

FROM STEREOCHEMISTRY TO SOCIAL RESPONSIBILITY

The Eclectic Life of Otto Theodor Benfey

James J. Bohning, *Chemical Heritage Foundation*

It was an "idyllic" period for a young boy born on 31 October 1925 into a Berlin family of culture and accomplishment. In the summer there were long hikes to the snow-covered areas of the Austrian or Swiss Alps, followed by a refreshing drink of naturally cool apple cider and perhaps a snowball fight with his friends. During the school year in Berlin, he was very happy with his elementary school teacher, who stayed with his class during the first four years of schooling. He even was caught up in the excitement accompanying the massive parades of Adolf Hitler.

But the innocence of youth and the protection of his parents could not shield Otto Theodor Benfey from being frightened when he watched some boys jeering another boy their age as they squeezed him into a wire trash basket and rolled him down a hill. When his family decided to send him to live with friends in England in 1936, he experienced a similar taunting from his Berlin peers which included statements about his Jewish background. Yet for the ten-year-old Benfey, the first two years in "exile" were still idyllic. He was staying in a "lovely place" with the Mendls, a family he had known in Berlin. He was attending the Watford Grammar School with their son, Wolfgang, who was Benfey's age. And for the first two summers, he went back to Berlin on transatlantic luxury liners, once seeing Max Schmeling returning after his defeat by Joe Louis. What he did not know was that his mother was hiding jewelry in his suitcases for safe-keeping with the Mendls when he returned to England.

As the political situation in Germany deteriorated, Benfey's family made plans to leave the country. His father, Eduard, had been the Chief Justice of the Supreme Court of Economic Arbitration during the Weimar Republic and had earned a doctor of law degree at Göttingen. At first he believed that Hitler "was a passing phenomenon who wouldn't be a serious problem," but after the *Kristallnacht* in November 1938, he also sent Benfey's younger brother and older sister to the Mendls in England. Benfey's mother, Lotte, refused to leave without her husband, but did apply for an American visa because her sister and brother-in-law, Anni and Josef Albers, who had been on the faculty at the Bauhaus, were then teaching at Black Mountain College in North Carolina and could vouch for her. Fortunately, the American consulate later put Eduard on his wife's application number rather than assigning him to the end of the list. Otherwise, Benfey is convinced, his father would never have gotten out.

Benfey's siblings stayed only a few months in England, and then joined their parents as the family immigrated to the United



As a Boy Scout in England, circa 1937

States. When the Mendls suggested that young Theodor should stay in England until the family was settled in their new home, he didn't object. "I was doing well at school and I was very happy there," Benfey recalls. Little did he realize that while his family would be starting out as typical immigrants in an "awful hole in New York and slowly working their way out of it," he would seven years later be "sailing in with a Ph.D. and a traveling fellowship to Columbia."

In spite of his Jewish family background, Benfey was baptized as an infant in the Lutheran church because his parents had converted during a time when many of the Jews were trying to forget their Jewish background and become assimilated into the German culture. When the bombing started in London, it became impossible for Ted and the Mendls to travel from Watford in the northwest suburbs to the only Lutheran church in the center of the city. Both Ted and Wolf Mendl were subsequently confirmed in the Church of England, but its "nationalistic attitude" and prayers for "destroying the Huns" disturbed Wolf's mother, who "had great sympathy for the German people and felt the suffering of the Germans under the

Nazis." She and Wolf found the Quakers a satisfactory religious community, while Benfey "went through the whole gamut of nonconformist churches before joining the Friends." It was a decision that would have far-reaching consequences for the rest of his life.

Even though his mother and father spoke English, Benfey had "minimal English" when he was first placed in the Watford Grammar School. But he quickly learned the language, and was urged to go into language teaching because of his German background. Considering that an insult because it was not something he had mastered but something he "just knew," Benfey found math and science more appealing, "in part because it required less facility in the language." Since the English education system specializes rather early, Benfey selected a science track that was university directed. He contemplated specializing in math, but wanted to bring it "down to earth, to do something useful and practical with it." In the British system science subjects were not concentrated

in a single year but administered in smaller doses. From age eleven on, he was exposed to some chemistry every year, with the other subjects going "forward in a similar manner." His chemistry teacher, "Inky" [R.W.] Knight, was not very exciting, but sufficiently "good and solid" to maintain interest through a prosaic exposure to substances and their properties.

It wasn't until he reached the sixth form (pre-university year) and was introduced to organic chemistry that he really became excited. Benfey found stereochemistry particularly inspiring because he had "always loved geometry" and had already worked through many of Euclid's proofs. It was then that Benfey decided to major in chemistry, and the geometric

aspects of chemistry have been important to him ever since.

With Knight's assistance, Benfey applied to universities, and was subsequently notified that University College London (UCL) had a place for him. While Eduard Benfey was still in Germany, he had been able to give some of his money to a Jewish fund that could still ship out money. Some of it went to Woburn House, a London organization that dispensed money for refugees who were separated from their parents or were otherwise in need. The crystallographer Rosalind Franklin did volunteer work there, and Benfey speculates that she may have processed some of this "Wundergeld" that helped with expenses as he started his studies in 1942, living in a

cooperative student hostel in the seaside resort of Aberystwyth in Wales, where most of the UCL chemistry department had been relocated. The only time the war got close to him there was during a physics lecture, "when the professor was talking about something having an impact, and at that moment a mine exploded at the end of the pier!"

Physically, the 30 stu-

dents from London were part of the University of Wales, and Benfey found the Welsh singing ability to be very "memorable." He was also impressed with the scholarships given to Welsh students who were willing to teach in the Welsh school system for four years, a concept that is slowly being adopted by some states in the U.S. some 50 years later. Living in the hostel brought contact with a diversity of other students, and a close friendship developed with Stephen Awokoya, who would later become a leader in science education in his native country of Nigeria and then head of science education for UNESCO in Paris.

The UCL students and faculty were partially integrated into



Benfey (left front) and fellow members of "The Lodge" hostel during his student days in Aberystwyth, 1944

the Welsh program, and the rigorous schedule called for an hour of lecture at 9:00 a.m. and 4:00 p.m., with labs in between, five days a week. Classes were not "quantized;" instead, one professor would lecture "until his subject ran out," and then another would begin a different topic. In addition to the traditional topics, some covered prosaically and some superbly, there was even Samuel Sugden talking about his parachor (a measure of surface tension used to deduce structure). Benfey found the organic lab, supervised by C. A. Bunton, to be most rewarding. He admits to a "tremendous esthetic delight in preparing colored, beautiful crystals," an enjoyment that in subsequent years he would pass on to his own students. Only a few years ago did he discover that the author of the lab text, Julius B. Cohen, was his father's first cousin (1).

During the two years Benfey spent in Wales, Christopher Ingold was a "benign presence." There were rumors that he spent three hours preparing each lecture. He lectured only on those areas he had worked on himself, except for "one strange series of six or eight lectures called "history of chemistry," which Benfey found "deadly dull" and which he ironically confesses turned him off "almost permanently from ever conceiving of teaching a course concentrating only on chemical history." These lectures, Benfey vaguely recalls, covered early ideas on stoichiometry, an area which had been impressively surveyed by Ida Freund in 1904 (2). Yet within the last few years Benfey has recognized that his interest in presenting topics historically, the sense "that you can't understand anything in the sciences unless you see it from its intellectual and historical context," stems directly from Ingold's organic lectures where topics such as aromatic substitution and the nitronium ion were developed in an historical context, as can be seen in Ingold's classic text (3).

In 1944 Benfey experienced the final examination endurance test, maneuvering through a marathon of six consecutive three-hour exams in a three-day period, followed by six-hour lab tests on qualitative and quantitative analysis, organic preparations and qualitative organic analysis. His physics minor was tested immediately afterward. Even though it was a "frightening" experience, he received the B.Sc. degree with first class honors. Sensing that after the Normandy invasion on 6 June the war might end shortly, the UCL contingent returned to London and Benfey was asked to continue with Ingold for the Ph.D. By that time Benfey was attending Quaker meetings regularly, and considered himself a pacifist. If he didn't stay at UCL, he would be subject to the draft and would have to file a conscientious objector request as a Quaker.

Acknowledging that for most of his life he didn't wonder where he would be going, but that it "just happened," Benfey agreed to remain, but informed Ingold that he could not work on a problem that was related to weapons and destruction, such as aromatic nitration, which had direct relevance to TNT. Ingold put him to work on aliphatic substitution and evidence for the carbonium ion (now called the carbocation). Benfey



Christopher K. Ingold

proceeded, "blissfully confident" that his topic could have no destructive consequences. Only later did he realize that mustard gas action involves the sulfonium ion, a carbonium ion analog. But nitrogen mustards also have medical applications, forcing Benfey to realize that "the purer the science, the more it is capable of constructive and destructive applications."

Although two wings of the main structure at University College had been destroyed by bombs, the chemistry building remained intact. The graduate students were lined up in a large basement laboratory, and Ron Gillespie, now at McMaster University in Canada, worked on the opposite side of Benfey's bench. Gillespie was preparing nitronium perchlorate, and had triplex glass panels between himself and his experiments for protection in case of an explosion. But there was only a wooden partition separating those same experiments from Benfey's bench, and it "wasn't even hardwood!"

With Patton's armies caught in the Ardennes Forest, the war continued through the winter, and the V-2's started striking London. Living back at Watford and commuting daily, Benfey remembers the difference between the V-1 used earlier in the war and the newer V-2. The V-1 was a pilotless drone, and when the sound stopped, "you knew it was about to descend and you ran for cover." The V-2 was a rocket that moved faster

than sound, giving no advance warning. "If you heard the explosion, you were safe, because it had landed elsewhere." Fortunately, they never got closer than about a mile from UCL.

Ingold had been using the effects of salts on the rates of alkyl halide hydrolysis reactions for evidence of the carbocation and Louis Hammett had proposed that there could be specific solvent effects of the salts affecting the dielectric constant of the medium. Benfey's assignment was to test the salt effects and demonstrate that they were only explainable by the carbocation mechanism. The kinetics became very complex, but he was able to show that two salts could have inverse effects depending on the leaving group of the alkyl halide, exactly the opposite of what Hammett had predicted (4). He is particularly proud of learning to determine chloride ion in the presence of bromide ion electrochemically, because he did that through his own literature search. At the time, Benfey didn't realize that his Welsh connection was following him experimentally, for it was K. J. P. Orton in Wales who had taught kinetics to Edward Hughes, who in turn "brought the kinetic emphasis to Ingold."

It was expected that the Ph.D. would be completed in two years, and Benfey remembers being very discouraged during his first year because he couldn't get repeatable data. He saw Hughes and Ingold daily, and was particularly encouraged when Ingold told him, "You'll do one-eighth of your work during the first year, and seven-eighths the second." The dichotomy of Ingold's personality is reflected in Benfey's description that in "personal relationships he was the most warm and gentlemanly individual; when you put a pen in his hand he could be absolutely vicious." Consequently, Americans were genuinely surprised by his charm when they first met him in this country.

Hammett "graciously" accepted Benfey's results, indicating that he wasn't fighting the carbocation but just offering an alternative explanation that needed to be explored. Based on Benfey's written research proposal, a London University postdoctoral traveling fellowship was awarded, paying for all his expenses to work with Hammett at Columbia for one year. It was assumed that Benfey would return to a suitable teaching position in England, and he indicates that not only was he "totally convinced that he was coming back," but that he had been "brainwashed" into believing that "no persons in their right mind would immigrate to America unless they had to as refugees. Culture was in Europe, and Americans were too materialistic."

When he arrived in New York at the age of 21, Benfey experienced "one of the most embarrassing moments" in his life. As the first postwar Ingold student to arrive in the States, he was visited by C. Gardner Swain, E. S. [Ted] Lewis, and George S. Hammond, who quizzed him on the real meaning of several of Ingold's papers. Although he had read Hammett's text (5), Benfey admits that he had never heard of them or their work, and was unable to discuss results in the wider context of physical organic chemistry. He found it "shocking" that UCL

did not encourage students to read the literature, and felt that when he did so it was something "that was not quite approved of," as if he were checking on his teachers. "Even though we were given a historical background in Ingold's lectures," Benfey concedes, "it was not to see that science keeps on changing. It was to show how science was being completed by UCL. We were taught chemistry as if it were the word of God - the answer."

Except for once-a-week conferences with Hammett, Benfey was all alone and had one year to produce results. His "strange" problem was on mercury-catalyzed solvolysis and olefin formation, which he claims he "sort of solved," but "never felt very confident" that he did "something significant." Hammett's name does not appear on the publication, which Benfey attributes to Hammett's desire to give him "stature" by indicating that Benfey was the only contributor (6). Benfey was impressed with the vigor and scientific turmoil at Columbia in 1946 and 1947, but in spite of the superb faculty talent there was little coherence between the professorial research groups. He admits that he was living "in his own little world" where his mental intensity was focused on his research problem and did not allow for much exploration and interaction.

Benfey's interest in the history and philosophy of science can be traced to his graduate school years at UCL. Although he was head of the Student Christian Movement at UCL, many of his peers were quite left-wing oriented, and some of the graduate students and faculty were members of the Communist party. Benfey's religious convictions led him to disagree with their philosophy that science was just the tool of capitalism and that after the war communism would take over, planning and organizing science to serve the people. Realizing that as "an amateur" it would be futile to sustain an argument with the communist proponents because they were so well informed and could "demolish you instantly," Benfey embarked on a reading program that began with Arthur Eddington and James Jeans. Eddington, who was a Quaker, made Benfey feel "it was safe to be influenced by him." During a confining illness, which he suspected was caused by a fellow student working with cyanide, Benfey's religious reading ranged from Albert Schweitzer's autobiography to the French Catholic writers and the English mystics (7). These religious interests continued at Columbia, where he attended 15-minute worship services at Union Theological Seminary in his morning transition between International House, where he was staying, and his own work at Columbia. Here he heard such luminaries as Reinhold Niebuhr, Paul Tillich and Arnold Toynbee.

Benfey's deep concern for the human condition is reflected in his reaction to the 1945 bombing of Hiroshima. Already sensitized by the increasing lack of feeling about killing humans as the Allies resorted to blanket bombing of German cities rather than pinpointing targets, he "walked in a daze through the streets, wondering whether humans had gone totally mad." He "seriously questioned what place there was

for someone with any kind of sensitivity and concern for doing constructive work to stay in science, if this is what can happen to scientific knowledge." It also forced him to be more aware of the "left-wing claims that this kind of activity had to be controlled." Influenced by Albert Schweitzer's example, he "toyed with the idea of switching to medicine" and even attended some biology lectures at Columbia, where he gave the idea more serious thought. He finally talked himself into staying in chemistry, working "as far as possible towards directing it in humanitarian directions." To justify that position, he rationalized that he could always get out later if his goal was unattainable.

After arriving in New York, Benfey had quickly changed his opinion about America, marveling at its technical proficiency and overwhelmed by its beauty. As a Quaker, he had heard of Haverford College and Rufus Jones, a leading theological figure who taught there. He had thought that if he were ever "stuck in America," Haverford would be the place where he wanted to teach chemistry. Nevertheless, he was amazed when "out of the blue" came a letter from the Haverford chemistry department saying, "Dr. Henry Cadbury of Harvard University Divinity School informs us that you might be interested in a teaching position." (Unknown to Benfey, his sister was in contact with Cadbury, a former Haverford professor, through the American Friends Service Committee in Cambridge, and told him about her brother.) Coming to the conclusion that he really wanted to stay in America, Benfey felt it was only fair to the British who were supporting him that he finish the calendar year at Columbia, and arranged to start at Haverford in January of 1948.

At the age of 22, Benfey became the fourth member of the Haverford chemistry department, which was graduating four to eight chemistry majors a year from a student body of about 500. William Buell Meldrum, the department head, had written a basic text in which the early chapters were organized historically and philosophically (8). Because of that and the Ingold influence, Benfey began his teaching career using that same historical emphasis, believing that "was the way to teach." Only later did he discover that it was very unusual. He was also prepared to introduce physical organic chemistry and reaction mechanisms into the first year organic course. But Meldrum told Benfey that he had contacted such stalwarts as Roger Adams and Henry Gilman, who agreed that approach was not acceptable. Thus Benfey "taught analytical and physical and all sorts of things," but never the first year organic course. He was allowed to present his "new" ideas as theory in a later course.

Feeling that it was "obvious" to have students involved in research, Benfey started with a "kind of gap-filling" project on molecular addition compounds between dinitrobenzoates and α -naphthylamine that reflected his own "enjoyment of qualitative organic analysis." The collected results from several summers of work supported by the Research Corporation re-

sulted in two papers (9). He also found that he could grow whiskers of the addition compound from vapor deposition of the amine, though this was never formally published (10). But it was not laboratory research that would become Benfey's forte. His brief career at Haverford was the launching pad for activities in chemical education and the history of science that remain life-long commitments, and have earned him much professional and personal respect.

In 1949 Benfey attended the founding meeting at Haverford of the Society for Social Responsibility in Science (SSRS), the brainchild of Victor Paschkis, a Viennese immigrant and engineer at Columbia. Most of the group were Quakers or like-minded people who were "energized by the Hiroshima bomb" and who:

... felt the need for scientists to see if there would be some way of influencing society to move, as far as possible, to the prevention of science being used for greater and greater destructiveness. They also wanted to see if they could help with problems where science could be used for good purposes such as in third-world countries.

The idea spread rapidly, with similar groups forming in other countries and among other disciplines. Benfey "threw himself into that organization," and became its second president in 1951.

Also in 1949, Benfey attended James B. Conant's renowned summer school on case histories in experimental science. Here he heard Leonard Nash and Thomas Kuhn among others, and the "excitement of getting at the original writings of such chemical pioneers as Boyle and Dalton, seeing their struggles within the total context of their work," gave him "the real impetus to explore the history of chemistry." His fascination with Prout's hypothesis, "because it involved a numbers pattern," led him to a more detailed study and ultimately a publication (11). But the Prout paper was another learning experience, for Benfey confesses that he knew "nothing about literature searches" and thought he was "terribly original." After being told his draft contained little that was new, he "slowly learned what was new and original, or at least what was somewhat novel." He acknowledges that it was Claude Deischer, Curator of the Edgar Fahs Smith Collection of the University of Pennsylvania, who helped him successfully rework the manuscript.

The developing intensity of Benfey's interest in the history of science is reflected in his early Haverford days. He spent the summer of 1950 "just reading the classic works in history and philosophy of science," and embarked on what would become an almost annual offering of a course on some aspect of the history and philosophy of science. Knowing that he could be demanding with the Haverford students, Benfey began by taking his first course through Kant's *Critique of Pure Reason* (12). Although "glad" he "plowed through it," Benfey concedes that he was uncertain how much of it he understood and

never dared to repeat this *tour de force* after Haverford.

When Yale's Henry Margenau came to Haverford as a visiting lecturer in physics and the philosophy of science, he started Benfey on yet another project. Yale was publishing a series of Ernst Cassirer's works in English and had already rejected the efforts of two translators for *Determinismus und Indeterminismus in der modernen Physik* (13). Margenau decided that Benfey was the person "to make something of it," and the result was Benfey's first book publication. Finding that he "enjoyed working over other people's translations and turning them into something useful," Benfey has continued this activity "off and on;" his most recent translation is of Fred Aftalion's *History of the International Chemical Industry* (14).

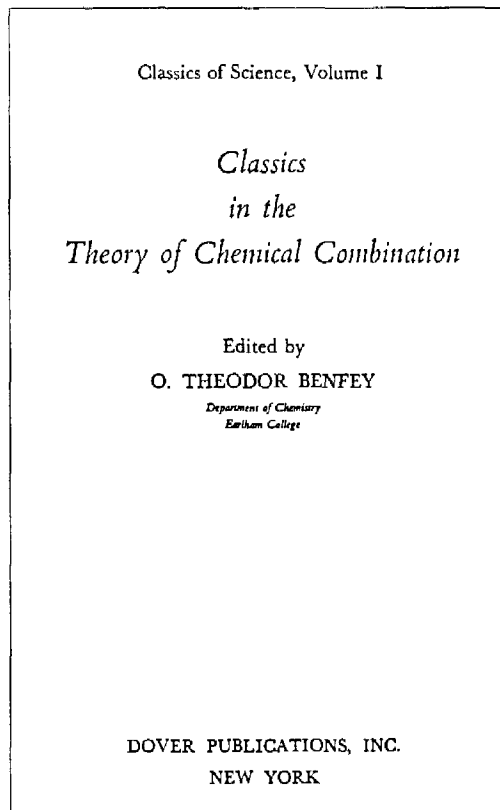
As the time approached for Benfey to take his first sabbatical leave, changing conditions in the chemistry department gave him cause for concern. Meldrum was retiring as chairman, and his successor was suspicious of Benfey, raised questions about his overall competence, and disagreed with his aims. Benfey credits his wife Rachel, whom he met while she was teaching at the Haverford Friends School and whom he married in 1949, with giving him the courage to leave Haverford, convincing him that he shouldn't work under someone who didn't want him (15). Although he had announced his resignation "with a great flourish to all the faculty," Benfey was granted tenure and his sabbatical half-salary by Haverford president Gilbert White, who said he deserved it "based on previous work." A financial gift from retired Haverford professor Albert Wilson provided additional help for his sabbatical year beginning in September of 1955.

For his sabbatical, Benfey chose Cambridge to be near his mother and grandfather, near Harvard University because of its prestige, and near Frank Westheimer because he was a physical organic chemist:

I had known about Westheimer because one chemical problem that I got fascinated with at University College was the racemization of optically active biphenyls whose optical activity was due to steric hindrance. I tried to figure out, from Ingold's teachings, what factors might have led to the observed order of racemization rates - size of substituent groups, inductive, resonance effects. That was the time I really did some literature searching and developed some ideas. I showed them to Ingold, and he rather liked them. Nothing came of that, but then I discovered that Westheimer had done calculations on the biphenyl racemizations. That intrigued me about him. I also had discovered he had worked on the nitration mechanism. So he seemed the right person.

With Westheimer, Benfey went back into research of a significant kind, working on a problem involving bipyridyl which was closely related to his earlier fascination with the biphenyl problem (16):

Westheimer was really delighted with this work, because it completed



something that he had published a number of papers on. It separates out the hydrogen bonding of an added proton from steric repulsion, and the resonance tendency to planarity as against nonplanarity.

Benfey also planned to work with Leonard K. Nash, trying to turn the development of organic structural theory into a case history for Conant's series:

I never went to Conant to talk to him about it because by then he was [High Commissioner to Germany]. I never saw him that year. I just went ahead and drafted the whole thing. I sent it to Harvard University Press, and they showed it to Conant. It turned out that Conant had attempted to do the same thing, and decided it couldn't be done, so he wasn't about to admit that I had done it. Luckily, that was the era when all the publishers were looking for supplementary texts to enrich the freshman curriculum. My book [*From Vital Force to Structural Formulas*] became number one in the series published by Houghton Mifflin, because the manuscript was all there, and it was exactly the kind of thing they wanted, quoting from the original papers and then commenting on them (17). That was exciting.

At Harvard, Gerald Holton was planning an English language equivalent of Wilhelm Ostwald's *Klassiker der exakten Wissenschaften* (18). He asked Benfey to prepare *Classics in the Theory of Chemical Combination*, which appeared as the first volume of the "Classics of Science" series published by Dover in 1963 (19). It contained complete papers by Couper,

Kekulé, Laurent, van't Hoff, Le Bel, and others. The 1858 paper by Kekulé on structure theory had not been previously translated in full.

When Benfey left for Harvard in 1955, he faced an uncertain future, having burned the bridge to Haverford without having a new one to cross. He was scared and nervous, especially since his third child was just seven months old. He had interviews with Boston University and with a representative from Claremont Men's College, but it wasn't until an unexpected letter arrived from Larry Strong at Earlham College in the fall of 1955 that his future would again be secure. At first, Benfey was skeptical of Strong's invitation to join the chemistry department, remembering that people at Haverford told him: "Whatever you do, don't go to Earlham." Haverford had "always felt it was way above Earlham, and in earlier years they had taken people with Earlham degrees and given them an extra year to prepare them for graduate school."

But by 1955 people were moving in the opposite direction. Wayne C. Booth, whose book *The Rhetoric of Fiction* "inaugurated a whole new direction in literary criticism," had already been lured from Haverford by Earlham (20). By the spring of 1956 Benfey had agreed to join the westward migration to Richmond, Indiana, a small town that he describes as then being "reactionary in politics" with "violently anti-United Nations and anti-British" attitudes. The Earlham faculty "were a very educated, intelligent group in a community that had very little awareness of them." In one period of high town-and-gown tension, the Earlham president had paid the faculty in dollar coins so that when they spent the money in town "the town people would realize just how important their local college was to the community."

When Benfey arrived at Earlham, the college stood on the brink of rapid change that would see it transformed into one of the leading liberal arts colleges in the country, due in no small part to the efforts of a new president, Landrum Bolling, a political scientist with "tremendous energy and vitality." He found the Earlham students "a delight because for many of them the intellectual atmosphere of the college was very exciting" and "markedly different from their own environment." While Haverford was a men's college at the time, with at least half of the students the sons of professionals, Earlham was coed; many of the students came from rural backgrounds or small towns. "One could see them blossoming and thriving under the stimulus of the new ideas. There were fields that were opened before them that they didn't know existed as possible for their careers." At Earlham, Benfey continued his Harvard experimental work with James W. Mills, now a professor at Fort Lewis College in Colorado. They looked at the next, more complicated case where two pyridyls are tied together to try and keep them flat. The results appeared in his last experimental paper, for by then Benfey was totally committed to chemical education and the history of chemistry (21).

Benfey was the third member of the chemistry department



Laurence Strong

at Earlham, joining Strong, a physical chemist, and Wilmer Stratton, an inorganic chemist. Benfey found Strong to be a "mature scientist who, at the same time, was very eager to do something new and interesting in chemical education":

We very soon started discussing what was wrong with the general chemistry course, and decided the problem was that there were too many subjects, going all over the map. We began to think that we ought to develop a curriculum where each course would deal with a much more concentrated group of subjects. It began with a course called "Particles of Chemistry," and then "The Covalent Bond," which was a freshman exposure to aliphatic organic chemistry and other non-ionic compounds in the context of bonding. That was followed by a course on ions, which included an introduction to inorganic qual and quant. There was a course on chemical energy, and then back to organic in the junior year with a course called "Resonance and Aromaticity." Advanced organic chemistry became "Kinetics and Mechanism."

In developing the new curriculum, Benfey and Strong focused on concepts rather than on "the classic divisions inherited from

the 19th century." In 1957, Strong was invited to a conference on precollege chemistry at Reed College. Organized by Harry Lewis of the Institute of Paper Chemistry, the group consisted of "disgruntled people who were worrying about high school chemistry." Strong proposed that the high school course should have "coherence and structure," not just a series of topics that colleges insisted should be covered. This was related to Jerome Bruner's concept "that the only way one can really understand a subject is by tying facts and details into a broader conceptual structure." The group encouraged Strong to seek funding for the development of the course he was proposing.

In the years immediately following the 1957 launching of Sputnik by the Soviet Union, the National Science Foundation became interested in curricular revisions as a means of lifting "American chemistry to keep ahead of any Soviet challenge." While Strong was looking for support for a new high school course, the new Earlham curriculum was published in the 1958 report of the newly formed and NSF-supported Advisory Council on College Chemistry.

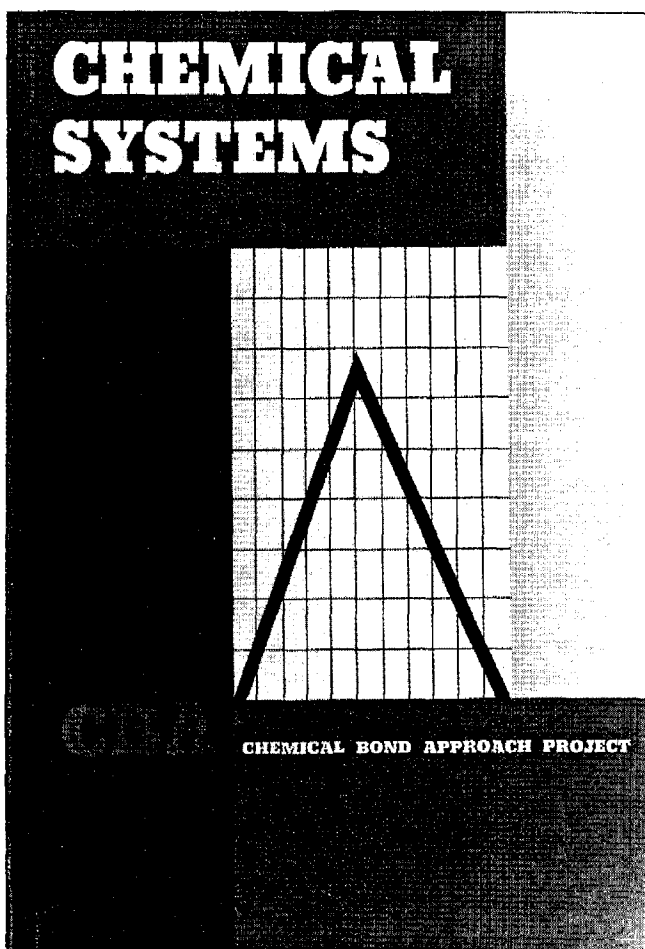
The major changes proposed by Strong and Benfey were not easily implemented because they were counter to "accepted practice." After adding a fourth member to the department, Earlham requested program approval by the American Chemical Society's Committee on Professional Training (CPT). Although the CPT was satisfied "on every count" of its usual criteria, they were skeptical about the "massive transformation" in the curriculum and refused to put Earlham on its approved list until the first group of graduates was produced under the new arrangement. With great satisfaction, Benfey recalls that there were three National Science Foundation Fellowship awardees in that first group. Faced with this evidence, the CPT not only placed Earlham on its list of approved chemistry programs, but "almost immediately" started using the Earlham model "as proof that they believed in curricular experimentation."

Another barrier to curriculum innovation was the lack of suitable textbooks. Benfey tried to teach the way he had learned in England, without texts, but found that "extremely hard." Laboratory innovation was easier, and many new experiments were developed. For the energy course, Strong and Stratton developed a small paperback entitled *Chemical Energy*, while other publications in that Prentice Hall series were used for supplementary and overview material (22). In retrospect, Benfey realizes that they should have created their own texts. "Even though we had the new names and the new concepts," he concedes, "we tended to slide back into being textbook courses." More importantly, they did feel freedom to move far and wide, and insisted that the students move in those directions as well. Although widely recognized and "warmly received," the Earlham program essentially had no imitators. Benfey doesn't know of anyone who switched to the conceptual approach in their program. "The general feeling was that

you just can't move that far from the textbook and the accepted practices."

But the Earlham group's impact on stimulating the development of new ways of teaching chemistry was not limited to the college level. NSF support was secured following the Reed College meeting on high school chemistry, and in 1959 a conference of high school and college chemistry teachers was held to begin writing a new high school text that would be known as *The Chemical Bond Approach (CBA)*. A preliminary version was already available in 1961 when Benfey was in Ireland, talking about chemical education and the CBA project to European high school teachers at a meeting sponsored by the Organization for European Economic Cooperation (23):

Before that we were training teachers. It was an absolute conviction that you just can't hand out materials. What we wanted the students and teachers to do was to think about the concepts and how they related to data, rather than to memorize. Both students and teachers always tried to find the easy ways of coping with material. We had trial schools all over the country. We had regional conferences. There were six-week-long summer institutes.



Cover of the final version of the CBA text, *Chemical Systems*

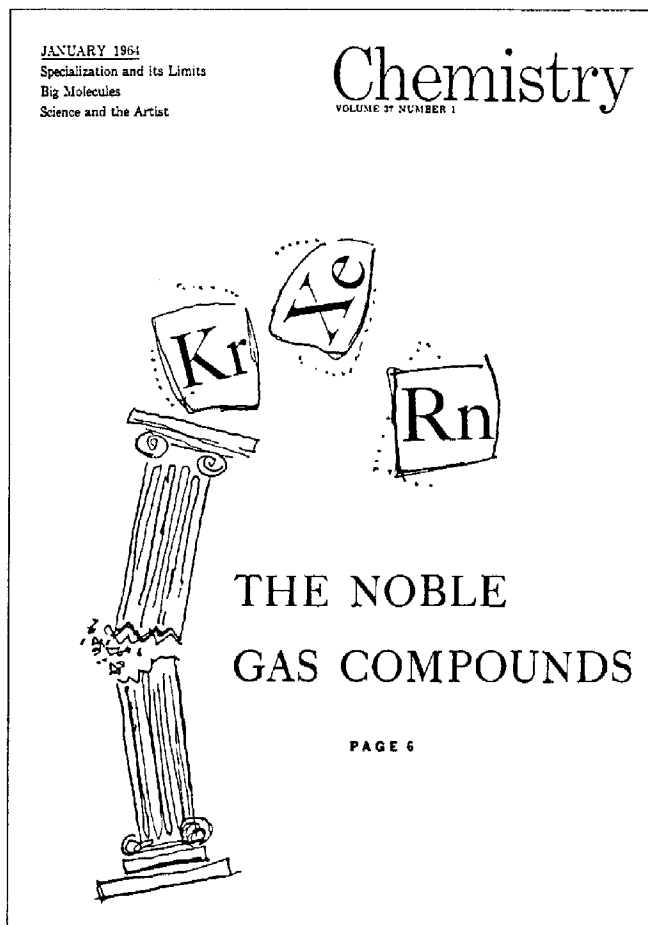
The CBA attracted interest all over the world, and by 1963 translations were in progress in Brazil, Japan, and Spain. Benfey even spent two weeks in Brazil in 1963, directing a teacher training program which was held at the aeronautical college at San José dos Campos. Many of the group could only follow written English, and found spoken English very difficult. For the teachers from the large German community in southern Brazil, Benfey found that if he used German words after English key words, "their faces would light up and they would catch on to whatever" he was talking about.

CBA had originally hoped to get ACS support, but the ACS felt CBA was "too radical" or "too set" in their ways for the ACS to have any input. Instead, ACS formed a national advisory board headed by Glenn Seaborg and George Pimentel, and launched the Chem Study project in 1959. According to Benfey, "they were much less innovative in repackaging chemical material. But it had a lot of prestige and a lot of money, and was much closer to accepted practice and more easily accepted and used by people trained in standard university programs." As a result, Chem Study received greater adoption and was translated far more than CBA. While the Chem Study text still appears in new editions, a second edition of the CBA text was never published.

In the midst of all this curriculum activity at CBA and Earlham, Benfey received an invitation in 1963 "that came completely out of the blue." The ACS had purchased *Chemistry* magazine from Science Service in order to acquire the name. Benfey was asked to become the editor, and was given the mission of developing a product that would serve the top 40% of high school chemistry students - those who had been stimulated by these new high school experiences. For the next 15 years Benfey managed to publish a highly-acclaimed journal, raising the subscriptions from the originally acquired 6000 to a high at one point of 30,000. Significantly, it served as the model for subsequent similar publications in Germany (*Chemie in unserer Zeit*), Canada (*Canadian Chemical Education*), South America (*Revista Iberoamericana de Educacion Quimica*), France (*Le jeune Scientifique*), South Africa (*Spectrum*), and Japan (*Gendai Kagaku*).

In his first year as editor, Benfey took a sabbatical leave at ACS in Washington. When he returned to Earlham, ACS agreed to pay one-third of his salary and thus reduce his teaching load. It was an arrangement no other ACS editor enjoyed. But *Chemistry* was not just printing articles submitted by others. In addition to Benfey there was a managing editor, an editorial assistant, and a secretary in Washington, and a lot of new copy was being generated in the *Chemistry* offices. Benfey's editorials were particularly incisive, and he credits ACS artist Joe Jacobs with the creation of the design and layout (24).

Feeling that chemistry courses dealt with the "internal" material of chemistry, Benfey devoted all of his concern as editor to fascinating students "by showing all the interconnec-



The cover of the first issue of *Chemistry* magazine (January 1964) to appear under Benfey's editorship

tions." He envisioned that the chemical community needed something like *Scientific American* but focused on chemistry. In fact, the readership did expand beyond the targeted high school student, and the magazine was read by high school teachers, university professors, and other professionals who found it a "useful way of keeping up with the whole of chemistry."

The initial mission, however, became part of the magazine's downfall during a growing attack on elitism. "Anything being produced had to serve everybody." It was also the era of accountability, and each unit had to be self-sufficient. Because *Chemistry* was under the Publications Division and not under dues-supported services, it had to pay for its proportion of the ACS building and other peripherals in proportion to its subscriptions. To save money, several monthly issues were combined, reducing the yearly output to ten issues. Finally, an ACS evaluation committee "decided to rethink" the whole purpose of the magazine, and determined that it could be done in-house. They suggested conditions under which Benfey could remain as editor, but he rejected them. When Benfey left

in 1978, the name, purpose, and format were changed. He was thankful that *Chemistry* under ACS was always under his editorship, and "that it didn't go on with a different editor and purpose to confuse readers."

In addition to his teaching, activities in chemical education, and magazine editorship, Benfey's scholarship in the history and philosophy of science continued to flourish during his years at Earlham. His papers often show an amazing combination of depth, breadth, and insight, with linkages spreading out in different directions to touch several intellectual regimens. He wrote about two "underdogs - Archibald Scott Couper (25), whose work on structural theory was overshadowed by Kekulé; and Lothar Meyer (26), whose work on periodicity was overshadowed by Mendeleev. His interest in

the creative process in science led to a translation of van't Hoff's inaugural speech after he had launched the tetrahedral carbon theory (27). Using the title, "The Role of the Imagination in Science," van't Hoff described the creative interests of many scientists, including their activities as

poets, musicians, and dramatists. Benfey also analyzed the two papers that Alexander William Williamson wrote about his ether synthesis, suggesting that the two versions "probably represented the period of transition to the modern way of reporting research," changing from personal pronouns to the impersonal passive style (28). He speculates that scientists did so because it is related to the feeling that "science is universally true. Once data are discovered, they have nothing to do with the particular context of the discovery or the scientists involved, and the publication should reflect that."

While Benfey was at Earlham there was considerable national interest in programmed instruction, a question and answer procedure for teaching with immediate feedback, and a method soon taken over by computers. When a number of

Earlham faculty agreed to develop and test such materials, Benfey decided that organic nomenclature and the writing of Lewis and resonance structures would lend themselves to this type of training. His *Names and Structures of Organic Molecules* was published by Wiley in 1966 (29). It was also at this time that Charles C. Price, Head of the NSF-sponsored Advisory Council on College Chemistry, asked Benfey to write *Introduction to Organic Reaction Mechanisms*, which became the first of the Council's "Interface Books," published by McGraw-Hill in 1970 (30). Appropriately, Benfey dedicated the book to Ingold, Hammett, and Westheimer.

During the Cold War period of the 1960s the American government became concerned that their overseas diplomats and representatives didn't know - and had great difficulty in

learning - foreign languages, forcing them to work through interpreters. The Soviet Union, however, would bring a complete staff who were fluent in the language. The U.S. government established centers for training area specialists, and Earlham became the Japan center for the Great Lakes Colleges Association.



Editing *Chemistry* magazine, Earlham College, circa 1964

Each year "somebody from Earlham was sent to Japan on a Fulbright-Hays Research Study Fellowship to broaden faculty horizons to include non-Western aspects," which Benfey describes as a "deprovincialization" process.

Benfey, his wife Rachel, and two of their three sons left for Japan in 1970 to spend a year at Kwansai Gakuin University in Nishinomiya. Even though he had spent the previous year studying the language with Japanese nationals at Earlham, he "still knew very little." Benfey regards the lack of a language skill as a benefit, for otherwise he would have spent "endless hours in libraries." Instead, he went looking for signs of geometric patterns, visiting antique shops, museums, local stores, and craft and pottery centers. At the same time, he continued to study the language by trying to translate a small

book by Kyoshi Yabuuchi on the history of Chinese science (31).

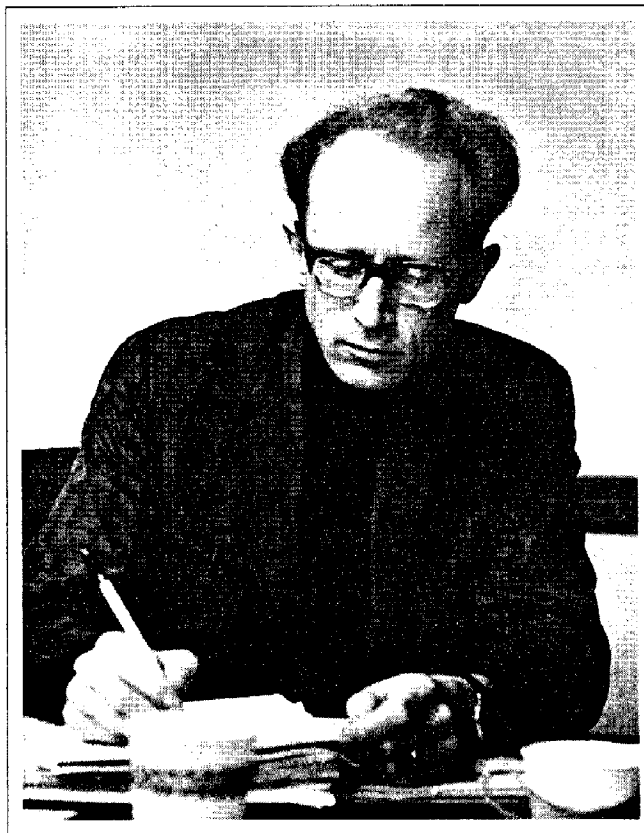
To Benfey, "structural theory is almost synonymous with chemical geometry" (32):

When I became interested in the Orient, I noticed Joseph Needham saying that one finds no interest in the regular solids in China or even much interest in geometry. I discovered that was just plain wrong. What Needham should have said was that there was no interest in ancient China in deductive Euclidean-style geometry. Endlessly in Japan and China one is aware of their love of geometric pattern. Chinese window lattices and Japanese wrapping papers attest to that. I think many of Euclid's conclusions just seemed too obvious to the Chinese to require elaborate demonstration.

Benfey was the first to point out the regular solid geometry in an 8th-century bronze spherical incense burner at the Imperial Treasure House in Nara, Japan, on which twelve pentagons can be seen (33). He has also speculated about how the Chinese might have come across the dodecahedron "because the usual assumption is that Euclid didn't get to China until 1600." To Benfey, "it's pretty clear that the dodecahedron was discovered by using vines in basketry." Hexagons were used to make flat surfaces, and to turn a corner one strand is omitted, leaving a pentagon at the corner. When only pentagons were used, the result was the wicker ball, 12 pentagons created by intertwining six equators, still used in ball games all over southeast Asia. While in Japan, Benfey also discovered a physical chemist who used origami techniques to train students in the construction of the regular solids. Benfey still delights audiences with his explanations of the relationship of geometry, chemical structure, and origami techniques which he continues to explore and develop.

When Grimsley Hobbs became president of Guilford College in North Carolina, he tried luring Benfey from Earlham. He and Benfey had known each other from their Haverford days, when Hobbs was a graduate student in philosophy. Later they shared in teaching a course in the philosophy of science at Earlham. Rachel Benfey was a Guilford graduate, but she and Ted were quite annoyed with the school for many years because it was so slow to integrate. By 1967 that had changed, primarily because the Friends World Conference would not accept the Guilford offer to host the meeting unless it was an integrated institution. In part this was because there was a large Quaker community in Kenya, where some African chiefs and their regions had become Quakers.

The Benfeys rejected Hobbs at first, but when he repeated the offer in the fall of 1971 after their return from Japan, they reconsidered. In Richmond, Indiana, they felt "the lack of cultural diversity and the distance from the major eastern seaboard centers." There was also the appeal of being able to create and head a chemistry department. Feeling they should stay at Earlham another full year, they agreed to accept the



At Guilford College, circa 1975

invitation, but not until 1973.

Benfey found a totally "blank" department when he arrived, for the one previous full-time member, Harvey Ljung, who had agreed to stay on for a one-year overlap period, decided to leave early. At a Quaker conference, Benfey met a former Earlham student, David MacInnes, who had a Ph.D. from Princeton and was teaching at a Friends school near Philadelphia. He subsequently became Benfey's long-term colleague at Guilford. Almost immediately they began establishing an unusual evening program for technicians at the newly arrived Ciba-Geigy agricultural, dye and chemical divisions and research groups at Greensboro. Rotating the basic chemistry courses through evening sessions, it was possible for a Ciba-Geigy employee who already had freshman chemistry to complete the degree requirements in three years. But it was a grueling pace for the faculty, who had to teach three-hour sessions of lecture and laboratory two nights a week.

There was a traditional opinion that of the Quaker schools, Haverford, Bryn Mawr, and Swarthmore were the leading intellectual group, followed by Earlham, with Guilford ranked slightly behind Earlham:

But all of that is changing now. In terms of intellectual stimulation, the delightful thing about Guilford was to be part of its transformation

from a very traditional campus to a nationally recognized one. I was involved again in an exciting transforming period both during the time Grimsley Hobbs and then later William Rogers were president. Rogers, a former colleague at Earlham, gave up a named professorship at Harvard to become president of Guilford in order to work out a vision he had of a supportive community, not just intellectual, but of a total community. It's been very exciting working on all three campuses because in each one, three new presidents were transforming campuses in directions I was very much in sympathy with.

Benfey's history of science course at both Earlham and Guilford was very popular because it was one of four courses that would satisfy the science requirement for non-science majors. Drawing up to 50 humanities students at a time, Benfey did not use a chronological approach but instead chose three themes - cosmology, atomism, and evolution. Out of that course came Frances Moore Lappé (who later wrote *Diet for a Small Planet* (34)), David Rhees (now director of the Bakken Library and Museum in Minneapolis), and William Newman (now on the Harvard history of science faculty).

Benfey's range of thought and interest is reflected in the joint courses taught with other Guilford faculty. One was on Oriental science, shared with William Beidler, a chemist who had moved into Indian philosophy. In a science and religion course he and Melvin Keiser discussed Michael Polanyi and Loren Eiseley. With Rex Adelberger from physics he taught a course in the history of technology.

It is a Quaker tradition "to retire early from worldly pursuits in order to devote time and energy to the needs of the Quaker community and other social concerns." Having found chemistry teaching and "endless involvements in a small college community ever more demanding," Benfey decided to take early retirement once his three sons were sufficiently independent. Since he and Rachel had met at Haverford and they liked the Philadelphia area, they searched for part-time possibilities there; eventually Benfey accepted a position as editor for the Beckman Center for the History of Chemistry (now the Chemical Heritage Foundation).

In an attempt to be "footloose and travel," the Benfeys sold their house and car and moved into a one-bedroom apartment in the Society Hill Towers of Philadelphia. When they discovered that wasn't their style, they eventually were accepted into the Bryn Gweled community in Southampton, Pennsylvania. Founded in 1940 by a group of Quakers and others who were "influenced in part by some theories of Henry George regarding land values, income taxes, and the evil of land speculation," Bryn Gweled now has 70 families who own their homes but have a 99-year lease on the two or sometimes up to four acres surrounding it. All 243 acres are communally held, and it is "designed for inter-racial housing, away from zoning laws." Benfey had known about Bryn Gweled from his SSRS days at Haverford, since many of the SSRS committee heads lived there. Wherever the Benfeys lived, they had always looked for

such a community, but never found one. Thus Ted Benfey has returned to some of his early roots in the United States, living in the supportive environment at Bryn Gweled while pursuing a myriad of intellectual concepts. His life continues to have a profound effect on others, including students and colleagues. His passionate concern for the human condition, which has permeated his personal philosophy, remains as a brilliant model for others to emulate (35):

Out of our self-examinations may come a new fusion of the means we have now mastered with the hopes and dreams of the human spirit to provide a fit habitat for all people. We must turn all that we possess into the channel of universal love.

References and Notes

Author's Note: All quotations, unless otherwise indicated, are taken from an oral history interview conducted by the author on 24 May and 5 June 1991. (See The Beckman Center for the History of Chemistry, Transcript #0094.) It is a distinct pleasure to work with Ted Benfey as a colleague at the Chemical Heritage Foundation. His meticulous, constructive, and supportive editing enhances manuscripts beyond any author's expectations.

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BY WAY OF EXPLANATION

Otto Theodor Benfey, Chemical Heritage Foundation

When I began contemplating early retirement from Guilford, I expected to fade quietly into the background from the world of activity and achievement. I never expected the recognition given me, including the plans for this symposium, Arnold Thackray's invitation to join him at the Beckman Center for the History of Chemistry, and with it a most satisfying faculty linkage with the University of Pennsylvania's Department of the History and Sociology of Science. Now I am again savoring the delights of being an editor - periodically seeing a mass of jumbled notes, manuscripts and pictures being miraculously transformed by my excellent production staff, led by Frances Kohler, into a pleasing product.

Not often does a group of academic and industrial research chemists and educators, historians and government officials participate in the same gathering. Yet such a group was