BIOGRAPHICAL MEMOIRS

Jack Lewis, Baron Lewis of Newnham HonFRSC. 13 February 1928 — 17 July 2014

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Jack Lewis was born and educated in Lancashire. He rose rapidly to become a highly renowned chemist who helped to pioneer the development of modern inorganic chemistry. He was one of the small group of scientists who led the expansion of inorganic chemistry from its renaissance, inspired by Professor Ron Nyholm in the mid 1950s, through the syntheses and study of new transition-metal and organometallic complexes. Their characterization was accomplished through the perceptive application of the newly available physical techniques of spectroscopy (electronic, vibrational and nuclear magnetic resonance), magnetism, mass spectrometry and X-ray diffraction. Jack completed his PhD at the University of Nottingham in 1952, and then held academic appointments in close succession at the University of Sheffield, Imperial College, London, and University College London (UCL) before being appointed Professor of Chemistry at the University of Manchester in early 1962. He returned to UCL as Professor of Chemistry for the period 1967–70 before being appointed the 1970 Professor of Chemistry at the University of Cambridge, a position that he held until 1995, when he was granted emeritus status. His dedication to the study and furtherance of inorganic chemistry was profound and his research achievements were made all the more remarkable when one considers his substantial additional high-profile responsibilities. In 1975 Jack became the first Warden of the newly established Robinson College in Cambridge, where he shaped and guided a progressive academic community until his retirement in 2001. Furthermore, his skill as a highly effective debater also took him, in 1989, to the House of Lords, where as a Life Peer he represented science with great enthusiasm and distinction until a few months before his death. He was a most effective chairman of the Royal Commission on Environmental Pollution from 1985 to 1992.
Early life and education

Jack Lewis was born in 1928 in Blackpool, the only child of Elizabeth and Robert Lewis. His father died only about two years later and, after his mother had remarried, he moved to live with his adored grandmother in Barrow-in-Furness. This was very convenient for the Barrow County Grammar School, which he attended with success from 1939 to 1946. His abiding sport at school was rugby union. From Barrow he gained entry to the University College, Nottingham, to study for the University of London External BSc degree, graduating with first-class honours in 1949. At the end of his first year Jack was elected to the student union, where he became social secretary and organized the Union Ball and other dances. Jack’s excellent quickstep attracted the attention of a certain Elfreida (Freddie) Mabel Lamb (figure 1), who entered the University of Nottingham in the same year as Jack to study mathematics and physics. Married in 1951 they had thus been married for nearly 63 years at the time of Jack’s passing.

Having decided that he would make his career in chemistry, Jack entered the research school at Nottingham to work under the supervision of Professor C. C. (Cliff) Addison (FRS 1970) on non-aqueous solvents. Jack’s PhD research involved the study of dinitrogen tetroxide and liquid sodium. Both are important inorganic liquids, the former being a component of rocket fuel and the latter a coolant for nuclear reactors. The dissociation of liquid N$_2$O$_4$ to NO$^+$ and NO$_3^-$ had earlier been established by Addison, and the research directed by him in a joint paper with Jack describes the reaction of zinc metal with liquid dinitrogen tetroxide (N$_2$O$_4$), as well as the rates and mechanism of their reaction together (1, 2)*.

* Numbers in this form refer to the bibliography at the end of the text.
This paper was the forerunner to many other papers by Addison and his group on the reactivity of N\textsubscript{2}O\textsubscript{4} with other reagents. It is a fine example of the application of physical techniques (determination of reaction rates, electrical conductivities, etc.) to inorganic preparations, a balance between measurement and preparation that exemplifies much of Jack’s subsequent work. A group photograph (figure 2) taken during this period shows Jack, partly obscured behind Norman Greenwood (FRS 1987), later Professor of Inorganic Chemistry, Newcastle upon Tyne, on the left and Cliff Addison on the right. Other work on N\textsubscript{2}O\textsubscript{4} at this time was carried out by his contemporary Alan Comyns at UCL, a person with whom Jack remained in touch for many years via their connection with British Titan Products and Laporte plc.

Jack obtained his PhD in 1952 and remained at Nottingham for the next two years on a postdoctoral fellowship supported by the Atomic Energy Research Establishment (AERE), Harwell, to work on the physical and chemical properties of sodium.

**EARLY ACADEMIC CAREER, 1954–70**

Jack chose an academic career and was appointed to an assistant lectureship, later a lectureship, at the University of Sheffield from 1954 to 1956, to a lectureship at Imperial College, London, from 1956 to 1957, and to a fellowship (1957) and lectureship (1958) at UCL, where he was promoted to a readership in September 1961. However, nothing is static: it was well known that Fred Fairbrother would be retiring from the Chair of Chemistry at the University of Manchester in September 1962. Jack applied for this position and, after very
protracted negotiations about the facilities and, in particular, the start-up grant (£13,000 plus a
lectureship was a lot of money to receive in those days), he was offered this chair and accepted
it as from 1 October 1962. He was only 34 years of age. After a scientifically very profitable
period in Manchester, Jack returned to UCL as Professor of Chemistry from 1967 to 1970, a
period that was referred to locally as his ‘second coming’.

Jack’s research interests expanded significantly during these periods at different universities.
This was partly because of the wide range of graduate and postdoctoral researchers and
visiting academics with whom he became associated or who chose to work with him. Jack’s
close association while at UCL with the distinguished Australian inorganic chemist Ron
(later Sir Ronald) Nyholm (FRS 1958) and his group also proved influential in determining
the direction of Jack’s research. One may examine Jack’s scientific career in terms of his
accomplishments at each of these universities.

**RESEARCH AT THE UNIVERSITY OF SHEFFIELD, 1954–56**

At the University of Sheffield Jack began an effective and lasting collaboration with
Ralph Wilkins (3). Here Jack developed an interest in magnetic studies of transition-metal
complexes, using both the Faraday and the Gouy methods. To undertake these pioneering
studies Jack built his own magnet, winding the coils for the electromagnets himself.

Linked to his earlier work with Addison, he also carried out a groundbreaking series of
studies on complexes of the nitrosyl ligand (NO). The rates of exchange of $^{36}\text{Cl}$ (obtained
from Amersham International) between (Me$_4$N)Cl and (Et$_4$N)Cl with NOCl were measured:
these are quite fast and were considered to arise from self-ionization of NOCl to NO$^+$ and Cl$^-$. This was later shown to have profound implications for nitrosation reactions using NOCl (3).

This difficult and dangerous work was supported by AERE Harwell and represented a new
departure for both Addison and Jack (2). Plates of zinc, copper and molybdenum were dipped
into liquid sodium under argon at various contact angles to study the ‘wetting’ of the metals
by the liquid; an ingenious torsion apparatus was devised for the work. The sodium metal was
a commercial sample and had to be purified by filtration at 150 °C through sintered glass. In
these circumstances it was found that zinc was wetted by liquid sodium, but that copper and
molybdenum were not, results that may have led to two later papers by Jack and Geoff (later
Sir Geoffrey) Wilkinson (FRS 1965; Nobel laureate 1973) on solutions of alkali metals in
ethers.

Jack’s study with D. B. (Brian) Sowerby expanded those on $^{36}\text{Cl}$ exchange with NOCl, but
here the substrates were POCl$_3$, AsCl$_3$ and SeOCl$_2$. It represents a rare but useful contribution
that Jack made to main-group chemistry. The paper reports exchange reactions between
(R$_4$N)$_{26}\text{Cl}$ (R = Me, Et) in CH$_3$CN, nitrobenzene and CHCl$_3$ with the substrates. For the first
two, the formation of [POCl$_4$]$^-$ and [AsCl$_4$]$^-$ was demonstrated, there being a direct interaction
between the oxychloride and $^{36}\text{Cl}^-$, first order in Cl$^-$ and oxychloride (4).

**RESEARCH AT IMPERIAL COLLEGE, LONDON, 1956–57**

Jack moved to Imperial College as a Lecturer in 1956; there he established a close research
association with Geoffrey Wilkinson on the synthesis and study of organometallic complexes.
He also collaborated with other inorganic colleagues, notably Denis Evans (FRS 1981), the local expert on nuclear magnetic resonance (NMR) spectroscopy, magnetism and the eating of red-hot curries. Jack co-supervised the PhD studies of William (Bill) Griffith, who comments—as did Martin Bennett (FRS 1995) (later at UCL and then at the Australian National University, Canberra)—that Jack’s lectures on inorganic chemistry were excellent. It was during this period that he also got to know F. Albert Cotton (Massachusetts Institute of Technology (MIT)), the US high-flyer in inorganic chemistry, who was collaborating with Wilkinson in writing the text of *Advanced inorganic chemistry* (Cotton & Wilkinson 1962).

Eight papers based on the research of Bill Griffith when a PhD student, on metal nitrosyl complexes, were published (5). In these papers, complexes already reported in the older German literature were examined by infrared spectroscopy and other appropriate techniques such as Gouy magnetochemical measurements applied to solids as well as aqueous solutions. Here, the brown complex \([Fe(NO)(H_2O)_5]^{2+}\) (which causes the colour in the old ‘brown ring’ test for nitrates) was shown to contain high-spin iron with three unpaired electrons per metal atom. Both the cation in solution and various solids containing it were studied, as were several other low-spin nitrosyls of iron, cobalt and copper, with a view to understanding the bonding of the coordinated nitrosyl (NO) ligand in such species.

**Research at University College London, 1957–61**

Jack’s stay at Imperial College lasted only 10 months: Ron Nyholm issued a call to Jack to come to UCL and join the vigorous group that he ran there. Ron had been responsible for the so-called ‘renaissance of inorganic chemistry’ in the mid 1950s and was attracting a large number of PhD students, postdoctoral fellows and academics from all over the world. Jack moved to UCL in late 1957, supported initially by a fellowship until he was appointed a lecturer there in early 1958. He became a Recognised Teacher of the University of London in April 1959, an appointment that, at that time, entitled a member of staff to supervise PhD students. He thus joined an international group of staff and doctoral students with a strong representation from Australasia and America. This necessitated the clarification of certain language difficulties, such as the meanings of ‘crook’, ‘digger’, ‘All Blacks’, ‘ANZAC’, ‘hogget’ and ‘lamb’! The in-house discussions in the research school concerning who could make the most striking discoveries and precision characterizations of new compounds were intense, as was the seemingly interminable banter on the outcome of cricket and rugby internationals. Jack may have been unaware of the somewhat dangerous version of table tennis carried out after hours in a corridor near his office in the ageing William Ramsay and Ralph Forster Laboratories.

Jack and Ralph Wilkins (University of Sheffield) had realized earlier that the effective characterization of transition-metal complexes and an understanding of their bonding and structures would require a detailed knowledge of many different physical techniques. Their co-edited book *Modern coordination chemistry: principles and methods* (11) was published in 1960 and proved ideal for this purpose, with chapters by F. J. C. Rossotti (thermodynamics), D. R. Stranks (reaction rates), R. G. Wilkins and M. J. G. Williams (isomerisation), T. M. Dunn (electronic spectroscopy), F. A. Cotton (infrared spectroscopy), and B. N. Figgis and J. Lewis (magnetism). The book became important reading for PhD students and postdoctoral fellows, not only at UCL but also in countless other universities worldwide.
Jack was not really a hands-on bench-top supervisor, but he was an excellent person with whom to discuss any difficulties with the research programme, career opportunities or, indeed, life problems of any sort. His biggest impact at UCL during this period was via his excellent communication skills at colloquia. In particular the Friday lunch-time colloquia (given by two different people each week) were usually attended by Ron Nyholm, Jack Lewis, Martin Tobe, Brian Figgins, Tom Dunn, Peter Pauling and the postdoctoral fellows and PhD students, and were both highly instructive and entertaining. Visiting academics in this period included Arthur Adamson (University of Southern California), Fred Basolo, Ralph Pearson, Jim Ibers and Lou Allred (Northwestern University), Al Cotton (MIT), Earl Muerterties (Dupont), Tom Meyer (University of North Carolina), Stanley Kirschner (Wayne State), Don Watts and Jim Parker (University of Western Australia), Stan Livingston (Sydney) and many others from ‘down under’, along with increasing numbers of Europeans, for example Lucio Cattalini (Padova), Victor Gutmann (Vienna), Klixbuhl Jorgensen (Geneva), and Asians, for example Shoichiro Yamada (Osaka). Woe to any person who had not sufficiently prepared their 20-minute presentation (with only 24 hours notice being given) to withstand all the relevant and penetrating questions from the floor! Jack took leave for the first six months of 1960 at MIT, where he developed his association not only with Al Cotton but also with many other leading American inorganic chemists.

One of Jack’s personal objectives at UCL was to understand the theory of magnetism, notably from and with Brian Figgis, who was an expert in both the experimental and theoretical side of transition-metal magnetism. The temperature-range liquid-nitrogen Gouy system built by Figgis in 1957 was very demanding in the complexity of its operation, but it did work until the mid 1960s and provided all the key results on magnetism from UCL. On the theoretical side Figgis and Jack were interested in the nature of the chemical bond in transition-metal compounds, as were many other inorganic chemists at that time. Figgis introduced the delocalization factor \( k \), better referred to as the fraction of time that the \( d \) electrons spent on the metal (\( k = 1 \) represents the ionic limit when the electron spends no time on the metal) (Figgis 1966).

Much highly original research in inorganic chemistry was completed by scientists within the Nyholm–Lewis group during these years (1957/58 to 1961/62) at UCL. Five exemplar topics are discussed below to provide a snapshot of these accomplishments (6–10, 12, 13).

In the first of these (6), Jack and colleagues carried out temperature-range magnetic susceptibility measurements on osmium, ruthenium, rhenium and iridium complexes with the \( d^3, d^4 \) and \( d^5 \) configurations and discussed the results in terms of Kotani theory. The relative importance of each assumption made in this theory was examined in the light of the magnetic results. This paper was the forerunner to a long series of studies on the magnetism of transition-metal complexes with various electronic configurations (\( d^1, d^2, d^3, d^8 \) and \( d^9 \)) and geometries (octahedral, distorted octahedral and tetrahedral) as well as of antiferromagnetic systems. Many such papers discuss the magnetic properties of the complexes studied with reference to the ligand field strengths, the interelectronic repulsions and the spin–orbit coupling of the ions, and the antiferromagnetism and magnetic exchange between the ions. In particular, those with David Machin and Frank Mabbs at UCL, and subsequently developed in Manchester, led to several further publications in this area.

In the second topic (7, 9), the coordination properties of the highly versatile ligand \( o \)-phenylenebisdimethylarsine, \( o-C_6H_4(AsMe_2)_2 \) (diars) were explored. The ligand was shown to form eight-coordinate complexes with titanium, \( TiX_4 \cdot 2\text{diars} \) (\( X = Cl \) or \( Br \)). The titanium
atom is bonded to four chlorine and four arsenic atoms to form a molecule with the classical
dodecahedral $D_{2d}$ symmetry of the $[\text{Mo(CN)}_8]^4-$ ion. VCl$_4$.2diars was characterized similarly.
This paper erased the long-held belief by inorganic chemists (including Al Cotton) that first-row transition metals such as Ti or V could not form adducts in which the metal atom had a coordination number of eight (figure 3). This research also demonstrated that ZrX$_4$ and HfX$_4$
(X = Cl or Br) formed isomorphous dodecahedral molecules (9), and later research (with David Kepert) demonstrated that NbX$_4$ similarly formed isomorphous dodecahedral complexes. These were paramagnetic owing to the d$^1$ electronic configuration of the niobium(IV).
Moreover, it was noted (with Bill Errington) that the reaction of diarsine with ZrCl$_4$ is much faster than that with HfCl$_4$, leading to the suggestion that the very closely similar elements Zr and Hf might effectively be separated through the different rates of reaction of their halides with diarsine. Although this did prove to be the case, the procedure was not economic because diarsine remained too expensive a reagent.

In the third topic (10, 11), the chemistry of titanium(III) was studied. This oxidation state for titanium had been difficult to establish owing to the large sensitivity to air and moisture of both its starting materials and any products. The necessary vacuum-line techniques, as originally developed and described in a thesis by Herzog from Jena, Germany, enabled the syntheses and study of several titanium(III) complexes to be carried out. Their characterization established the coordination chemistry, properties, electronic spectroscopy and magnetism of titanium(III) complexes. This allowed the recognition of the features in common with those of related vanadium(III) and chromium(III) complexes. Distortion of the ligand field from octahedral was established for both the ground and excited states of each complex, and the various ligands were placed in the spectrochemical series. Much research by Robin Clark (FRS 1990) and others in the mid 1960s in this field was funded by the British Titan Products Company in Billingham, a company whose research department, managed by Alan Comyns, was keen to develop the coordination chemistry of titanium and the industrial uses of titanium compounds.

In the fourth topic (12), metal–metal bonded complexes were classified into four main types: metals, concentrated metal compounds, covalent compounds and metal–donor compounds.
Conditions favouring the formation of covalent metal–metal bonds were discussed, attention being paid to the electron configuration and the effective electronegativity of the metal atom. The electronegativity of the d\textsuperscript{10}s\textsuperscript{1} atoms, for example in gold, was considered, and the formal similarity of these atoms to the halogens was emphasized. The compounds Ph\textsubscript{3}PAu[Mn(CO)\textsubscript{5}], (Ph\textsubscript{3}PAu)\textsubscript{2}Fe(CO)\textsubscript{4} and (Ph\textsubscript{3}PAu)Co(CO)\textsubscript{4} were synthesized and their physical properties were compared with those of Mn(CO)\textsubscript{5}I and Fe(CO)\textsubscript{5}I\textsubscript{2}. This paper led to the frequent use of the fragment Ph\textsubscript{3}PAu as an isolobal substitute for hydride in metal carbonyl cluster chemistry. It also encouraged extensive further studies on the syntheses and properties of metal–metal bonded complexes at UCL, notably by the Lewis group during Jack’s second period there, and later at Cambridge and elsewhere.

In the last of these topics, the formation was reported of chelate complexes with the general formula [LPtX\textsubscript{2}] (X = Cl, Br or I) with tertiary phosphines and arsines (L), containing the pentenyl group, having the formula CH\textsubscript{2}=CH(CH\textsubscript{2})\textsubscript{3} ER\textsubscript{2} (E = P, As). In these, both the olefinic double bond and the phosphorus or arsenic atoms were coordinated to platinum(II) metal centres. Although transition-metal complexes of Group 15 donors and of olefins had been well established by 1961, it was only then that the idea of using a ‘hybrid’ ligand containing both types of donor was realized (13). This was extended in the full paper (8) to the ligands 4-pentenyldiphenylphosphine, CH\textsubscript{2}=CH(CH\textsubscript{2})\textsubscript{3}PPh\textsubscript{2} and PhE{(CH\textsubscript{2})\textsubscript{3}CH=CH\textsubscript{2}}\textsubscript{2} (E = P or As). To extend the range of such complexes and to study the reactivity of the olefin modified by the metal, less flexible phosphorus-based or arsenic-based donors containing 2-vinylphenyl or 2-allylphenyl substituents proved to be advantageous. For example, bromination of planar PtBr\textsubscript{2} complexes of 2-CH\textsubscript{2}=CH(CH\textsubscript{2})\textsubscript{n}C\textsubscript{6}H\textsubscript{4}AsMe\textsubscript{2} (n = 0, 1) gave octahedral Pt\textsuperscript{IV}C σ-bonded species.

**Research at the University of Manchester, 1962–67**

When Jack moved to Manchester as Professor of Inorganic Chemistry in October 1962 he took the magnetochemist David Machin with him from UCL to help to set up and run this area of physical inorganic chemistry. Shortly afterwards he appointed Frank Mabbs (also ex UCL) as a research fellow (1963) and then as a lecturer (1964), Mike Ware (ex Oxford) as an assistant lecturer (1964) and then as a lecturer (1966), Brian Johnson (FRS 1991) (ex Nottingham) as a research fellow funded by the Department of Scientific and Industrial Research (1964) and then as a lecturer (1965–67), and Malcolm Gerloch (ex Imperial College) as a lecturer (1966–67). Jack thus formed an effective group that remained in operation for several years and, with Brian Johnson’s help, developed metal cluster chemistry during this period.

A year after Jack moved to Manchester, his close friend Ron (now Sir Ronald) Mason (FRS 1975) (an X-ray crystallographer) moved to the Chair of Chemistry at the University of Sheffield. The two young professors would occasionally meet at a hostelry in the Pennines somewhere between Manchester and Sheffield and plot out the future of inorganic chemistry in the UK, or so it was thought by the young bloods, who derived some comfort from this speculation. In Manchester Jack also became well acquainted with Geoffrey (now Sir Geoffrey) Allen (FRS 1976), and their friendship continued into the new millennium, when Allen, Mason and Lewis would lunch together at the Athenaeum Club in London several times a year to discuss science and politics.

Brian Robinson (University of Otago) has provided much information on the Manchester period. He comments that the confluence of new routine physicochemical techniques, the
installation of a high-pressure facility to synthesize metal carbonyls on site and Jack’s rapport with a like-minded Australian organic chemist, Arthur Birch FRS, were keys to this success. Moreover, Jack’s enthusiastic approach to research and his ability to attract enthusiastic and able postgraduate students and ‘lieutenants’, as well as his personal vision, created a platform for his prolific research output from Manchester. Research activity during this time was concentrated in three key areas: the synthesis and spectroscopic analysis of carbonyl complexes especially metal carbonyl clusters, the reactions of coordinated ligands, and magnetochemistry. Jack’s time at Manchester may therefore be seen as a period of transition, with the organometallic/carbonyl cluster research laying the groundwork for the later advances in this area at UCL and in Cambridge.

Significantly, Jack was among the first inorganic chemists to embrace modern physical techniques, including mass spectrometry and X-ray crystallography, for the characterization of the systems on which his group was working. This was especially true for his investigations of metal carbonyl complexes. These complexes lent themselves to routine mass spectrometry, a technique ‘owned’ at that time by the organic chemists, who were unhappy with the consequence of this inorganic intervention, namely that the probe had to be very carefully cleaned after use! This technique launched the work on metal carbonyl clusters that became a mainstay of the Lewis–Johnson collaboration over the next two decades (18).

The mass spectroscopic fragmentation patterns together with infrared spectra of carbonyl hydrides confirmed for the first time the presence of M–H–M bridges in these clusters. The mass spectra also showed the sequential loss of carbonyl groups from the metal clusters, and this, together with a careful analysis of the isotope patterns from the clusters, enabled the formulae of the clusters to be established and also provided an indication of the likely metal cluster core geometry without the need for an X-ray structure determination. The analysis of clusters by mass spectrometry was extended successfully to include the identification of new, unusual, clusters containing interstitial non-transition elements (14, 23). The synthesis and mass spectra of many new polynuclear complexes were reported (15–17, 22) in the late 1960s.

One of Jack’s other key research areas was that of understanding the reactivity of ligands coordinated to transition metals; again, the latest methods of chemical analysis were used to establish the nature of the complexes. A series of papers describing detailed studies with infrared and NMR spectroscopy, and sometimes magnetochemistry, of carbon-bonded platinum-β-acetylacetonate (19) were published. The acetylacetonate work provided a background for future studies on coordinated ligands, but it was the influence of Arthur Birch that initially produced the forward-looking research directed at the propensity of coordinated ring systems to undergo electrophilic attack. This research cemented Jack’s reputation in classical organometallic chemistry and highlighted the role of transition metals, sometimes as catalysts, in many organic reactions (21). The work describes the reaction of triphenylmethyl fluoroborate on 1,3-dieneiron complexes and the subsequent reactions with nucleophiles on the resulting dienyl cation. The investigation of metal olefin complexes resulted in several papers emanating from the final years at Manchester (24).

Jack also continued his work on magnetochemistry, begun at UCL, working in collaboration with David Machin, Frank Mabbs and, later, Malcolm Gerloch, all of whom developed their independent careers. Keith Murray (Melbourne) believes that Jack’s significant contribution to the development of inorganic magnetochemistry at Manchester was to introduce the subject into the curriculum via textbooks and reviews written with his collaborators and by books such as that by B. N. Figgis (1966).
The papers that had the most impact were those describing the variable temperature magnetic behaviour of the polynuclear complexes with strong linear M–O–M interactions: Cu carboxylates, Cr₃ and Fe₃ carboxylates, and, probably most importantly, Fe^{III}OFe^{III} cores in [Fe(salen)]₂O (salen = ethylenebis(salicylimine)) (20). These d-block polynuclear complexes demonstrated strong Heisenberg exchange coupling; the complex’s stereochemistry was interpreted with molecular orbital theory. The fundamental ideas on exchange coupling developed in these papers stood the test of time, predating the metalloprotein and metalloenzyme work of the 1970s onwards.

Many chemists from throughout the world will recall with great pleasure the generous hospitality of Jack and Freddie during this period.

**Research at University College London, 1967–70**

Jack returned to UCL as Professor of Chemistry in October 1967, accompanied by Brian Johnson and Malcolm Gerloch as lecturers. They operated during this period largely as a separate group within the Inorganic Chemistry section at UCL, although there was much joint discussion at departmental colloquia.

Ewen Smith comments that when he returned from the USA to UCL in 1967 on a fellowship to work with Ron Nyholm, he found that Ron was away at the time and that Ron’s cryogenic equipment for the study of the magnetism of transition-metal complexes over a temperature range was not suitable for low-temperature single-crystal spectroscopic studies. He also needed appropriate preparative facilities. Jack immediately realized his difficulty and asked him to associate with—not join—Malcolm Gerloch’s group, which had good magnetic balance facilities and also facilities with which to build the apparatus needed to grow large ion-doped single crystals. Robin Clark also made available his spectroscopic cryogenic set-up. Ewen thus made a good start and regarded Jack very highly both as a scientist and as a human being.

Memories from this period shed light on old-style chemical laboratory hazards! Jack had inherited the tiled benches in the old Ralph Forster and William Ramsay Laboratories from electrochemists via a group of biologists whose snails had, on occasion, died on the benches. Light was shed on this phenomenon when some tiles were removed to reveal pools of mercury underneath them; the human occupants of the laboratory seemed to be healthy—probably because of the thick dust film over the mercury. The large preparative laboratory was next door, and health and safety were taken seriously but in a way regarded as primitive in the present era. The open drains under the benches could lead to interesting fires if one of the many researchers poured solvent down the sink only for it to be set alight by something else further along in the drain. The most notable risk was from carbon monoxide leaking from some of the equipment. This led to shouts and evacuation of the building by everybody, including Jack, whose office was along the corridor. Ewen remembers Jack saying to him that there was a budgie kept in the laboratory at one point but it died and, after that, they relied on human detection of odours.
Jack Lewis

Research at the University of Cambridge, 1970–95

Jack was invited to take the Chair of Chemistry at Cambridge from 1 October 1970, and Brian Johnson and Malcolm Gerloch accompanied him from UCL. Two of the themes that emerged during the 1960s, namely the reactions of coordinated organic ligands and metal carbonyl clusters, flowered through the next decade or so (28, 30), and recognition followed rapidly for Jack (FRS in 1973, knighthood in 1982) (figure 4).

Three aspects of osmium cluster chemistry have proved to be very influential in coordination chemistry, heterogeneous catalysis and surface science. There is an appealing analogy between the reactions of ligands on a metal cluster and those occurring on a catalytic surface in heterogeneous catalytic reactions—‘the cluster-surface analogy’. Jack saw clearly that by using modern spectroscopic and diffraction techniques it was easier to determine what processes were occurring on the surface of a cluster than it was in a complex heterogeneous system, and that the understanding gained from the cluster chemistry could then be applied to the real catalytic systems.

This field was transformed by the development of new methods of producing a solvation site within \([\text{Os}_3(\text{CO})_{12}]\) by oxidizing a carbonyl group with trimethylamine oxide (30) (figure 5). The lability of the solvent molecule, \(\text{CH}_3\text{CN}\), created a low-temperature entry point to observe the stepwise activation of ligands by the cluster. For example, C–H cleavage of the ethene in \([\text{Os}_3(\text{CO})_{11}(\text{H}_2\text{C=CH}_2)]\) could be tracked through the vinyl complex \([\text{Os}_3\text{H}(\text{CO})_{10}(\text{HC=CH}_2)]\) to a vinylidene, \([\text{Os}_3\text{H}_2(\text{CO})_{9}(\text{C=CH}_2)]\). In each stage there is loss of a carbonyl ligand and this is offset by the coordination of the new Os–H and Os–C bonds. The \(\text{C}_2\) ligand is initially coordinated to one osmium, moves to an edge in the vinyl complex, and spans the face of the cluster in the vinylidene. Similarly, a two-step route from \([\text{Os}_2(\text{CO})_{12}]\) via the ‘unsaturated’ 46-electron cluster \([\text{Os}_6\text{H}_2(\text{CO})_{16}]\) had been developed to yield the cyclohexa-1,3-diene complex \([\text{Os}_3(\text{CO})_{16}(\text{C}_6\text{H}_8)]\), in which the diene was coordinated to a single osmium vertex.

Figure 4. Jack (right) celebrating the award of his FRS in 1973 with Sir Alan Battersby FRS (centre) and Professor Ralph Raphael FRS. (Online version in colour.)
The diene is also relatively labile and so the complex opened up selective ways to synthesize alkene and alkyne complexes, with different ligands being coordinated to a vertex, edge or face of the cluster.

Also related to the idea of the ‘cluster-surface analogy’ was the development of synthetic routes to higher nuclearity clusters in which there would effectively be a bigger metal surface with more potential coordination sites to mimic the metal surface. This field developed strongly from a detailed study of the thermolysis of \([\text{Os}_3(\text{CO})_{12}]\), which resulted in the isolation of pentanuclear to octanuclear clusters (25). The shapes adopted by the clusters were intriguing and stimulated much development of cluster bonding theories, with these clusters showing a remarkable relationship to the electron counting methods developed by Ken Wade (Durham) (FRS 1989) in borane chemistry and then extended by Mike Mingos (Oxford) (FRS 1992). There was indeed a rationale behind the cluster in \([\text{Os}_6(\text{CO})_{18}]\) (a capped trigonal bipyramid) not adopting an octahedral cluster framework, and \([\text{Os}_7(\text{CO})_{21}]\) incorporating a cage with a capped octahedron geometry (29). It was also shown that reduction of \([\text{Os}_6(\text{CO})_{18}]\) to its dianion, increasing the number of skeletal electron pairs from six to seven, did indeed result in a reorganization to an octahedral cage (26).

This work inspired the development of pathways to new high-nuclearity clusters of ruthenium and osmium at Cambridge. One of the trinuclear complexes that had been synthesized with a solvating organic ligand was \([\text{Os}_3(\text{CO})_{11}(\text{pyridine})]\) (30). Pyrolysis of this complex provided a route to a metallated pyridine ligand, attached to both trinuclear \([\text{Os}_3\text{H}(\text{CO})_{10}(\text{NC}_5\text{H}_4)]\) and pentanuclear \([\text{Os}_5\text{C}(\text{H})(\text{CO})_{14}(\text{NC}_5\text{H}_4)]\) clusters (31), with the latter also containing a carbide ligand. After chromatography on silica, the pentanuclear...
hydride, \([\text{Os}_2\text{H}(\text{CO})_{15}]^+\), was also a significant product. This may have been a precursor to the elegant \([\text{Os}_{10}\text{C}(\text{CO})_{24}]^{2-}\) cluster, which was the predominant species after long reaction times. This complex has many features relevant to heterogeneous metal catalysts: the tetracapped octahedral cage is a fragment of the face-centred cubic metallic structure, there is an interstitial carbide, and each face is essentially a (111) surface saturated with CO. The idealized symmetry in solution is \(T_d\) and as a result the \(^{13}\text{C}\) NMR spectrum of the cluster exhibits just two resonances for the terminal carbonyls: one from the four capping Os(CO)\(_3\) and the other for the six Os(CO)\(_2\) centres of the core octahedron; there is no evidence for any rapid exchange of CO between the two sites. An Os(CO)\(_3\) unit contributes no electrons to the skeletal electron count, and so, with the core cluster being an octahedron, this cluster cage too could be accommodated in skeletal electron counting methods. Just as single-crystal surface science studies provide atomic-scale definition of the events on heterogeneous catalysts, with large metal particle sizes, the high-nuclearity clusters provided calibration points for nanoparticulate catalysts (Johnson 1999).

NMR spectroscopic studies showed that in many of the carbonyl complexes the carbonyls were fluxional on the NMR timescale; that is, they moved over the cluster surface. With other researchers, such as Brian Heaton (Liverpool) working with the group of Paolo Chini (Milan), characterizing the structures of these complexes in solution proved to be challenging as a result of unexpectedly simple NMR spectra at room temperature. Hopping of ligands between sites and even fluxionality of the cluster cages could be monitored by variable-temperature NMR studies. At Cambridge, an elegant and influential study was developed on \([\text{Os}_3(\text{CO})_{10}(\text{PET}_3)_2]\) and \([\text{Os}_3(\text{CO})_9(\text{PET}_3)_3]\), for which both \(^{13}\text{C}\) and \(^{31}\text{P}\) NMR spectroscopy were used (27). In both complexes, all the phosphines adopt the same sites: an equatorial location always with a \(\text{P–Os–Os–CO}\) axis. As a result, in the tris-phosphine complex, which has an idealized symmetry of \(C_{3h}\) local to the cluster, there are just two \(^{13}\text{C}\) sites: axial and equatorial (2:1 ratio). These coalesce at 20 °C, demonstrating site mobility. For the ruthenium analogue the coalescence temperature was 10–20 °C lower, and this relates well to the proposed mechanism via an intermediate with a structure like that of \(\text{Fe}_3(\text{CO})_{12}\). Generally, the relative stability of bridging sites decreases on descending a triad of transition elements. The phosphine also has a role in lowering the barrier to bridge formation. The proposed mechanism involves the pairwise formation of two bridges from one axial CO from each of two metal centres. It is a selective process along a single Os–Os edge, and for the lower-symmetry bis-phosphine complex this does not result in total CO scrambling. However, at higher temperatures the two inequivalent \(\text{PET}_3\) ligands exchange sites. So this second process, taken in combination with the lower-energy exchange by the bridged intermediate, does result in total CO site exchange. This kind of study probed the energy differences between ligand arrangements in the clusters, and the effects of the nature of the metal and auxiliary ligands on these energy differences. Such patterns could be relevant to the mobility of metal surfaces with or without promoters and poisons.

The early years of the 1970s were a very exciting time to be part of the Lewis/Johnson research group in Cambridge. John Evans (Southampton), who was one of Jack’s first PhD students, remembers the special atmosphere of enthusiasm and optimism present, which allowed imagination to flow. Jack’s leadership and provision of resources gave his students the freedom to be inventive and they took pleasure in being able to report on progress during Jack’s morning rounds through the group. Jack displayed the rare capacity to keep his own pressures in the background and give each student his full attention.
Jack’s passion for cluster chemistry spread internationally and he frequently welcomed leading cluster chemists from around the world, including Al Cotton, Paolo Chini and Arndt Simon (Max Planck, Munich), to interact with his group at this time. Typically, Arndt remembers not only Jack’s enthusiasm for clusters but also the kindness he showed to him and others.

By the mid 1980s Jack and Brian had firmly established the Cambridge cluster group as the premier team studying cluster carbonyls of the iron triad, and had determined the archetypal structural motifs for clusters with nuclearities between three and ten metal atoms. The reactivity and manipulation of organic ligands once attached to the cluster surface continued to be of great interest. Jack’s team carried out many reactions with alkenes and alkynes that were bonded to clusters, but one of the most spectacular and elegant pieces of chemistry was the formation of a trinuclear osmium cluster in which a benzene ring was coordinated parallel to the triangular osmium unit, in a new face-capping mode. The cluster \([\text{Os}_3(\text{CO})_9(\mu_3-\eta^2:\eta^2:\eta^2-C_6H_6)]\) was obtained from the deprotonation of \([\text{Os}_3(\mu_2-H)(\text{CO})_9C_6H_7])\) with \([\text{CPh}_3][\text{BF}_4]\) and 1,8-diazabicyclo[5.4.0]undec-7-ene. The cluster was characterized by \(^1\text{H NMR spectroscopy}\) and a single-crystal X-ray diffraction study (32). A similar bonding mode for benzene was observed in the hexanuclear ruthenium cluster \([\text{Ru}_6C(\text{CO})_{12}(\mu_3-\eta^2-\eta^2-C_6H_6)(\eta^6-C_6H_6)]\), obtained using a different synthetic methodology. The cluster \([\text{Ru}_6C(\text{CO})_{14}(\eta^6-C_6H_6)]\) was initially reduced with methanolic NaOH to produce the \([\text{Ru}_6C(\text{CO})_{12}(\eta^6-C_6H_6)]^{2-}\) dianion, which was treated with \([\text{Ru}(\eta^6-C_6H_6)_2(\text{PhCN})_3]^{2+}\) to produce \([\text{Ru}_6C(\text{CO})_{14}(\mu_3-\eta^2-\eta^2-C_6H_6)(\eta^6-C_6H_6)]\).

The development of new, more efficient routes to higher-nuclearity osmium clusters, containing up to 20 metal atoms, continued throughout the 1980s and 1990s (34). The synthetic routes to these materials involved the pyrolysis or thermolysis of lower-nuclearity clusters under a range of conditions. The nature and number of the products obtained were very sensitive to the conditions used and, in general, the yields of the products were low.
However, the isolation and characterization of these higher-nuclearity clusters represent the identification of some of the first nano-clusters or particles, which are now of major importance in materials chemistry and catalysis. The two largest clusters synthesized and characterized by the Lewis–Johnson group were the dianions \([\text{Os}_{17}(\text{CO})_{36}]^{2−}\) and \([\text{Os}_{20}(\text{CO})_{40}]^{2−}\) (figure 6). These clusters were obtained by the vacuum pyrolysis of \([\text{Os}_3(\text{CO})_{10}(\text{NCMe})_2]_{10}\) at temperatures above 260 °C and at initial pressures of ca. 10\(^{-3}\) Torr. The \([\text{Os}_{17}(\text{CO})_{36}]^{2−}\) dianion contains a trigonal-bipyramidal core of 14 osmium atoms which is capped by three additional osmium atoms, whereas the \([\text{Os}_{20}(\text{CO})_{40}]^{2−}\) dianion has a tetrahedral cubic close-packed metal core of 20 osmium atoms and is the only example of a totally symmetric array of metal atoms of this nuclearity. It remains the largest osmium cluster carbonyl to have been isolated and structurally characterized, and the surface of this tetrahedral cluster is analogous to a fragment of a 111 metal surface (34).

Jack was among the first to understand that if carbonyl clusters were to have practical applications in the area of catalysis the yields of these materials needed to be scaled up. It was unlikely that this goal would be achieved by thermolysis or pyrolysis methods because of the difficulties in controlling the products obtained. His group therefore started to explore cluster build-up reactions that occurred under much milder conditions, and much of this work involved addition reactions through the unsaturated cluster \([\text{Os}_3(\mu-H)_{12}(\text{CO})_{18}]\) and the lightly ligated ligand cluster \([\text{Os}_3(\text{CO})_{10}(\text{NCMe})_2]_{10}\). However, the addition of cationic metal fragments to anionic metal clusters also proved to be a low-energy and effective way of building medium-nuclearity clusters in good yields. This approach was elegantly illustrated in one of Jack’s last publications on cluster chemistry, namely the use of the \([\text{Ru}(η^5-C_5H_5)(\text{NCMe})_3]^+\) cationic fragment to produce mixed-metal phosphine-stabilized clusters through anionic coupling reactions (37). Thus the room-temperature reduction of \([\text{Os}_3(\text{CO})_{11}(\text{PPh}_3)]\) with K/Ph\(_2\)CO and subsequent coupling with \([\text{Ru}(η^5-C_5H_5)(\text{NCMe})_3][\text{PF}_6]\) yielded the pentanuclear clusters \([\text{Os}_3(\text{CO})_{11}(\text{PPh}_3)/(\text{Ru}(η^5-C_5H_5)_3)]_2\) and \([\text{Os}_3(\text{CO})_{11}(\text{PPh}_3)/(\text{Ru}(η^5-C_5H_5)_3)]_2\) and the tetranuclear cluster \([\text{Os}_3(\text{CO})_{11}(\text{PPh}_3)/(\text{Ru}(η^5-C_5H_5)_3)]\) in good yields.

Jack Lewis was considered by one of his last PhD students to work on cluster projects, Lutz Gade (Heidelberg), to be the single most influential person in shaping not only his career as a scientist but also the entire way in which he approached a scientific challenge. Jack characteristically allowed him great freedom to develop his project independently but always offered deep insight into how challenges might be overcome.

From the early 1990s, Jack opened up a new area of research involving the chemistry of monomeric, oligomeric and polymeric platinum alkyne and poly-yne materials (33). This work stemmed from the earlier transition-metal cluster studies of metal alkynes because of his realization of the interesting optical and electronic properties that these materials might have, particularly in the solid state. His research, and the complementary work in Cambridge of Richard Friend (FRS 1993) and of Andrew Holmes (FRS 2000) on related organic materials, has led to the development of a new area of materials chemistry, and groups worldwide are now developing materials related to Jack’s original compounds for a range of opto-electronic applications (35). One of his first papers in the area described the synthesis of a range of new alkyne complexes of platinum and rhodium, in which new routes involving the use of bis-trimethylstannyl(acetylide) complexes afforded high yields of high-molar-mass organometallic rigid-rod polymers. In a later paper, in 1997, he showed elegantly that chemical manipulation of dinuclear platinum acetylide-functionalized oligothiophene complexes could be used to fine-tune the electronic properties of these systems (36).
Although Jack retired from the 1970 Chair of Chemistry at Cambridge in 1995, his interest in chemistry remained undiminished. He retained his exceptional intellect and sharpness of mind right up until his passing, and even 10 days before he died he could talk about chemistry and make insightful comments as to the way any project should be developed.

**ROBINSON COLLEGE**

In 1973 Robinson College was envisaged by its founder, David (later Sir David) Robinson, the entrepreneur and philanthropist, and a group of Trustees from the University of Cambridge including Professor Jack Linnett FRS, the Vice-Chancellor. From this early stage Jack was invited by the Trustees to become involved in the planning, building and development of Robinson College, and to become the first Head of House. Jack’s commitment to the process was unwavering and the college was opened formally by Queen Elizabeth II in 1981 with Jack as its first Warden, a post that he held with distinction until 2001.

One of the first three Fellows appointed by Jack to join the Robinson project in early 1976 comments that there was, at that time, simply a vast building site and that besides the college Officers, there were just three other Fellows designate. Barely four decades later, the same site is the centre of a richly varied and thriving community: this is an extraordinary achievement, made possible by David Robinson’s benefaction and Jack’s legacy of breathing life into the college. The task with which Jack had been entrusted was immense. Whereas the older colleges had evolved over centuries, Robinson College was to be built and set up in the space of five years. Not only did a large and complex building have to be constructed, but the whole social structure also had to be put in place: Fellows, tutors, students, administrative, secretarial, domestic and gardening staff had to be appointed, chefs and porters recruited, and statutes and regulations had to be drawn up. Fellows only much later realized what sacrifices he and Freddie had been required to make: for years they were unable to be out of reach or at any great distance from Cambridge. Yet entirely positive and even joyful memories of those early years of development were cemented, especially when the first enterprising students arrived—a handful of graduates in 1977 and a pilot intake of undergraduates in 1979, then many more when the new building was taken over in 1980. Fellows retain vivid memories of a first informal concert-cum-revue in the Hall—good-humoured satire was there from the start, and testified to the positive spirit that Jack engendered around him. This nurtured a college society that is unusual in its friendliness and lack of factionalism, perhaps one of Jack’s greatest achievements.

Underlying the practical decisions were important philosophical issues. Robinson was the first Cambridge college to admit both men and women undergraduates from its inception, thereby breaking with tradition. What should be the characteristics of a new college in an ancient university? Jack built a Fellowship that was totally mixed and balanced in terms of disciplines, gender and age, and was open to both new and older ideas of what a college might be. Jack understood the importance of a cohesive social structure and from the start Jack and Freddie warmly welcomed Fellows and partners to many social occasions. Jack’s vision was never just domestic: he also aimed at building up an intellectually active, open-minded academic community. From the start he attracted a variety of distinguished visitors from across the world, a great privilege and enrichment for such a young college. Frequent visitors to Cambridge such as Malcolm Chisholm (FRS 1990) (Ohio State) and John Fackler (Texas...
A&M) remember the warm welcome offered by Robinson College and the abiding kindness of Jack and Freddie.

When the college was finally built and staffed, Jack apparently knew everyone, whether porter, gardener, cook or housekeeper. He possessed a genuine interest in everyone he met, together with an extraordinary gift of conveying the impression that he had all the time in the world to deal with their problems. Undergraduates, too, were impressed that someone of such eminence had time to talk to them. Embedded in the chapel wall at Robinson College is a plaque recording the gratitude of the Fellows for the outstanding contribution of its founding Warden for, as the words inscribed on the staircase built in Jack’s honour express it, his wisdom shaped the college and made it what it is today.

The Royal Commission on Environmental Pollution

While in Cambridge Jack became involved in politics, and his interest in the environment grew. In 1982 he was appointed to the Royal Commission on Environmental Pollution (RCEP) and succeeded Sir Richard Southwood as its chairman in 1985. During his six-year term in this role the Commission undertook five studies, leading to the 12th report on Best Practical Environmental Option (1988), the 13th report on The Release of Genetically Engineered Organisms to the Environment (1989), the 14th report on GENHAZ—a System for the Critical Appraisal of Proposals to Release Genetically Modified Organisms into the Environment, the 15th report on Emissions from Heavy Duty Diesel Vehicles, and the 16th report on Freshwater Quality.

According to Thomas Radice and Professor Susan Owen, Jack took over the reins very smoothly at the RCEP and quickly established a good rapport with the colleagues he inherited from previous enquiries. Mrs Thatcher had possibly approved of his appointment because he was considered to be a safe pair of hands, less likely to produce difficult reports as had happened under Lord Flowers FRS (Nuclear Power and the Environment) and Sir Richard Southwood FRS (Lead in the Environment).

In the event the freshwater study, initiated in 1986, took a very long time to be completed and caused some concern within Whitehall. At a time when the consequences of water privatization were requiring the establishment of a new regulatory authority and the EC Waste Water Treatment Directive was threatening to distort the investment programme of the water industry, there was some dissatisfaction that the report was not published until 1992. However, once finally published the report was acknowledged to provide an influential contribution to the determination of priorities for improving freshwater quality in the environment.

The 13th report, on the release of genetically engineered organisms, was published in July 1989, five months after Jack had taken his seat as a crossbench peer. This report heavily influenced the drafting of Part VI of the 1990 Environmental Protection Act and Jack played a major role during the course of the Bill’s progress through the House of Lords in aligning the legislation yet more closely to the RCEP’s recommendations. The government’s response to this report was delayed until 1993, when the Secretary of State for the Environment acknowledged that, thanks to the RCEP’s 13th report, the UK now had in place a comprehensive and comprehensible system for releases of genetically modified organisms, one that could be adapted to meet the needs of modern science and industry along with minimal environmental pollution.


**THE HOUSE OF LORDS AND OTHER ACTIVITIES**

Jack’s interest and work in the area of the environment led to his appointment to the House of Lords in 1989. John Selborne FRS and Thomas Radice have commented that Jack’s well-received maiden speech in support of the Nature Conservancy Council on 27 July 1989 and interventions on the Environmental Protection Act established his reputation in the House of Lords as an authoritative contributor to environmental debates. He was never assertive, invariably courteous and always patient with others who might have been less familiar with some of the more intricate issues. When the Environment Bill was before the Lords in 1995 he moved amendments to promote better national management of air quality, an issue that had been highlighted in 1994 by the RCEP’s 18th report on Transport and the Environment.

After retiring from the RCEP Jack took on the role of chairing the subcommittee of the House of Lords European Communities Select Committee, which had the remit to scrutinize draft European legislation that concerned environmental policies.

Among the reports produced by Jack’s subcommittee was one on Packaging and Packaging Waste in 1993 and another in 1995 on Environmental Issues in Central and Eastern Europe: the PHARE Programme. After leaving the chair of the subcommittee he served on the main European Select Committee from 1997 to 2001 and was a co-opted member of the Science and Technology Committee for several inquiries that needed to call on his unrivalled expertise on environmental protection. In his later years he spoke infrequently, but when he did so he was always heard with great respect.

Jack’s intellectual curiosity led to his involvement in many other fields. He was fascinated by how the world worked and how it could be made to work better. Jack always had an interest in education, and higher education in particular. In Cambridge he chaired several of the Overseas Trusts, which funded many international students in all disciplines to study at the university at every level. He also helped to create the Judge Institute (later Cambridge Judge Business School) and was chair of its first Faculty Board.

Jack maintained his passion for the environment as President of the National Society for Clean Air and Environmental Protection and through his enthusiastic support for increasing the UK’s low level of woodland cover. One of Jack’s greatest areas of focus was waste. He was a popular and hard-working chair of Veolia Environmental Trust, which allocates landfill taxes to good environmental causes, and was influential generally in the waste industry.

He was also interested in the medical applications of science to combat, in particular, cancer, Alzheimer’s disease and arthritis, serving as President and a trustee of Arthritis Research UK from 1998 until 2012.

Over the last few years of his life Jack battled with cancer and with heart problems, but he maintained his enthusiasm for science until the very end. With great perseverance, he stoutly did his best to give his views to various environmental committees and organizations, and to provide references in support of his younger colleagues up until a few weeks before his passing.

**CONCLUDING COMMENTS**

It is no exaggeration to state that Jack Lewis, Baron Lewis of Newnham, made an outstanding contribution to the scientific and academic life of the nation. Jack’s development of new research areas and new groups within chemistry departments across the UK was exceptional...
and his work was honoured with the award of both the Royal Medal of the Royal Society (2004) and the Longstaff Medal of the Royal Society of Chemistry (2010) (figure 7). His effective chairmanship of the RCEP and of various research councils, and his wider parliamentary contribution in the House of Lords of scientific expertise and sharp intellect, were instrumental in shaping key government policies.

Jack’s influence and reach were recognized internationally and he received numerous awards from all over the world. His opinion was sought widely abroad and at home, and he acted as a referee for the appointment of many scientists to academic positions at all levels, to prizes and awards of many societies, and to numerous research councils. His establishment and wardenship of Robinson College has created an ongoing legacy that nurtures new scholarship and reflects Jack’s abiding interest in developing and supporting the next generation of thinkers. Indeed, Jack is remembered not only as one of the most influential scientists of his generation but also as a man whose kindness and generosity enriched the lives of those fortunate to have known him.

**Honours**

1973  Fellow of the Royal Society
1983  International Member, American Academy of Arts and Sciences
1985  Davy Medal, Royal Society
1987  Foreign Associate, US National Academy of Sciences
1994  American Philosophical Society
1993  Chevalier, Ordre des Palmes Académiques
Biographical Memoirs

1995  Accademia Nazionale dei Lincei
1996  Polish Academy of Arts and Sciences
       Commander, Cross of the Order of Merit (Poland)
1982  Knighted
1989  Created Baron Lewis of Newnham
2004  Royal Medal, Royal Society
2010  Longstaff Medal, Royal Society of Chemistry

Jack also received honorary doctorates from 20 universities.

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The frontispiece photograph was taken in February 1989 and is reproduced courtesy of the Chemistry Department, University of Cambridge.

REFERENCES TO OTHER AUTHORS


BIBLIOGRAPHY

The following publications are those referred to directly in the text.


(32) 1985 (With M. P. Gomez-Sal, B. F. G. Johnson, P. R. Raithby & A. H. Wright) Benzene in a new face-capping bonding mode: molecular structures of \([\text{Ru}_6\text{C(CO)}_{11}(\mu_3-\eta^2: \eta^2: \eta^2-C_6\text{H}_6)(\eta^6-C_6\text{H}_6)]\) and \([\text{Os}_3(\text{CO})_9(\mu_3-\eta^2: \eta^2: \eta^2-C_6\text{H}_6)]\). *J. Chem. Soc. Chem. Commun.*, 1682–1684.


