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MEMOIRS

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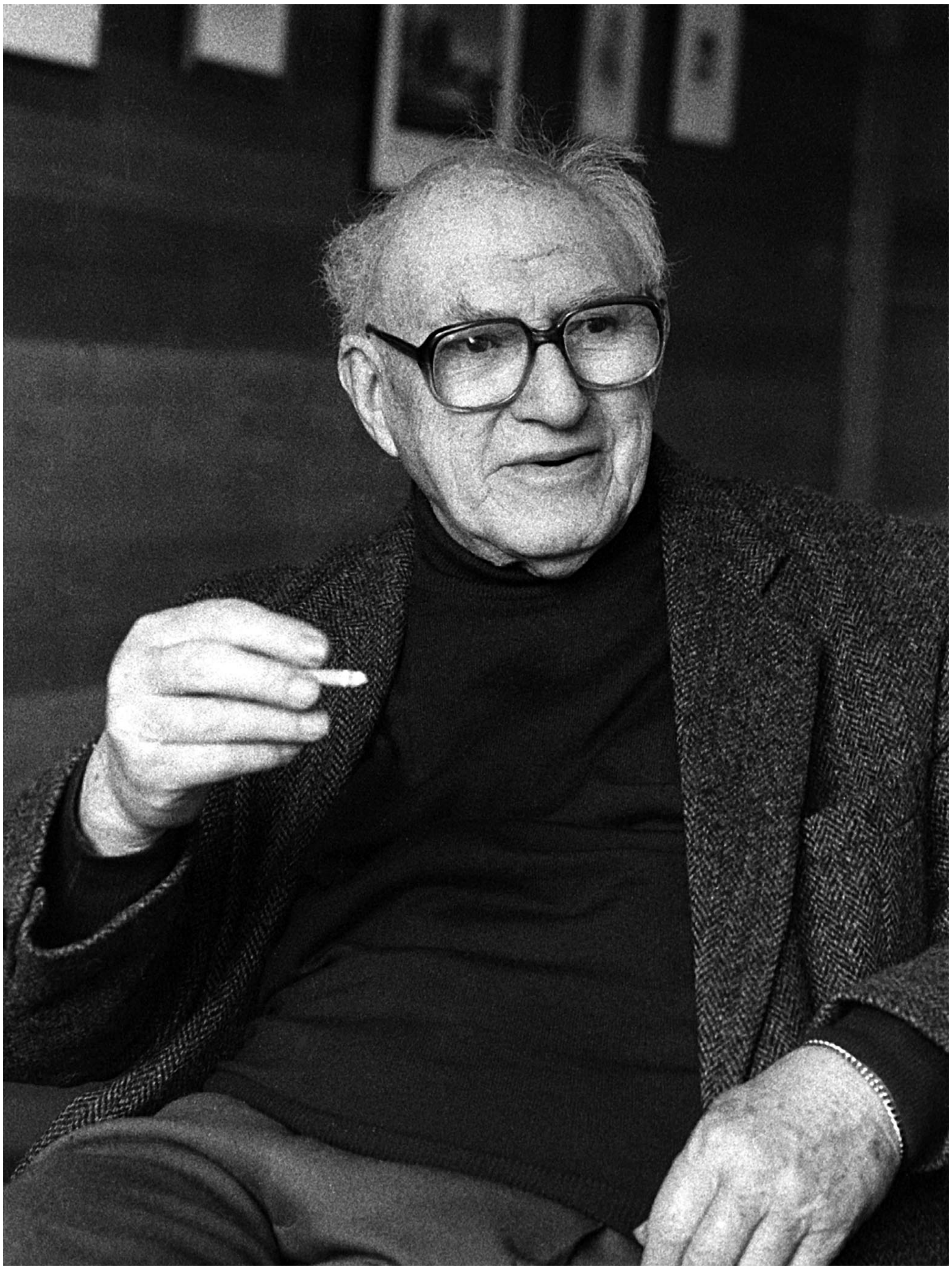

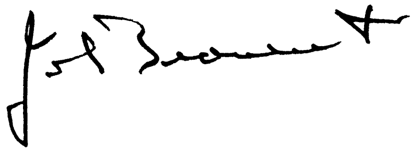

SIR JAMES WILLIAM LONGMAN BEAMENT

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There were two dominant scientific passions in Jimmie Beament's life: insect physiology and the mechanism of hearing (and psychoacoustics). These accompanied his other passions—his family, music, and Queens' College, Cambridge. Throughout his career, Jimmie's research field remained very much his own, covering permeability and respiration in insects, orientation of lipids, the resistance of insect eggs to desiccation and to insecticides; and latterly the surface adhesion of pollen and the interaction of plant surfaces with rain. Jimmie never had time for research that needed the newest, biggest or most expensive bits of kit. Rather he preferred to choose problems that had never been solved because the *means* of attacking the problem did not exist. Thus Jimmie (with collaborators such as R. H. J. Brown & K. E. Machin) designed and built innovative, specialized equipment—he was a precision engineer as well as a scientist. Every strand of his life reflected his extraordinary energy and his desire always to move onwards. As in his science, so in his artistic life: from acting to music, first writing revues then as a performer; followed by serious composition and significant works on the theory of hearing and instruments.

Above all Jimmie was a polymath—one of an increasingly rare breed of scientists who have a broad understanding of science … and more.

Early days

James William Longman Beament, known always as Jimmie, was born on 17 November 1921 at Ashland Farm, Crewkerne, in Somerset. He was the only child of Tom and Elisabeth Beament (*née* Munden); Tom, (the second son in a family where it was traditional for the eldest son to inherit the family farm) was a bachelor until his fifties, having spent his earlier years as an apprenticed butcher and then working for a prospecting company in German South-West Africa (later Namibia). Tom took over the farm in mid-life when his elder brother was killed

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in a farming accident; he had no option but to learn the farming skills from the farm labourers. Ashlands had been farmed by the Beaments since 1670 (and probably from 1420). Jimmie's mother (widowed, as a result of war action, just 10 days after her first marriage) was determined that Jimmie would have a career other than in farming (mainly because of the depression in the 1920s and 1930s)—a desire that she had an important part in fulfilling. And it was fulfilled right through to the gradual disposal of the farm through Jimmie's life, thus ending the family's long association with Crewkerne.

Jimmie received a traditional education in the local grammar school but as a child was relatively isolated. He learned basic farming skills through having to help on the farm in holidays, but his mother was diligent in ensuring he was well immersed in books and music from an early age—these two themes, music and agriculture, weave their way throughout Jimmie's life.

His early interest in music was fuelled by weekly Salvation Army visits and the annual fair, but as soon as he had saved enough to buy a ukulele (and later a guitar) he began to teach himself harmony. It was only when he went up to Cambridge that he first heard classical music, later to be an integral part of his life.

After Higher School Certificate, Jimmie took the entrance examination to Queens' College, Cambridge, was awarded an Exhibition and went up in 1940 to read natural sciences. Queens' was chosen because of a schoolteacher who had been there—and it proved a serendipitous choice, because Queens' became an important part of Jimmie's whole life, scientifically, administratively and socially. He read mathematics, physics and chemistry and was enthralled by the lectures of Alexander Wood and by his major work, *The physics of sound* (Wood 1981). Wood first stimulated his interest in acoustics, a theme with which he became increasingly fascinated throughout his life. He gained first classes in his first two years and came top of the Part I classlist: consequently he was invited to stay on for another year rather than join the services. C. P. Snow suggested that he specialize in zoology, with particular emphasis on insects—an inspirational (and again serendipitous) suggestion that delighted Jimmie's mother. Jimmie was bemused as to its relevance to the war effort—all science was supposed to be directed towards that end—but in due course his work contributed significantly. Outside science, he had a full and varied student life; a high point was his founding of Queens' College's amateur dramatic society, the 'BATS' (of necessity, having been instructed by the Dean to put his vocal talent to good use after a 21st birthday celebration, fuelled by Somerset cider).

In the summer before his final year, Jimmie was one of a group of young biologists recruited to count eels—seen as a potential wartime food supply—on northern rivers and test a primitive light trap developed and built at the Freshwater Biological Association's base at Wray Castle on Windermere. The project had no immediate useful outcome but stimulated his thinking about the design of scientific instruments, something that was to stay with him all his life.

Insect physiology

On leaving Cambridge, Jimmie went to work at the London School of Hygiene and Tropical Medicine (later the London School of Tropical Medicine), headed by P. A. Buxton FRS. V. B. (later Sir Vincent) Wigglesworth FRS was there, too, performing pioneer research on the moulting cycle of a blood-sucking bug, *Rhodnius prolixus*, believed to be a vector of Chagas' disease in South America. Wigglesworth stimulated Jimmie's interest in the wetting and waterproofing properties of the insect integument or cuticle, a topic that was to be a dominant theme in his scientific career.

It had been known since the 1920s that insects were resistant to desiccation (how could such small animals survive in dry habitats unless they conserved water efficiently?). In 1935 J. A. Ramsay (FRS 1955), a Fellow of Queens', had suggested that this was due to wax. Wigglesworth's detailed research on transpiration through cuticles was paralleled by Jimmie's studies on the waxes that could be extracted from those cuticles by solvents (1)*.

Cuticular properties are also important in determining how insecticides both adhere to and penetrate insect surfaces. The importance of understanding these properties was obvious: during and after World War I, more people died from insect-borne diseases than had been killed in action. Natural insecticides (pyrethrin from chrysanthemums, derris from tropical root, nicotine from tobacco plants) were absorbed through being eaten, but blood-sucking disease vectors such as *Rhodnius* seemed immune because the cuticle (which lines part of the insect gut) was impervious to such simple poisons. Jimmie started working with P. A. Buxton FRS on lice, widespread in southern Europe and the Russian front and virulent in transmitting typhus.

Whilst lodging in London, Jimmie first heard the music of Delius (of which he remained a devotee and whose influence is evident in his later compositions). As a research student he played piano in pubs and hostels for pocket money. This dual passion for music and insects led to at least one bizarre episode. Wigglesworth's research on *Rhodnius* and Jimmie's work with Buxton on lice both needed large numbers of these insects. Lice will only feed on humans, and although later on a system of feeding *Rhodnius* on rabbits was developed, at that stage the experimenters also fed these bugs on themselves. Jimmie went around with aluminium tins tucked inside his socks 16 hours a day with the lice feeding off himself which just about kept up with the experimental demand. He later told the story of how a similar tin containing early-stage *Rhodnius* nymphs fell off his leg during a concert at the Albert Hall. The insects were never heard of again! Experiments with DDT on vagrants living rough in London confirmed the power of DDT in killing lice; this was put to great effect in inhibiting a major outbreak of typhus in Naples in 1944.

Wigglesworth and Beament demonstrated not only that waxes were responsible for insect waterproofing but that there were considerable differences between species. Some species (such as cockroaches) are coated with a soft wax or grease that becomes permeable at a relatively low temperature and is only partly protected by cement, and are hence easily killed by detergents. Others have a harder wax that remains impermeable at temperatures well above those lethal to the insect.

Jimmie Beament's work on insect waxes and on lice led to his second major field of research: the structure and waterproofing of insect eggs, on which he became an international authority. Insect eggs are faced with all the problems confronting adult insects, but to an even higher degree. Eggs are smaller, and hence have a greater surface:volume ratio and a comparably raised risk of desiccation—but the embryo within also needs to respire; it must therefore have means of access to atmospheric oxygen. The eggshell is also the critical barrier that a pesticide has to penetrate if it is to be effective. Jimmie's work on the structure and waterproofing of *Rhodnius* eggs was the first comprehensive investigation undertaken, and led to a

* Numbers in this form refer to the bibliography at the end of the text

series of seminal papers (2–4, 7, 8). *Rhodnius* eggs are flask-shaped with a cap that the emerging insect pushes off. Jimmie showed that the cap has about 200 blind-ended tubes running through it (and a further 15 open at both ends, through one of which fertilization occurs). By using lead naphthanate dissolved in paraffin, he was able to demonstrate that these 200 tubes or 'pseudo-micropyles' were the egg's respiratory system: if they were blocked, the egg asphyxiated (10).

In 1947, PhD completed, Jimmie Beament returned to Cambridge as a member of the Agricultural Research Council's (ARC's) unit of Insect Physiology, again under Wigglesworth. He continued to work on insect eggs, including those of flies (5, 9), ticks (6) and red spider mite (11), and indeed insect eggs remained a research theme that continued to absorb him through to 1987.

Jimmie's work on ticks was done in partnership with a fellow-member of the ARC Unit, A. D. Lees (FRS 1968). They discovered that the tick eggshell was a simple envelope secreted by the female from a grease gland with two fingers (like a glove), from which she spreads grease on every one of about a thousand eggs at one laying (6). He and Tony Lees also collaborated in research on the red spider mite, which was proliferating because of over-spraying of DDT in orchards—the DDT also killed the black kneed capsid, which kept the red spider mites under control. For this research Jimmie designed some ingenious environmental cabinets, and with Tony Lees's help discovered that the mites' eggs are 1/50 of a millimetre in diameter and that the adult produces one egg at a time, deposits it on a leaf, covers the egg in plastic wax and attaches silk 'guy-ropes' to hold the egg in place: if the egg is tilted the exposed unwaxed bottom causes the egg to dry up. Whether or not the leaf is senescing causes the mite to lay an egg full of a red pigment related to vitamin A, or not (11).

In the early 1950s the Cavendish Physics Laboratory obtained its first electron microscope. Wigglesworth, who was a guiding light for Jimmie, was a brilliant dissecter and microscopist but was not at home with complex equipment. Jimmie saw the opportunities that electron microscopy offered to investigate the fine structure of the insect respiratory system. Insects breathe through pores (spiracles) along the sides of their bodies. The spiracles, which can open and close, lead to a network of fine tubes (tracheae and tracheoles) ramifying into the body. The finest tubes are too small for their detail to be made out by normal microscopy. Jimmie prepared samples from *Rhodnius* and was able to show that the tracheoles comprised an extremely thin membrane, supported by a helical reinforcement of hard but flexible material. This exemplified his dexterity as well as his intuition and scientific reasoning. This work was exhibited at a Royal Society Conversazione alongside Malpighi's 1669 monograph on the silkworm (from the Royal Society's Library) in which the tracheal system was first illustrated.

Music, drama and science

On his return to Cambridge in 1947, Jimmie Beament renewed his links with Queens' and took up where he had left off in the world of music and drama. He reinvigorated the BATS, joined Camille ('Pop') Prior's 'Theatre Group' and started writing incidental music for plays and revues.

While in London Jimmie had married Monica, and she returned to Cambridge with him, but the marriage was dissolved in the early 1950s. He met his second wife Joyce (*née* Quinney) through the theatre, and she played a leading role in several BATS productions.

Throughout the 1950s and 1960s science and music absorbed Jimmie's life in almost equal parts. Blessed with the need for only a few hours sleep each night (an advantage he had throughout his life), he was able to compose incidental music to many Cambridge productions. Jazz was emerging as important to him—he had that enviable ability to improvise at the piano. His interest in theatre continued, and he became licensee and senior treasurer of the Cambridge Amateur Dramatic Club (ADC). His wife, Joyce, managed the accounts.

From the outset of his scientific career, Jimmie Beament had been an active member of the Society for Experimental Biology (SEB) and published many of his most important papers in the *Journal for Experimental Biology*. In 1953 he was elected the Society's Zoological Secretary. In 1955 he resumed research on insect waxes and waterproofing. J. A. Ramsay had studied the evaporation of water from cockroaches in 1935, and V. B. Wigglesworth had shown that the wax of these insects was mobile and only partly protected by an outer cement layer. Jimmie examined the mobile wax in detail, demonstrating that it was mobilized with short-chain paraffins and alcohols, including octane and octanol (13).

In the mid-1950s some of his and Wigglesworth's early work on the wetting and waterproofing properties of insects had been extended and questioned by one of their students, M. W. (later Sir Martin) Holdgate, and this was one factor in Jimmie's decision to revisit this whole area in the late 1950s and early 1960s.

It must have been a delight for Jimmie to collaborate with his friend K. E. Machin, an erstwhile radio astronomer who had the same approach to scientific method as Jimmie's. Together with R. H. J. Brown, they provided, every day in the department coffee room, a wonderful resource for people needing help in the design of apparatus. Machin and Beament devised an electronic thermostat (15) accurate to 1/100 of a degree. This enabled Jimmie to investigate the relationship between temperature and the permeability of insect cuticles more precisely than ever before. The partnership with Ken Machin led to a more sophisticated version of the electronic temperature control, enabling them to confirm that many terrestrial insects each had a different temperature at which their wax changed and became permeable to water. Major papers on the waterproofing mechanism of both terrestrial and aquatic insects followed (16–18). This research also gave Jimmie an insight into the biological thermostat that insects employ. For example, locusts have a wax that becomes permeable to water at about 39 °C, allowing the muscles to be cooled by the evaporation of water; locusts also have (solar) radiation sensors so they can dispose their bodies according to how much they need to warm up.

A rather bizarre study of a separate kind followed a suggestion by J. A. Ramsay. Jimmie anaesthetized cockroaches (with CO_2, so as not to contaminate the grease) and put drops of water onto them, to find that on coming round, after a period of hyperactivity, the insect became paralysed. This raised the question as to whether the hyperactivity caused the release of some chemical substance that led to the paralysis (and, if so, whether there was an opportunity for a synthetic insecticide) (14).

Cockroaches have a mobile grease that spreads readily on a water surface. But if cockroaches are dipped in water until no more grease is released, the insect still remains waterproof and unwettable because of the wax bound to the cuticle. Jimmie recognized that a comparable binding mechanism must exist in aquatic insects, which have wax layers that give them a considerable measure of impermeability, despite being submerged most or all of the time. He showed that many species have soft waxes that become permeable at low temperatures (even below 20 °C), presumably as a barrier against water inflow from the environment. Such insects may be wettable or unwettable according to their mode of life and their detailed surface structure and chemistry: the whirligig beetle *Gyrinus* has a marked ridge around its waterline (and eyes split into above-water and below-water sections) and it is unwettable above water and wettable below (18, 21). His work also demonstrated that the permeability of an insect cuticle is influenced by the orientation of its polar wax molecules and that this is the basis of its well-known asymmetry as a water barrier—a topic that had interested him over many years (12).

His period as secretary of the SEB came to an end and in 1960 he submitted his Cambridge ScD (four large papers, two reviews and a letter to *Nature*). It was in this period that he received offers of a Chair in several universities in the north of England, but Joyce's asthma made the then-polluted air of a northern industrial city unsafe for her—but in any case he knew that his heart was in Cambridge. Sadly, Joyce died shortly afterwards, leaving a vacuum in Jimmie's life (and in his theatrical involvement).

In 1960 Jimmie was asked to organize the second SEB Symposium, and he chose 'Biological Receptor Mechanisms' as its theme—a key decision. He invited George von Békésy (just a few months before he was awarded the Nobel Prize for his discoveries concerning the physical mechanisms of stimulation within the cochlea) to give the keynote lecture; Jimmie's interest in the science of hearing and music was truly kindled, an interest that was a core theme of his work for the next 35 years. His practical involvement with music also continued unabated. In 1961 he joined the orchestra of the Cambridge Technical College as a double-bass player, and it was there he met Juliet Barker, a viola player and a violin maker; this was a natural partnership, which he shared for the rest of his life. At about the same time he was appointed to the lectureship vacated when J. W. S. Pringle FRS was elected to the Oxford chair of Zoology (before that appointment he had been a Principal Research Officer of the ARC) and his career drifted away from predominantly research towards a life that included administration and teaching. Along with the lectureship came a Fellowship of Queens', thus cementing an emotional tie stretching back 20 years.

Jimmie relished his work as a Fellow of Queens' even though it plunged him into administrative jobs such as Tutor for Graduate and Research Students, and Senior Treasurer of the Amalgamated Clubs. He had a knack of making easy contact with students—as his involvement with the BATS and other Cambridge drama and music groups had demonstrated. Indeed, some of the older Fellows of Queens' had thought him a bit too unorthodox to fit the staid collegiate culture. The college soon realized the immense value that he added to the Fellowship. There followed a period with more and more music-making, much of it in groups with Juliet, to whom he became engaged (and married) in 1962. In 1963 he was awarded the Scientific Medal of the Zoological Society of London.

In his early days as a lecturer Jimmie recognized the need to integrate courses across allied subjects (but that until then had suffered from working in independent silos)—subjects such as zoology, botany and genetics. He was the architect of the cell components of an integrated course that in essence survived within the Natural Sciences Tripos well into the following century.

In 1961 Jimmie made the connection between the way in which electric microphones work and the way in which wax molecules align themselves. He recognized that melting wax in an electric field aligned the polar molecules: he measured the electric field surrounding the wax molecules on insects and then by applying a strong field was able to demonstrate that the orientation of the wax molecules was reversed—thus enabling an unwettable surface to be made wettable, and *vice versa*. This discovery had several implications and led to a letter to *Nature* (19).

While still thinking about how insects controlled which parts of their surface were wettable and which were not, he turned his attention to their respiratory systems. The spiracles where the tracheal tubes come to the surface act as valves that are closed when the animal is resting (and needs to minimize water loss) and opened when an enhanced oxygen supply is required. He then turned to the question of how the tracheal system, which is fluid-filled in embryo insects, becomes air-filled at hatching. V. B. Wigglesworth and others had assumed that this was done by fluid absorption by the cells lining the respiratory tubes and had speculated about the forces involved. Jimmie recognized that the process would be greatly facilitated if the tubules were lined with polar molecules whose orientation could be reversed, making the tubes unwettable and expelling the water. This discovery rebutted the traditional theories of insect evolution of freshwater aquatic insects and resulted in a major paper in the *Proceedings of the Linnean Society* (20).

Administration

In 1964 Jimmie Beament was elected to the Fellowship of the Royal Society and was also invited to be a member of the General Board, one of Cambridge's principal committees. In 1965, as a member of the Board, he chaired the university's Committee on the Future of Agriculture, set up in response to the University Grants Committee's conclusion that there was excess capacity of agriculture in UK higher education. The Committee concluded that the Department of Agriculture should be replaced by a Department of Applied Biology, a subject gaining relevance and popular support as a consequence of the 'environmental revolution' that had been stimulated in part by the appearance in 1962 of Rachel Carson's seminal book *Silent spring* (Carson 1962). In 1966 Jimmie was disappointed not to be elected to succeed C. F. A. Pantin FRS to the chair in Zoology (and headship of the department). The electors, seeking 'new blood', preferred another insect physiologist who had spent time in the department as a visiting researcher, Torkel Weis-Fogh of Copenhagen. However, in the same year Jimmie was appointed Reader in Insect Physiology; there followed a period during which he threw himself into administration.

Jimmie Beament had a huge capacity for work. In times of greatest pressure he turned to composition as his escape. After his early production of incidental music for plays and revues, he now started writing operettas for College May Week concerts, which were often skits on ballads. This was a time of developing student unrest in Cambridge, and by bringing together dons and students these operettas surely contributed to greater mutual respect and understanding. Indeed, Jimmie played a principal role in devising a new constitution for the Queens' student union and Junior Combination Room, including the innovation of student representation on the Governing Body of the College.

Through student performances of his compositions, lecturing on acoustics in the Music Tripos, and playing double bass, Jimmie won the admiration of many talented student musicians who subsequently had distinguished careers: Anton le Fleming, Mark Elder, Andrew Davis, and Richard Hickox, to name a few. He was made a Member of the Composer's Guild of Great Britain in 1967.

The student troubles having mainly been dealt with, in 1968 at the request of the Royal Society he went to Ghana (shortly after the coup that ousted Kwame Nkrumah) to advise on the effective utilization of Lake Volta, a man-made lake that covered 10% of the country but was only 60 feet deep. Creation of the lake had caused huge problems for the fishing industry. The *Tilapia*, which were the most important fish, had not increased in number as expected because they had insufficient food—as a result of which they became harder to catch in a bigger environment. At the same time mosquitoes and the blackfly that transmit river blindness and bilharzias had proliferated. Jimmie realized that the minutely thin layer of windborne red laterite dust that covered a large area of the lake was the reason why insects were inhibited from laying their eggs.

In 1969 he was offered the Drapers Chair of Agriculture, with a mandate to implement the recommendations of his report to the university and convert the Department of Agriculture to a Department of Applied Biology. He accepted and rose enthusiastically to the challenge of creating his own department and research environment. Not surprisingly, the transformation brought major challenges, academic and cultural, transitional and longer-term. And as head of department, he became responsible for the 1000-acre university farm—a reunion with the land that he had never expected!

He continued to carry an administrative load at the college; the student troubles still lingered on. He enjoyed being lampooned in Smoking Concerts, annual collegiate events that contributed to the thawing of senior–junior relations. During this period Jimmie also became a Syndic of Cambridge University Press and in 1970 he was appointed a member of the Natural Environment Research Council (NERC). Under this administrative load, his research output understandably dwindled.

As chairman of the NERC group responsible for terrestrial ecology, he visited all the institutes created by the previously independent Nature Conservancy, which had been incorporated as a statutory committee of NERC. Those institutes had been established to support the practical work of the Conservancy in safeguarding nature, and there were tensions when the Conservancy, as a NERC committee, resolved in 1971 to petition Ministers to remove it from the Research Council and place it instead under the newly constituted Department of the Environment. Many of the research scientists in the Conservancy institutes disagreed, and Jimmie, together with C. E. (later Sir Cyril) Lucas FRS, reviewed the options and recommended that they should stay with NERC even if the conservation branch was separated. In November 1971 Lord Rothschild's report proposed a customer–contractor relationship between research institutes and the users of their work, and this provided a way out of the dilemma. The conservation functions were transferred from NERC to a new Nature Conservancy Council, and Jimmie found himself centrally involved in the creation of a new Institute of Terrestrial Ecology formed from the institutes that stayed with NERC. He was directly involved in the appointment of M. W. Holdgate, his former student, as its first Director.

In 1978 Jimmie Beament succeeded V. C. Wynne-Edwards FRS as Chairman of NERC, a post he held until 1981. This elevation made him a member, *ex officio*, of the Advisory Board for the Research Councils and enormously increased his workload. In partnership with the Secretary of NERC (his Cambridge contemporary, R. J. H. Beverton FRS) he steered the Council through a difficult period, as Rothschild's customer–contractor principle established itself and Government-funded science came under increasing pressure. In 1980 he was knighted for his services to science. In the same period it was decided that the post of Chairman of NERC would become a part-time salaried one. In 1981 he stood down in favour of Sir Hermann Bondi FRS, although he remained a member of the Research Council for two further years.

All this work with the Research Council was done alongside Jimmie's continuing responsibilities in Cambridge. In 1977 he engineered the move of Applied Biology into the massive Austin Wing, recently vacated by the Cavendish Laboratory. Meanwhile the Department of Zoology was going through a difficult period. Torkel Weis-Fogh was involved in a tragic car accident in which his wife was killed and he himself was severely injured. Two years later, Torkel took his own life, ending an unhappy period for Cambridge zoology.

And more science and music

On retiring as Chairman of NERC, Jimmie Beament chaired the Central Electricity Generating Board's (CEGB's) Biological Research Advisory Committee and supported CEGB biologists in setting up new experimental research on the causes of acidification in lakes—then being blamed uncritically on 'acid rain'. At Loch Fleet in Galloway it became clear that the principal cause of the problem was the influx of organic acids produced by the decay of moss and of pine tree litter in the afforested catchment. Having 'limed' the lake, within 18 months it returned to having microorganisms, insects, fish and plant life. The research demonstrated that the deposition of sulphate and nitrate from the atmosphere was only one potential cause of acidification and that all the interactions within the catchment needed to be evaluated—something later to be the focus of joint research between the Royal Society and the Norwegian and Swedish Academies of Science at an experimental site in southern Norway. But although he presented the work to a three-day Discussion Meeting at the Royal Society in 1983 ('Ecological Effects of Deposited Sulphur and Nitrogen Compounds') it was not what the media wanted to hear and it received scant attention.

The world was changing and the need to get involved with industry-funded research was becoming ever more important, something with which Jimmie was not always comfortable. However, he formed a research group with the Research Director of Geest and developed a surface coating for bananas that inhibited their ripening without the need for refrigerated transport. With more time available to him, Jimmie was also able to return to basic science and he became interested in the surface properties of pollen and its adhesion to bees as well as in the various mechanisms that flowers have for preventing rain from destroying their pollen. He observed that bees, in response to certain stimuli, seem to be able to generate a charge of static electricity on their surface that enables them to collect pollen. He made a miniature gold-leaf electroscope to charge a honeybee when it landed on it. With Corbet and Eisikowitch (24) he then showed that the stigma of a flower, which receives the pollen from bees, is insulated by a thick layer of wax when it is immature and that when it is ready to receive pollen the wax breaks up and effectively becomes earthed, attracting pollen from a bee by an induced charge.

A collaboration with S. A. Corbet resulted in Jimmie's last two scientific publications, which investigated mosquito eggs (23). *Culex* mosquitoes produce a raft of about 150 eggs, which float on water. Refuting previous theories (that the eggs were held together by surface tension or by adhesion) they showed that the surface of the egg shell has precisely spaced pegs that interlock with other eggs, the female packing them together as she lays them. Sally Corbet went on to discover detergent-type materials that would sink the eggs and so kill them.

In 1989 Jimmie was awarded the Grundy Medal of the Royal College of Military Science. In the same year he retired from his university posts but he continued to serve Queens', chairing the committee to decide the fate of students who had failed exams, and becoming the

College Health and Safety Officer, using his experience to set up robust practices and structures. He served as Vice-President of Queens' from 1981 to 1986.

However, the urge to compose was strong and Jimmie's later years were dominated by music. A productive period of mature compositions included the production of a string octet, his first string sextet, a string quintet and then a second string sextet. In 1997 *The violin explained* (25) was published—a work that addressed the age-old problems of string tension, glue and varnish. There followed a series of lectures, including to the British Violin Makers Association at Dartington in 1999. Then came the book he had thought about ever since he had met von Békésy in 1961: *How we hear music* (27), in which he dealt with the perception of harmony and how musical sounds are coded by the sensory machinery in the ear. The book built on a paper he had written in 1977 (22). Also in 1999 his 1st String Sextet (26) was published; the acknowledgement by the established musical world that this signified probably gave him more pleasure than any of his scientific publications.

Jimmie Beament maintained an agile interest in all aspects of science throughout his career, balanced by a keen love of music and of his family and home—he did not enjoy holidays, preferring to spend his time maintaining his house and latterly, of great satisfaction to him, supporting Juliet in 'The Workshop', where she (later with one of their sons, Christopher) developed the increasingly popular violin-making classes. Jimmie invented innovative tools for use especially in the repair workshop and was as happy making them as writing his books or his music.

Acknowledgement

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The frontispiece photograph was taken in March 2003 by B. A. Callingham.

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