

THE LESSER KNOWN CHEMIST-COMPOSERS, PAST AND PRESENT *

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The most prominent chemist-composer was Alexandre P. Borodin (1833-1887), organic chemist, about whom much has been written (1). The chemistry and music of another chemist-composer, Lejaren A. Hiller, Jr., (1924-1994), polymer chemist, have been the subject of several publications (2). In addition to Borodin and Hiller, there were four previous chemist-composers, George Berg, amateur chemist-composer, Sir Edward W. Elgar, amateur chemist-composer, Georges Urbain, inorganic chemist-composer, and Emil Votoček, organic chemist-composer. There are also three contemporary chemist-composers, E. L. Bearer and Morris Kates, both biochemists, and Carlo Botteghi, industrial chemist. Their chemistry, music, and short biographies will be presented.

Previous Chemist-Composers

George Berg, Amateur Chemist-Composer (~1720-1775) (3-5)

Although the exact date is not known, George (or Georg) Berg was born about 1720 and as some sources suggest in Germany. He was an organist and a teacher of violin and harpsichord. At the Ranelagh Gardens in the late 1750s he probably played either the organ or the violin. He was elected a member of the Royal Society of Musicians in 1763, and was listed in Thomas Mortimer's *The Universal Director* as 'composer & teacher on the harpsichord, Lincoln's Inn Fields.' In the same year he won a gold medal from the Gentlemen and Noblemen's Catch Club (5). Although publication of his songs continued into the nineteenth century, the last book of his music appeared in 1769. He was elected a member of

the Society of Arts in 1769 and served on the Polite Arts, Mechanical Arts, and Chemistry committees. By 1771 he was organist at St Mary-at-Hill, Billingsgate, London, where he remained until his death.

He was a composer of instrumental and vocal music, including a collection of songs, especially those he wrote for entertainments performed at the Marybone, Ranelagh, Spring Gardens, and other pleasure gardens (entertainment complexes) in London. He published six books of Ranelagh songs; but nothing survives of his operas, his oratorio, *The Cure of Saul*, or of his ode, *The Invitation*. In 1763 he won a prize with one of his glees, *On Softest Beds*. A glee is an unaccompanied song for three or more solo voices in harmony (4). In 1759 he was the first to use the word sonatina in his *Twelve Sonatinas or Easy Lessons* (6). His galant works are considered cliché (5). Galant is a musical style featuring a return to classical simplicity after the complexity of the Baroque era. He was best known for his catches and part-songs, many of which were published in anthologies. Catch is a type of round in which the lines of music often interact so that a word or phrase is produced that does not appear if it is sung by only one voice (4). Part-songs written for multiple voices may be performed with or without instrumental or orchestral accompaniment. He also wrote an opera *Antigone* that was performed at Spring Gardens in London in February, 1764.

His more than 672 experiments in glassmaking were described in his "Experiment Book" (3,4). He was interested in learning chemistry, as it appears that he had no formal education in chemistry or glassmaking. Other objectives of the experiments were to prepare a clear glass melt, produce colored glass, some of which would

be imitations of natural gemstones, and make glasses for enameling metals. He was able to make colored glasses that could be ground and used to color enameled wares. He made gem-like glasses, either for the carved or molded "cameos and intaglios" that imitated antique stones or for the more prosaic false stones set into buckles, jewelry, picture frames, or other small metal wares. The Falcon, Salpetre Bank, and Whitefriars glasshouses allowed him to use their muffle or wind furnaces. These furnaces were found in the workshops of goldsmiths, watchmakers, and other artisans who might regularly use enameling colors. He probably used a smaller version, a kiln, for most of his experiments. For some of his products, he calculated the proportional gravity ratio of weight of glass in air to its weight in water for some of his products in 1766. In 1765, Delaval (7) suggested that proportional gravity or specific gravity was related to the color of glass. Perhaps Berg did not find this helpful as he did not use it after this year (3).

Berg died in 1775, between April 17 and May 4 (3).

Sir Edward William Elgar, Amateur Chemist-Composer
(1857-1934) (8-10)

Edward W. Elgar was born on June 2, 1857 in Broadheath, England. His father, who with his uncle owned a musical instrument shop, played the organ at the local Catholic Church. In addition to the organ, Edward played the bassoon, piano, and violin as well as being a conductor. When he was eleven, he wrote tunes for a play staged with his siblings, which were later published as *Wand of Youth Suites*. Ten years later, he composed *Harmony Music Four and Five Intermezzos*. In 1879 he became the conductor of the Worcester Amateur Instrumental Society and bandmaster to the Attendant's Orchestra at the Worcestershire County Lunatic Asylum in Powick. During the 1880s he played Popular Concerts in Birmingham, was a soloist at violin recitals for clubs, and taught violin to young middle-class ladies. In 1889 he married one of his pupils, Caroline Alice Roberts. One year later he composed a religious composition, *The Dream of Gerontius*, Opus



Sir Edward William Elgar

38, based on the poem of the same title by Cardinal Newman, a Catholic theologian. It relates the journey of a pious man's soul from his deathbed to his judgment before God and his settling into purgatory. In 1899 he completed the score for *Enigma Variations*. This was the work that finally secured his reputation as a composer of national and international standing. In this piece, fourteen people and one dog are featured. The first two *Pomp and Circumstance Marches* were composed in 1901 and the fifth and last in 1929. About the first march, he appreciated its worth and is quoted as saying: "I've got a tune that will knock 'em - knock 'em flat! ... a tune like that comes once in a lifetime ..." Elgar had 'arrived' (9).

His interest in science, prompted by new technology of the gramophone, led him to be the first major composer to record one of his own works in 1914. He conducted his composition, *Carissima*, in his first recording at the Gramophone Company on the "His Master's Voice" label, generally referred to as HMV. The company's London studios were located on an upper floor to minimize the effect of traffic noise and vibrations. The music was played with only a few instruments that could be clustered close enough to the recording horn. During World War I he wrote patriotic pieces such as *WWI*. He received many honors, including being created Knight Commander of the Victorian Order (K.C.V.O) in 1928.

After this event, he was known as Sir Edward Elgar.

One of his other interests was chemistry (11). At his Hereford house, Plas Gwyn, he set up a small laboratory in the basement. His manuscript of the *Prelude to The Kingdom*, dating from January 1906, bears the stains of his chemistry experiments. In August, 1908 he moved his laboratory to part of an outhouse. It was called The Ark because of the nesting of doves in the shed, and it had a telephone link to the house. A story about Elgar's hobby was related by W. H. Reed (12):

One day he made a phosphoric concoction which, when dry, would "go off" by spontaneous combustion.

The amusement was to smear it on a piece of blotting paper and then wait breathlessly for the catastrophe. One day he made too much paste; and, when his music called him, and he wanted to go back to the house, he

clapped the whole of it into a gallipot, covered it up, and dumped it into the water-butt, thinking it would be safe there.

Just as he was getting on famously, writing in horn and trumpet parts, and mapping out wood-wind, a sudden and unexpected crash, as of all the percussion in all the orchestras on earth, shook the room, followed by the "rushing mighty sound" he had already anticipated in The Kingdom. The water-butt had blown up; the hoops were rent; the staves flew in all directions; and the liberated water went down the drive in a solid wall.

Silence reigned for a few seconds. Then all the dogs in Herefordshire gave tongue; and all the doors and windows opened. After a moment's thought, Edward lit his pipe and strolled down to the gate, andante tranquillo, as if nothing had happened; and the ruined water-butt and the demolished flower-beds were pre-historic features of the landscape. A neighbour, peeping out of his gate, called out, "Did you hear that noise sir: it sounded like an explosion?" "Yes," said Sir Edward, "I heard it: where was it?" The neighbour shook his head; and the incident was closed.

When he moved to London in 1912, he turned to microscopes to satisfy his scientific curiosity.

Hydrogen sulfide (H_2S), known from alchemical times and variously named sulphur water or "Holy Water" (13), stinking sulphurous air (14), hepatic air (15), and—by Lavoisier—as "unknown combination" (16), became recognized as an important reagent for inorganic qualitative analysis (17). Elgar was one, although an amateur chemist, who produced a device to generate this important reagent, which he knew as sulphuretted hydrogen. As he wrote in a letter to August J. Jaeger, dated November 11, 1908 (10):

You will perhaps be amused - I hear that the 'new Sulphuretted Hydrogen Machine designed by Sir Edward Elgar' is to be manufactured & called the 'Elgar S.H. Apparatus'!! I will not offer to send you my invention - you would soon tire of it - although a nice toy.

This toy was "about as small as a hand (finger tip to wrist)." There is an inner chamber with a small hole at the top connecting it to the outer vessel. "The bottom of the outer vessel is perforated with a series of about 15 small drilled holes" (12, 18). It was made by the firm of Philip Harris (12, 18), and one is kept at Elgar's birthplace (19). His godsons, Atkins (20) and Kennedy (21) have written that it was patented. Atkins stated that it was "in regular use in Herefordshire, Worcestershire, and elsewhere for many years" (20).

Elgar died on February 23, 1934. He and his wife had one daughter.

Georges Urbain, Inorganic Chemist-Composer (1872-1938) (22,23)

Georges Urbain was born on April 12, 1872 in Paris, France. While he was studying at the École de Physique et Chimie de Paris, he was an assistant in the mineralogy chemistry laboratory where he met Pierre Curie, who inspired him to make chemical research his life work. In 1894, after he graduated as an Ingenieur-chimiste, he entered the Faculté des Sciences de Paris, where he started research in rare earths in the Laboratory of Organic Chemistry of Charles Friedel. Four years later he received the DSc. After six years in industry, he was appointed Assistant Professor of Analytical Chemistry at the Institut de Chimie, Sorbonne, Paris. In 1908 he was promoted to Professor of Mineral Chemistry. During World War I he was



Georges Urbain from (24)

Director of the Chemical Laboratory of the Technical Section of the Artillery, a member of Inspection des Etudes et Expériences Chimiques de Guerre, and President of the Comité Scientifique des Poudres et Explosifs and the Commission de Substances Explosives. In 1928 he became Professor of General Chemistry, Director, Institut de Chimie de Paris, and Codirector and Director of the Chemical Service, Institut de Biologie Physico-Chimique.

He was very popular with the students who "rose in a body when he entered the room" and "listened with such complete attention that there was not a murmur to be heard in the class of three hundred fifty students" (23). For his war service, he was made Chevalier la Legion d'Honneur in 1918 and Commandeur in 1933. In 1921 he was elected to the Académie des Sciences. He was an Honorary Member of the Chemical Society of London

and Corresponding Member of the National Academies of Belgium, Spain, and the USSR. He served as president of the French Chemical Society, Société de Chimie, and Société de Minéralogie.

Urbain was also a musician who played the piano and composed. Some of his compositions included, *A la veillée*, *Chanson d'Automne*, *Sur l'herbe*, and *Magagnose et Dyonisos*. In 1924, he wrote the book *Le Tombeau d'Aristoxène. Essai sur la musique*, in which he applied the scientific method to the study of music (25). In addition, he was a painter and sculptor.

In 1879 Lars F. Nilson separated Marignac's ytterbia into scandia and a new ytterbia, which Urbain then separated into neoytterbia and lutecia (ytterbium and an unknown element) in 1907. In the same year, K. Auer von Welsbach reported the spectra and atomic weights of two elements in ytterbia, which he named after the stars aldebaranum and cassiopium. Urbain named the element lutecium (Roman name for Paris), which was later changed to lutetium. Between 1895 and 1912 he worked on the rare earths and performed more than 200,000 fractionations to afford the elements samarium, europium, gadolinium, terbium, dysprosium, and holmium. In 1911 Urbain had studied element number 72, which he called celtium. The discoverers, D. Coster and G. von Hevesy, however, named it hafnium in 1923. He also discovered the law of optimum phosphorescence of binary systems and carried out research in isomorphism. He converted an analytical balance into a thermobalance before Kotaro Honda and discovered the law governing efflorescence of hydrates in a dry atmosphere. He also served on the International Commission on Atomic Weights.

Urbain wrote several books dealing with various chemical topics, spectrochemistry, 1911 (26), chemistry of complexes with A. Sénéhal, 1913 (27), chemical reactions, 1925 (28), and a general chemistry text with P. Job, G. Allard, and G. Champetier, 1939 (29).

Urbain died on November 5, 1938.

Emil Votoček, Organic Chemist-Composer (1872-1950)
(8, 31-32)

Emil Votoček was born in Arnau (Hostinné nad Labem), Bohemia, on October 5, 1872. After graduating from the gymnasium, he attended the School of Commerce in Prague where he developed an interest in chemistry. So, he transferred to the School of Chemistry (now the Prague Institute of Chemical Technology) of the Czech Technical University. In 1893 he received a diploma with the

degree of Ingenieur (33). Then he continued his studies in Germany, first at Mulhouse in Alsace-Lorraine, and a year later at Georg-August University in Göttingen. He returned to the Czech Technical University as an Assistant in 1895 and was promoted to Docent in 1905. One year later he was appointed Extraordinary or Associate Professor of Organic Chemistry and was promoted to Ordinary (Full) Professor of Inorganic and Organic Chemistry in 1907. He served as Rector of the University during 1921-1922, and in February, 1939 he was forced



Emil Votoček as Rector of the Czech Technical University from (32)

to retire by a decree from the Department of Education. However, he enrolled as a student so that he could continue his research. After the conquest of Czechoslovakia by the Germans, the universities were closed by order of the German occupation officials on November 17, 1939, until the country was liberated in 1945.

Although he was regarded as a learned and respected professor, he was often hot-tempered and irritable. His research laboratory was known as "Devil's Island," which represents the appearance and the mood in the laboratory (32). He lectured in both inorganic and organic chemistry and wrote textbooks in both fields. K. Preis and he wrote the inorganic text with Jaroslav Heyrovský (34). In the organic text (35) he introduced a new classification of organic chemicals dependent upon whether a compound was derived from the original hydrocarbon by substitution on one, two, or more carbon atoms. He also wrote a laboratory manual and a book of exercises in organic chemistry (36).

Votoček received honorary doctorates from the Czech Technical Universities of Prague, 1948 and Brno, 1927, the Universities of Padua, Nancy, and Toulouse, 1929, and from the Sorbonne. He was an honorary member of the Polish, Italian, Spanish, and Romanian

chemical societies, the Société de Chimie Industrielle, and the Société Chimique de France, which awarded him the Le Blanc Medal; and he was named Officier de la Légion d'Honneur and Officier de l'Instruction Publique. Other honors included the Ordine Corona d'Italia and Commander of Poland's Order of Polonia Restituta, 1932. He was nominated for the Nobel Prize in Chemistry in 1933, a year in which it was not awarded (32). However, one of his students, Vladimir Prelog, received the Nobel Prize in 1975 for his research into the stereochemistry of organic molecules and reactions, which he shared with John Cornforth for his work on the stereochemistry of enzyme-catalyzed reactions. On the centenary of his birth, 1972, a commemorative medal was minted and is awarded by the Rector of the Prague Institute of Chemical Technology as the highest recognition of scientific activity,

He played the double bass in addition to being a musicologist and composer. Among the 70 songs and works for piano and ensembles he wrote are *Allegretto grazioso*, 1932, *Thema con variazioni for piano and Soprano Voices*, 1934, *Trio for Piano, Violin, and Violoncello*, 1938, *Serenade for French Horn and String Quartet*, 1943, *Czech Polka*, 1944, *From Dawn to Dusk of Life*, 1945, and *The May Fairy Tale*, 1949. In 1946 he published the book, *Musical Dictionary of Foreign Expressions and Phrases* (37).

Among his many literary achievements were several chemical dictionaries for different languages: *Shorter German-Czech and French-Czech Chemical-Technical Dictionary* with B. Setlík, 1906 (38); *Czech-German-French-English-Italian-Latin Chemical Dictionary*, 1941 (39). He also published several for other sciences: *Czech-French-Terminological and Phraseological Dictionary for Chemistry, Physics and Related Sciences*, 1924 (40); *Polish-Czech Chemical Dictionary with Partial Regard to Mathematics, Physics, Geometry and Mineralogy*, 1931 (41). Two dictionaries dealt with the Czech and French languages: *Czech-French Conversation and Phraseology*, 1939 (42) and 1924 (40). He published two volumes containing all postmarks used in Bohemia up to 1918 (43). In 1929 he started the journal *Collection of Czechoslovak Chemical Communications* with Jaroslav Heyrovský, who received the Nobel Prize in Chemistry in 1959 for work in polarography. They also served as the editors until the journal ceased publication in 1939. When the journal resumed publication after World War II in 1947, Heyrovský continued as sole editor (44).

Votoček's research on artificial dyestuffs, carbohydrates, and analysis of natural products was published

in 300 articles. One of his main research interests was saccharides, especially methylpentoses. This interest was developed during his stay in Göttingen, where he worked with Bernard C. G. Tollens, who was noted for his research of the chemistry of saccharides. He studied the derivatives of rhamnose, L- fucose and its D-isomer, which he named rhodose. To describe two sugars that can be converted into each other, he invented the term epimers and the term epimerization for the reaction. He introduced the use of nitrous acid in the oxidation of sugars and synthesized a number of saccharides and saccharide acids and alcohols. Some of his efforts were devoted to nomenclature in carbohydrates and (with Alexander Sommer-Batěk) in inorganic compounds. He also served on the IUPAC Commission on the Nomenclature of Organic Chemistry. One of his studies on the derivatives of carbazole led to its application as an analytical reagent (Votoček's reagent) for the determination of sulfite in the presence of thiosulfate and thionate. He also introduced the use of sodium nitroprusside as an indicator in mercurimetric titrations. A more comprehensive account of his chemical work can be found in Ref. 32.

On February 17, 1906, he married Libuše, the daughter of an Austro-Hungarian minister; they had two sons and a daughter. He died October 11, 1950 in Prague.

Contemporary Chemist-Composers

The tradition of chemist-composers continues to the twenty-first century as illustrated by the activities of three contemporary chemist-composers, E. L. Bearer, Morris Kates, and Carlo Botteghi.

E. L. Bearer, Biochemist-Composer (8, 45)

Elaine L. Bearer was born on April 1, 1949 in New Jersey. Her early education began at age 6, and by age 9, the first performance of one of her compositions took place. After studies at Juilliard Prep School, she matriculated at Carnegie Institute of Technology, where she studied both music and computer science. Composition studies were with Carolos Surinach, Virgil Thompson, Don Wilkins, and Nicolai Lopatniff. She left Carnegie Tech after two years to travel to Paris, where she worked with Nadia Boulanger, the famed composition teacher. Returning to New York, with an interest in computer "algorithms" to generate sound, she completed a B. Music in 1970 from the Manhattan School of Music. From 1970 to 1973 she was an instructor in music history and appreciation at Fairleigh Dickinson University. Then she was recruited to San Francisco by Lone Mountain College as an Assis-



Elaine L. Bearer

tant Professor of Music in 1973, after having withdrawn from the Ph.D. program at NYU, which awarded her an M. A. in Musicology in the same year. After teaching composition at Lone Mountain, SF State University, and the San Francisco Conservatory, she decided to attend medical school. While preparing at Stanford University, she was a postgraduate research assistant in neuroscience with John Nicholls and a teaching assistant for Donald Kennedy. She was the first graduate from the M.D.-Ph.D. program at University of California, San Francisco in 1983. Then she served a residency in pathology there for two years. After a year at the Centre Médical Universitaire, University of Geneva, Switzerland, she returned for a postdoctoral fellowship in biochemistry with Bruce M. Alberts. In 1991 she joined the Department of Pathology and Medicine of Brown University as Assistant Professor. One year later she was appointed Adjunct Assistant Professor in the Department of Music. After six years, she was promoted to Associate Professor in both departments and Professor in 2004 in the Department of Pathology and Medicine and in 2005 in the Department of Music and in 2006 in the Division of Engineering. Since 1993 she has served as Director and Codirector of The San Lucas Health Project, which provides the indigenous Maya of the San Lucas Toliman, Guatemala region with free year-round primary health care.

One musical composition, *The Nicholls Trio: A Musical Biography of a Scientist*, is dedicated to her mentor, John Nicholls (45, 46). The final movement was inspired by electrical patterns in the neurons of leeches, which Nicholls studied. The piece was premiered at the annual meeting of the Society for Neuroscience in 1994. Her *Magdalene Passion* (45, 46), an hour-long oratorio for chorus, orchestra, and five soloists, was premiered in 2000 by the Providence Singers under Julian Wachner

In her research in molecular biology of actin-cytoskeleton, Bearer investigates dynamic cellular behavior. Presently, she uses a range of microscopic imaging and molecular techniques to understand the mechanisms of

these dynamics by using model systems, including squid giant axon, transport of Herpes simplex virus, and human blood platelets. Some of her recent studies address fundamental questions pertaining to learning and memory. She has published 45 papers on her research and is the editor of *Cytoskeleton in Development* (47) and co-editor of *Nature and Nurture* (48).

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Carlo Botteghi, Industrial Chemist-Composer (1938-2002) (49,50)

Carlo Botteghi was born in La Spezia, Italy, on March 5, 1938. In 1963 he graduated in chemistry from the University of Pisa. He continued there as a Lecturer of Organic Chemistry in the Faculty of Engineering until 1968. Then he took a research position at ETH (Polytechnic Institute) in Zürich, Switzerland, as Forschungsassistent and Oberassistent. He was also Lecturer in Organic Chemistry in the Faculty of Engineering and Director of the high pressure laboratory. In 1975 he became Professor of Industrial Chemistry at the University of Sassari, Italy, and Director of the Institute of Applied Chemistry. After ten years he became Professor of Industrial Chemistry at the Università Ca' Foscari di Venezia (University of Venice), Italy. In addition to teaching various courses in the area of industrial chemistry, he served as Director of Department of Chemistry for two 3-year terms.



Carlo Botteghi from (50)

He studied piano and music composition privately and has been registered in the Music Section of the Italian National Register of Authors since 1960. As a musicologist, he concentrated mainly on Pietro Mascagni (1863-1945), who was one of the important Italian composers at the turn of the 20th century, best known for his first masterpiece *Cavalleria Rusticana*. He was a noted Mascagni scholar or Mascagnano and the head of the Centro Studi Mascagnani of Livorno. In 1995 he wrote the music for the song *Mascagni* with words by Luigi Biagioni. It may be found on a CD entitled *Cieli*

di Toscana (Tuscan Heavens) performed by the popular Italian singer, Andrea Bocelli. In 1981 Carlo Botteghi wrote *Magari tu and Una giornata senza te* with words by Antonio Strinna. His book, *Le Suggestioni della Musica* (The Splendor of Music) was published in 1992 (51). In 1997 he published an essay on the opera, *Parsina*, entitled *Parisina –il dramma musicale di Gabriele D’Annunzio e Pietro Mascagni* (Parisina-the musical drama by Gabriele D’Annunzio and Pietro Mascagni) (52).

Botteghi published 150 papers in organic chemistry, homogeneous catalysis, hydroformylation, and carbonylation. One of his interests was conservation of buildings, and he did research in the synthesis of polymeric materials for this use. From 1995 to 1998 he also taught Conservation of Materials in Historical Buildings at the Architecture University Institute in Venice.

Botteghi died suddenly on September 19, 2002 and was survived by his first wife, Maria Grazia Bacci, and their two sons and his second wife, Vera Bellagamba, and their son.

Morris Kates, Biochemist-Composer (53,54)

Born in Galati, Romania, on September 30, 1923, Morris Kates was brought to Ottawa, Canada, one year later. He received a B.A., 1945, M.A., 1946, and a Ph.D., 1948 from the University of Toronto. After receiving his doctorate, he continued at the University as a postdoctoral fellow and then moved to the National Research Council of Canada, where he was first a Postdoctoral Fellow (1950-1951), and then a research scientist until 1968. In that year, he transferred to the Department of Biochemistry, University of Ottawa, as Professor, where he remained until he retired in 1989 as Professor Emeritus. During his tenure at the University of Ottawa, he served as Chairman of the Department of Biochemistry (1982-1985) and Vice-Dean (Research), Faculty of Science and Engineering. In 1995 he was named the Morton Lecturer, an award by the Biochemical Society to a lecturer who has made an outstanding contribution to lipid biochemistry. He also received the Supelco Award for lipid research from the American Oil Chemist Society in 1981. An issue of *Biochemistry and Cellular Biology* in 1990 was dedicated to him in honor of his valuable contributions to biochemistry in Canada (55).

Kates developed his twin passions for science and music during his youth and began studying violin at the age of 11. By the time he was in high school, he began composing music and exploring the world of laboratory

science. During his university studies he took courses in music harmony, counterpoint, and composition and played in the University of Toronto Orchestra. When he was at the National Research Council, he played in orchestras and



Morris Kates from (53)

string quartets in Ottawa. His first formal composition in 1946 was *Theme and Variations for Piano*, which was revised for strings in 1964. In 1990 he composed *Columbus* for baritone and full orchestra, and two years later, *Festive Suite for Brass Quintet and Strings*. His composition for choir and string quartet *Water—Source of Life* was released in 2000. He is an Associate Composer with the Canadian Music Centre and a member of the Canadian League of Composers.

Kates has published about 220 articles on the analysis, structure determination, biosynthesis, and membrane function of cellular phospholipids, the nutritional value of lipids, and the production of biodiesel fuel. One of his research projects was the discovery and study of a new class of glycerol-diether lipids in bacteria named *Archaea* that live in extreme environments. He is currently associated with the Ottawa Biodiesel Research Group in the Department of Chemical Engineering at the University of Ottawa, whose “main objective is to produce biodiesel in a cost-effective way by overcoming several barriers to biodiesel profitability”(56).

His books include *Techniques of Lipidology: Isolation, Analysis, and Identification of Lipids*, which is now in the second edition (57). In 1980 he and Arnisa Kulis edited *Membrane Fluidity: Biophysical Techniques and Cellular Regulation* (58), and four years later, with Lionel A. Manson, he edited *Membrane Fluidity – Biomembranes*, Vol. 12 (59). In 1990 he edited *Glycolipids, Phosphoglycolipids, and Sulfoglycolipids*, which is volume 6 of the *Handbook of Lipid Research* (60). Three years later he coedited *The Biochemistry of Archaea (Archaeobacteria)*, *New Comprehensive Biochemistry*, Vol. 26, with D.J. Kushner and A.T. Matheson (61).

Kates is married to Pirkko Helena Makinen, and they have three children and seven grandchildren.

Observations

The chemist-composers described above are experimental chemists; two amateur chemist, two biochemists, an industrial chemist, an inorganic chemist, two organic chemists, and a polymer chemist, but none is a physical or theoretical chemists. In performing experimental work, one sometimes involves “hunches” in solving problems, which may be more similar to the brain processes used in composing music than the abstract reasoning needed in solving problems in physical or theoretical chemistry. This does not apply to chemist-performers because some are physical chemists (e.g., Wilhelm Ostwald). Nor does it apply to several of the scientist-composers who are also mathematicians and physicists (62). It may be that the sample of nine chemist-composers is too small to derive any correlation between the area of chemistry pursued by the chemist-composers and their music.

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