key chapter of his influential book, *The Reign of Law* (1867, ch. 3).

The 7th Duke of Argyll as an early progenitor of flight? The Cayley-Campbell correspondence

Throughout his adult life, and in his many literary works, Argyll frequently mentioned and gave credit to his father for instilling his interest in birds and subsequently mechanics. In one obituary of the 7th Duke, the author noted, "He was attached to scientific pursuits and was well acquainted with the principles of chemistry and mechanics" (Cave 1847, 81). The 8th Duke noted in a seminal explanation of the principles of bird flight in *The Reign of Law* that:

> I owe to my father … my knowledge of the Theory of Flight which is expounded in this chapter … his love of mechanical science, and his study of the problem during many years of investigation and experiment, made him thoroughly master of the subject (Argyll 1868a, 170).[3]

Indeed, during the early decades of the nineteenth century when investigation into manned flight was "liable to derision and ill-natured remark" (quoted in Reese 2014, 8), John Campbell carried out his own experiments in secrecy with a small team of men (primarily

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[3] Argyll's use of the term 'theory' in relation to bird flight constitutes an actor's category that I employ where relevant in this paper. It would be difficult to sustain the idea that 'theory of flight' was being used in the same expansive sense as Charles Darwin's 'theory of evolution' or Michael Faraday's 'field theory'. Rather the word 'theory' was used by aeronautical enthusiasts in conjunction with a number of other terms in relation to bird flight such as 'explanation', 'principle', and 'hypothesis'. Further on the status of 'theory' in Victorian science, see Hull (2003).

John Hart and Robert Bryson) whilst corresponding extensively with Sir George Cayley (1773–1856)—a leading aeronautical figure. More generally, aeronautical enthusiasts considered this discipline a science from very early on, and in practice the main savants working in this area—Campbell and Cayley among them—were ornithologists who studied the principles of bird flight, as well as engineers who attempted to apply those principles to machines and engines that they built. The roots of George Campbell's involvement in aeronautics lay not with himself but with his father.

In the 1810s John Campbell began writing letters to Cayley. Their correspondence continued well into the 1820s and reveals to a great extent the types of struggles faced by early enthusiasts of aerial navigation. After reading the papers on flight by Cayley in the *Philosophical Magazine*, with great appreciation, Campbell wrote a letter to Cayley on the 29 November 1817 to reveal his up until then extremely secretive support for experiments in aerial navigation. He stated, "It is now above thirty years since I first became impressed with the idea that aerial navigation either in the large or the small way was possible and at that time I collected all [the] information that the then state of science afforded."[4] In Campbell's next letter, gratified by the positive reception of Cayley's reply and, no doubt feeling an air of freedom to speak on such topics openly, Campbell expounded on his thoughts about flight. He stated that if we could harness the correct principles of flight, we could go beyond current ballooning technologies and "aerial navigation may be attained," but in order to do so we would need to take the "larger bird for our models and with this we should be more likely to attain this object in view, than by attempting to guide bodies actually floating in the atmosphere. A bird is by no means a floating body." At the end of the letter, Campbell mentioned that Cayley should not make any public mention of it until satisfactory experiments had been carried out, because it was unnecessary to draw public attention.[5] This caution reflected Campbell's awareness of the wider pessimistic attitude towards the idea of aerial navigation, as well as his worry that a premature publicizing of their experiments would only hinder their progress. In a letter back to Campbell, Cayley wrote that "it is an extremely difficult thing to construct a purely mechanical aerial vehicle." This being the case, Cayley suggested to Campbell that they should each contribute the substantial sum of £50 for the purpose of experimenting together, especially if ever they had the chance to meet; Cayley lived in Brompton whilst Campbell was in Inveraray Castle.[6] J. Laurence Pritchard, one of

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[4] National Aerospace Library (hereafter NAL), Cayley-Campbell correspondence, 29 November 1817.
[5] NAL, Cayley-Campbell correspondence, 18 December 1817.
[6] NAL. Cayley-Campbell correspondence, 19 January 1818.

Cayley's biographers, has surmised that this probably constituted "the first occasion in the history of aeronautical science where two men of scientific attainment entered on experiments of this kind" (1961, 107).

Although it is possible to form only a rough picture of the types of experiments that John Campbell carried out through his letters, it is clear that he indeed did give much time to aerial experimentation. In August 1818, Campbell speaks of a failed experiment in London where the wings of a contraption were too "powerful" and so could not move with sufficient velocity to raise the greater weight of a 28-pound object (presumably the engine) at hand. He also speaks in the same letter of tests done in Glasgow with an engine which had been applied to a pair of "narrow wings" which in this case did fly around a room used for the experiment, however this too had problems of its own.[7]

In contrast to such engineered experiments by savants like Cayley and Campbell, other proposed methods of flight failed to promise practical feasibility. In an 1835 issue of a popular mechanics magazine, one author speculated on a method of aerial navigation where one might attach thirty-three eagles in a specific configuration to a wickerwork whilst dangling a piece of meat in front of them. This then would compel them to fly forwards, and then one would control the direction of flight by angling the meat in the desired direction. The anonymous contributor was not so ignorant, however, to assert this as *the* method to achieve aerial navigation, and he concluded to the editor that "I will not trouble you anymore on a subject which may appear in its childish state, as bordering on the ridiculous" (Anonymous 1836, 200). This anecdote thus underlines the seriousness with which Campbell pursued his interest, despite the more popular (if not ridiculous) discussions that occupied the entertaining space of fanciful speculation. In either case, we see the common interplay of ideas cross-pollinating aerial navigation with ornithology.

The foundations of the Aëronautical Society

The Victorian aeronautical enthusiasts sought more formal means by which to network and further their studies. Cayley himself attempted to establish an aeronautical society four times during his life, but to his anguish not enough support was mustered, and his earnest attempts ended in failure (Reese 2014, 9-10). In fact Cayley's generation did not produce an aeronautical society, but the next generation of enthusiasts indeed did. Some two decades later, rumblings of an ultimately successful effort took place at the annual meeting of

[7] NAL, Cayley-Campbell correspondence, 19 August 1818.

the British Association for the Advancement of Science (BAAS), held in Birmingham in 1865, where the British inventor Frederick William Brearey (1816–1896) presented to the Meteorological Section, "Remarks upon Aerial Navigation, Suggested by Mr Glaisher's late Balloon Ascents," with the appeal:

> Now that public attention was directed to these scientific efforts, and that the balloon was becoming more than a toy, he [Brearey] would at once propose the formation of a society, to be supported by subscriptions and donations, by which experiments could be conducted in its own grounds, and with its own apparatus, for the furtherance of investigations in aërology locomotion (BAAS 1865, 17).

By "scientific efforts" Brearey referenced the record-breaking ballooning ascents that the meteorologist James Glaisher (1809–1903) and aeronaut Henry Tracey Coxwell (1819–1900) achieved, reaching the unprecedented ascent of 37,000 feet (BAAS 1863, 385). By the mid-nineteenth century, aside from mere entertainment and exhibition purposes, ballooning had found use in three distinct areas: reconnaissance in war, scientific exploration, and communication between distant geographical points (Anonymous 1862, II: 184). Despite its co-opting by showmen for public entertainment, ballooning nevertheless provided serious scientific amateurs like Glaisher a stage upon which to perform a range of experiments, especially into atmospheric phenomena (Holmes 2013, 193-225). For this reason, Glaisher joined Brearey and others in mobilising to establish an aeronautical society, particularly because he recognised the lack of progress in achieving aerial *navigation* amid the constraints of ballooning technology. As he later recalled,

> The desire which influenced me was to ascend to the higher regions and travel by its means in furtherance of a better knowledge of atmospheric phenomena...I soon found that balloon travelling was at the mercy of the wind, and I saw no probability of any method of steering balloons being obtained. It even appeared to me that the balloon itself, admirable for vertical ascents, was not necessarily a first step in Aërial Navigation, and might possibly have no share in the solution of the problem. It was this conviction that led to the formation of the Aëronautical Society a few years since… (Glaisher 1871, xiii).

Within a year of Brearey's appeal, the would-be founding members of a society met at the 8th Duke of Argyll's London town house, Argyll Lodge, Campden Hill, to lay the groundwork.

> The preliminary Meeting of the Council of this society was held at the residence of His Grace the Duke of Argyll, on the 12th day of January 1866 (ASGB 1866).

Six men attended: in addition to Argyll, Glaisher, and Brearey, there was Hugh Welch Diamond, Francis Herbert Wenham, and James William Butler—also men of science who aspired to realise aerial navigation. Glaisher read an address noting that the subject of aeronautics had not yet been properly recognised as a distinct branch of science due to the unscientific nature of ballooning. He stated that "balloons have been, with but very few exceptions, employed merely for exhibition or for the purpose of public entertainment" and "sundry performances". These public ballooning feats simply pandered to the public taste for "the grotesque and the hazardous, which have tended so far to degrade the subject [of aeronautics]" (ASGB 1866, 5-6). Contrasting the failure of ballooning with the goals of the newly formed society, Glaisher stated that

> A chief branch of inquiry by the Society would be the department relating to the mechanical expedients and inventions for facilitating aerial navigation, and obtaining or aiding a change of locality at the will of the aeronaut. Nearly all contrivances for this purpose have hitherto failed, or have only been successful to a very limited extent. (ASGB 1866, 7).

With the establishment of the ASGB it was confidently hoped that aeronautics might finally "take its standing among the sciences" (ASGB 1866, 6). After this address a number of important formalities were discussed and officially decided on, such as how the society would be funded (annual subscriptions and donations), who could become members (men) and Associates (women), and the naming of the president (Argyll), vice-presidents (the Duke of Sutherland, Argyll's brother-in-law; Lord Richard Grosvenor; and Lord Dufferin and Claneboye), treasurer (Glaisher) and honorary secretary (Brearey).

A second preliminary meeting was held again at Argyll Lodge a month later, on 12 February 1866. Brearey reported on having written a letter of application to the Commissioners of Patents, asking for a record of all patents relating to the subject of aeronautics. His application was successful, and the Commission provided the ASGB with all of the specifications that Brearey had requested (dating back to 1617!). Also at the meeting, Argyll read a letter to Sutherland (in the chair) suggesting that an application be made to the South Kensington museum for space in which to deposit models of flying machines. Importantly, at this early stage Argyll suggested that the society should aim to publish a journal. This suggestion likely resulted in the society's *Annual Reports,* a fundamental resource for understanding the early progress of aeronautics prior to the achievement of manned flight. In the ensuing months, further meetings of this council were regularly held, typically at Stafford House, Sutherland's imposing London palace—again offering a context for aristocratic domestic science.

Argyll became involved in other crucial elements of the Society's formation, in connection with France. By 1863 a group of men in France, including Felix Nadar, the first person to take aerial photographs, had already established their own *Société d'encouragement de la locomotion aérienne au moyen du plus lourd que l'air*. The president, Jean-Augustin Barral (1819-1884), had heard about the nascent British society, and with little time wasted proposed that the two societies enter a co-operative partnership to work toward achieving the mutual goal of aerial navigation. At the 23 May 1866 Council meeting, after reading this proposal, Argyll was directed to sign the letter of reply accepting the French society's request. This communication marked the beginning of an established friendship between the two societies that would last for years.

1866: The Aëronautical Society established

Following the series of preliminary council meetings, the first public meeting of the ASGB was held on the 27 June 1866 in the Great Room of the Society of Arts in London. Since 1843 Prince Albert had been president of the Society of Arts, and before his death in 1861, he sent a letter to Argyll in 1859 stating that "you seem to have absolutely mastered the nature of the birds' flight and the causes which stand in the way of aerial navigation succeeding on the principles as yet followed" (Argyll 1906, II: 184-185). Although it may have been a stretch to suggest that Argyll had "mastered the nature of the birds' flight," the noblemen's shared, liberal ideas in applying science and art to industry proved useful in securing the Society of Arts as the meeting place for the ASGB. (Edward VII, eldest son of Prince Albert, had swiftly taken to the presidency of the Society of Arts by 1863).

At the first meeting Argyll as president took the chair, and Brearey made an introduction giving five of his own reasons for the establishment of the Society. These reasons included the well-known problem of ridicule and lack of current respect for the study of aeronautics, which could only be alleviated with action. On a more existential level, the fulfilment of an “almost universal desire” to obtain more command over the “comparatively unoccupied space which has continually eluded all attempts” was another driving force (ASGB 1866, 8). For reasons such as these the ASGB was being “established for the advancement of Aërial Navigation, and for Observations in Aerology connected therewith” (RAS 2016, 48).

After Brearey’s remarks, Wenham proceeded to read his paper, “On Aerial Locomotion and the Laws by Which Heavy Bodies impelled through Air are Sustained.” His paper suggested from observation that in general birds, especially large birds, did not exert as much muscle energy as was commonly thought. In many cases they could sustain flight with minimal to no wing motion for extended periods of time, partly owing to speed, and partly to the ratio of wing span to body weight. His paper also importantly proposed for the first time, the idea of superposed wings on gliders based on his observation of pelican flight formations, that is, gliders with four or six wings, as opposed to two, in order to increase the lift area. This very idea became the basis for many early aeroplane designs in the twentieth century (ASGB 1866, 10-40). Wenham alongside Argyll (as we will see below) represented some of the first major British theorists dedicated to uncovering this otherwise hidden aspect of ornithology.

After Wenham concluded, Argyll declared his appreciation for the new theory that tackled a problem on which not much work had been undertaken (ASGB 1866, 40-41). He then conveyed his own thoughts on how aerial navigation would work in the future. He suggested that flying machines would traverse the air with a motive force, using mechanical engines instead of muscular power, like a bird flapping its wings (this idea would be contested throughout the nineteenth century). He then proposed why this would be beneficial not just for the small circle of enthusiasts at the meeting but the rest of humanity, suggesting that vessels would be able to carry multiple people as opposed to just an individual. As Argyll noted, the mechanical principles of bird flight, up until this point, suffered from a lack of serious scientific study aside from a few theories that had become largely accepted due to their popularity. One notable theory that Argyll referenced was William Paley’s *Natural Theology* (1802). One section of Paley’s book, often overlooked by historians of science, is one of the rare, early attempts to give a lucid description of the mechanics of bird flight. However, in one section Paley invoked a theory that by the time the ASGB had been established was largely discredited. After beautifully describing the anatomy of birds in a chapter on “Comparative Anatomy,” in order to show how wise the Creator of those birds was, Paley went on to say that “the bodies of birds are blown up [through the inhalation of air] from their lungs...and thus rendered buoyant” (Paley 1803, 162). In contrast, one of the fundamental principles that had been established by aeronautical experimentalists since the time of Cayley and John Campbell was that birds were *heavier-than-air* at all times, and at no point did they float on air owing to their buoyancy.[8]

Aristocracy, science, industry and influence

Historian of aviation Richard P. Hallion wrote favourably about the beginnings of the ASGB as being “a quintessentially Victorian institution: the creation of upper-class gentlemen and nobles possessing a passionate curiosity about flight, a special sense of responsibility for the future of the realm … and a belief they had a special obligation to work for societies benefit” (2003, 115). Contrary to prevailing negative narratives portraying secluded and unproductive upper-class Victorians, especially towards the end of the nineteenth century, the ASGB was headed by prominent aristocrats: the Duke of Argyll, the Duke of Sutherland, and the politician and businessman Lord Richard Grosvenor. Hallion continued, “Thanks to the Duke of Argyll and a group of like-minded colleagues, a society existed for the encouragement of reputable experimentation and the exchange of reliable information” (2003, 119). He also noted that, acting as an important patron of science before the rise of state sponsorship, the six men who met at Argyll Lodge on the 12 January 1866 “formed the most important aeronautical organization created prior to the twentieth century’s tremendous proliferation of governmentally supported research establishments” (Hallion 2003, 115). As Ruth Barton (2018) has shown among other Victorian scientific societies that benefited from co-operation between aristocrats and middle-class men, it is clear that the involvement of the aristocracy in the ASGB contributed an air of respectability and confidence amongst middle-class enthusiasts of aerial navigation. Over the course of the late Victorian period, this respectability and confidence slowly infected the wider aeronautical community as well as the general public, as we shall see below.

Respectability was not limited to the ASGB by any means. A case in point involving Argyll is the British Association for the Advancement of Science. In their seminal book *Gentlemen of Science* (1981), Arnold Thackray and Jack Morrell touched on the importance of aristocratic patronage in the early years of the BAAS (109-18). As a reformist association against what they saw as the retrogressive spirit of the Royal Society, the BAAS established

[8] NAL, Cayley-Campbell Correspondence, 18 December 1817.

itself as a cultural force during the nineteenth century with the intention of representing British science as a whole, a claim fraught with nationalist and imperialist overtones. A large part of this vision would be accomplished through complicated but fruitful relations with gentlemen (and, at times, gentlewomen) of rank. This of course often equated to a strong preference for liberal minded, scientifically attuned aristocrats who served as symbolic figures representing the supposed positive values of science and British culture. Inevitably, there was a hierarchical system of leadership in the BAAS that typically barred Catholics, Tories, women (apart from roles as patronesses or ticketed guests at the annual meetings) and, according to their standard, no working-class men. This hierarchy was mirrored to a large extent by the ASGB, although in contrast to the BAAS women could become members of the ASGB (albeit Associates) from the very beginning. This emphasis on respectability and yet liberal orientation helps to make sense of Argyll's election to the BAAS presidency in 1855. Born into a Whig family with early achievements in geology, Argyll was a prime candidate to promote the goals of the BAAS. In his 1855 address Argyll made a case for the economic benefit of the application of abstract (or theoretical) science to industry claiming that "the moment any result of science becomes applicable to the arts, the unfailing enterprise of the commercial and manufacturing classes takes it up and exhausts every resource of capital and of skill in giving to that application the largest possible development" (BAAS 1856, lxxxi). Eleven years later Argyll put his words into action as a founder and first president of the BAAS. Uncovering "Theory of Flight" represented the abstract aspect of science and the eventual invention of a manoeuvrable flying machine was, for Argyll, that theory put to practical and ultimately industrial use.

Just a year after Hallion's assessment of the noble class, historian Martin J. Wiener (2004) advanced the idea that the middle and upper classes otherwise known as the "articulate" classes held an "ambiguous attitude towards modern industrial society" thereby aiding heavily in the decline of its industrial spirit (ix). By studying the origins and members of the ASGB Wiener's thesis is strongly challenged by my own work in two ways. First, by focusing on the aristocratic Argyll family, we see a sustained concern for the study of mechanics and its potential applications lasting throughout the nineteenth century. And, second, we see the complete reverse of Wiener's argument; that is to say, it was precisely *because* of these upper-class Victorians that an industrial science—now professionalized—shifted from obscurity into recognition. In the eyes of Argyll and his colleagues gentlemanly respectability lay at the heart of liberal industrial progress and the final goal of aerial navigation was but one manifestation of this grand vision.

Argyll's country house science

Before we consider further the impact of Argyll's ideas on flight, it is necessary to emphasise the significance of domestic spaces for scientific practice amongst Victorian aristocrats in general, and the Campbells in particular. Argyll's explanation of the principles of bird flight developed as a direct result of this tradition and so it cannot be separated from his work. We have already seen how as a boy Argyll utilized Ardencaple Castle as his primary base for observation and experimentation; this was a method that remained with him throughout his life. In contrast to Argyll's public work, in various London meeting chambers, his domestic spaces afforded him private retreats conducive to his studies of nature—within what historians often categorize as a form of private laboratory (James 1989, 3). In Argyll's autobiography we see a clear case of this in his London house; his wife Ina, Duchess of Argyll wrote that he used to speak of "the refreshment it afforded him to turn from important matters affecting the welfare of the nation, which required strenuous and engrossing thought, to the restfulness of Nature" (Argyll 1906, II: 336). Some extracts from Argyll's 1876 personal diary show what he undertook once back in his private laboratory. On 26 April at Inveraray Castle Argyll noted that, "the little spotted woodpecker has made his appearance in the garden and one day I saw him in the act of producing his peculiar rattle" (Argyll 1906, II: 337). Argyll also kept various natural history diaries throughout his lifetime in order to record his observations and discoveries. Reading through his diaries the reader is taken on a fascinating and extremely personal tour of Argyll's private life in which one is tempted to conjure up visual images of Argyll in his country houses surrounded by nature as he intently observes the behaviour of the various wildlife he encounters. These brief extracts from just one of many diary entries contain Argyll's sightings of a number of birds such as ospreys, oystercatchers and kestrels at Inveraray Castle, May 1872:

> My attention was attracted by the vociferous cries of a pair of oystercatchers flying over to loch, and circling round a very large bird which at first, and at a considerable distance I took for a black backed gull. It soon, however, wheeled nearer and suddenly stopped in the well-known hovering position which proclaims the osprey…The hovering of the osprey is very different from that of the kestrel

being sustained by a sort of heavy and laborious flapping which gives the impression of difficult laborious exertion….[9]

This practice of returning to the private was not at all unique to Argyll, rather, it was an integral aspect of Victorian aristocratic domestic science, involving a highly influential network that included Argyll and others, typically connected through family and marriage (Opitz 2004). Another clear example of this method of practice, can be seen in John William Strutt, 3rd Baron Rayleigh (1842-1919), appointed as Professor of Experimental Physics at University of Cambridge's Cavendish Laboratory in 1879. Although this new role provided him with an otherwise ideal space to conduct experimental research, he would still revert back to working in his country-house at Terling Place, Chelmsford (Essex) whenever possible. Not unlike Argyll, Rayleigh showed an inclination for retreating to his private laboratory space; according to Opitz (2004, 158), "Rooms in the Cavendish Laboratory substituted for his Terling workshops, though he returned to his country laboratory to work at experiments during vacations." As Opitz (2004, 153) argued, in the context of the debates over scientific naturalism (see Barton 2018), "Extensive country-house networks … provided influential, alternative visions for professionalizing science than those advocated by the scientific naturalists. The evangelical, private practice associated with the aristocratic circle represents an important, domestic tradition extending beyond the Victorian period…." Argyll's own practice of country house science fits within this pattern, particularly given the theological framing of his ornithological studies, to which I now turn.

Argyll's theology of flight in *The Reign of Law*

Argyll, like his father, was a keen observer and experimenter on birds. Nowhere is this better seen than in chapter three ("Contrivance a Necessity") of Argyll's most popular book *The Reign of Law* first published in 1867 (and reaching a fifth edition by 1868). Historians are well aware of the popularity of the Argyll's book throughout the century. However, whilst they have correctly pinpointed one aspect of its enduring reputation being Argyll's powerfully-argued contribution as one of the leading theistic evolutionists alongside his contemporaries Richard Owen (the anatomist), and St. George Mivart (the Catholic biologist) in the "post-Darwinian controversies" (Moore 1979; see also Gillespie 1977), they have tended to overlook the other compelling reason for the book's sustained reputation: its

[9] ICA, bundle 299, diary entry from May 1872, page 1.

continued relevance in the mechanical world of aeronautical studies within and beyond the Victorian period. The study of bird flight and the subsequent attempts to actively apply those theoretical principles to manned flight became an increasingly common theme as the nineteenth century progressed. Whilst unskilled in engineering (unlike his father), Argyll was a seasoned ornithologist, and his ornithological studies provided a highly valuable resource for both wider popular circles as well as within smaller scientific ones.

In line with a long tradition of English natural theology dating back to the Protestant reformation, Argyll's key thematic approach, employed in all of his writings on science and religion, was summed up at the end of chapter two in *The Reign of Law* where he stated that

> It is, indeed, the completeness of the analogy between our works on a small scale, and of the Creator on an infinitely large scale, which is the greatest mystery of all. Man is under constraint to adopt the principle of Adjustment, because the Forces of Nature are external to and independent of his Will. They may be managed but they cannot be disobeyed.... How imperious they are, yet how submissive! How they reign, yet how they serve! (Argyll 1867, 126-27)

By "principle of Adjustment" Argyll meant our ability as humans to manipulate the laws of nature in order to be inventive. In effect Argyll argued that creation was nothing short of the work of God who chose to govern through immutable forces of nature. These "Forces of Nature" could not ultimately be broken, hence their immutability; however, they *could* be manipulated or "Adjusted," and it was this capability to manipulate the laws which provided man with the ability to study, experiment, and utilise nature as the means towards directed ends. Chapter three of his book then detailed his study of birds, including the laws and principles that govern their ability to fly. Argyll articulated his aims for the chapter upon his understanding of the relationship between the mind of God and the mind of man. For Argyll, God had created birds in nature to fly, but this was a height that Argyll believed man could also ascend to if only we could come to understand the correct principles of flight that God had embedded in nature because He had made these laws accessible to man (Argyll 1867, 128-31).

Argyll's chapter on flight is broken up into various sections that delve into the mechanism of bird flight. He first speaks on the apparent contradiction of a bird's sustained flight in the face of the effects of gravity. It is here where one of the most foundational principles of flight is stated and expanded upon. How can birds fly with gravity constantly acting to pull them down? Argyll argued contrary to common perception that gravity

> …is the very Force which is the principle one concerned in flight, and without which flight would be impossible…. Birds are not lighter than the air, but immensely heavier. If they were lighter than the air they might float, but they could not fly. This is the difference with a bird and a balloon. A balloon rises because it is lighter than air, and floats upon it. Consequently it is incapable of being directed … no bird is even for an instant of time lighter than the air in which it flies; but being, on the contrary, always greatly heavier, it keeps possession of a Force capable of supplying momentum (Argyll 1867, 133).

Here, Argyll made a case for how ornithology offered a more promising basis for the emerging science of aerial navigation than ballooning, given the latter's lack of susceptibility to control in the air. He continued on to describe other key feature of bird flight, such as the precise construction of a wing which is broken up into three parts—primaries, secondaries, tertiaries (Fig. 2)—and the elasticity of air, and how that enabled a bird to manipulate airflow in a certain direction to aid its upward lift and sustained flight. In one section of the book, Argyll employed an extremely useful human analogy discussing the effect of wind on an umbrella. He raised a seemingly difficult problem, that is, when a bird flaps downwards in order to raise its body upwards in the air, it has to inevitably flap upwards again in order to position its wings for the next downward flap. This being the case, why does not the upstroke neutralise the effect of the downstroke, effectively rendering the bird unable to gain any lift at all? Argyll's answer is two-fold. The first part lies in the convex structure of a bird's wings. In order for us to better understand this Argyll asks us to think about what happens when strong winds flow against an umbrella, "the air which is struck by a concave or hollow surface is gathered up, and prevented from escaping, whereas the air struck by a convex or building surface escapes readily on all sides." This is the same with a bird wing; a wing is designed with a convex shape so as to allow the wind over the top escape with "comparatively trifling injury to the force gained in the downward blow" (Argyll 1867, 140). The second part of the answer has to do with the nature of feathers. According to Argyll, on the downstroke the design of feathers enables them to seal shut like a membrane enabling the wings to push down on the air underneath which in turn raises up the bird up. However, on the upstroke, because the feathers are such that they are not bound together, they will open up converting them into separate valves through which air can rush through. This means that the upstroke will not cancel the downstroke (Argyll 1867, 141).

Argyll tackled a number of other mysteries. One was the question of how a bird moves horizontally and not vertically? Argyll explained that this was achieved through (1) the horizontal angle of the bird in flight; (2) the narrowness of the bird when in forward motion actively allowing it to cut through the wind; and (3) the ability of the bird to periodically strike the air below its wings in order to keep effective balance between gravity and the force of the air (Argyll 1867, 135). Another mystery was about how some birds could soar in the air. Argyll, taking seagulls and the larger species of hawks as his examples, suggested that soaring "can only be done when there is a breeze of sufficient strength." Because gravity is always pulling the bird down, a counterbalancing force—the flapping of a bird's wings—is needed. "In order to bring these two forces to nearly a perfect balance, and so to 'soar', the bird must expand or contract its wings exactly to the right size, and hold them exactly at the right angle" (Argyll 1867, 149). A final example taken from the chapter is on the function of a bird's tail—Argyll in opposing the prevailing view that tails assisted primarily in steering, argued that based on his observations on such birds like the Kestrel, tails were used by birds instead primarily for general balancing and stopping (Argyll 1867, 170-71). He also considered the different wing shapes and sizes and their varying purposes for specific types of birds, such as birds who spend most of their time flying (e.g., the wandering albatross) and other birds who spend relatively little amounts of time flying (e.g., the woodcock). Argyll neatly synthesised his thoughts in the conclusion to this ornithological chapter. After proclaiming balloons to be but "mere toys," his semi-prophetic vision for heavier-than-air flight—i.e., aerial navigation based on the laws ordained by God—is expressed with all the clarity of a formidable political orator:

> When Science shall have discovered some moving power greatly lighter than any we yet know, in all probability the problem will be solved. But of one thing we may be sure—that if Man is ever destined to navigate the air, it will be in machines formed in strict obedience to the mechanical laws which have been employed by the Creator for the same purpose in flying animals (Argyll 1867, 180).

As I described above, the ASGB had established a mutual friendship with the aeronautical savants in France such to the extent that a year after the release of his book, Argyll was commissioned to publish five articles in the *L'Aéronaute: Bulletin Mensuel International de* *la Navigation Aérienne* based on his ornithological chapter in *The Reign of Law*. Each article dealt with one of five aspects of bird flight: the relation of gravity to birds in flight (Argyll 1868b), how birds direct themselves forward in flight (Argyll 1868c), the muscular force for various types of birds (Argyll 1868d), the structure of bird wings (Argyll 1869a), and the ability of some birds to suspend themselves in the air without moving forward (Argyll 1869b). The publication of Argyll's works outside of Britain within the context of aerial navigation studies, demonstrates both the international reach of his ideas as well as the recognition of the relevance of ornithology—in this case, based on country house science—to the question of mechanical flight.

Difficulties and debates over the principles of bird flight

Based on my scan of the ASGB's annual reports, it seems that Argyll's work on bird flight received the most attention by the society between 1875 and 1882, although there are earlier and later mentions as well. A number of disagreements fomented in a polite, gentlemanly fashion, to better understand the correct principles of bird flight. In general, from 1860s to the 1890s the sheer number of papers on the principles of bird flight that circulated through the society is astonishing.

By the 1870s a number of Victorians were working on understanding the flight of birds, and some notable developments had been made. Examples included the first aeronautical exhibition organized by the ASGB held in June and July 1868 at the Crystal Palace. During the exhibition Argyll devised an experiment using a pair of dried bird's wings (attached to a horizontally stretched wire) to show how the natural configuration of wings necessarily propelled a bird forward when flapping. At the same exhibition, John Stringfellow won a prize of £100 for building the lightest steam engine, weighing 13 lbs. The creation of the world's first wind tunnel in 1871 by Wenham and John Browning, a well-known British scientific instrument maker, was yet another important milestone furthering research into wind dynamics (ASGB 1868; ASGB 1871, 5-9; ASGB 1872, 4-24). In the ASGB's annual report for 1878, Brearey gave some remarks on bird flight and its imitation by mechanical models. He observed that considering the amount of work that had gone into trying to understand the laws of bird flight, an ornithological society should have been designated "except for the fact that we only study the bird as a means to an end" (ASGB 1878, 16-17). This was certainly true: the Victorians who eventually made the biggest strides in the field of aerial navigation were indeed the engineers working on the problem. However, without a basic understanding of the laws of flight these eventual engineering landmarks would have been near impossible.

In ASGB's annual report for 1880, Argyll's work on birds once again became the topic of debate. With Argyll not present however, it was left to a few of his supporters to defend his views. The basis of the debate centred around the question of how a bird was able to remain at rest in the air seemingly without flapping its wings. Argyll had argued in *Reign of Law* that certain birds had the capability to remain stationary at a fixed point in the air. This was due to the bird shortening its stroke in the air and altering the perpendicular angle of its body's direction so that the wing struck forwards instead of vertically as would do in normal flight. It would also need to have a superabundance of sustaining force (i.e. endurance), and for this reason heavy birds could not perform this motion but lighter birds, with superabundant sustaining power and longer, sharper wings, could. As an example, Argyll noted that the kestrel would hang its body at a greater or lesser angle to the plane of the horizon, when remaining at a fixed point in the air. When there was little or no wind, the sustaining force was kept up by the short, rapid action of the pinions (the outer part of a bird's wings) as well as the long tail being spread out like a fan to assist in reducing any possibility of forward motion. When the wind was strong there was no need for any wing action, as the force of wind acted as a counterbalance on its own to the force of gravity (Argyll 1867, 169-70) (Fig. 3).

One attendee (unnamed[10]) argued that contrary to Argyll's theory a bird cannot remain in the air without forward motion, since its weight would cause it to fall downward. The wind being more or less horizontal, however, would push the bird backwards. "Therefore, if the bird merely lays itself on the wind, as the Duke says, it must take a direction between the two forces" (ASGB 1880, 54). Henry Davis, a supporter of Argyll's explanation, argued that the description did have merit to it, despite committing a mistake in using the word "momentum" to describe a mysterious force, apart from the wind and the bird's wings, that acted to keep the bird stationary (ASGB 1880, 56-57). Another attendee ("W.C.E.") proposed a contrasting explanation in which bird wings moved "virtually" —i.e., the birds made subtle shifts, imperceivable to the human eye, in their wings' extension that enabled prolonged suspension without forward motion (ASGB 1880, 39-40)—and he noted a

[10] In the ASGB reports, often correspondents and meeting attendees are mentioned with little or no identifying information, consistent with a wider practice of anonymity in Victorian periodical and popular science publishing, as one means by which to uphold norms of social respectability and yet exert 'anonymous power' in public intellectual debates; see Secord (2000, 17-24).

fallacy that Davis, following Argyll, introduced into his argument, by looking at a kite, as opposed to the bird, as an example. The kite (W.C.E. said), is acted upon by three pressures, its weight (i.e., gravity), the wind, and the tension of the string; however, birds are only acted upon by two, those being their weight and the wind. He therefore summarised that Argyll's analogy added a third pressure for birds in order to resemble the kite, an untenable assumption which Davis, although professing to supposedly understand, did not elucidate (ASGB 1880, 64). To conclude this debate, another attendee (identified under the pseudonym "Cheyletus") pointed out that no theory except Argyll's had been put forward against W.C.E.'s idea of "virtual" wing motion. However, Cheyletus ended by remarking, "I only hope that the subject will be thoroughly investigated, if only to say that we have found out and made clear another of 'nature's mysteries'" (ASGB 1880, 66).

These debates over the details of bird flight implied an ongoing hope in apprehending the correct principles that governed both muscular and mechanical flight, and in that regard, the unresolved questions proved highly frustrating as the decades went on. This frustration coincided with a decline in the ASGB's membership during the last quarter of the century. However, as we shall see the internal frustration in Britain was not mirrored internationally, and in places such as Germany, the United States, and France aeronautical enthusiasts would continue to work actively towards the final goal, the developments to which we now turn.

The state of aeronautics from 1890 to 1903

The last decade of the century was an awkwardly paradoxical period in British aeronautics. By the 1890s the ASGB had lost a large number of members and the society was heavily in decline. The death of Brearey in 1896 as well as the sudden death, caused by a gliding accident, of the British aeronautical pioneer Percy Pilcher in 1899 had a drastically negative impact on aeronautical experimentation in Britain. There was also a sense of frustration by many of the members of the ASGB. Indeed, after thirty years of study and practical experimentation, no one had successfully manoeuvred through the air in a manned machine and safely landed, and the full principles of bird flight were still largely unknown. In the ASGB's 1893 annual report, Brearey noted that that the society could previously boast a membership of over 100, but as of recent years it had struggled to reach even up to thirty (ASGB 1893, 73). To be sure, the society members did recognise that progress *had* certainly been made. In his concluding remarks to the 1890 annual report, Brearey observed that "We have got some distance from the speculative theories of the early days of this society" (ASGB 1890, 96). But in the end, this "distance" did not achieve the lengths hoped for at the society’s formation in 1866. If we now juxtapose this rather bleak outcome with the actual state of aerial navigation internationally–propelled, no doubt, by the efforts of the ASGB—aeronautics had made unprecedented progress and had effectively become a more respectable science (in contrast to ballooning), whereas back in the 1860s it could scarcely hope to have claimed this recognition.

A few landmarks help to elucidate this. By the 1880s Hortatio Philips (1845-1924) was able to build his own (updated) wind tunnel (Hallion 2003, 117), and leading German engineers such as Otto Lilienthal (1848-1896) had made promising flights on gliders, although like Pilcher he would also tragically fall victim to one of his own inventions. About the same time, Rayleigh had explained the dynamics of the soaring of the Albatross—anticipated 400 years ago by Leonardo da Vinci, according to one recent analysis (Rayleigh 1900, 233-34; Richardson 2018). Amidst the growing interest, Chicago was stage to an international conference on aerial navigation in August 1893, and the American engineer Octave Chanute (1832-1910) published his *Progress in Flying Machines*, a key text in aeronautical development, in 1894. The Boston Aeronautical Society was established in 1895 with the aeronautical author and experimentalist James Means (1855-1920) as one of the founders. Lastly and most interestingly, although the membership of the ASGB had significantly decreased in quantity, the *quality* of membership and attendance by the 1890s was of a substantially high standard. Among the members were men like Harim Maxim (USA), Horatio Philips (UK), Percy Pilcher (UK—until his death in 1899) and Octave Chanute (USA). All of these savants made notable strides in aeronautical studies as engineers and/or theorists of flight, publicists, and experimentalists. In the same place that Brearey had commented on the decline of the ASGB membership (in the 1893 annual report), he nevertheless congratulated the society for its influence extended to all parts of the world where aeronautics was pursued. Ultimately, although British aerial enthusiasts might have been severely lacking in spirit, they had not yet given up, and because of this their persistence had a crucial impact on the wider study of aerial navigation.

In support of ASGB’s international importance Means stated that

> The best of the world’s knowledge of aeronautics is to be found in the two thousand pages of these [ASGB annual] reports. The organization has never been a large one, and probably years will pass by before the importance of its twenty-nine years of work will be fully understood and appreciated. Even as the missal painters kept art alive during the Dark Ages, so has this band of men kept aeronautics alive

> during the years in which their branch of science has been by the many regarded almost as a pseudo-science. The editor wishes to make the fullest acknowledgement of the debt he owes to this society (Means 1895, 136-37).

Notwithstanding the mythologizing of the ASGB as a masculine club ("band of men," overlooking the women Associates), Means's retrospective appreciation of the society underlines its international reputation even amid its floundering status in the mid-1890s.

Victorian newspapers offered further, often contrasting, observations on the progress of aeronautical developments. A story on "Ballooning" appearing in the *Daily News* in September 1875 critiqued the lack of progress made by the ASGB within the decade it had been established. Preferring balloon technology over the seemingly impractical attempts to establish aerial navigation (reasonable, given the comparably successful record of balloon technology) the story concluded,

> … but, if there is to be a society for the navigation of the air, it would be just as well for its energies to be exerted in the only direction where any tangible results [i.e. ballooning], even the slightest, seem attainable.[11]

This pessimism contrasts sharply with another newspaper report on 8 September 1893 which read,

> The subject of transit through the air has emerged from the regions of fable and fancy, and is now being thoughtfully studied by the leading scientist. No less a savant than Professor Graham Bell said recently: "I have not the shadow of doubt, that the problem of aerial navigation will be solved within ten years. That means an entire revolution in the world's methods of transportation and of making war…."[12]

These words by the American inventor Alexander Graham Bell, in stark contrast to the disparaging words of Lord Kelvin (quoted at the opening of this article), could not have been any more prophetic. Almost exactly ten years later the Wright brothers completed the first

[11] Newspaper clippings box located at the NAL. Identifying information is cut from most of the newspapers such that it difficult and sometimes impossible to locate the author and/or publisher.
[12] Newspaper clippings box located at the NAL.

successfully controlled flight in the world for a length of twelve seconds on 17 December 1903 at Kill Devil Hills, North Carolina, USA (Hallion 2003, 184).

The Wright brothers of course did not work in a vacuum. Their success was foundationally built upon the trial and error of the nineteenth century enthusiasts, and the brothers gave credit where it was due. In 1909, Wilbur Wright recognized Cayley's pioneering work: "Cayley carried the science of flying to a point which it had never reached before and which it scarcely reached again during the last century" (quoted in Hallion 2003, 105). Fully steeped in the aeronautical literature, and as active correspondents with fellow engineers, the Wright brothers were fully aware of the UK debates, including Argyll's thoughts on flight. We know that Means's compendium, *The Aeronautical Annual* (1895-97), directly inspired them; in a letter to Means on 15 January 1908, the brothers cheerfully stated, "We are very glad to know that the Annual is to be continued. The old Annuals were largely responsible for the active interest which led us to begin experiments in aeronautics."[13] Means released his compendium in three volumes, starting from the historical roots and subsequent developments of aerial navigation, from the famed experiments of Leonardo da Vinci right through the latest aeronautical inventions of the late nineteenth century. This was and still is one of two of the most important works of this nature for the period (the other being Chanute's, mentioned above). As well as certain extracts from the ASGB meetings being featured in the book, a modest number of extracts taken from Argyll's *Reign of Law* were also featured in Means's first volume, under "The Problem of Man Flight" (Means 1895, I: 146-49). This was a chapter that detailed the theoretical problems in flight and the promising developments that had been made during the century. Means cited sections of Argyll's work, remarking that it was "a most notable chapter in which the flight of birds is analyzed," adding: "Every student of the subject of flight should read the interesting work [of Argyll] just mentioned. We may not agree with all the conclusions which are reached, yet the author gives most stimulating food for thought. The following chapters are the most striking, showing, as they do, advanced ideas" (Means 1895, I: 146-47). As we see from the wider dissemination of Argyll's ideas, despite the waning status of the ASGB the influence of its members attracted an international readership which in turn undergirded the success of the Wright brothers.

[13] Library of Congress, Manuscript Division, Wilbur and Orville Wright Papers, General Correspondence of James Means, 1942, 15 January 1908.

Conclusion

Argyll's vision for flight stemmed from his father's own infectious commitment to mechanics and aerial navigation. A perusal of the 7th Duke's activities suggests that in his own right he should be recognised by historians for his key role, as a nobleman, in the experimental pursuit of aerial navigation. In regular correspondence with Cayley, the 7th Duke investigated the principles of bird flight in an attempted to construct flying machines adapted to human beings at a time when aerial navigation was still seen as frivolous. Following in his father's footsteps then, the young George Campbell leveraged his various homes as his private laboratories, and particularly during his early years the influence of family in matters of both science and faith shaped his undertakings. All of this positioned him to becoming a founder, first president, and patron of the ASGB, culminating in his publication of *The Reign of Law*.

In summary, I argue critically that if Mathurin J. Brisson and Comte de Buffon can be seen as the progenitors of ornithology in the second half of the eighteenth century (Farber 1997, 7-26), the mid-nineteenth century work of Argyll and Wenham, underpinned by the establishment of the ASGB, can be seen as a critical turning point at which bird flight studies expanded dramatically in its theoretical nature and likewise in its popularity. Aside from a few individuals such as Thomas Walker, the 7th Duke of Argyll, and Cayley, who had conducted some studies in this area, most ornithologists during the first half of the century did not focus much, if any, attention on theories of flight. If we compare this to the latter half of the Victorian period, we can see a steady increase of enthusiasm with many more studies on bird flight conducted, discussed, and debated (see Means 1895, II: 61-62). As I have stressed in this study, country and town house science, as a form of aristocratic, theistic scientific practice, is a most salient theme traceable throughout Argyll's contributions, and this remains neglected in historical studies. It becomes clear from an assessment of the noble class, that Argyll was part of a wider circle of theistic aristocrats who infused their own amateur style of research into wide ranging domains of professional science, in Argyll's case, spanning from the opening of new branches of ornithological and aeronautical studies, to the to the formation of new institutions and societies for the advancement of science, as we have seen with the ASGB. Contrary to common perception, in many of these cases, the aristocrats were the ones leading these initiatives. In conclusion, I argue that Argyll's role in late-nineteenth century science not only proved significant to the advancement of aeronautics, but that his contributions existed as part of a larger Victorian tradition characterised by aristocratic respectability motivated by a theistic agenda. Indeed, as advanced by Opitz

(2006), we see here the persistence of this tradition well beyond the confines of the Victorian period.

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