Celebrating Chemistry and Art: National Chemistry Week 2001

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Abstract: For the year 2001 the theme of National Chemistry Week, the American Chemical Society's annual outreach program, is "Celebrating Chemistry and Art." Various examples of chemists who also made contributions to music, literature, and poetry are presented. The relationship of chemistry to such visual arts as painting, sculpture, photography, and art conservation is discussed. Useful resource articles are also cited. The history of National Chemistry Day, the brainchild of 1989 ACS President George C. Pimentel, and its successor, National Chemistry Week, are briefly discussed, as well as the desirability of a change in date because of competition from election news in the media. The new date for NCW, beginning in 2002, is announced for the first time.

Introduction

National Chemistry Week (NCW) is a fun-filled community-based program sponsored by the American Chemical Society's Office of Community Activities (Figure 1) [1]. It reaches millions of people with demonstrations, hands-on activities, open houses, contests, workshops, exhibits, classroom visits, and positive messages about chemistry. It is celebrated annually by the society's 189 local sections, educators, practicing chemists, industrialists, and others dedicated to chemistry. This year the ACS, founded in 1876, also celebrates its 125th anniversary.

Around the country mayors have issued official proclamations about NCW. For example, in Fresno, California, Mayor Alan Autry cited as reasons for declaring November 4–10 National Chemistry Week in the city of Fresno:

• Chemistry is essential for meeting our basic needs, improving the quality of our lives, and maintaining a strong economy.

• Citizens are increasingly called upon to make decisions on political, scientific, and technological issues in which chemistry plays a central part.

• The late Professor George C. Pimentel of the University of California, Berkeley, who originated the idea of National Chemistry Day, which evolved into National Chemistry Week, was a native of Fresno.

• America's chemists and chemical engineers wish to communicate with the public about the many benefits that chemistry brings to our lives and to respond to the public fears about the risks associated in the popular mind with chemistry and chemicals.

Chemistry and Art

The theme of this year's NCW is "Celebrating Chemistry and Art" [2]. For years I have maintained that research is as much an art as a science [3], that the scientist is as personally involved in his creation as is the artist, and that the sciences and humanities have much in common [4–5], "The Two Cultures" notwithstanding [6]. Novelist Lawrence Durrell has called science "the poetry of the intellect," and J. W. N. Sullivan has written that "it is the scientist, not the poet, who is the dweller in dreamland."

Because "scientific research is not itself a science [but]…is still an art or craft" [7], explicit rules for the conduct of research cannot be given, but what of the highly touted scientific method? Many scientists deny that there is such a thing as *the* universally applicable scientific method. Instead, chemist and former ACS president Joel H. Hildebrand wrote of "the methods of scientists" [8], which a given scientist may choose and combine to express his own individual personality, much as a painter selects and blends his colors or a composer chooses to write either a symphony or sonata. In his or her choice of a research problem and choice of the methods to solve it, a scientist exercises and expresses his or her own individuality. Who says that the scientist, unlike the artist, does not make value judgments [9]?

Music

Through the centuries science and music have been associated [10]. Intimate links between the two date from the time of Greek philosopher and mathematician Pythagoras of Samos (ca. 580 B.C.–ca. 500 B.C.). He discovered not only that the square of the hypotenuse of a right triangle equals the sum of the squares of the other two sides but also that the major intervals in a musical scale by dividing a vibrating string into proportional lengths. Although physics and music seem to have a special affinity, epitomized by Albert Einstein and his violin, chemistry has received increasing attention as evidenced by articles and letters concerning chemists who have combined a career in chemistry with one in either music performance or composition [11].

A number of chemists have been musicians, and a number of musicians have been chemists. Probably the most famous chemist–composer, the Russian, Alexander Borodin (1833–1887) (Figure 2) [12], Professor of Chemistry in St. Petersburg, is better known as a composer. His melodies provided Robert Wright and George Forrest with the themes for "Stranger in Paradise," "Baubles, Bangles, and Beads," "This Is My Beloved," and other favorite songs in their popular Broadway musical "Kismet." Similarly, when

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Figure 1. National Chemistry Week logo. http://chemistry.org/ncw. (Courtesy, American Chemical Society).

Figure 2. Aleksandr Porfir'evich Borodin (1833–1887), portrait with autographed excerpt from his opera, *Prince Igor*. Figurovskii, N. A.; Solov'ev, Yu. I. *Aleksandr Porfir'evich Borodin: a Chemist's Biography;* Steinberg, C.; Kauffman, G. B., Transl.; Springer-Verlag: Berlin, Heidelberg, New York, 1988; p 98. (Courtesy, Springer-Verlag).

thousands of students march down the aisle at graduation to the strains of "Pomp and Circumstance," they have English composer Sir Edward Elgar (1857–1934), an amateur chemist, to thank for the music [13].

Czech chemist Emil Votoček (1872–1950) provides another case of a scientist who combined careers in disparate fields. His success as an outstanding researcher in saccharides as well as a university lecturer and professor, linguist, lexicographer, and musician and composer shows that the differences between the sciences and the humanities do not necessarily lead to conflict [14]. Another case is that of French chemist Georges Urbain (1872–1938), an authority on the rare earths, who discovered lutecium (atomic number 71) and made contributions to spectroscopy, magnetism, cathode phosphorescence, and the determination of atomic weights, was also a gifted painter, sculptor, and musician [15].

In 1996 the father-and-son team of Christian A. Wamser and Carl C. Wamser presented a memorial tribute to American chemist–composer Lejaren A. Hiller, Jr. (1924–1994). Carl C. Wamser also organized and presided at a symposium, "Lejaren A. Hiller, Jr.: Chemist and Composer," at the 212th National Meeting of the ACS, Orlando, Florida on August 25, 1996. It featured papers about Hiller and the evolution of computer chemistry and computer music, and it included performances of excerpts from Hiller's musical works as well as compositions by Elgar and Votoček [16].

There are an even larger number of chemists who are musical performers. In an interview chemist Martin D. Kamen (b. 1913), codiscoverer of carbon-14 and himself an accomplished violist, told me [17]:

> The list is endless. For starters there's Gerry Edelman, Rockefeller University, a violinist; Hugo Theorell, the Swedish Nobel laureate biochemist, also a violinist; Kai Linderstrøm-Lang, the Danish biochemist, another violinist; John Postgate, the English microbiologist and jazz trumpeter; Jerry Meinwald, Cornell, a flautist; and Waldo Cohn, a cellist, who was the founder and conductor of the Oak Ridge Symphony…. It's unusual to find a cultured European intellectual who isn't also a musical performer.

Literature, Poetry, and Playwriting

C. P. Snow, the Cambridge University chemist–spectroscopist, best known for his *Strangers and Brothers* series of novels, lamented about the abysmal lack of communication between scientists and humanists in his influential and controversial book, *The Two Cultures and the Scientific Revolution* [6]. Yet, as I have demonstrated above and on other occasions [18], the wellsprings of creativity for both artists and scientists are the same. Thus we should not be surprised that poets or playwrights have written on science. As cases in point we can cite Germany's poet, dramatist, novelist, and philosopher, Johann Wolfgang von Goethe (1749–1832), and his research on color and minerals [19]; August Strindberg (1849–1912), Sweden's greatest playwright, often called "the Shakespeare of the North," who dabbled in alchemy and chemistry [20]; and Edmond Rostand's legendary, swashbuckling French playwright and poet Cyrano de Bergerac (1619–1655), who used science to popularize new theories and "predicted" a number of later discoveries such as the phonograph and the atomic structure of matter [21].

Conversely, a number of scientists have written poetry, for example, physicists J. Robert Oppenheimer (1904–1967) and Alan Lightman (b. 1948), the anthropologist Loren Eisley, and the immunologist Miroslav Holub. We chemists can claim Joseph Frederick Bunnett (b. 1921), who wrote a scientific article in free verse [22], and Primo Levi (1919–1987), the Italian chemist, novelist, and Holocaust survivor whose prose often verges on poetry [23]. More recently, two prominent American chemists, who fled the Holocaust in Europe, have embarked on literary careers in addition to pursuing their award-winning scientific contributions—Carl Djerassi (b. 1923), creator of the "Pill" [24], and Roald Hoffmann (b. 1937), the 1981 Nobel laureate in chemistry (Figure 3) [25].

The name of Vienna-born Carl Djerassi is almost synonymous with the first and most widely used oral

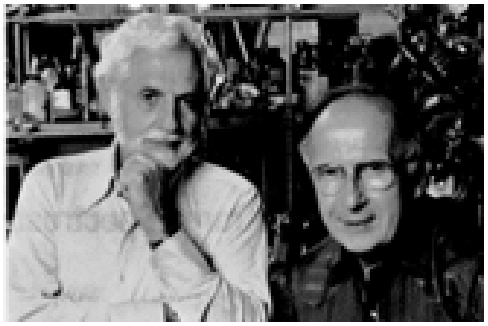

Figure 3. American Chemical Society Joseph Priestley medalists Carl Djerassi (left) and Roald Hoffmann (right), coauthors of the play, "Oxygen." Photograph by Robert Barker. (Courtesy, Roald Hoffmann).

contraceptive agent, norethindrone (19-nor-17-α-ethynyltestosterone), which he synthesized in 1951—half a century ago. He has also actively contributed to the fields of steroids, antihistamines, anti-inflammatory agents, alkaloids, terpenoids, antibiotics, sponge sterols, and physicochemical techniques. On July 5, 1978 Djerassi's daughter Pamela, an artist who had been chronically depressed for years, committed suicide, and Djerassi decided that his response to this tragedy would be "to create something living out of a death…patronage of the type that would have benefited Pami" [26]. Together with his third wife and fellow Stanford University faculty member, Diane Middlebrook, he founded an artists' colony at his SMIP (Syntex Made It Possible) Ranch in the Santa Cruz Mountains. It provides a secluded environment where composers, visual artists, choreographers, and poets can express their activity. Administered by the Djerassi Foundation, its Resident Artists Program has supported more than 600 artists. Djerassi is also an avid art collector.

Djerassi wrote several short stories, which were published in 1988 as *The Futurist and Other Stories*. Following a cancer operation in 1985, Djerassi decided "to test the seriousness of [his] intellectual commitment to a new literary career…[proceeding] concurrently along two paths—one fictional, the other autobiographical" [26]. Accordingly, he has written several novels, most dealing with science and scientists in what he calls "science-in-fiction" [27], autobiographies [26, 28], memoirs [29], a book of poetry [30], and two plays, one of which, *Oxygen*, coauthored with Roald Hoffmann, has received considerable critical acclaim [31].

Like Joseph Conrad, whose native language was Polish but who won fame as a writer of novels in English, Hoffmann was born in Poland. Now Professor of Physical Science at Cornell University, he was introduced to poetry while he was an undergraduate student at Columbia University by the renowned teacher, writer, poet, and critic Mark Van Doren. Entranced by his courses in the humanities, he would have switched to art history if he had not encountered two excellent chemistry professors; however, the primary reason for his choice of chemistry was his summer research experiences at the National Bureau of Standards in Washington (1955, 1956) and the Brookhaven National Laboratory (1957).

Hoffmann began writing poetry in 1977, but it was not until 1984 that his work began to be published. His work is characterized by vivid metaphors and images, many drawn from scientific concepts or ideas as well as academic themes; yet many of his verses speak to a wider audience. Exotic locales, drawn from his extensive travels, form the *mise en scène* of many of his poems that deal with otherwise everyday personal events and experiences. Hoffmann's first poetry book, *The Metamict State* [32], contains 47 of his poems, involving his experiences both inside and outside the laboratory. Fourteen of these were published in various magazines, journals, or books between 1984 and 1987. A number of the poems in his second collection, *Gaps and Verges* [33], were written during his residency at the Djerassi Foundation SMIP Ranch. He has also published a third collection of poems, *Memory Effects* [34].

Hoffmann has written [35],

> I have no problem doing (or trying to do) both science and poetry. Both emerge from my attempt to understand the universe around me, from my own personal affection for communicating, teaching what I've learned, and from my infatuation with language—the English language, as well as other languages that geopolitical accidents have thrust into my head.

A true Renaissance man, Hoffmann has written many popular articles and books on science that have emphasized the esthetics of chemists' work [36]. He was the narrator and presenter for "The World of Chemistry," a series of 26 half-hour programs on the Public Broadcasting System (PBS) that aired in 1990 and was broadcast widely abroad [37]. He has admirably succeeded in realizing his self–imposed roles of scientist, poet, articulate spokesman for science, and teacher.

The Visual Arts

Form and color are two areas of crucial interest to both chemists and visual artists [38]. In fact, numerous chemists, including me, were initially attracted as adolescents to the central science by the beautiful and intriguing colors of many chemical compounds as well as by the color changes that take place during chemical reactions, including the reactions of acids and bases with indicators [39]. According to Michael Freemantle, "color is the most visual, pervasive example of the importance of chemistry to our lives" [40]. This common concern of both chemists and artists with color and form has led Mary Virginia Orna to organize and teach a course on chemistry and art for art majors at the College of New Rochelle [38]. For more than a quarter century she has devoted herself to field work and research on the topic and has enriched the scientific and educational literature with her findings [38, 41–47].

Although there are undoubtedly chemists who have been painters, sculptors, potters [48], metal workers [49], or photographers, and vice-versa, chemistry plays such a direct role in the visual arts that almost every visual artist uses chemistry, either directly or indirectly, in his or her work. Sculptures can be made of wood, metal, plaster, clay, marble, plastic, or other materials. Each material acts in a certain way depending on the chemical compounds or mixtures that compose it. The behavior of these materials can often be related to the familiar electromotive series [50]. These substances control how the material can be carved, bent, chipped, or smoothed [2]. The paper or canvas that an artist uses is also composed of chemicals. He or she can draw pictures with crayons, paints, pencils, or chalk. Each of these is composed of different chemicals and gives different visual and textural effects [2].

Figure 4. A Modern pigment shop in Venice, Italy, where traditional painters can buy pigments to mix into paints themselves. (Courtesy Michael Douma).

Crayons are made of wax produced from petroleum hydrocarbons. Paints are made of either water or oil with added chemicals called pigments [41, 42, 44, 46, 47, 51–53] (Figure 4). Different pigments produce different colors. The colors perceived by our eyes are caused by the transition of electrons in atoms or molecules from one energy level to another. Different transitions produce different colors [54].

Egyptian Blue ($CaCuSi_4O_{10}$) is the oldest known synthetic pigment, having been found in mural paintings at least 3000 years old [38]. Azurite ($2CuCO_3.Cu(OH)_2$) was used as early as the fourth Egyptian dynasty (ca. 2575-2465 B.C.), and it was the most important blue pigment used during the Middle Ages by European painters. Natural ultramarine, derived from the mineral lazurite ($3NaAlSiO_4.Na_2S$; lapis lazuli), was more famous but much less used. It has been identified in sixth- and seventh-century Afghanistani wall pigments, but it has now been replaced by synthetic ultramarine, an important commercial product.

Alizarin (1,2-dihydroxyanthraquinone) and indigo ($C_{16}H_{10}N_2O_2$), organic pigments obtained from plants but now artificially synthesized by chemists, have been used since prehistoric times [47]. Inorganic artists' pigments used in ancient times include Chinese vermilion (HgS), verdigris ($Cu(C_2H_3O_2)_2 \bullet 2Cu(OH)_2$), and Venetian red ($Fe_2O_3$). Cochineal, derived from the body of a female cactus insect (*Coccus cacti*), is a pigment but can also be used as a dye as in 18th-century British military uniforms worn by the "Redcoats."

Although we call pencils "lead pencils," they contain no lead but rather a combination of clay (hydrated aluminum silicates) and graphite (a form of the element carbon).

Chalk is primarily calcium carbonate ($CaCO_3$), found in nature as the mineral limestone or the marble used by Michelangelo Buonarroti (1475-1564) to create masterpieces such as his "David" and "Pietà." Michelangelo spent four years lying on his back painting a fresco (Italian, "fresh") on wet plaster on the Sistine Chapel ceiling. As the wet plaster dried, its calcium hydroxide combined with the air's carbon dioxide to produce calcium carbonate, which traps the paint so that it cannot peel, chip, or wash off:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$$

Photography, which literally means "writing with light" in Greek, employs chemicals such as silver salts or dyes that are sensitive to light. The amount of light that strikes the silver halide or dye determines how dark it turns. Photographs are produced when different amounts of light strike a surface or film covered with these chemicals. Of course, developing also involves chemical reactions [55].

Some chemists conserve, preserve, or restore deteriorated works of art such as the "Last Supper" (1495–1497) of Leonardo da Vinci (1452–1519) [56, 57]. Others authenticate old masterworks, prove alleged forgeries [58], or date artifacts such as the Shroud of Turin. The solvents and other materials used by artists may be poisonous, and chemists can evaluate the hazards involved and suggest safety measures to prevent accidental poisonings [59].

Resource Articles

Through the years numerous articles on chemistry and art have appeared in various journals and magazines. In April 1980 the *Journal of Chemical Education* featured a special section of nine articles by seven different authors, which have been cited separately above [60]. On the occasion of National Chemical Week the October 2001 issue of the same journal contained a special section of six articles by six authors, which have been cited separately [61–65]. It also included a detailed annotated and classified bibliography of previous *Journal of Chemical Education* articles [61]. Additional articles appeared in the November 2001 issue [66]. Magazines such as *ChemMatters* (October 2001) have also carried articles related to National Chemistry Week [57, 67–69].

The Need for a Time Change

National Chemistry Day (NCD), expanded to National Chemistry Week (NCW) since 1989, usually takes place around local, state, or national election time and therefore competes for publicity with political events every other year. For a number of years, many of us have been writing NCW articles for our local newspapers, and it is usually "touch and go" as to whether the newspapers will have space for them. Because the 2000 national election was particularly newsworthy, one of my articles [70] appeared only on the very last day of NCW (Nov. 11, 2000)—after all of the local NCW activities had occurred. My conversations and correspondence with other ACS members, including past presidents and others involved with NCD and NCW, have revealed similar difficulties, and they have supported a change in date.

History of National Chemistry Day

National Chemistry Day (NCD) was the brainchild of the late George C. Pimentel (1922–1989) [71], ACS president in 1986, as one of the primary projects of his presidency [72], but NCD did not materialize until 1987 during Mary L. Good's presidency, with her enthusiastic support. The date was decided upon, not by Pimentel, but as the result of a process of elimination by a consensus of individuals. Bad weather eliminated the winter months, and the National Science Foundation's competing National Science & Technology Week (NSTW) eliminated the spring. NSTW has since been discontinued, but competition remained from Easter and

similar holidays as well as the spring ACS meeting. Because participation by academics was desired, the summer months were not desirable, and September and early October would not have allowed sufficient time to prepare for the events in schools. Mid-November and all of December were eliminated because of Thanksgiving and year-end holidays. The date of November 6 was decided upon because in 1987 it fell on a Friday, allowing local sections to continue activities through the weekend. According to then NCD Coordinator Randall Wedin [73],

> In choosing the date for NCD, we took into account a large number of considerations—academic calendars, weather conditions, holiday schedules, local section calendars, dates of ACS meetings, amount of planning time needed, and optimum date for maximum press coverage.

On May 5, 1987 Congressman Doug Walgren of Pennsylvania introduced H.J. Res. 265 designating Nov. 6, 1987 as NCD; however, the resolution was never enacted, and no governmental action was ever taken to establish NCD or NCW. ACS officials decided that better use could be made of time and money than by pursuing this option. Although the President of the United States "does not make any proclamations or declarations of any sort" [74], he or she may, if requested, send a letter of encouragement to the ACS.

History of National Chemistry Week

Although the ACS did not declare a NCD for 1988, it was celebrated by some local sections. In 1989 the ACS expanded NCD to a full week (Sunday through Saturday) as a biennial event. In that year it took place from October 29 to November 4. Its encroachment upon three days in October shows that there was nothing sacrosanct about confining it to November. Beginning with 1993 it became an annual event held during the first complete week in November.

Proposed Date Change

I relayed the above facts to William H. ("Jack") Breazeale, Chairman of the ACS NCW Task Force, and to a number of ACS presidents, members or staff who had been involved with NCD or NCW or had expressed interest in these events. I proposed changing the date of NCW so that in the future it does not compete for newspaper and other media coverage with local, state, or national elections, holidays, meetings, or other events that might detract from the attention that it merits. Congress or the U.S. government would not be involved in any date change so it could be entirely the decision of the ACS NCW Task Force, Board of Directors, and the membership at large.

I suggested that the date of NCW be changed to the last full week in October, which, in some years, would include Mole Day, October 23. It would not conflict with Hallowe'en except in rare cases, and if that were to pose a problem, the date could be changed to the penultimate full week in October.

In 1986 George Pimentel received a letter from a Wisconsin high school teacher, accompanied by ten students' letters, suggesting that Mole Day would be more appropriate as the date of NCD [75]. This suggestion was rejected because [73]

> focussing too much on Avogadro's Number and the definition of a mole could dilute the message we want to convey. In fact, the scientific notation that lies at the heart of your choice of October 23 as Mole Day might intimidate some non-scientists and lead them to conclude that chemistry is hard to understand and is not relevant to everyday life.

However, I suggested that if the inclusion of Mole Day within NCW has a strong appeal, the date could be the last week in October that includes October 23. My main concern was that the date be changed from the present first full week in November.

I enlisted the help of Jeanne Pimentel, George's widow, who fully supported my petition by stating [76],

> I am sure that changing the date would not be counter to his [George C. Pimentel's] wishes and that he would approve of any action to further his original purpose for NCD—to "provide a focal point for activities and programs that demonstrate the commitment of chemists and chemical engineers to building the public understanding of chemistry….and highlight the role of chemistry in raising the quality of life, in meeting societal needs, and in contributing to the nation's economic strength"

Mrs. Pimentel kindly appeared before the NCW Task Force in San Diego, CA on March 31, 2001, immediately before the 221st ACS National Meeting (April 1–5, 2001). Our petition was viewed favorably, and the date of NCW was changed to the fourth week in October, beginning with 2002.

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