To Dad, The Explorer

With the innocence and joy of a child
Exploring
Peering under the stone elsewise ignored
Touching
With infectious joy those he knew
Finding
Awe and mystery in the world around
Growing
To enjoy and cherish the moments few
Loving
Those who shared the joy of life with him
Realms of the mind
He delved deeply
Depths of the remote
He challenged firmly
Mountain air
He breathed blithely
Flowing water
He floated gracefully
Once grounded in the world material
There was a path through the imagination
To immortal fields of thought only lightly touched
Where now he dwells, unburdened and free
Leaving here only the great love held
In the cherish of loved ones memories

Michael C. Giddings,
University of Wisconsin, Madison, Wisconsin

SHORT BIOGRAPHY OF J. CALVIN GIDDINGS

J. Calvin Giddings, Distinguished Professor of Chemistry at the University of Utah, died October 24, 1996, at the age of 66 after a prolonged battle with cancer. Professor Giddings' many accomplishments in science, outdoor exploration, and environmental preservation will be long remembered.

His scientific work focused on methods of chemical separations. He established his reputation in chromatography, one of the most widely used techniques in industry and research. Even today advances in chromatography are being made that rely on his precise theoretical treatment of the mechanisms involved. He went on to invent the technique of field-flow fractionation (FFF), which has been applied to numerous practical problems in fields ranging from medicine to fabrication to environmental studies. He was the director of the FFF Research Center at the University of Utah, the internationally recognized center for FFF studies. He founded FFFractionation, a Utah-based company, to develop and market FFF techniques worldwide.

Giddings authored or coauthored more than 400 publications and edited 32 books. He wrote the books *Unified Separation Science*, a graduate text on the fundamentals of separation science, and *Dynamics of Chromatography*, published in 1965, which remains a classic work in the field. He founded the journal *Separation Science and Technology* and served as its executive editor for 30 years. He received numerous honors for his work, including American Chemical Society Awards in Chromatography and Electrophoresis, in Analytical Chemistry, and in Separation Science and Technology, the Tswett Medal in Chromatography, and the Nichols Medal from the New York Section of the ACS. He was awarded an Honorary Doctoral Degree from the University of Uppsala in Sweden, the 1991 Governor's Medal in Science and Technology, and was twice nominated for a Nobel Prize in 1984 and 1992.

A graduate of American Fork High School and Brigham Young University, Giddings began chemistry research at the University of Utah where he earned his Ph.D. in 1954 under Henry Eyring. After a brief research appointment at the University of Wisconsin, Madison, he returned to join the faculty of the University of Utah in 1957.

Giddings was a lifelong explorer with a great passion for the outdoors. From his early love of exploration he developed a long list of major accomplishments in mountain climbing, skiing, and kayaking. He made numerous first and early ascents in the Wasatch and other mountains, including the first ascent of the sheer west face of Lone Peak and an early ascent of Zion's Great White Throne. He was the first to explore a number of back country ski routes in the Wasatch Range. He was one of the pioneers of kayaking in Utah and became one of the foremost kayakers in the world. Giddings with his kayaking friends were the first to run numerous western rivers including Cross Mountain Canyon of the Yampa, the Black Boxes of the San Rafael, Zion Narrows, the Escalante, sections of the Price and Sevier Rivers, and the Muddy River in Utah and the South Fork of the Salmon and Big Creek in Idaho.

This exploration culminated in his focusing on the longest and largest river in the world: the Amazon. In 1975 he organized and led the first expedition to successfully descend the Apurimac River, source of the Amazon, from its headwaters in the Andes to the Amazonian jungle. This epic struggle has recently been chronicled in his book *Demon River Apurimac*, published by the University of Utah Press shortly before his death. This book is a finalist in the Banff Mountain Book Festival. In later years Giddings took up mountain biking with equal enthusiasm, leading his family, friends, and colleagues on many biking adventures.

His love of the outdoors led him to become one of the pioneers of the Utah environmental movement. Having acquired an intimate knowledge of the area surrounding Lone Peak through his climbing and skiing experiences, he proposed that this spectacular region be protected as Utah's first wilderness area at the time of the enactment of the Wilderness Act. The Lone Peak Wilderness Area was indeed created several years later.

Giddings played many other major roles in environmental preservation. He was instrumental in initiating the Wasatch Mountain Club's conservation activities, participated in the founding of the American Rivers Conservation Council (now American Rivers), and cofounded Utah's Save our Rivers Committee whose activities in particular focused on preserving the Provo River's beautiful canyon. He also served as the president of the nationwide American Whitewater Affiliation and as a member of Negative Population Growth's board of directors. He recognized the importance of education and of bringing a scientific perspective to the environmental debate and authored the text *Chemistry, Man, and Environmental Change*, which received an award for Outstanding Environmental Achievement in Education from ROMCOE in 1973.

Cal Giddings always loved the adventure of being off the beaten track, whether in science, in exploring new mountains or rivers, or in bushwhacking with his dogs near his canyon home.

TRIBUTES TO J. CALVIN GIDDINGS

Steven B. Giddings,
University of California, Santa Barbara, California

On October 24, 1996, at the age of 66, my father, J. Calvin Giddings, lost a prolonged and courageous battle with cancer. He leaves behind a broad legacy in science, in exploration, in environmental preservation, and most of all in the many lives on which he has had a positive influence.

Throughout his life Dad maintained a great passion for and curiosity about the natural world. In chemistry he contributed a great deal to the field of separation science, including the invention of Field-Flow Fractionation and other related techniques. His remarkable publication record included authorship on more than 400 publications, editing of 32 books, and authorship of two others. The quality and depth of his research was recognized by numerous awards, and its utility led to the founding of a company, FFFractionation, to make his techniques widely available. There is much more that could be listed here, but what was, perhaps, most important to him was not the numerous honors his work received but rather just the joy of seeing his separation methods applied to the many problems for which they could be useful, in a wide range of areas extending beyond industry to medicine and environmental studies.

His passion and curiosity extended far beyond science, and combined with a zest for adventure and a love of the outdoors led him to a long career of outdoor exploration. His outdoor enthusiasm was kindled through trips with his own father to the mountains near their American Fork home. Later in life, he began to further explore these and other mountains on his own. His climbing career included numerous first and early ascents, including the first ascent of the west face of Lone Peak, prominently viable from the Salt Lake Valley floor. Other notable ascents include Zion Canyon's Great White Throne, Devil's Tower in Wyoming, and climbs in the Tetons. He also was one of the pioneers in discovering numerous back country ski-touring routes in Utah's unique Wasatch Mountains.

Still later, he turned to a long career of river exploration. Beginning with homemade kayaks, the first in Utah, and techniques learned from a book, his enthusiasm led him to explore many western rivers. The list of his pioneering descents is too long to give here, but river runners will recognize among them a number of respectable runs such as Cross Mountain Canyon on the Yampa, the Black Boxes of the San Rafael, Idaho's Big Creek, and the South Fork of the Salmon. Even today these runs are considered significantly challenging.

Earlier generations of explorers such as John Wesley Powell had already navigated the West's major rivers such as the Colorado, so in looking for even greater challenges, Dad had to look elsewhere. His focus shifted to the longest and largest river in the world: the Amazon. The longest tributary (hence the recognized source) of the Amazon is the Apurimac River in Peru. In 1974 he and a partner mounted an expedition to kayak some of the upper canyons of this river, but were soon turned back by the recognition that their resources did not allow them to continue with a sufficient safety margin. He returned with a larger expedition in 1975, and despite enormous hazard and toil managed to descend a large fraction of the canyons of the Apurimac. This adventure is chronicled in his book, *Demon River Apurimac*, which he was fortunate enough to see published just before his death.

Beyond these remarkable achievements, Dad's love of exploration and adventure, and joy in sharing it with friends and family, pervaded his life. In later years his focus shifted to mountain biking, which he began at age 56 with a ride on Moab's challenging Slickrock trail. He found that mountain biking opened up a whole new way of seeing new sights, discovering new surprises, and simply having fun. Even on hikes near his canyon home he found happiness exploring, always looking for a new path to tread—and frequently leading family and friends through thick brush and enduring the consequent joke that he loved bushwhacking.

Out of my father's love for the natural world came a strong vision that it needed protection. He early realized the fragility of the environment, and the many disasters both real and potential that unbridled development and population growth was visiting on it. He became one of the pioneers of the Utah environmental movement. Soon after the passage of the Wilderness Act, he proposed Utah's first wilderness, the Lone Peak Wilderness Area, which won protection several years later. He was a leader in several local environmental organizations, and also participated in the founding of the American Rivers Conservation Council (now American Rivers). Realizing the crucial importance of arresting unlimited population growth, he also served as a member of the board of directors of Negative Population Growth.

He also recognized the importance of education and of bringing a scientific perspective to the environmental debate, and authored the text, *Chemistry, Man, and Environmental Change*, another of his pioneering works which has been widely used as a textbook to educate students about the relation between chemistry and the health of the planet. This book received an award for Outstanding Environmental Achievement in Education from the Rocky Mountain Council on the Environment in 1973.

But beyond this list of accomplishments, and many more not listed, there is another equally important legacy left in the influence that he had on others. He had a remarkable ability to inspire others to achieve beyond themselves. In all that I observed, this was almost universally done through gentle encouragement rather than through intimidation or other means. He was truly a leader, with a talent for not making you feel like you were being led. He was able to inspire colleagues, students, friends, and family solely through his understated enthusiasm.

As a father, he has been an inspiration both in outdoor adventure and in science. He would almost always include the family in outdoor trips. He introduced my brother Mike and I to hiking and skiing in the Wasatch at an early age, and slightly later to kayaking on Utah and Idaho rivers. He took great pride and delight in seeing our development, and was always there to rescue us when we took the inevitable fall while skiing or swim through the rapid while kayaking. We were able to share in some exploratory descents of rivers, although others were beyond us. Later, when I took up climbing myself, Dad gave guidance, sometimes too firm for the rebelliousness of a teenager but possibly keeping me alive nonetheless. Despite the fact that he had given up climbing himself, he joined me on several occasions so that he could share in his son's growth in the mountains. He planned family trips to kayak other exotic rivers such as the Nahanni in the Northwest Territories, the Tatshenshini in Alaska, and the Grand Canyon of the Colorado. He always watched over us, yet let us develop independence.

Beginning at an early age he taught me to always apply logic and reason to the mysteries of nature. I learned that most things could be explained by science, and that those that could not were just interesting puzzles waiting to be solved. He recognized the great importance of mathematical learning, and introduced me to calculus long before it would ordinarily be taught. This mathematical background served as the foundation for my career as a theoretical physicist. My inspiration in physics came later, when he explained to me some of the truly weird properties of quantum mechanics and I decided that if the world of physics was that different from ordinary experience I had to learn about it. He helped arrange for me to enter college early, and constantly gave me encouragement in my studies. In particular, he urged me to take as much math as possible—an extremely valuable suggestion. As my knowledge in my area of physics gradually surpassed his, he always asked me to explain the latest ideas, who the players were, and what I was working on in my research.

Although he allowed himself to take pride in his sons, he was nearly the definition of humility, generosity, and tolerance. I don't recall him ever speaking in self-aggrandizing terms. In fact, even as his son it was difficult to learn about his many accomplishments—only rarely and reluctantly did he speak of them. He was generous almost beyond reason, and always wanted to lend a helping hand to those who needed it. He was tolerant of other's views, even if they were widely divergent from his own, and he respected people for who they were and accepted them despite their flaws. This did not mean, however, that he accepted untruths or flawed reasoning: he was always patiently insistent on ferreting out the truth, guided by logic and reason.

Gone in body, he leaves behind his wife, partner, and best friend Leslie, his two sons, Steven and Michael, two brothers, and two sisters. However, Dad will long live on in the imprint that he has made in so many lives. His impact extends over a wide range of human endeavor. His scientific work continues to grow. His vision has helped preserve a small part of the natural world, and continues to influence others to fight to save us from the destruction of our environment. His adventures and explorations will be widely remembered both by those who were lucky enough to share them and by many others inspired by them. Finally, his ability to lead family, friends, and colleagues to achieve beyond their own expectations will live on, although perhaps his leadership will be even better than it was in life.

Lee J. Clark
Safford, Arizona

To appreciate the relationship that I had with Cal, one needs to know a bit about our family. I am the oldest son of Cal's oldest sister and am eight years younger than Cal. My mother and Cal were particularly close, with he being her "baby" brother. My family lived in Arizona and California while I was growing up and it was a long day's drive to travel from where we lived to the Giddings' residence, and we made that trip approximately twice each year (once during the summer and then again at Thanksgiving). These were fun times because we got to visit with our cousins and uncles. We determined that the eight year difference between my age and Cal's was probably a critical number, maximizing the aggravation factor with me wanting to go everywhere that he went but too small to keep up. He was patient, though, and allowed me to come much of the time. Cal was small and wiry in stature and I inherited my size from my father's side of the family. I was probably Cal's size by the time I was 12 or 13 years of age, but no match for his strength, agility and speed.

The Giddings dairy herd was small, but needed attention at least twice per day, and during the summer, sometimes the whole day would be needed to bale hay and truck it from the pasture back to the home place. Cal grew up in this environment and learned a strong work ethic. Along with the work, however, there were lighter moments. I learned from Cal that if you turned the key off while driving the old Ford truck through town that it would backfire as soon as the key was turned back on. This served as some amusement to us at the expense of some innocent people along the route from the pasture to the home place.

During the winter months the corral would get pretty mucky. Manure would build up several inches deep, so Grandpa and my uncles would wear irrigating boots to feed the cattle and get them in for milking. Since we were visiting, I went out to see Cal do his chores. At first I stayed out of the corral where it was relatively clean and dry, then Cal started joshing with me so I started out into the corral to "get" him. I found that I could throw a small tuft of hay in front of me to step on and keep my feet relatively clean. As he moved out further into the corral, I followed one step at a time with tufts of hay keeping me high and dry. Then one more step and the tuft and my foot sank about a foot into the mucky ripe manure, much to Cal's delight. A series of railroad ties had been laid out in front of the feeding stanchions to keep the cows dry and clean while they were eating. Cal had lured me off the ties and into the mire! That night at dinner, I was just about invited to eat elsewhere as my shoes and lower pant legs retained their barnyard odor.

Cal threw the shotput in high school and set a school record with the 12 pound shot that stood for many years. The fact that made this feat so astounding was his size, and the thing that made it possible was his determination. He had a couple of practice shots at home (one of which was brass) and he spent time practicing to perfect his technique. He must have spent time exercising, even though I don't ever remember seeing him do it. He could do pushups with one arm and could suspend his body between two chairs with his head on one chair and his heels on the other. He kept himself in top physical condition.

He loved to hunt and had an ancient double barreled 12-gauge shotgun. The unique characteristic of the shotgun was that if the front trigger was pulled, both barrels would fire. More than once, in the excitement of the hunt, the front trigger was inadvertently pulled. The resulting recoil knocked Cal to the ground and on some occasions separated the barrels from the stock.

Skiing and mountain climbing were other passions. He had the patience to work with me in both areas. I never became proficient in either of those sports but we enjoyed some mountain hikes together, including the ascent of Mount Timpanogos.

Cal and both of his brothers were river rats, rafting the Colorado River on several occasions. This was undoubtedly the beginning of his love affair with wild rivers. He found that kayaks were much more maneuverable than the lumbering rubber rafts and not finding any to his liking, he made his own. He conquered many wild rivers, the crowning accomplishment was probably his treks down the Apurimac River in Peru.

He loved dogs. I remember a beautiful Airedale that he had on a family outing up American Fork Canyon. We were exploring along the creek coming down from the reservoir when the dog found a beaver. The encounter was short lived and the dog came yelping back to safety after having been paddled soundly by the beaver. He had another dog named Doby; I believe it was an Australian Shepherd. The special thing about Doby was his jumping ability; Cal was really proud of this dog.

As I entered college studying chemistry, our interactions were raised to a different plane. I remember talking with him while he and Dr. Eyring were working on the theory for chromatographic separations. He had some clear plastic cubes which they used for their initial model to describe how chemicals would be separated as they passed through a column. My interest in chemistry was a direct result of Grandpa Giddings making it exciting and Cal's working on the cutting edge in this area.

The quest of many in the academic community is to find "what made Cal Giddings tick?" I don't have an answer to that question, but to begin with, he was born of goodly parents. His mother was a Mormon girl raised in a conservative pioneer lifestyle and his dad was a Protestant from a wealthy family with holdings in the Dakotas, Oregon and Hawaii, a devoted high school teacher of chemistry, physics and debate, and farmer with dairy cattle and an orchard. The unique genetic combination from his parents provided him with a mind with high intellectual capacity and a body that was small but strong. He was taught in his youth to work hard and be responsible and he developed a strong work ethic and determination. He had the exceptional opportunity to work with a world class scientist. Cal told me that Dr. Eyring had more good ideas in a year than most people had in a lifetime. He was sure of himself, whether climbing a sheer cliff, descending a cataract in his kayak or developing new techniques in separation chemistry. And when he believed in a thing, he made time to do it, whether it was to start a group to protect animals or the environment or organize a group to conquer the Apurimac. He was very unassuming, as a youngster growing up, he was just my uncle, fun to be with, always doing exciting things, just like all uncles ought to be.

Ingrid Thompson Fuhriman
Bellevue, Washington

Children are born with a sense of wonder and awe for the world in which they live and with a desire to learn and explore that world. Most of us become a bit jaded by life, and that dulls that natural sense of wonder and joy for most, but not for my uncle, Calvin Giddings. He was always searching and seeking for new knowledge with a voracious curiosity whether he was seeking results in his scientific research, his explorations of unknown regions or simply finding out "why?" He was an extraordinary man of genuinely fine character and integrity. A scientist—adventurer—athlete—author—father—husband and friend—a true Renaissance man, he excelled at it all. His contributions to science were great, but he was no inaccessible ivory tower academician. He was a man of personal charm, wit and humor. He lived a life that was a tribute to his parents and a reflection of the values and the high expectations that they imbued in him. (His father, too, was a chemist, humanitarian, explorer). Cal was well-rounded and brave and fun and funny.

I would like to share a few memories of precious moments of everyday life that I shared with him. I feel fortunate to have shared that same time and space on this planet and invite those of you who knew him and who read this to let these experiences spur your own memories of days and times spent with Cal.

He was physically strong. When he was in high school and I was a very little girl, I would get points with the neighbor children for letting them come over to watch his acrobatic stunts. They especially enjoyed watching him walk around the front yard on his hands. I also remember sitting on the lawn at American Fork High School watching him at football practice and riding with him bareback on a horse around the Giddings farm.

I remember the tone of Grandma Giddings' mock scold on Saturday mornings when she'd call, "John Calvin Giddings, get down here for breakfast." That was pancake day and I was taught early to cook pancakes the way he liked them—nearly burned on the outside and raw in the middle. I thought he was weird because he liked canned milk on his cake when he lived on a dairy farm and could have cream like the rest of us, and also because he had a barrel in his room covered with screening where he kept willow branches and caterpillars which would soon turn into monarch butterflies. I thought he was magic because he could swing a bucket of milk around and around and upside down and the milk wouldn't come out. He was a great skier. He helped me get my first pair of skis. Unfortunately, I had not inherited his athletic ability as my numerous splendid crashes proved.

When I got older and was teaching at Pleasant Grove High School, I dropped in on Grandma Giddings one day. She had a big smile of pride on her face. "Oh, that Cal. He never tells me anything," she said. She had just heard on the radio of yet another honor and still another foreign country. She was proud of the honor, but more proud still of the fact that he never bragged about his many accomplishments—even to her!!! Indeed one of his most endearing characteristics was his incredible modesty in face of equally incredible achievement. He almost seemed puzzled as to what all the fuss was about as the honors piled up from all over the world.

He was so brave during his extended illness. Even then he kept his sense of wonder and appreciation for the beauties of the world around him. The last time I saw him he was remarking on the beauty of the colored leaves around his home in the canyon. He spent this time writing his last book (nominated a prestigious award)—in fact, my most recent experience with him was during the last few days reading his marvelous book on his premier navigation of the upper Amazon Canyons on the "Demon River Apurimac." In this book his voice can once again be heard by all of us, as usual, adventure and science and philosophy mixed with humility, and so I would like to conclude my tribute by sharing his last journal entry from his exploration of the Apurimac River as chronicled in that book. He writes:

"On Sunday I penned my final journal entry; "We leave Luisiana . . . at 11 A.M., headed for Ayacucho, then Cusco. The plane bounces noisily down the cleared canefield, and is aloft. Towering clouds cover the mountains to the left, between us and Ayacucho. These mountains, now eroded down to about 14,000 feet, leave the Apurimac in a wide gentle valley, its fight gone. Still, in total depth, it is . . . over 10,000 feet, for here the Apurimac flows less than 2,000 feet above the level of the sea.

"And so we begin the long process of gaining elevation to get over the mountains and clouds. We fly way down the Apurimac Valley, creeping ever higher, over river, jungle, and dots of civilization... Down 30 miles to where the Montaro enters, and where these two giant rivers combine waters to form the Ene.

"We are 11,000 feet high, and we make a broad, sweeping circle... to gain more elevation. Then, at the place where the Apurimac becomes diluted into another river and ends its official reign of the upper Amazon, we point toward the clouds, and this great river disappears from view. I shall never return.

"For four years the Apurimac had held me spellbound—a giant unnavigated canyon full of mysteries. 'Go and explore it,' my inner self urged, 'go try the unheard of' And when I tried, I found a fascinating and strange people and vistas of beauty never seen before. And I found hard Andean rock and crashing water and almost unendurable toil.

"Triumphant? No, not in the least. Humble. Thankful. More appreciative of the grandeur of our Earth. Glad to be headed home!"

Renee Giddings Packer
Sandy, Utah

To the world, Cal was a renowned scientist and great explorer. To me, he was simply an uncle, part of my security rim of family members who gathered from time to time for Thanksgiving dinners or canyon outings. Occasionally, I would catch glimpses of the scientist or explorer as I overheard others mentioning his various awards or heard his tales of Macau Picchu, African Safaris, or kayaking adventures.

From 1983 to 1985, my view of Cal widened as I had the opportunity to work as a secretary for David M. Grant, a long time colleague of Cal's. During those two years, on an almost day to day basis, I saw how Cal interacted with others. Despite his numerous achievements and accolades, he accorded everyone the same respect and treatment whether they were a colleague, a secretary, graduate student, or niece. Cal did have one flaw, however, his office was too small for all the stacks and stacks and stacks of journals, correspondence, research, papers, and what else he chose to keep in his office. He only had enough room for two small trails, one leading to his chair behind the desk, and the other leading to his visitor's chair. (I'm told that this is a family trait!)

In early September 1988, my admiration for Cal turned into awe as Cal's courageous nature saved his newly built canyon home from the flames of a roaring forest fire. He defied an eviction order, sent his loved ones to safety, and through a long smokey night, with flames—some as high as 50 feet—lapping within 20 yards of his home, he stayed with the home cutting down trees and keeping the roof watered down until the major threat had passed.

In 1993, as part of my senior thesis in History, Cal allowed me to interview him. At that time, he fielded questions on his life, his family, and his hometown of American Fork, Utah. Giving such an interview is not an easy task, especially when there is no prior knowledge to the questions, and while very little of Cal's information filtered through to my paper, Cal still gave me a treasure trove of family history and an insight into what made Cal what he was.

Cal was raised on a farm owned and operated by his parents, Luther Edwin, Sr. and Berneice Crandall Giddings in rural American Fork, Utah. Although farming was only a part-time occupation for Cal's hardworking dad (he also taught science and agriculture full-time at American Fork High School), Cal only remembered family members working the farm which raised various crops for family and market consumption. Cal was expected to complete his share of chores, and had many fond memories including times spent with his Dad while camping out in the desert West of their home as they watched over their turkeys grazing on grasshoppers. Cal's most prized memory, however, was the silver dollar he received from his Dad for milking a cow and getting so many gallons of milk within a certain challenged time period. For Cal it was a marvelous prize. His least favorite memory was having to sleep upstairs in their coal-oven heated farmhouse during the long cold winter nights with only two oven-heated wheatbags, one at his feet and one in his arms, keeping him from becoming a human icicle.

Just as Cal's values and hardworking ethics were influenced by his parents' examples, Cal's ventured pathway into the sciences was as well. Grandpa was a highly educated man, and he made learning science a natural phenomenon and passion at home. Like his father, Cal developed a love of watching and exploring nature and its many wondrous changes. At one point, because of his vast insect collection, Cal actually considered becoming an entomologist. In high school, however, once he had an opportunity to formally learn about physics and chemistry, Cal had a change of heart and decided to become a chemist. His first love, however, was not chemistry—it was physics, and had Brigham Young University had a stronger physics than chemistry department while Cal was attending as a student in the early 1950s, all the discoveries and improvements which Cal made in his area of expertise would have been left for others to achieve, and perhaps the area of physics would have been vastly different than what we know today.

For the rest of my life, however, the one memory of Cal which will always remain with me is the last memory I have of Cal. The day before he died, I went to his home to visit him and his wife, Leslie. Although his physical condition had deteriorated to the point where moments of precious consciousness were rare, and during those times conversation was extremely limited to eye contact or yes and no answers regarding his physical needs, he still found an energy reserve to show me how he felt about our relationship. As I sat with him, I read the book he had just completed, *Demon River Apurimac*, about his kayaking adventure on the headwaters of the Amazon. During one of his periods of consciousness, I told him what a beautiful book it was. He smiled, then he suddenly became very agitated. He looked over towards a pen on a nearby table and began gesturing as if he were writing. It touched me that if I had let him, he would have expended part of his remaining energy to autograph my book. He then asked me to hold his hand just before he once again fell asleep. As I held his hand and listened to the background music of one of Beethoven's piano concertos, I knew that I would miss him and I began to mourn for past times not taken and for future times shortchanged.

Dr. Woodruff C. Thomson
Provo, Utah

I have known J. Calvin Giddings for fifty-five years. He was a man of genuine, excellent character —totally honest, a strenuous enemy of hypocracy, pretense, and subterfuge.

Having received excellent scientific preparation as an undergraduate at Brigham Young University, Dr. Giddings assiduously continued his learning under the tutelage of top-ranking professors at leading research universities, both at the University of Utah where he earned his Ph.D. under Dr. Henry Eyring's direction and while doing post-graduate work at the University of Wisconsin and Harvard University. He, in turn proved to be an outstanding mentor to many graduate students of physical chemistry at the University of Utah where he held the academic rank of Distinguished Professor.

His relationships with the graduate students whom he taught and trained were exemplary. Many of these students were from countries that have cultures different from American culture. Time and again Calvin had these students in his home for holidays and took them on skiing, river running, kayaking, and mountain activities. From his youth he had been an avid and venturesome participant in all of the above activities. He studied glaciers and glaciation in Alaska, and he organized and led the first successful exploration and descent of the upper canyons of the Apurimac River in Peru, the most remote source of the Amazon River. (This amazing adventure is brilliantly recounted in his book, *Demon River Apurimac*, which he saw off the press only a week before his death.) He did mountain climbing in the United States and abroad and explored all of the parks and scenic areas of his beloved Southern and Eastern Utah. He and a friend were the first to scale the sheer face of Lone Peak in the Wasatch Mountains, and it was Calvin who was responsible for establishing the Lone Peak Wilderness Area.

In spite of his academic renown and the many honors he received, Calvin retained the touch and perspectives of the common man, a reflection of the high values imbued in him by his parents as he grew up in American Fork, Utah. There was nothing pretentious in his demeanor—in fact, he may have seemed somewhat shy and unobtrusive when one would first meet him. But on further acquaintance, one would discover his personal warmth and his sly, intelligent humor. He read widely from important literature from outside his field of expertise and cultivated interests in the arts and music. All in all, he was somewhat the desirable Renaissance man, a "Humanist" in the true sense of that word, which is too often misunderstood and maligned.

Calvin Giddings was a caring and devoted husband and father. He instilled in his two sons, Steven and Michael, his own avid desire to learn and to live fully and honorably. Both are scientists and environmentalists. Steven, a Ph.D., teaches at the University of California, Santa Barbara, and Michael is completing his doctoral program at the University of Wisconsin.

Calvin was not a cloistered, inaccessible scientist who limited himself narrowly to an esoteric aspect of a broad field of scientific research. His contributions of research and inventions expanded "pure science" significantly, but at the same time they have had immediate and long-lasting effects on everyday applications in business, industry, and society, including matters affecting our medical, physical, environmental, and societal welfare.

A true measure of the man Calvin Giddings was demonstrated during the last several weeks of his life. When the piercing pain of his consuming cancer would justify crying out in anguish, he was stoically silent and responded by smiling and talked about boyhood fishing in the Mill Pond and exploring caves in American Fork Canyon. When his strength permitted, he worked on manuscripts of scientific papers. He continually thanked others for helping him, especially showing appreciation for the tender, loving care of his beloved wife, Leslie.

Dr. J. Calvin Giddings qualified as an example of Ralph Waldo Emerson's "Man Thinking"—taught first by Nature, then by books. To have known "Cal" was a privilege. To honor his memory is a pleasant duty.

Jim Sindelar, Executive Director of the American Whitewater Affiliation 1972-1980,
Member 1975 Apurimac Kayak Expedition, Contoocook, New Hampshire

Although most of the readership of this Journal knew Cal as a teacher and scientist, I was privileged to know him as an outdoors man who loved exploring rivers by kayak. Cal started running whitewater with the University of Wisconsin Hoofers Outing Club in open canoes in the 1950s. With his companions from the Salt Lake City area, he made the first descents of a number of western river sections, including Cross Mountain Canyon of the Yampa in Colorado; the South Fork of the Salmon, Big Creek, Falls River, and Teton River in Idaho; and the San Rafael, Escalante, Virgin, Muddy, Price, and Bear Rivers in Utah. Accounts of several of these appeared in the American Whitewater Journal during the 60s, 70s, and 80s. His most noteworthy first descent was the epic 6 week self-supported kayak expedition down Peru's Apurimac River in 1975. This expedition was finally detailed in his newly released book (finished just prior to his death) *Demon River Apurimac*, University of Utah Press.

It had long been Cal's dream to claim a first descent of one of the worlds major rivers, and his search for unexplored rivers led him in the early 70s to the Apurimac in Peru. As he states in his book:

> The Apurimac is born in a trickle of meltwater in a snowfield in the Andes of southern Peru, at about 17,000 feet elevation. It flows 4000 river miles to the sea, making it the longest tributary and thus the true source of the Amazon. The river starts cutting canyons and gorges at about 13,000 feet elevation and, flowing northwest soon becomes deeply entrenched in the Andes. It remains in deep canyons for 300 to 400 miles, after which it emerges as a large easygoing jungle river at about 2000 feet elevation. Except for the jungle river and a few short segments higher up navigated by French explorer Michel Perrin, the Apurimac Canyons were unexplored at that time.

As befits a scientist, his research and preparation for this venture were meticulous. He spent several years gathering information, including a year as a Fullbright Professor at the Universidad Cayetano Heredia in Lima, Peru, where he split his time between teaching, which also polished his Spanish, and researching his river. During that same year (1974), he and kayaker Roger Turnes from the U.S. launched the first tentative foray on the river at about 13,000 feet above sea level and quickly hit rough going. Undermanned to begin with, and after making only about 30 miles in 4 days, about half the progress expected, they decided to leave the river, hoping to return better prepared another time.

Cal continued gathering information during his remaining time in Lima, and in the following year, 1975, returned to launch the Apurimac Kayak Expedition with 4 other kayakers: Dee Crouch of Boulder, CO, Chuck Carpenter of Los Angeles, CA, and Gerry Plummer and Jim Sindelar from NH. The expedition started from the village of Pillpinto at an elevation of 9300 feet on September 1, carrying food and equipment for the first two weeks, with plans to resupply for the final 4 weeks at the Cunyac bridge, one of the few access points on the river. Thirty-three days later after traveling some 240 river miles and dropping 7300 vertical feet, the expedition reached Luisiana, its planned destination, at an elevation of 2000 feet.

Following a decade later, the widely publicized Amazon Source-to-Sea Expedition (National Geographic Magazine feature article and Joe Kane's book, *Running the Amazon*) made no mention in their accounts of the fact that Cal's expedition had preceded them through the most remote and difficult sections. Even now, despite numerous improvement in river running equipment and technique in the past two decades, the 240 mile section first traversed by the Apurimac Kayak Expedition in 1975 has seldom been attempted due to poor access, numerous nasty portages that discourage rafts, and the armed and hostile guerrillas of the Sendero Luminoso.

Phyllis R. Brown
University of Rhode Island, Kingston, Rhode Island

When J. Calvin Giddings died on October 24, a brilliant light in analytical chemistry went out. Cal was the consummate scientist. Many picture him as the dedicated, passionate theoretician, thinking only in terms of mathematical models and equations. Others think of him for his combination of theoretical concepts and experimental work. However, the Cal Giddings I knew was a renaissance man, a man for all seasons; a man of great depth, breadth and intellectual curiosity. He was a meticulous scientist, a superb writer, and an articulate teacher. He loved nature and the out-of-doors, and was a renowned explorer, dedicated environmentalist and avid sportsman.

Cal did not confine his outdoor activities to such civilized sports as mountain climbing and skiing. He was a white river kayaker and an explorer. In 1975 he organized an expedition for the first successful navigation of Peru's Apurimac Rivers, which is the source of the Amazon. This expedition on an unexplored river was through one of the deepest canyons in the hemisphere. His curiosity was not confined to unexplored places. He was also interested in other cultures and had been to Russia, China, South America and Africa to learn about other countries and to give invited lectures and courses.

Cal once wrote about Henry Eyring, his Ph.D. advisor, "He was never afraid to tackle anything. With profound intuition, deep physical insight, and razor-sharp mathematics, he could break any process down into essential parts and then synthesize a physical mathematical picture." These words were prophetic! They were a perfect description of J. Calvin Giddings, who had the ability to picture in his mind a complex process, to describe it mathematically and then to paint a word picture clearly and concisely. An outstanding example in his simplification of the statistical treatment of band broadening to the random walk model of chromatography. Even my undergraduates could see a picture of what was going on in a column. In 1959 Cal also developed the non-equilibrium theory which is a powerful tool for describing band broadening in terms of kinetic and diffusion processes in real columns. The results obtained are models of simplicity and accuracy.

In the early 1960s Cal was interested mainly in understanding chromatography and in describing it with physical and mathematical models. He soon became interested in optimization and proposed that optimum velocity could be used as a compromise between diffusion and rate processes. He thought of liquid chromatography, not as a system different from gas chromatography, but as the same system with different parameters. He "saw no need for new theory, only new numbers and operating conditions."

In 1965 he reported that for the analogy between gas chromatography and liquid chromatography to be complete, a comparison of column efficiencies was important. He predicted that column parameters would be found that would make liquid chromatography as powerful as gas chromatography. He also predicted that particle size for liquid chromatography would be small $\sim 2\text{–}20\ \mu$m, that large pressure drops would be required, and that liquid chromatography would be better than gas chromatography for very difficult and complex separations. In 1965 he compared the theoretical limit of speed of separation of gas chromatography with that of liquid chromatography and proposed that the comparative speed of separation depends on the relative viscosity and diffusivity of gases and liquids.

To Cal, theory was important not only because it provided the power of prediction, control, correlation and calculation, but also to elucidate and simplify mechanisms of physical and chemical phenomena. Throughout his career, Cal firmly believed that understanding the theoretical basis of a process was fundamental and in his papers he illustrated that theory, when carefully applied, can guide the development and optimization of a separation system. As he wrote "theoretical work is like laying the bricks of a satisfying edifice—tying diverse chromatographic phenomena to dynamic roots which lead to predictions of efficiency."

Cal's work was not just in the theoretical realm. His theoretical work was done in conjunction with sound experimental investigations, and in 1964 he did a classical study concerned with the theoretical limit of separability. In 1965, his famous book, *The Dynamics of Chromatography*, Volume I, was published by Marcel Dekker, Inc.

His early work was done with gas and paper chromatography. Both entailed a mixture of theoretical and experimental work. The paper chromatography work, which is least well known, is still quite relevant to modern TLC and the GC work is the basis of modern HPLC. In 1965 he started off in a new direction. He developed the concept of a chromatographic like system in which retention is controlled by an external field. This technique is called "field-flow fractionation" (FFF) and it extends the range of chromatography from small molecules upwards to macromolecules and particles of every shape and size. He was a tireless innovator and his contributions to the development and understanding of this technique are unique and monumental.

Cal published over 400 articles, most of which are on chromatographic topis. However, some of his articles are on such diverse subjects as flame kinetics, detonations, nuclear kinetics, snow and avalanche physics, steady-state kinetics, and probability factors in nuclear holocausts. He also wrote articles on his outdoor activities and exploration expeditions. In his slowest year, he only published one article, but in other years he published as many as 15! He also found time to be founder and executive editor of the *Advances in Chromatography* series and the Journal *Separation Science*. He was ahead of his time back when he edited a book in 1972 with B.M. Monroe, *Our Chemical Environment* and then in 1973 wrote an outstanding textbook for undergraduates, *Chemistry, Man and Environmental Change*. Some of the topics he was interested in 20 years ago were air and water pollution, contamination of our environment by heavy metals and pesticides as well as ozone, the greenhouse effect, and nuclear energy.

Cal received worldwide recognition and many awards for his pioneering work in analytical chemistry, separations, and chromatography. Among the many awards he has received are the National Award in Chromatography of the NE Regional Chromatography Discussion Group, the Award of the Chromatography Society, The M. S. Tswett Chromatography Medal, the ACS award in Analytical Chemistry, the ACS award in Separations Science and Technology, A Fulbright Fellowship to work in Peru, and tucked in among the scientific awards is the Romcoe award for outstanding environmental achievement in education.

I worked closely with Cal on the *Advances in Chromatography* series and I will remember him not only for his brilliance, his knowledge and his integrity but also because he was a gentleman in every sense of the word. Although I recognize his unique and outstanding contributions to analytical chemistry, I will always remember him for his kindness and his friendship. He had a most profound effect on the lives of everyone who knew him. I was proud and honored that Cal was my friend and I miss him greatly.

Eli Grushka
The Hebrew University, Jerusalem, Israel

It is very difficult for me to write this memorial note. How does one eulogize a very close friend, a colleague and a mentor? The notion that Cal is no longer with us is hard to accept. Here was a man that did everything right: He was an avid pursuer of outdoor activities, he led his life according to his environmental convictions and yet, he succumbed to genetics.

Cal was a separation science giant. With his very strong background in physical chemistry and his excellent ability to see the connections between real world phenomena and the theoretical equations that describe these phenomena, he made some milestone contributions to separation science. His book entitled *Dynamics of Chromatography* is still a must book for all chromatographers. This is no mean feat considering the fact that the book appeared in 1965. His theoretical approaches to zone spreading in chromatography, which are summarized in the book, were the foundation to more recent developments in the field. *Dynamics of Chromatography* anticipated many of the advances that were made after the book appeared! It is a pity that the book is out of print.

Around the time that *Dynamics of Chromatography* appeared in press, Cal made two other extremely important contributions: (a) the establishment of the *Advances in Chromatography* series (together with Roy Keller) and (b) the launching of the journal *Separation Science*. The *Advances* series, which is still going strong at present, gave the then relatively young field of chromatography a measure of legitimacy. Also, the series provided a means of bringing leading-edge reviews, written by top experts, to the burgeoning cadre of chromatographers. Some of the chapters in the early volumes are still as valid today as they were at the time of publication. Cal was the executive editor of the series until the early 1990s.

Separation Science is the major journal in the field. It is truly an interdisciplinary publication, drawing authors from diverse research areas. It was as unique when it first appeared as it is today. Cal was its editor until recently, when his illness prevented him from devoting the time and energy that are needed to run a first-class journal.

Cal always strove to find a unified approach to separation science. I remember vividly sitting in a class that he taught in 1968 where he first advanced his ideas for classifying separation methods. At that time he spoke about the combination of relative displacements and bulk displacements. It was a fascinating tale because it was simple, neat and it made lots of sense. In the years that ensued, he further elaborated on the topic, publishing a chapter in the *Separation* volume which I edited in the mid 80s, of the *Treatise on Analytical Chemistry*. In 1992, when he felt that his approach was fully developed, he published a book entitled *Unified Separation Science*. The book is again unique. It is not a compendium of separation techniques, rather, it is a serious attempt to find the common thread that connects a great many, if not all, separation methods.

Cal is also responsible for inventing, developing and commercializing a new separation method, namely, field-flow fractionation (FFF). The idea for FFF came to him while white-water kayaking in the early 60s. A large number of his publications in the last twenty years dealt with the theory, instrumentation and application of FFF. This separation method is particularly suitable for large molecules and for particle separations. I was involved with FFF in its very early days, during my postdoctoral stay with Cal. Thus, I know the great advances that were made in this area. I also know the strength of his commitment to FFF. It is sad that he will not see the full success of the technique.

I could keep elaborating on Cal's various contributions and achievements. I could analyze his many hundreds of papers. I could talk about his commitment to a better environment (he even wrote a general chemistry textbook which stresses the environmental aspects of chemistry). I could describe his outdoor activities, including his famous Amazon trip.

I could attest to his great dedication to good science and to scientific integrity. I could enumerate all of the awards that he received for his scientific achievements. However, none of these activities would change the plain, simple and cruel fact that Cal is no longer with us.

To me Cal was first a mentor and then a friend. In 1967, as a fresh Ph.D. in analytical chemistry, I came to his lab with awe. My two-year stay in his laboratory helped to shape my career. During that stay we also became friends, and that friendship has lasted until his death.

With Cal's untimely passing, science has lost a giant. We are all the poorer for that. He will be greatly missed.

John H. Knox
University of Edinburgh, United Kingdom

It seems no time since I spent a memorable sabbatical working with Cal Giddings along with my wife, Jo, and our family of three small boys. It was in fact 33 years ago, 1964, from January to September. Cal and I first met at the "International Gas Chromatography Symposium" organized by the redoubtable Al Zlatkis and held in Houston, Texas, in January 1963. This was to be the first of the renowned series of meetings which became the International Symposium on Advances in Chromatography. This title was taken over by Cal when he initiated the series of review volumes with Marcel Dekker entitled *Advances in Chromatography*. These volumes have become an important part of the literature of Chromatography, greatly to Cal's credit.

Cal's tragic death after a long and courageous struggle with cancer was not altogether unexpected to those of us who were aware of his illness. Nevertheless, it came as a shock and brought great sadness to his colleagues and friends. His contributions to separation science are recognized as exceptional and are acknowledged worldwide. Cal was one of the great physical scientists of our generation, and his loss will be felt deeply by the chromatographic community.

Cal and I immediately struck up a rapport which was perhaps best illustrated by our discussions at that early symposium. I well remember having a vigorous discussion with Cal and Howard Purnell on the various pressure correction factors which should be applied to the terms in the van Deemter and Golay equations. In particular, Howard and I were unaware that the factor $(9/8)(\pi^2 - 1)(\pi^4 - 1)$ had to be applied to the mobile phase terms. We both thought that no correction term was necessary. Cal explained why we were wrong and eventually we were convinced. On another occasion, Cal and I were sharing a taxi and discussing axial diffusion in packed columns (the B-term of the van Deemter equation). We came up with what seemed a great idea, namely that the obstructive factor, γ (in the term $H_{\text{diff}} = 2\gamma D_m/u$) could be found rather easily by injecting an unretained sample into the GC column, stopping the flow for a measured time and determining the extra band spreading when the flow was restarted at its original rate. What we recognized was that the flow or drift velocity was so much smaller than the molecular velocity that diffusing molecules would not know whether or not they were actually drifting along the column. Accordingly, this method should give an accurate value of γ. The method proved very successful, and at their next Zlatkis Symposium, Lilian McLaren and I published a paper on this topic. The method is, of course, applicable not only to gases but to liquids, and could well resolve some of the difficulties in interpretation of diffusion rates of retained solutes in HPLC columns. We did try this some years ago but our experiments were not extensive enough to reach useful conclusions.

These early meetings led to an invitation from Cal to spend a sabbatical year in his lab as an NSF senior visiting research scientist. I eagerly took up this opportunity. It was an exciting time. The fact that my wife and I and Cal were all keen skiers made the invitation particularly attractive. Cal was in the final stages of writing his book, *Dynamics of Chromatography*: *Part 1*. He would give us lectures on the various chapters in the forthcoming book. These were absorbing occasions with his group of research students and revealed Cal's extraordinary grasp of the fundamentals of chromatography. Among Cal's group at that time were Paul Schettler, Margo Eikelberger, and Alexis Kellner. We were a somewhat eccentric group and most of us were as interested in the outdoor life as we were in science. One of the great features of the group was that Cal, himself, was such an enthusiast for the wilderness areas of his home state. If it turned out to be a particularly fine day, Cal would announce, "Let's go skiing today," and all work would cease! Later in the year after the snows had melted, he would come into the lab with, "How about a desert trip this weekend," or "How about a canoe trip down the Yampa tomorrow." This mixture of work and play contributed to a great spirit in the lab. Times were more relaxed than now, but as a way of running a research group, this brought out the best in people and generated all sorts of novel ideas. We worked at that time in the old "Chemical Engineering Building," long before the present "modern" chemistry building was built or even thought of. The great thing about an old building is that you can drill holes in the walls, screw things to the benches, hack out cupboards, and not worry too much about mercury under the floorboards! Some amazing experiments were done. I remember packing a high pressure GC column which was the height of the building. The column was suspended from roof level and filled with fine firebrick. The material was packed down by an eccentric spindle mounted in a small electric hand drill. This was held in contact with the column and moved up and down the column. I cannot remember if the experiment was a success, but it was fun! Another feature of these days was the availability of ex-army supplies. Much of the electronics (very simple then) could be purchased for a song at the local army surplus store.

Cal and I decided that I should do some experiments to test his "coupling theory." Cal had proposed that the basis of the A-term in the van Deemter equation was not as simple as generally thought. What was really happening in a packed column, according to Cal, was that the dispersion which arose from the velocity variations across any flowing fluid was counteracted by two processes. The first came from the nature of the stream lines themselves which were tortuous and along which there were velocity variations. This was the basis of the constant A-term in the van Deemter equation. The second was diffusion of the analyte molecules across the direction of flow. This was recognized by the C_g-term in the Golay equation. Up until then, these two terms had simply been added (*i.e.*, $H = A + C_g u$). Cal saw that this was wrong. They should be combined in a different way, harmonically, that is: $H = \{(1/A) + (1/C_g u)\}^{-1}$.

Having made this conceptual breakthrough, Cal recognized that, in reality, the situation was still more complicated, and he proposed that there should be five such terms added together to allow for different ranges of velocity inequality in a packed bed. My object was to test these ideas. I could not use a GC system because this would require too high pressures and too fast recording to reach the necessary velocities. Furthermore, it was expected that turbulence would set in at rather low velocities anyway and this would confuse the analysis.

I, therefore, chose to use a liquid chromatographic system. HPLC was still some years in the future. I set up the first LC in Cal's lab; up until then everything had been GC. It was very simple. The detector consisted of a tungsten lamp and two photocells, one viewed the lamp through a blank cell containing eluent, while the other looked through eluate from the column. I used what is now grandly called a bubble cell after showing that it provided the least dispersion of any cell design. Potassium permanganate was the solute, and its absorbance was kept constant by dissolving it in 0.1 M potassium nitrate. The eluent was delivered to the column under pressure from a head of mercury through a length of fine hypodermic tubing. All this worked brilliantly and I was able to determine H as a function of velocity over a very wide range. What I found was that H rose gradually with velocity but not according to any equation so far proposed. The best empirical relation was $H = \{(1/A) + (1/C_g u^n)\}^{-1}$.

The value of n was around $1/3$, but there was no simple explanation of this. Nevertheless, Cal's contention that the A-term was velocity dependent and tended to a constant value at high velocities held. At the highest velocities H actually began to fall due to turbulence. A good physical explanation of the velocity dependence of the A-term has yet to be given.

Work as I have said was interspersed with play. Cal was a superb skier in the powder, and we tried to follow. Various expeditions were organized into the Wasatch mountains. On one memorable occasion, Alexis Kelner—no mean skier and a dedicated photographer—carried an enormous plate camera with a telephoto lens. With this he produced some superb photographs. The snow was tinged with red dust which apparently came from the desert. On another occasion, Alexis was commissioned to make an enormous print for the Wasatch Mountain Club, something like 8 ft by 5 ft. The projector had to be mounted from the ceiling, and the paper on the floor exposed for something like 30 mins. Development and fixing was achieved in a specially constructed tank made from a plastic sheet supported at the edges by wooden beams. This was a time for doing the impossible with the help of inspired innovation! Kayaking provided another example. This was the summer sport. Kayaks may have been available to buy, but it was more fun to make your own. Cal had made several previous models in fibreglass with home-made molds. By 1964 he had developed a sophisticated shape with a long thin bow and stern. Fibreglass and resin were available in the city. When a new kayak was required we all got together on a sunny afternoon, and sloshed resin onto woven glass fiber cloth pressed into the mold. It was a messy job and everyone had glass fiber itch for days afterwards. Choosing the right day, the resin hardened fast in the sun. A kayak was made in an afternoon and ready for use the next day. We did not have built-in seats, so control was difficult and Eskimo rolling impossible. But kayaking down the great rivers in Utah was an experience never to be forgotten—exciting and hugely enjoyable.

Several years later, after Cal had kayaked in South America and become highly expert, I was attending an HPLC meeting in California, and made a weekend trip to Utah to join him in a kayak trip down the Colorado. By this time we had proper equipment. Both of us had become proficient with the Eskimo roll. This was one of the great kayaking expeditions with heavy rapids requiring vigorous paddling through large waves. The ability to roll reliably was important! The rapid called Skull (with good reason) was especially formidable. We were in the company of a group of other adventurers in rubber inflatable rafts. They paddled frantically and perilously down this rapid. We kayakers thought better and carried around.

On a later occasion, in 1990, my wife and I were attending an ACS Meeting in Boston. We followed this with a visit to Salt Lake and met up with Cal's wife, Leslie, and a number of our old friends from 1964. Still skiing 26 years after, were Cal himself, Gayle Dick, Professor of Physics and Dean of Graduate School, and Alexis Kelner, still taking photographs. It was an enjoyable and sentimental occasion with much talk of old times as well as the present.

I stayed again with Cal and Leslie in 1994 midway through a consultancy visit to California. We skied cross country with Alexis in the woods near their home in Killyon Canyon accompanied by their much loved dog, Saba. I can still hear Cal shout out, "Saba, Saba, come back," as Saba ran off deep into the cottonwoods stalking an elk. At that time in Edinburgh we were working on capillary electrophoresis (CE) and had found a curious dependence of plate count upon velocity. In CE one expects the plate count to increase linearly with the applied voltage and with the velocity. This is because band broadening under ideal conditions in CE arises only from axial diffusion (B-term broadening). We found a fall away from this relation and, indeed, an actual fall in N as the voltage was increased. We had long discussions about how this could occur without a satisfactory answer. In the end, the explanation turned out to be simple. The capillary was heated by the current, and the diffusion coefficient of the analyte increased so much that the efficiency actually declined. This was the last time I saw Cal. He was already ill at the time, although nothing was mentioned.

I have said little about Cal's personal contribution to the advance of chromatography. This is partly because I hope to deal with this elsewhere, and partly because I wanted to set down more personal reminiscences. Cal's contribution to chromatography has been enormous, and has revolutionized our way of thinking about the whole process. I have referred to his treatment of the eddy diffusion problem above, but it is his non-equilibrium theory that has given us the greatest insight into the kinetics of the chromatographic process. This is a hugely powerful tool for the characterization of the mass transfer contributions to band broadening. The whole non-equilibrium concept has clarified our understanding of a range of separation techniques including all forms of chromatography as well as electrophoresis. The idea that chromatography, to be efficient, must take place under near-equilibrium conditions clarified a number of areas. In particular, it proved that selectivity of gel permeation chromatography could not be explained by the different diffusion rates of analytes into the pores of the packing material. Because one must be working close to equilibrium, the reason for partial exclusion has to be stearic (or at least thermodynamic), not kinetic.

The non-equilibrium theory gives an exact solution to the problem of the band spreading to be expected from beds with various configurations of stationary phase or stationary zone. For modern liquid chromatography, the solution to the problem of dispersion by a bed of porous spherical particles is the most important. The contribution to H arising from slow mass transfer enables us to calculate the effective diffusion rate within the particles of the packing material. The packing material contains both stagnant mobile phase and true stationary phase. We know the diffusion rate within the stagnant mobile phase, and, therefore, have a way of determining diffusion rates in surface layers (*e.g.*, ODS bonded to the surface of the silica. It is just unfortunate that there has been very little research into mass transfer in such materials. Good experimental work would materially improve our knowledge of surface diffusion, and could have important implications for catalysis.

The contributions of Calvin Giddings to chromatography will be his lasting memorial, and, along with A.J.P. Martin, he will always rank as one of the truly outstanding contributors to the development of the theory of chromatography. He will also be remembered by his invention of the whole range of field-flow fractionation techniques, and for his lifelong concern with environmental affairs.

Milos V. Novotny
Indiana University, Bloomington, Indiana

My admiration for Professor Giddings' work in separation science goes back to the beginning of my scientific career in Czechoslovakia. This was many years before I met Cal Giddings in person. I developed a healthy respect for the power of chromatographic techniques first as a biochemistry graduate student during the mid-1960s. Serendipitously, my desire to learn more about the nature of chromatographic separations coincided with the availability of a fellowship in the internationally recognized Institute of Analytical Chemistry in Brno. This was to become the beginning of a most professionally rewarding career in separation science.

During my "scientific apprentice" years in Brno, I came across Giddings' name in the literature with amazing regularity. He was a leading theoretician in an exciting field, in which young aspiring experimentalists, like myself, tried to find their own orientation. Not surprisingly, my enthusiasm for Giddings' publications were shared by several of my co-workers in the institute, almost regardless of their previous educational experience or theoretical background (the institute had on its scientific staff a wide spectrum of people, ranging from physical and analytical chemists to biochemists, like myself, to chemical engineers). This uniform enthusiasm illustrates to me one of the outstanding legacies of Cal Giddings' life accomplishments; he was not just a theoretician whose papers would excite a selected group of individuals like himself. Without compromising the fundamental principles and mathematical rigor, he was able to convey important messages to a great number of experimentalists. The clarity of his presentation, the simple elegance of his conclusions and his easy writing style have had a wide appeal to the separation science community. This is, perhaps, best reflected in his masterpiece, *Dynamics of Chromatography*, published in 1965, the book has been immensely successful in explaining some difficult scientific concepts with ease, and many generations of graduate students have appreciated it to this date.

In 1966, I was initially delighted when I was assigned by Dr. Jaroslav Janak (then director of the institute) to join the research group exploring the role of high pressure in chromatography. This was precisely the part of the field where J. C. Giddings was known as a chief advocate of this direction and its leading scientist. I still remember fondly numerous discussions of Giddings' papers with my friend and the next-door mentor, Dr. Josef Novak, for that was the most intensive period of learning the fundamentals of chromatography in my life. In fact, Dr. Novak was scheduled to join the Giddings group in Utah as a postdoctoral fellow, but for political reasons, his trip never materialized—this was Communist Czechoslovakia during the 1960s. Our experimental work in "dense-gas chromatography" did not result in publication because of the experimentally elegant studies of Sie and Rijnders in the Netherlands (now viewed by many as the most defining point of the field of supercritical fluid chromatography), which just appeared in the literature and overshadowed the best we could offer to publish with our primitive instrumentation in Brno. Our work on the use of carbon dioxide came to a halt, further strengthening my determination to seek research opportunities in the West. This was a great disappointment. In retrospect, I learned much and found Giddings' publications most enlightening, both scientifically and philosophically. Briefly, I took up supercritical fluid chromatography once again in 1970 (this time, with Al Zlatkis in Houston), but the subject was already in the large shadow of the immensely successful HPLC.

Cal Giddings leaves behind a most profound legacy. As a theoretician (a true pupil of Henry Eyring) of the field of separation science, he was second to none. He predicted some of the most important trends in our field: the theoretical limit of liquid chromatography (*Anal. Chem.* **35**, 2215 [1963]) and its interpretation to what was to become HPLC, dense-gas chromatography, now better known as supercritical fluid chromatography, the positive effect of high field strength in electrophoresis (*Sep. Science* **4**, 181 [1969]); importance of multidimensional separations; and last but not least, his work in field-flow fractionation, a methodology to which he largely devoted the last productive years of his life. As an idealist and a true prophet of our field, Cal Giddings had often worked on ideas that lay dormant for many years afterward. And, he undoubtedly had to face people who considered at least some of these ideas to be "impractical." His own transition to a more experimental work during the late 1960s might have been hastened by some of these "imperfections" of the real world. I remember him being genuinely pleased about the renaissance of supercritical fluid chromatography during the 1980s. During the most recent period, Cal was emphatic about field-flow fractionation, the field that he had conceived and largely developed. In spite of its current technological difficulties, FFF may still have a bright future.

The stimulatory effect of Giddings' papers on my own work were numerous. His publications from the 1960s about the theoretical limits of gas and liquid chromatography were a continuous inspiration in developing capillary-size (microcolumn) chromatographic methodologies. Reading over again some of his publications sustained my determination (some may say stubbornness) to demonstrate that supercritical fluids have some inherently advantageous properties in terms of both separation and detection. Al Zlatkis' motto that "there is a place, somewhere, for almost any chromatographic methodology ever proposed" together with Cal's statement that "theory (when correct) and experiment (if carefully executed) should describe the same truths" still ring in my ears. And, the emphasis on the continuity and importance of cross-fertilization among the different separation techniques is something that I can still at least vaguely associate with Cal Giddings' philosophy. Directly, or indirectly, I feel these sentiments have been shared by at least some of my students and, by now, probably their students as well! Starting with capillary supercritical fluid chromatography, the idea that Milton Lee and I started to explore together in the late 1970s, Milton has been comfortably making transitions from the gas-phase to the condensed-phase separations in much of his subsequent research efforts. In his pioneering work on capillary zone electrophoresis in 1981, Jim Jorgenson cites a Giddings paper from 1969 as being fundamental to his own approach to "brute force" in electrophoresis. Interestingly, in his 1991 book, *Unified Separation Science* (Preface), Giddings refers to capillary zone electrophoresis as "the most revolutionary methodology." These are just two examples coming immediately to my mind, but I am certain that there are additional lessons to be found in the many papers written by this extraordinary scientist and educator during his productive life.

Cal's personal friendship is something that I have cherished throughout my career. I enjoyed our long discussions, ranging from science to political matters. I always looked forward to meetings in which he and I ended up on the same program. When going to a conference overseas, we often called each other to coordinate our plans. We shared the "adventures" of a trip to the Soviet Union in 1985. There we jointly accepted a preliminary invitation to a conference in Bulgaria, with the idea of doing some mountain-hiking on the side. (That trip never materialized for me—Cal got his official invitation in time, but mine did not arrive, due to the Bulgarian bureaucracy, until one week before the actual conference.)

At one time, I actually seriously considered a move from Indiana to the University of Utah, and the idea of becoming Cal's faculty colleague was a strong drawing card. For a variety of reasons, mostly of a personal nature, I decided to stay in Bloomington. In spite of some disappointment that my decision caused, Cal and I remained good friends. During Cal's visit to Indiana University, shortly before the beginning of his health problems, we discussed the possibility of collaborating on the fractionation of large polysaccharides. I sincerely regret that we never started—a most dreadful disease, which had also claimed the lives of both of my parents and another good friend in the past, terminated the life of Cal Giddings, a most wonderful human being and our scientific colleague. We will sorely miss him.

Charles H. Lochmueller
Duke University, Durham, North Carolina

I first learned of Cal's work while preparing to postdoc for L. B. "Buck" Rogers in 1966. Buck wanted me to work on pressure stabilization of protein conformation on-column and it seemed important to find what could be found on the dynamics of chromatography as well as the usual thermodynamic equilibrium models. Over the years, Cal would become one of my models for scientific rigor, a reviewer of my papers and a fellow speaker in ACS symposia. What impressed me the most was his willingness to swim upstream against the torrent flood of qualitative thought in separations.

I can fairly say that Professor Giddings' approach had its influence on my own research. The model we proposed for the texture of bonded phases 20 years ago, the recent work in spatial gradients to do electromigration separations and to enhance the resolution of polymers in RPLC were outgrowths of studying people like Cal Giddings, and studying what it is that leads people like Cal to see the importance of what may be hidden in slight disagreements between theory and measurement. And, frankly, I admire his decision to take time to discover hidden valleys, unknown streams or take a kayak to the Amazon. And I admire the fact that he had a sense of humor and could be quite excited in ordinary conversation. (Although, little he ever said to me qualified as ordinary.) My former undergraduate student in independent study at Duke, Joel Harris, went from Duke to Purdue to Utah. After his tenure at Utah, we went back to doing work of joint interest. It was during a visit to Utah that I had the following experience with Cal while using a "loaner" office next to Henry Eyring himself.

We were discussing how one becomes involved in chemical separations as a field and Giddings related this story of his mentor and his effect on Cal's research direction. "One day we were in the lab and Eyring came in (as he often did) brim full of another insight and wanting us all to stop and listen. 'What do you know about chromatography?' he asked us. (Not that much, if the truth were to be told.) And then for about 2 hours, he went through a detailed lecture on his ideas. You know, everything I have done in my career was outlined in that two-hour session!" I like to tell that story because it was not a falsely modest statement on Cal's part. No, he believed that that event had had a real influence on him. That is not to suggest that he thought—or anyone should think—that Cal was handed a lab manual and went about following the recipes for a quarter of a century. What it meant to me was that he was secure enough in his own work to give credit to the person who had had so much influence on his scientific views. Typical Giddings. And when I run across former students while visiting schools or national labs, it is not hard to detect the effect he has had on their scientific perspectives either. There have been very few like him, sadly. It is an honor to participate in some small way in paying tribute to a scientist that has had so much influence on the pure and practical aspect of chemical separations. And just as I wrote that, I saw his smile and heard him laugh again.

Leslie S. Ettre
Norwalk, Connecticut

Those who know a little about Greek mythology, might remember the origin of *Pallas Athena*, the goddess of wisdom; she was supposed to leap forth from the brain of his father, Zeus, mature, and in complete armor.

In our field, chromatography, almost everybody started by first having a learning period—using the technique for some practical analysis, and then advanced from there onto the next level, the science of the technique. Only a few persons could immediately jump to the highest level of "science," developing new and original theories without going through the learning period. In other words, coming from nowhere, already mature and in full armor. As part of this group I consider *Archer Martin*, the inventor of partition chromatography, simultaneously describing theory and practice; *Jan van Deemter*, the developer of the rate theory, the basis of our understanding of chromatography; *Marcel Golay*, who in his famous paper on the telegrapher's equation presented in April 1956 at the National Meeting of the American Chemical Society (predating van Deemter's paper) logically derived the theoretical background of the chromatographic separation process and then followed this up by the invention of open-tubular columns, elaborating also their complete theory; and Cal Giddings who, just out of graduate school, provided a fresh explanation of the chromatographic separation process with his generalized non-equilibrium theory (commonly called the "random walk theory") and about a decade later, invented a new separation process, field-flow fractionation.

Others who were close to Cal can elaborate his achievements and influence on the evolution of separation science much better than I could do it. I only want to contribute a few personal remarks.

I met Cal first at a Gordon Conference in 1960 or 1961. It was a wonderful late August in New Hampshire and Cal, Roy Keller and I became good friends. I even made a detour when coming home, driving them to Boston to catch a plane. In the subsequent years we have met at the many meetings which took place almost every half a year. Both he and I were early birds and usually had breakfast together when the others were still asleep. Cal told me about his outdoor activities, mountain climbing, kayaking, about the Utah wilderness, and then 15 years later, about his expedition to Peru, exploring the Apurimac River. Some of his stories were like the stories I read in my youth about the wild west and the early pioneers.

Cal's contribution to chromatography was tremendous. One should particularly emphasize the ease how he could immediately approach a subject by pointing to the fundamental question and then exploring it theoretically. This is already evident in his random walk theory. He used the same approach when dealing with the new technique of temperature programming which was essentially developed empirically; picking up a few crucial questions and then answering them step by step, indicating the way to optimize the conditions. As he pointed out, only this way "can provide an increased convergence between theory and experiment." Probably nowhere is this approach more evident than in his twin papers published in 1963 in *Analytical Chemistry* discussing the effects of column variables on plate height. It was the second of these papers which laid the foundation to modern liquid chromatography, pointing out the steps to be followed to approach the performance of gas chromatography.

According to a Latin proverb, *verba volant, scripta manent*, the spoken words fly away, but the written words remain. Cal was well aware of this principle, not only in his own work but also concerning the whole field. His theoretical treatments were summarized in the textbook *Dynamics of Chromatography*, published in 1965. He also realized the importance of periodic summaries of important results and the need to have a forum available in which these can be published. The *Advances in Chromatography* series he started with Roy Keller represented such a forum. Cal was also a strong advocate of the philosophy to consider chromatography not as an independent discipline, but part of a much broader field, as one of the many separation methods. This was the reason that in 1966 he founded the journal *Separation Science*, his book on *Unified Separation Science* published just five years ago represents the culmination of this unified approach.

Some time ago when I was asked to provide guidelines on how to select winners for certain awards, my suggestion was to consider how would the field look if the person in question wouldn't have done anything, is there something that we would really miss? In the case of Cal, the gap would certainly be tremendous, and it is difficult to consider the field of separation science without his contributions.

It is very difficult to say goodbye to a friend, to somebody with whom one participated for almost two scores of years in the evolution of a field. The only consolation is the realization that future generations will remember his achievements and—what is even more important—utilize it in their work.

Milton L. Lee
Brigham Young University, Provo, Utah

It is ironic that I graduated from the University of Utah with a bachelor's degree in chemistry without meeting Cal Giddings while I was there. In fact, the only knowledge of chromatography I acquired as an undergraduate was from a brief exposure to classical adsorption chromatography in an organic chemistry laboratory. I can only imagine what my graduate advisor, Milos Novotny, must have thought in my first interview with him when I told him that I knew nothing about chromatography, but thought that it would be an interesting subject to study. How could a student graduate from the University of Utah with little or no knowledge of Cal Giddings and chromatography?

I soon learned about both as a graduate student at Indiana University. Milos often referred to Cal's book, *Dynamics of Chromatography*, in discussions in the research laboratory and in the graduate course in chromatography that I took from him. Since we were heavily involved in glass capillary column gas chromatography in those days, Milos reminded us often of Cal's statement in the book about the relative importance of efficiency and selectivity: "To separate a large number of solutes simultaneously, the requirement for narrow zones is critical. If the relative migration rates were changed, we would merely scramble the peak locations, improving some separations and hindering others. If each peak or zone were reduced in width, each and every peak would be more completely isolated from its neighbors." Cal Giddings always had a clear and almost poetic way of explaining things.

It was a pleasure to get to know Cal after I joined the faculty at Brigham Young University. With only 50 miles separating our universities, it was easy to communicate. I also became acquainted with Marcus Myers and Karin Caldwell who carried much of the responsibility for the magic that occurred in Cal's laboratory. Frank Yang, who had spent considerable time with Cal, first as a graduate student and later as a postdoc, became a good friend, and I gained more insight and respect for Cal from him. I benefitted early from Cal's international reputation because many visitors from around the world who came to see him would spend an extra day to visit me at Brigham Young University.

I have always appreciated Cal's support of my research efforts. He was a strong supporter of our efforts in capillary supercritical fluid chromatography, especially at the time that our patent was being challenged. In a sworn affidavit to the United States Patent and Trademark Office, he made the following statement: "In various aspects of our early work, we used both not-very-dense supercritical fluids in capillary tubes and dense supercritical fluids in other experimental configurations, but not in capillaries. However, we cannot claim to have combined these two advantageous techniques: capillary chromatography and supercritical fluid chromatography. It is my opinion that the combination of dense gases and capillary columns, as described in the patent, merits patent protection. While it is easy to claim after the fact that the invention would be obvious to one skilled in the field, it turns out that this unique combination was not so obvious at the time. Despite its significant advantages, the concept certainly eluded me and other people involved in the early development of dense gas chromatography. I believe that the insightful combination of the two key ingredients of chromatography noted above—capillary tubes and dense gases—will prove to be one of the major inventions in the field of chromatography." I believe that our patent was upheld primarily because of Cal's modesty and support.

I was pleased when Cal told me that he was planning to start a company to manufacture and market his field-flow fractionation instrumentation. Having recently gone through this exercise myself, he was interested in all of the details. We spent many hours talking about the various approaches and pitfalls. I enjoyed subsequent comparing of notes about our ventures outside the ivory towers of academia into the business world.

I feel a special kinship with Cal Giddings. We were both raised in rural Utah towns, with a love for animals and the outdoors. We were both primarily educated in Utah schools. We both selected the field of separation science for study and research. We both accepted faculty positions in chemistry departments at major Utah universities. We both taught graduate and undergraduate chemistry students, and directed research programs in separation science. We both founded and edited research journals in the field of separation science. We both founded new companies to manufacture and market separation science instrumentation. We both organized international symposia series to promote specific separation techniques. Cal Giddings has provided a well-marked path with large footsteps for me to follow. If I manage to leave behind only a fraction of the legacy that Cal has left with us, I will have succeeded.

Cal Giddings was a brilliant pioneer in the field of separation science. He blazed the trail in chromatography and provided a quantum leap in its understanding. However, he left the rest of us to carry on in pushing back the remaining frontiers. There is still work to do. In his own words: “The basis of chromatography is a kaleidoscopic blend of interrupted geometry, ubiquitous diffusion, and erratic flow. The practical tasks required of it are equally varied and complicated. The collection of unique rules to cover the nearly unlimited diversity of chromatography will be out of reach for a long time to come.”

Ted Eyring
University of Utah, Salt Lake City, Utah

Having worked on the same chemistry faculty with Cal Giddings for over thirty-five years I have many pleasant memories of him. I took five years out of my university education to do other things, and as a first year graduate student in chemistry at the University of Utah, I finally began taking some of the undergraduate chemistry courses I had missed in my pursuit of other interests. Thus Cal was one of the faculty instructors who taught me undergraduate physical chemistry. Cal already had a formidable research reputation. However, not enough can ever be said about the flair Cal had for making the mathematical aspects of chemistry accessible and interesting to his students. He could explain chemical concepts as only someone can who understands the subject very deeply. Cal was simultaneously one of the most challenging and most agreeable teachers I ever encountered in a university classroom.

One of Cal’s equally noteworthy qualities was his capacity to see the potential for good things in other people. In one case, a student had performed poorly in an undergraduate class that I had taught, and I had come to the precipitous conclusion that this student would never amount to much. Cal, however, took this student into his research operation and encouraged him to excel in professional pursuits other than chemistry. This former student has since gone on to make a number of very positive contributions to the quality of life of those of us who live along the Wasatch Front.

Cal will be sorely missed not only in the broad field of separation sciences but also particularly as a teacher and mentor of students in the University of Utah Chemistry Department.

Jack Kirkland
Rockland Technologies, Newport, Delaware

A giant in the field of separations now has passed on, but not without leaving an indelible mark that will never be forgotten. The creative and tireless efforts of Cal Giddings have affected all areas of separation technology, which in turn, have touched the lives of all mankind. Cal’s work initiated and stimulated important achievements in many areas of scientific endeavor.

I first met Cal at a symposium on gas chromatography at Michigan State in Lansing, Michigan, in about 1960. There, he was deeply involved in early theoretical discussions on mass transfer effects in packed beds and capillary columns with Marcel Golay, A. J. P. Martin and others. It was then obvious that Cal had much to contribute to the theory and practice of separation science. His interest in the basics of chromatography resulted in his landmark book, *Dynamics of Chromatography*, published in 1965. This important work not only set the tone for quantum improvements in gas chromatography, but also formed the basis for the exciting developments in high-performance liquid chromatography (HPLC) that shortly were to follow. My own HPLC studies in subsequent years were strongly influenced and guided by Cal’s careful and accurate explanations of separation basics, and especially his predictions of optimum systems.

In 1966 Cal invented a new form of separation, field-flow fractionation (FFF), the science of which he pursued strongly to the end. Again, I leveraged his unique insight and began FFF programs within DuPont that resulted in analytical characterizations of significant importance. Cal’s extensive studies in FFF have resulted in the development of a family of new FFF separation methods that strongly impact many areas of science.

Cal Giddings always was a strong and vocal supporter of environmental safeguards, and to that end, wrote a significant book, taught appropriate courses, and provided advocacy whenever possible. His sincere efforts in this field will long be remembered and appreciated.

I personally count myself very lucky to have known Cal Giddings. Our many technical discussions and friendly social encounters will long be recalled and treasured. I will miss him, but will remember that the world is certainly a better place because Cal Giddings was here and made his mark.

Barry L. Karger
Northeastern University, Boston, Massachusetts

It's hard to imagine that Cal Giddings has passed away, given the vigor with which he lived his life. I knew Cal for over 30 years and found him to be a close and loyal friend.

My first experience with Cal occurred in 1966 when I followed him in a lecture as a part of the Al Zlatkis Chromatography Symposium Series. Dennis Desty was the chairman, and Cal overran his lecture time, describing important concepts in separations. Since I was a young, relatively unknown scientist, Desty was determined to get back on schedule and cut my lecture time by 1/3. To say the least, I was quite flustered and had difficulty ending in a coherent fashion.

Cal's contributions to a basic understanding of band dispersion in chromatographic operation were seminal and significantly contributed to the current design of HPLC columns. He appreciated more than most the competing contributions of mobile phase flow, particle diameter and kinetics of mass transfer in optimization. While he is most known for his chromatographic contributions, his work on resolution in zone electrophoresis and isoelectric focusing is still quoted frequently. He also introduced and strongly promoted field-flow fractionation, a method for large particle and molecule separation.

Cal also made a major contribution to the education of scientists in separation science through his books, *Dynamics of Chromatography*, and more recently, *Unified Separation Science*. As one who coauthored a textbook in his field, I can say that his texts were lucid and demonstrated a depth of understanding of the field.

Most especially, I remember the quiet, gentle manner of Cal in all my interactions with him. One time, only a few years ago, I visited the University of Utah and had supper with him alone at the Hotel Utah. We talked about the future directions of the field of separations and his predictions. It was a most pleasant dinner—I learned much about Cal's work schedule, his interest in the West and his joy of life. Indeed, every time I met with him was enjoyable.

We are in a transition from the giants of chromatography of the 1960s through the 1980s to a new generation. I hope the newer generation appreciates all that these individuals contributed to the foundations we have today. Cal Giddings is at the top of the list of these giants.

Frank J. Yang
Micro-Tech Scientific, Sunnyvale, California

Thursday, October 24, 1996, was a day of sorrow and loss for me, my family, and the scientific community. That day, my mentor, Dr. J. Calvin Giddings, passed away after two years of battling with cancer. The news came as a big shock to me and my wife; we had heard just a few weeks ago that Dr. Giddings was recovering and had made a trip to Lasalles Mountain with his family and friends. I believed that Dr. Giddings' strong determination, courage, and physical strength would pull him through. Besides my personal mentor and inspiration, he was a giant in separation science, an inventor of field-flow fractionation, and a great environmental teacher. His death was not only a great loss to his family, but also to his friends and the many individuals of our scientific community.

I had the fortune to begin my undergraduate research study in 1966 in gas chromatography, learning from Dr. Giddings' newly released book, *Dynamics of Chromatography*, which I believe to be the "bible" of chromatography. My admiration for his work lead me to join his group in Utah in 1969 and to choose my life-time career in this very rewarding and enjoyable profession of separation science.

When I first met him face to face after arriving from Taiwan in 1969, my first reaction was surprise at discovering Dr. Giddings to be so young, having already accomplished so much as a well renowned scientist in separation science. At that meeting, I also found Dr. Giddings to be a wonderful human being. I was grateful for his kindness in offering an advance of my scholarship to pay for my tuition fee upon learning that I had less than $80 to begin my life in America. It was my most rewarding time to be with Dr. Giddings. I had the chance to ask Dr. Giddings face to face any questions that I had about his book, *Dynamics of Chromatography*. I also enjoyed weekly group meetings with him where I had a chance to talk about experimental results, problems, ideas, and plans, and the opportunity to learn a great deal from group members. Particularly, I was amazed at Dr. Giddings' intuition for and insight into every aspect of both the experimental and theoretical details of every project. His profound knowledge in the fundamental principles of chromatography allowed him to design experiments with an uncanny ability to predict outcomes.

One week after joining Dr. Giddings' group, I began working on dense gas chromatography using pressures up to 40,000 psi. To investigate the new frontier under Dr. Giddings, I could learn from the "master" not only the fundamental principles of the technique but also the skill required to design, build, and repair the necessary laboratory equipment. With the help of Professor Marcus Myers, I learned techniques for making high pressure connectors, high pressure flow cells, high pressure pumps, high pressure flow controllers, field-flow fractionation channels, membranes, etc. The invaluable experience I attained in high pressure hydraulic systems had become extremely useful for my current career in the development of techniques and instrumentation for HPLC and micro-HPLC. My study on dense gas chromatography was later abandoned due to the difficulty in obtaining reproducible sample injection at 20,000 to 40,000 psi pressure using a manually controlled on/off valve. Although this work did not result in any publication, it was a valuable lesson in both the theory and instrumentation in dense gas chromatography. This experience later became useful after joining Dr. Milton Lee in 1986, in the development of instrumentation for supercritical fluid chromatography (SFC).

In 1970, after ending the study on dense gas chromatography, Dr. Giddings asked me to work on sedimentation field-flow fractionation. It was a great time of discovery for both the theoretical work of Dr. Giddings and the experimental work of his group. We had a great time generating experimental data; Lyle Bowman, who took over dense gas chromatography study, and I decided to make our office a 24-hour living quarter with bed so that we could make timely injections between runs (we wished we had a high pressure autosampler at that time).

In 1973, I graduated from Dr. Giddings' group after completing four publications. I later rejoined Dr. Giddings' group again in 1975 after a short postdoctoral study with Professor Stephen Hawkes at the Oregon State University. Armed with good experience and knowledge in field-flow fractionation and stimulated by Dr. Giddings' continuing inspiration, I was able to reach the most productive peak of my research work. I had produced data and material for more than 10 publications during my work for Dr. Giddings between 1975 and 1976. I left Dr. Giddings' group for Varian Associates in 1976. I am thankful to have had the chance to graduate from Dr. Giddings' group. I am also extremely grateful for his kindness in providing a research scholarship to fund my graduate study. My wife and I were proud to name our only son, who was born in 1977, "Calvin," after Dr. Giddings.

After graduating from his group in 1973, I maintained contact with Dr. Giddings. I was very happy to stay in Salt Lake City again between 1991 and 1993 helping to manage FFFractionation, Inc., a company founded by Dr. Giddings and his associates for the purpose or providing field-flow fractionation instrumentation and technical support to associates and friends of the scientific community. The application of field-flow fractionation for the characterization of macromolecules, particulate materials, and biological samples grew significantly. Dr. Giddings' work in establishing FFFractionation, and the Center for Field Flow Fractionation established strong roots for continuing growth in the applications of field-flow fractionation techniques in many academic as well as industrial laboratories.

I sincerely regret that I was not able to return to Salt Lake City to visit Dr. Giddings more often in the past few years. It seems too soon to experience the loss of someone who has been so important in my life. I will sorely miss him.

Michel Martin
ESPCI, Paris Cedex, France

I met Cal Giddings for the first time at the 2nd International Symposium on Column Liquid Chromatography in Wilmington (Delaware, USA) in May 1976. It was then agreed that I would come to his lab six months later.

When, some months earlier, Georges Guiochon, my thesis supervisor, informed me about a postdoctoral position open in Professor Giddings' laboratory, I immediately took this opportunity to work with this man whom, in the mind of a young student, I considered to be "the" theoretician of chromatography. During my thesis years, especially while reading his book, *Dynamics of Chromatography*, I had indeed been quite impressed by the extensive theoretical and mathematical description of the chromatographic process which was new for me. I felt quite lucky to be offered a possibility to work with such a great scientist.

I arrived in Salt Lake City in November 1976 with my wife and our (then single) son and we were welcomed by Cal at the airport. Among various research topics suggested by Cal, I chose to work on field-flow fractionation (FFF), a technique I had just heard about. It was exciting to discover a new method of separation and a new application domain, more so as the results came, especially those on high-speed thermal FFF. Also, I appreciated greatly the friendly working atmosphere with the students and other postdocs and, especially, with Marcus Myers and Karin Caldwell who were then the pillars of Cal's lab. The pleasure I found working in the lab, linked to the discovery of the wonderful landscapes in the Salt Lake area and of the American West, contributed to make our stay in Utah marvelous. Also, when Cal offered me to stay a second year, we accepted without hesitation.

Each time Cal came to the lab, the discussion was very stimulating. During this postdoc stay, I had the chance to attend his class on the Principles of Chemical Separations. His class notes were later extended to become the contents of his famous and illuminating 1991 textbook, *Unified Separation Science*. During this course, I was strongly impressed by the way Cal could decipher numerous separation methods into their basic physico-chemical characteristics and classify them in a few categories according to the shape of the chemical potential profiles involved and the flow characteristics. I could say, with some liberty, that his mind was dancing with the molecules or particles across their paths through the separation media. Through his whole research career, Cal was fascinated with separation science. He made significant and major contributions to the understanding and development of chromatography. He was the inventor of field-flow fractionation and his group at the University of Utah contributed the most to the development, advancement and recognition of FFF, authoring around 35% of the approximately 700 articles published on FFF up to now. But I would think that his contributions to the development of separation science and to the unification of separation methods best illustrate Cal's ability to unravel the complexities of the physico-chemical processes, especially those transport processes involved in separations, into their essential parts and then synthesize a physical-mathematical picture. Probably, as a consequence of his clear vision of the physical processes, I found his articles very clearly written. I frequently recommend that my students read Cal's papers, not only to learn about FFF or separation science, but also to learn how scientific ideas and experiments can logically be presented and to see examples of good scientific writing.

My research activities have been definitely influenced by the two years spent with Cal in Utah. Back in France, I started experimental and theoretical research on FFF and I am still mainly involved in FFF today. Naturally, I had occasions to meet Cal, especially during the International Symposia on FFF that he initiated in 1989. Each time, it was an opportunity to become stimulated again from Cal's lectures or from private discussions and to share scientific questions. Cal was for me "the" reference concerning fundamental aspects of separation science. This reference is sadly missing today.

Over the years, my consideration for Cal has progressively shifted from an admiration for the theoretician of chromatography of my student years to a fascination for the exceptional intuitive physical chemist, and to a deep respect for the rich personality of the human being that Cal was. At the end of each FFF Symposia held in Utah, Cal, and his wife Leslie, welcomed their friends to their wonderful home built at the top of a canyon in the Wasatch Mountains. During the years, at these parties or at the tables of Mexican restaurants that Cal particularly enjoyed and during his courageous fight against cancer, besides the scientist, I discovered progressively the simplicity of a man deep in harmony with nature. Through his scientific and outdoor activities, Cal left us a message of encouragement for unifying scientific development and full respect of nature, for the benefit of humanity, as he worked to unify separation science and strived for nature conservancy.

Jerry W. King
USDA, Peoria, Illinois

During his lifetime, Cal Giddings made many seminal contributions to physical chemistry and particularly the expanding field of "separation science," a term that he coined during the time I spent with him at the University of Utah. Many of those contributions are legendary to those of us who toil in the separation sciences and in particularly chromatography: stochastic theory of chromatography, coupled theory of gas chromatography, dense gas chromatography, field-flow fractionation, and unified separation science. However, I should like to comment on one key contribution that Cal made which has influenced myself and others who conduct research in the areas comprising supercritical fluid technology. This is the correlation of the solvent power of a dense gas, *i.e.*, a supercritical fluid, with Joel Hildebrand's solubility parameter concept.

Cal was not the first scientist or engineer to recognize the relationship between a substance's cohesive energy density and solvent power of a compressed gas (J. Prausnitz [1]), but his insight and advocacy of the principle in terms of explaining the basic features of solute solubilities in supercritical fluids, is unparalleled. By combining the classical thermodynamic definition of internal pressure with the well known Van der Waals equation of state, Cal created a framework that could rationalize the observed solubility trends of a diverse array of solutes in dense fluids. He further provided in his classical, often cited paper in *Science* [2], a correlation between the critical properties of a fluid and its reduced density, that permitted the solubility parameter of the fluid to be calculated at any pressure and temperature. It was my privilege at the University of Utah to work with Cal on integrating Pitzer's Law of

Corresponding States into this predictive scheme and to test the agreement between theory and experiment as it applied to the emerging area of "dense gas chromatography" [3]. Others who followed, particularly Lyle Bowman [4], enjoyed considerable success in using this theoretical framework to correlate basic solubility trends of many solutes in several supercritical fluid media. Unfortunately, much of this work remains unpublished to this very day.

Upon leaving Utah, I had several opportunities to apply this basic concept which Giddings developed in several facets of my research, both in industry, academia, and more recently as a government scientist. This included invoking the "pressure dependent" solubility parameter to explain the general solubility trends exhibited by polymers in supercritical fluids [5] and the solvent power of supercritical carbon dioxide (SC-CO_2) towards lipids and oils; the latter subject an area of considerable research over the past fifteen years [6]. Others [7, 8] in the engineering community have also utilized the concept to explain the salient features of supercritical fluid extraction as practiced on a larger scale than I believe Professor Giddings would have anticipated when he first rationalized the concept.

With the development of supercritical fluid chromatography (SFC) and its extraction analogue in the 1980s, Giddings' version of the solubility parameter theory found even more widespread use. A critical linkup has been provided by King [9] between a solute's molecular structure and solubility parameter and the solubility parameter of the dense gas, thereby allowing approximate solubility levels to be estimated in such dense fluids. Interestingly, this correlation has been cited most recently in numerous Ph.D. theses, but the seminal principle behind such a correlation is due to Giddings' ground breaking effort over twenty-five years ago. More recently, this author has combined Giddings' basic concept with Flory's interaction parameter [10], to provide a frame-work for applying and optimizing analytical supercritical fluid extraction (SFE), including the prediction of the "threshold pressure," another concept that Giddings coined during his earlier dense gas chromatography studies which was to be the forerunner of modern SFC. It should be noted that many other investigators in diverse areas of science and engineering have made use of Cal's theoretical concepts [11, 12]; the number of studies and applications are too numerous to list in this brief tribute.

In closing I should like to note that not all scientists and engineers were entranced by J. C. Giddings' solubility parameter concept as applied to dense gas or supercritical fluid technology, and some have often criticized the theory since it failed to explain all of the observed phenomena that occur in the supercritical fluid region. However, it was never Cal's intention to provide a theory that would consummate this niche of solution chemistry, as he noted [2], but to "justify our tentative approach by noting that researchers who desire to utilize the technique (high pressure gas chromatography) face a vacuum when seeking rational rules for the design of their equipment." Given the fact that his theoretical concepts are still in use close to thirty years later is a sign of their widespread applicability and, perhaps, Cal's own internal genius.

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Gary H. Thompson
Northglenn, Colorado

A mouse invaded Dr. Giddings' office and began living there. This didn't bother Cal at all, given his kind spirit and environmental outlook, but it was very upsetting to his secretary. My lab and desk were next to Dr. Giddings' office, so the secretary—I believe her name was Dorothy Martin—and I planned to get rid of the mouse and not say a word about it to Cal. The trap was baited and placed in Cal's office. The expectation was that the mouse would come out at night and we could dispose of the body before Cal came in. However, that same afternoon, at 2:00 p.m., there was a loud "snap." A moment later Cal walked in, and without a word, dropped the trap—and its victim—on my desk, then did an about face and left. I was quite concerned that I had really angered my major professor. But Dorothy said, "It was either the mouse or me. Don't worry. I'll protect you!"

I was the first of Dr. Giddings' graduate students to demonstrate field-flow fractionation, if I remember correctly, using two 1″ square by approximately eight feet long tubes clamped together with $300 worth of C-clamps! The "gasket" between was a loop of Teflon electrical wire insulator; this proved to be necessary since no ordinary gasket could hold the organic liquids being used and successfully seal the not-too-uniform surfaces over the length of the tubes. Hot oil was pumped through the top tube, cold water through the bottom, to create a temperature gradient. I mentioned the difficulty of doing this to Dr. Giddings, adding that I wished I were smart enough to be a theoretician and could simple assume "two infinite, flat, parallel planes" as he did, so the worst mechanical problem I would experience would be mechanical pencil failure! Cal responded to the comment about theoreticians with, "It is not as easy as it may seem!"

I have seen Cal only a few times since graduating in 1969. My memories are of a brilliant, yet kind and considerate man. He accomplished so much in the field of separations and yet had time to enjoy life, traveling abroad, kayaking and hiking in many places around the world.

Hyung Kyu Shin
University of Nevada, Reno, Nevada

I first met Cal Giddings when I enrolled as an undergraduate in the first quarter of physical chemistry which he was teaching in the Fall of 1957 at the University of Utah. He had just returned to the Department of Chemistry as an assistant professor after a postdoctoral appointment in Joe Hirschfelder's group at the University of Wisconsin working on the kinetics of chain-branching reactions. He did his graduate work on nonequilibrium rate processes with Henry Eyring at Utah. My first impression of him was a very rigid and tough instructor, but I quickly found him to be considerate and thoughtful, genuinely interested in teaching us. His teaching was most stimulating, and he always tried to teach us fundamental concepts with a detailed picture of physical aspects.

Cal was a young, dynamic member of the faculty, full of energy for both teaching and research. I was impressed with his intuitive interpretation of advanced concepts and clear presentations of his research at departmental seminars. I concluded that he would be an excellent person to work with for my graduate degree. In my senior year, I approached him about the possibility of having him as my graduate advisor. I came from Korea two years earlier and had a severe English language problem, yet he listened very patiently and explained his research. The meeting was most inspiring, and I was quickly infected with his passion and drive for scientific research.

When I joined his research group in the summer of 1959, Cal was in the process of finishing research programs on nonequilibrium rate processes and was moving into the field of chromatography. He still had several projects on reaction kinetics in progress and continued to publish in that area. Among papers published on reaction kinetics was work on the relaxation time model for free radical concentration in complex reactions, which I found to be most interesting. Although I did some work on diffusion of liquids in porous media, the main part of my research was the continuation of this relaxation time model for reactions taking place in a nonsteady state.

While I was working on reaction kinetics, Cal's main thrust was directed toward problems in the field of chromatography. By 1959, he had already published several papers in this area, including a paper on molecular dynamic theory of chromatography in 1954 with Henry Eyring, stochastic considerations on chromatographic dispersion published in 1957, and nonequilibrium kinetics and chromatography in 1959. The models and concepts which he developed in these papers became the foundation to his outstanding career in separations science.

I recall that Cal's office desk was always full of papers and books. He rarely used the desk, for he preferred to write his papers using an old wooden stool with a round top as his desk. When I had meetings to discuss my work with him, I had to put my own papers on that stool. It was the most prominent place in his office throughout his research activities during those days. He had that stool throughout my graduate work and I am sure he used it for many more years after that. He probably even used it in the new chemistry building, where the department moved some years later. I know he liked that small stool.

Graduate students often played volleyball games in front of the old chemistry building during lunch hour, and Cal always joined us. He was an energetic assistant professor and mixed well with graduate students. He was also an avid outdoorsman with a great passion for the outdoors in the early days of his career at Utah. He often invited me to join his outdoor activities including hiking and river kayaking. I still remember hiking with him in the Wasatch

Mountain area. Amid research and teaching duties, he regularly participated in physically demanding activities in the back country. Perhaps, he was recharging his mental energy for scientific inquiry through outdoor life.

Cal was one of the most imaginative and productive physical chemists of our time, and the most remarkable aspect of his contributions to the science was his ability to combine unique theoretical insight into complex molecular processes with innovative experimental programs. He was a gifted researcher with immense physical intuition. He taught me how to do research, and more importantly, how to think about problems and build models at the fundamental level. It was quite an exciting opportunity to work with him, and he guided me through my graduate studies with patience and encouragement and helped me immeasurably in gaining a postdoctoral position in 1961. His teaching has been, and still is, my strength through my professional career. He continued to be a very generous and supportive mentor throughout my postdoctoral appointment and subsequent professional career.

Cal has left a lasting impression and legacy in science. The untimely passing of such a vibrant man is a great loss to chemistry. He will be missed in the scientific community, for which he did so much.

Edward N. Fuller
Allied Signal, Kansas City, Missouri

I was priviledged to have had Cal as my mentor during the time I was a graduate student at the University of Utah. Cal was a superb teacher and a brilliant research scientist. In my view, his most significant accomplishments were his contributions to the theory of chromatography and the origination of field-flow fractionation. He was energetic and highly dedicated to his career. I was continually amazed at the number of projects he worked on simultaneously.

In working with numerous graduate students and postdoctoral fellows, he had high expectations and the courage to allow considerable freedom. He gave needed direction but was always ready to listen and readily accepted contributions from others. He provided encouragement and keen insight when problems were encountered. He was unfailingly patient and fair. Cal always demonstrated the highest integrity in his dealings with everyone. He was generous in sharing credit. For three of four publications which we worked on together, he insisted that my name be listed first. In any case, I would have felt honored to have been listed last as a co-author with him. He possessed excellent writing skills. His suggestions and additions always improved the final product. None of us who worked with him over the years felt that we carried him. Clearly, it was the other way around.

Equal in importance to his accomplishments as a scientist is the influence for good that he had on the lives and careers of those with whom he worked. We learned not only technical skills but much about living. Cal was a great man and a good man whom we admired, respected, and loved as a friend. Cal will be missed and never forgotten.

Karl-Gustav Wahlund,
Lund University, Lund, Sweden

The first time I came into contact with the name "J. Calvin Giddings" must have been in the late 1960s or early 1970s when, as an undergraduate student, I was attending the research seminars of Professor Göran Schill in the Department of Analytical Pharmaceutical Chemistry, Faculty of Pharmacy of Uppsala University, whose research group made great efforts during the late 1960s and through the 1970s to implement the ion-pair extraction principle in column LC. The main struggle was to obtain fast and efficient systems with high resolution for multicomponent samples, especially those of biological origin. We were consistently preoccupied by trying to improve column packing methods, finding better support particles, and so on. The real break-throughs had to wait until modern low-dead-volume sensitive detectors and micron-size particles became generally available, and column packing methods had improved. During this time of development, I remember Göran Schill often saying things like, "Cal Giddings has said that this is possible," when we were discouraged about the slow and irregular progress in our experiments. Schill was referring to Cal Giddings' masterpiece book, *Dynamics of Chromatography*, in which it was postulated that LC had an advantage over GC for extremely difficult separations. Schill, who himself had a strong quantitative approach to interpreting research results, probably immediately fell in love with the book, and then throughout his career always referred to it. It was really written with the purpose of educating all of us who had difficulties in putting chromatography into a general scientific framework, succeeding in this goal due to Cal Giddings' pedagogic and crystal-clear language.

I remember many other cases when reference was made to Calvin Giddings in regards to various kinds of phenomena in chromatography. This could be skewed peaks or anything else that we needed to understand more about. "Oh, there is a paper by Giddings which explains that.—You should look it up," was a common comment. We are, therefore, a generation of researchers in Sweden who hold Cal Giddings in great esteem. We believe that Cal Giddings was one of the very few really great scientists, and we respect him enormously for the work he did to increase the understanding of the mechanisms behind separation processes.

Later, I did a post-doc with Cal. At the time, I seriously contemplated whether or not this was something I would be able to carry out. I was introduced to Cal at some international meeting, and I tried to explain why I wanted to work with him. I said, "You are doing such excellent work in combining theory and practice." He answered, "Well, we are trying at least." This is a typical example of his modesty.

I tried to ask him questions, the answers of which would indicate what skills he required from a post-doc. I thought one needed to be able to do a lot of theory and, therefore, should be quite skilled in mathematics. But Cal said that wasn't necessary. "You only need to know some calculus." "What's that?" I asked. He didn't really answer. He didn't seem to understand my question. I think he was surprised that I didn't know what calculus was. I went back home, bought some English textbooks on calculus, and found that I had actually learned some of this many years ago. I just was not familiar with the English terminology in mathematics. We kept in contact by letters and I finally ended up in Cal's lab; my apparent ignorance about calculus did not seem to have bothered him.

While in his lab, I noted how little his graduate students were aware of his basic and pioneering contributions to chromatographic science. This was probably a function of Cal's extreme modesty. Once, one of his graduate students was quite excited to tell me that when he had studied some of the reference literature in chromatography, "there were references to him everywhere."

The way Cal Giddings approached theory is worth a comment. He once told me, "There are so many people who do page by page of meaningless theory. One should engage in that. You can theorize on anything. But you should only engage in it if it can lead to some significant advancement or improved understanding." I think this is one of the hallmarks of Cal's work. His theorizing always led to a useful aspect or insight at the end, and it guided him to new inventions and different or improved experiments. He was a master in making approximations that remained within the limits of what they were supposed to be used for. His intuition and imagination seemed usually to be right. Sometimes we did not understand on what basis he made his conclusions. Maybe sometimes he himself did not understand it. But he was usually right. We could see that afterwards.

There were occasions, however, when he was not right. He sometimes became so fond of his theory, which described an idea he had, that he just expected the experiments to fit. When experimental facts disturbed his model, it took some time before he could accept it.

Theoreticians work in different ways. Some are not satisfied until they arrive at mathematical descriptions which are exactly right and complete. They get in trouble when reality is too complex to describe. Others are satisfied with theoretical models that describe phenomena within certain limits governed by experimental reality. I think Cal Giddings was of the latter kind. If you read his papers, you will understand. In his book, *Dynamics of Chromatography*, he writes "...the laboratory rules of chromatography may be best achieved by a combined application of principles and intuition, the latter the fruits of experience." And further, "...the mastery of theory and principle makes possible the free movement between the multitude of specialized developments and suggests new approaches."

Joseph A. Gardella, Jr.
SUNY, Buffalo, New York

Professor J. C. Giddings had a profound influence on my career as a faculty member at a major research university, stemming from a small but important conversation held while I was a graduate student. To me, it is a reminder of all the little things that are part-in-parcel of mentorship and how important those things are in development of careers.

As a third year graduate student at the University of Pittsburgh, I was the President of the Phi Lambda Upsilon chapter, the graduate student club in the Chemistry Department. One duty I had was to organize the annual Phillips Lecture, a distinguished lecture series held each spring. With consultation from faculty, we had chosen Professor Giddings as the Phillips Lecturer, and I had the priviledge of hosting duties.

On our way to the airport after the lectures and dinner, Professor Giddings quietly asked me my career intentions; after listening to perhaps forgettable discussions over dinner with us, I hope he was longing for something more substantive! In any case, I told him I hoped to teach at an undergraduate institution; that I enjoyed my research in surface chemistry of polymers and environmental surfaces, but that I wanted to teach, and I was afraid that the emphasis on research at a major research university would be stiffling to my desire to work with students.

Cal Giddings' response surprised me; he challenged me to reject the conventional wisdom about teaching in a research institution and pointed out that research institutions needed committed faculty to teach well while pursuing excellence in scholarship and research.

That comment and idea stuck. It was something I had not heard. I was encouraged by many to try my hand at a research level faculty position, but always with the sort of conventional thinking that research would be the most important (read *only*) priority.

Interestingly, two years later I found myself postdocing at Utah, not with Cal Giddings, but with Ted Eyring. I did not see Professor Giddings a lot, other than desiring interactions with his research group on surface chemistry, which I enjoyed. My most memorable discussion was his relating white water rafting and kinetic theory of separations. He told this during a slide show of one of his trips to the Amazon over lunch. That anecdote helped me prepare my lectures on separation science and I still tell it today.

After fifteen years at SUNY Buffalo, with modest research accomplishments, enough to climb the ranks here, I have increased and focussed my commitments to teaching and service. I believe academic scientists must do a better job of balancing these three (research, teaching and service). My research mentors (David Hercules and Ted Eyring), taught me a lot about balancing these commitments while striving for excellence. I hope that my influence beyond the lab and classroom at Buffalo and in the scientific and local community is some reflection of how Cal Giddings challenged me to think about a bigger perspective. It is a view which should be more widely promoted.

I am not a chromatographer (but I have many friends who are!!!) so I cannot speak to the technical leadership of Cal Giddings. But the human touch here, with one graduate student, should be remembered by a larger community, just as we remember the technical accomplishments, the commitment to the environment, and to excellence. I am saddened by his passing, but will always cherish these valued recollections.

Pierluigi Reschiglian

In 1988, when I started my Ph.D. studies in Italy, I didn't know what field-flow fractionation (FFF) was. Professor Dondi, my Italian advisor, had purchased an SdFFF system from FFFractionation Ltd., and so I asked Professor Giddings if I could spend a few months at the FFFRC labs to get some experience with setting up a centrifuge.

"So, Luigi, what do you want to do in Salt Lake?" was Prof. Giddings' first question as soon as I met him, as I sat down in front of him. I thought it was funny that he should ask me that, since, frankly, I had no prompt answer to his question. I suddenly realized that I had to get up off my behind and try to get the best out of my stay. It was his terrific advising skill that made the task successful.

"You mean, besides going skiing?" I finally answered. This made him laugh, which was just the first among many times I saw him smile because of my questions or answers. Since that time, we often had talks about skiing or mountain biking rather than separation science. I am certain he was happy we did it that way. However, whenever we discussed FFF, I had the feeling that I had to use many more words to explain what I had in mind than he did. An awareness of his terrifically quick and sharp thoughts was the dominant sensation whenever I talked to him. I was forced, indeed, to speed up my CPU clock. I worked at the Center for 8 months, in all. I dealt with experimental validation of Professor Giddings' unified approach to secondary-order effects in FFF retention. I produced a lot of data on this; however, at that time, they did not fit into a straight line. The theory still needed some improvement. When I returned to Italy, I felt somewhat frustrated, and Professor Giddings was not happy, either. "Is there really no way, Luigi, they could fit into a line?" he asked one day on the phone from Santa Barbara, just a few days before I left. "There is just one way —I must stretch the PC screen!" I answered. We had fun that time on the phone.

On my last day at the Center we talked about my data, and he told me, "I think one day we will have a paper together." Since that time, I have waited for this dream to come true. In fact, the work appeared in *Analytical Chemistry* on February 1, 1997.

From that first experience on secondary interactions in FFF, which often resulted in unwanted sticking of the sample to the channel walls, I have become interested in quantitative aspects of FFF. This is the topic that I have mostly dealt with since moving to Bologna as an assistant professor in analytical chemistry. A review of our approach to this topic is described in a following issue in Professor Giddings' memory.

Victor P. Andreev

Professor J. Calvin Giddings was the first Great Scientist and first American I met and became acquainted with in my life. It was in 1991. Of course, before this I had read many of his papers and had some mail communications with him, but a personal acquaintance is something different.

Maybe it is my personal Russian view, but when I think of America, I first see Professor Giddings. I will try to explain this.

I believe that American culture is centered around the hero and a strive for perfection. I believe that Prof. Giddings was very much like the heroes of American westerns: very clever, very brave and very laconic. It is practically impossible to be as perfect as a hero of the westerns in real life, but he managed to do it.

And the even more remarkable thing, I have never heard anyone say something negative about him. During the ITP-96 Symposium in Prague (September, 1996) somebody (probably Prof. Ernest Kenndler from Vienna, but I am not sure) told me: "He (Prof. Giddings) has long ago known all we are doing now."

I came to the same conclusion myself. In 1992, while staying in Salt Lake City, I showed Prof. Giddings my draft concerning FFF with asymmetrical electroosmotic flow generated in the channel from the nonequal zeta-potentials of the walls. He understood me immediately, opened one of his files, and took a sheet of paper out of it. It was a draft dated 1978. Professor Giddings had written about the possible advantages of asymmetric flow profiles in FFF channels. He proposed in this draft to use for FFF the linear flow profile generated between two rotating coaxial cylinders. In the same draft he also proposed to use a combination of Quette flow and Poiseuille flow in FFF.

As shown in this paper, the combination of counterdirected Poiseuille flow and linear electroosmotic flow was very perspective in regards to an increase in selectivity and efficiency. This is very characteristic of Professor Giddings (and heroes of American westerns)—to give very laconic and precise advice.

Joe Davis

J. Calvin Giddings played a more significant role in my life than any individual of whom I can think, except my dear parents. I have no intention of commenting on his work, anymore than Adam probably felt a need to comment on the Garden of Eden (the reader may interpret this figuratively or literally, depending on his religious persuasions). Both spoke for themselves. Fortunately for us all, Cal's fruits of knowledge have not been taken away from us, as was the Garden, and now sadly to say, Cal himself.

As a mentor, he was unsurpassed. His lucid ability to communicate physical principles to those around him was one of his outstanding traits. I was spoiled as a graduate student by basking in the glow of his profound knowledge, which he carried not with pomposity but with quiet assurance. It was only after I began working on my own that I realized how feeble is the light cast by so many of us, myself included, when compared to that glow.

Cal was more than a mentor to me; he was a big brother. I felt I could unburden my dark secrets—both professional and personal—to him. Like a big brother, he tolerated a lot of nonsense from me. Even today, there circulates in limited circles a photograph of me with a dead mouse in my mouth . . . which was shown at group meetings, and at which Cal just grinned. And, like a kid brother, I rarely was hesitant to ask for his advice. That I failed sometimes to take it is not a testimonial to its worth but to my inability to perceive its worth.

Now, knowing that I can never seek that advice again, I wish that I had listened more. Peace.