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Memories of Carl from an improbable friend

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Improbable Beginnings

The Tower Room in the Beckman Institute goes silent as all heads turn to the door. An unearthly figure in a full neck brace strides into the room and takes a seat at the end of the long conference table. Already seated are representatives of the W. M. Keck Foundation, the Provost, several Deans, myself, and a few others from the campus. The site visit by the foundation was the moment of truth that would determine whether we would receive a \$1.25 million grant to launch the W. M. Keck Center for Comparative and Functional Genomics at the University of Illinois. Although we knew Carl's participation was critical, none of us from the university expected Carl to attend, because the previous day he had fallen from a ladder and badly injured his neck. Earlier during the meeting, when Roxane Ford from the Foundation asked, "Where is Professor Woese?" we had to apologize for him being unable to attend because of the accident. It was clear that Roxane was disappointed and wanted to hear directly from Carl about the significance of "phylogenomics," which would be the scientific theme of the proposed Center. Until that moment, our bid was on the ropes without having Carl weigh in. I was the PI on the grant, but Roxane clearly wanted to hear from Carl.

Carl, in obvious discomfort, is sitting erect, his head held in place by a medieval plastic sleeve that pushes his chin toward the ceiling. Roxane welcomes him and asks, "So Professor Woese, what does phylogenomics mean to you?" All heads turn to Carl. He takes a long breath, closes his eyes, and delivers an unrehearsed statement, a stream of scientific consciousness that blows the intellectual socks off everyone in the room. We all sit in stunned silence for a moment, knowing that Carl had just done something extraordinary. Something up until that time, given his reputation, no one would have expected him to do. In that frozen moment in time, we knew that the day had been one won. Two months later, I received a check in the mail for \$1.25 million dollars. And that is how the genomics revolution at the University of Illinois was born back in 1997, a revolution that 10 y later led to the opening of the \$75 million Institute for Genomic Biology (IGB)—Carl's physical and intellectual home until his death in 2012.

How did it happen? What led Carl to weighing in for me and for the campus on that fateful day? It is hard story to begin,

knowing that it is impossible to convey the full depth of our relationship. In his later years, I probably knew Carl better than anyone, save for Nigel Goldenfeld who began his connection with Carl several years later. Carl had always said that our friendship was improbable. Indeed, that was true. I, a young faculty member in the Department of Animal Sciences working in cattle genetics, and Carl, nearly 30 y my senior, and a world-famous physicist-turned-microbiologist who had made one of the greatest scientific discoveries of the 20th century. We had very little in common other than an intense passion for science. But over the course of the next 15 y, our lives were inextricably linked through a chain of truly extraordinary events.

It started with visits to Carl's laboratory after I had been asked in 1996 to serve as the Director of the University of Illinois Biotechnology Center. I had heard about Carl from the microbiologists in my department, Marv Bryant (a giant in his own right), Bryan White, and Rod Mackie. My own research was taking on more of an evolutionary bent, as our work on developing detailed comparative maps of mammalian genomes rapidly progressed. I wanted to meet Carl and decided to send him an email to see if he would talk to me. I had heard some scary stuff about Carl, so I had to be prepared and did not wish to annoy him with trivial matters. To be ready, I took the time to read some of his seminal research papers and was truly awed by his discoveries and his penetrating writing style. I wanted to impress him, but more importantly I just wanted to meet the person that had quietly changed our understanding of biology. I could have never imagined where it would all lead.

I cannot say exactly when I had my first visit with Carl, but I do vividly remember the encounter. I recall walking up the outer staircase of Morrill Hall facing Goodwin Avenue. I walked past the yellowed fraying shrines of Carl's early phylogenetic trees that hung in the hallway and on the door. I turned and there he was, a head of radiant white hair, feet up, leaning back in an old leather-backed metal chair snuggled up to his computer located on a messy lab bench. There was a tense moment and then Carl broke the ice with a big welcoming smile and an invitation to come in and look around, as if he'd expected me his whole life. He gave me a quick tour of his lab and office complex, joyfully showing me his famous autoradiographs, pulled reverently from yellowed envelopes and cardboard boxes. Our first conversation lasted about three hours, and I came away with the feeling as if I'd just encountered a true visionary. I listened to him intently as I had countless times thereafter, and he listened to me with an open mind, seemingly finding great pleasure in hearing things he knew little about. Carl immediately caught on to the deep evolutionary principles I was trying to uncover in studying

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comparative mammalian genome organization, and to my pleasant surprise, became quite enthusiastic about our approach and results. When our meeting ended, he invited me back any time to chat. I took up his offer, and we had many impromptu meetings over the next year to discuss various things; science, campus politics, world events, and his frustrations with the scientific establishment, who at that time, still resisted his ideas (the open dispute with Ernst Mayer exploded about a year later in the pages of PNAS). I was riveted by stories of the early days of molecular biology and microbiology, spanning from Schrödinger to Spanier and van Niel. These discussions got progressively more intense over the years, as we started to weigh issues in evolution as a science, and Carl's developing obsession with Darwin. Carl frequently dropped by unexpectedly in my office in the Edward R. Madigan Lab, and I would pop in on him when I was over on his end of the campus. For some inexplicable reason he took a liking to me, and I absolutely adored him for his lack of political correctness, acerbic wit, fluid mind, and his scientific genius. Make no mistake, Carl Woese was a genius—an imperfect idiosyncratic genius, and something of a “scarred revolutionary” as he was called in *Science*. He could be mercurial and seemingly irrational (refusing to go to Washington in 2000 to receive the National Medal of Science because he did not want to shake Bill Clinton's hand). But to the few close to him, Carl was also a person of rare humility and humanity. No doubt, others in this issue will confirm this with their own stories.

Starting in 1994, my lab was doing lots of DNA sequencing on an ABI 373A machine that I managed to wangle funding for from my college and department—something very visionary for a College of Agriculture at that time. In my role as Director of the Biotechnology Center, which had a small DNA sequencing service, I surmised that automated DNA sequencing was going to be big—very big—and that all of biology, agriculture, and medicine would soon be transformed by its simplicity and relatively low cost.^a The Human Genome Project was just getting started in earnest, but there were relatively few labs that had successfully scaled up for high-throughput sequencing. Carl always knew that microbial genome sequencing would eventually be the proof he needed to convince even the most gilded skeptics of the validity of the third domain.^b When I inherited his old machine as Director of the Biotechnology Center, I preserved it in storage for the future. Over coffee with Gene Robinson one afternoon, Gene suggested that I look into approaching the Keck Foundation for a grant to help the Biotechnology Center. We just needed a concept. I had described my idea to Gene about how we could link up efforts for all species being worked on by the campus in a unified intellectual framework. Several years earlier, in a car on the way to the 1994 Winter Olympics in Lillehammer^c with Øystein Lie (driving), the late Glen Evans, Rex Gaskins, and Larry Schook, I had come up with the term “phylogenomics” that seemed to cleanly describe the area of science we had stumbled onto. Everyone, especially Glen, seemed to love it.^d This concept was resurrected for the proposal to the Keck Foundation, and it gave me a solid reason to approach Carl to gain his support.

By that time, I could tell that Carl had begun to believe in me as a friend and a campus leader. With a vision to deliver genomics

to all biologists on our campus, I went to Carl with the phylogenomics concept for the Keck grant. We talked about it for some time, and I remember him getting very excited about the prospects of unifying the campus' genomics efforts. He began to actively advocate with administration on my behalf, and for genomics, having nothing at all to gain from this himself. Only later did I fully understand what might have been the motivating factor for him to support us whippersnappers—Carl could always see into well the future. And, as he later said many times, his future was with us.

This is what led Carl to the Beckman Institute on that fateful day during the Fall of 1997. The W. M. Keck Center for Comparative and Functional Genomics quickly turned into an astounding success for the campus. It enabled many biologists the opportunity to have relatively early access to DNA sequencing, bioinformatics, and microarray technology. Two very notable examples are Gene Robinson, for whom the Keck Center produced a cDNA microarray of honey bee cDNAs for in just a few months, and David Clayton, who we did similar for with the Songbird. Both went on to be leaders of genome sequencing efforts for their respective species of interest, producing several outstanding papers in *Science* and other top journals using the new tools for functional genomics produced by the Keck center. As the first adopter, I too benefitted greatly, and I shared all of the knowledge I had gained to make efforts with other species a success. The success of the Keck Center clearly gave me street cred with Carl, and others on campus. The Keck Center is still in existence today and is running stronger than ever. I could not be more proud, and it would not have happened without Carl's intervention and advice. Phylogenomics in its broadest sense is still alive and well at the University of Illinois.

Harris—I Need a Cow!

Late one morning, I am at my desk and the phone rings. “Harris—Carl here. In need of a big favor. Can you get me cow? I need a cow! You know, one with a hole in its stomach.” I replied, “Uhhh, would you like that delivered to your office or your house?” The unmistakable Woesian roar of laughter on the other end of the phone probably echoed through all of Morrill Hall. Carl explained that a German film crew had arrived to tape a documentary, one of the first I believe, on his discovery. Carl wanted to show them precisely where his first methanogen came from. Because I was in the Department of Animal Sciences and still doing work on bovine leukemia virus (which tied us to Sol Spiegelman, the person who hired Carl at Illinois), I told Carl I'd see what I could do, as he needed his cow that morning! To Carl's great delight and gratitude, I was able to arrange for my colleagues at the dairy to produce a lovely cow, complete with a rumen fistula. When we arrived a couple of hours later on a beautiful Spring day, there she was, standing in front of the main office waiting for her film debut. It was immediately clear that Carl had not been around cows since his childhood—or maybe never! As the crew began to set up, he had this petrified look on his face, and kept glancing nervously at the hole, apparently

praying that nothing would fly out or reach out and suck him in. I could not resist the temptation to photograph a nearly frozen Carl standing next to that cow, which I assiduously promised him never to reveal to the public. Anyway, the filming went off extremely well, with Carl explaining that the “archaeobacteria” with the first non-bacterial 16S rRNA signals came from a cow’s stomach, a cow that lived right there at the University of Illinois dairy. In fact, these *Methanobacterium* spp. were first isolated by Marv Bryant from the Department of Animal Sciences, who was studying rumen methanogenesis. As Marv related the story to me, he later gave his isolates to Ralph Wolf for his biochemical studies of methanogenesis, and these were later given by Ralph to Carl.^c Carl would tell me many times that Ralph never really knew what he had. The cow had won the day, and this story became a local legend.

The Middle Years

During the next few years, Carl and I became deeply involved in plotting the future of biology at Illinois. His thoughts about the centrality of evolution in biology and beyond influenced me deeply, both in my own science, and in my views about how the unique strengths of UIUC could be leveraged to be a leader in the so called “new biology.” Carl was customarily in the background, with me and a handful of faculty leaders laying the groundwork for the “post-genomic era” at UIUC. It’s a very long story of how it happened, but our big break came at a meeting with members of the UI Board of Trustees, when I presented our plan. The Chair of the Board, Gerry Shea, got extremely excited, left the room to call then Governor Ryan (now serving time for the “licenses for bribes scandal”) to describe our ask for a new interdisciplinary sciences building that would build upon advances in genomics and promote economic development in the State. Ryan was immediately receptive and we were off and running. Just like that. Remember this was 1999, at the height of the dot-com bubble, and the Illinois economy was doing very well. What resulted was a \$75 million capital development project for a “Postgenomics Institute” (I would soon change this awful name to the Institute for Genomic Biology, after I was appointed Founding Director) that would eventually transform the life sciences on campus. Carl was extremely influential with senior campus administrators, particularly Provost Richard Herman, in supporting the ambitious and unique program that we had envisioned. At our frequent meetings, Carl would lecture me on how important it was that I seize the agenda and push for the institute’s financial and scientific independence from the Colleges. We were all strong supporters of the “Beckman Model” (after the Beckman Institute for Advanced Science and Technology at the University of Illinois), which established UIUC as an early leader in interdisciplinary research at the interface of human biology, information science, and engineering. There, Larry Smarr had established the National Center for Supercomputing Applications (NCSA), leading to Mosaic, the first web browser. The institute had a strong leader in Jiri Jonas, a chemist and member of the National Academy of Sciences. We envisioned a

similar organization in the new institute that would be driven by genomic discovery, and Carl, who had worked mostly alone for his entire career, was an enthusiastic supporter. It was during this time that Carl became convinced that he could not solve the riddle of evolution without the help of others. It was a huge personal transformation, and one that brought out a new Carl for us all to understand. It ended Carl’s isolation in Morrill Hall, resulting in fresh young troops, including Nigel Goldenfeld, Bruce Fouke, Isaac Cann, and others. All of us had different and unique relationships with Carl, and we all treasured him in our own ways.

In 2003, with funding for the new building fully secured by another infamous Illinois Governor, Rod Blagojevich, construction finally began on the new building. When it came time for the campus to choose the first director, we discussed many potential people, explored leads, but none turned out to be very promising. Carl was pushing me to declare my interest, but I was quite reluctant because my research program was really taking off in exciting new directions. What came next was quite surprising to me—a call from Vice Chancellor for Research Chip Zukoski, a good friend and great administrator, to see if I would be interested in the position. Apparently, Carl had been working behind the scenes on the Provost to have me appointed as Founding Director. When I went to see Carl for advice on whether to accept, he was ready. He told me that he understood how important my research program was to me, but that this was an historic opportunity for which there was no one else to lead. He didn’t twist my arm, but he made it very clear that in his mind the success of the new institute would depend on me. I am not trying to sound egotistical here, but this is exactly what Carl laid on me—and it was quite heavy coming from him. Other faculty on the campus I respected also urged me to consider. Eventually, and somewhat reluctantly, I relented and accepted the position in May 2003. I will admit that Carl’s nudging was one of the key factors in my decision.

The years that followed were ones of immense excitement as the institute rose out of the ground and the campus gained great momentum from the simultaneous winning of the Crafoord Prize by Carl, and the two Nobels, one by the late Paul Lauterbur (Physiology and Medicine) and Tony Leggett (Physics). It was also a period where my relationship with Carl deepened and matured. Carl surprised me by inviting me to the Crafoord Prize ceremony in Stockholm in February of 2003, along with his long-time friend and collaborator Gary Olsen. It was an incredible honor to be there, and I learned much from the symposium in Carl’s honor and the small cadre of his respected friends from Europe. The glittering dinner at the Grand Hotel in Stockholm was a truly memorable event, with Carl the center of the King and Queen of Sweden’s attention. Carl was not one for pomp and ceremony, but this was one event that he took most seriously and with great pride. Afterward, on special occasions, he displayed his medal and we reminisced about those magical two days. For Carl, winning the Crafoord Prize by himself was a tremendous vindication and he joked that winning the Crafoord alone (especially without Craig Venter) was better than sharing a Nobel. In reality, I am certain that Carl coveted a Nobel Prize. Unfortunately, his major contribution was in biology, for



Figure 1. Carl, Gay, Rosane, and I at an IGB party honoring my election to the Royal Swedish Academy of Agriculture and Forestry, February 21, 2008.

which there is no Nobel Prize. And, until recently, there was no solid angle for him to win a Nobel because there was no direct application to medicine or physiology. The irony is, at the time Carl's death, it was apparent that the tremendous advances in the field of human microbiome research were enabled by Carl's (and Norman Pace's) methods and discoveries. Carl had been nominated for a Nobel Prize before, and I know that he had supporters within the Royal Swedish Academy of Sciences. There was a strong movement afoot to nominate him again. His contribution to understanding microbiomes just might have done the trick. Unfortunately, we'll never know.

As time went on, Carl had become like a member of my family. I visited his house frequently, sharing the gastro-ethnic joy of bagels, lox, and pickled fish on the weekends, and he joined us for dinner at our house. His favorite was to meet us at Timponi's for pizza, where he always received special attention from Ray Timponi, the proprietor. Not a social person by nature unless other stimulants were involved, these affairs tended to be relatively short and sweet. He hosted my parents at his home and got to know my children. For a long time, a picture of my kids adorned the refrigerator in the kitchen. Every Christmas, two huge bags of Carl's famous home-made peanut brittle (never two batches the same) were lovingly delivered to my office, one for me and one for my parents. And when I began a new phase in my personal life with Rosane, Carl and Gay accepted her immediately. Carl really adored Rosane and affectionately called her

"The Rose" (Fig. 1). We spent many happy evenings together that I will always cherish. I even managed to convince Carl to attend a Fighting Illini basketball game (Fig. 2), perhaps the most unlikely achievement of my career at Illinois! And on my 50th birthday, Carl and Gay presented me with a most beautiful set of engraved Riedel crystal wine glasses—an act of love and generosity.

The Institute for Genomic Biology— Carl's New Home

In late 2007 the IGB finally opened its doors, after an eight year effort. It was a huge celebration for the campus, and one I spent the last four years preparing for since being named Founding Director in 2003. The institute really hit the ground running. The entire scientific program for the institute was established in advance, and the administrative team was fully in place to manage the transition. Within two months, about 75 faculty moved into the institute, eventually reaching nearly 100. The institute faculty was organized into Themes, each with about 9000 square feet of open lab space and offices designed for interdisciplinary research. The themes were selected by a competitive process that involved peer-review of white papers by an external committee of distinguished scientists that I had selected. The core eight original IGB research themes included "Biocomplexity" led by Nigel Goldenfeld, and had Carl as a founding member. This Theme was successful even before the IGB opened, having received a large NSF grant to fund its core research activities. However, there was one big challenge we faced, and that was convincing Carl to move from his old lab into the IGB. After more than 40 y in Morrill Hall, Carl did not take moving lightly. It was a tenuous process. Carl eschewed a grand office that I'd offered, favoring one that was properly suited to him; close to Nigel and young scientists, as well as his able and beloved assistant Debra Piper. After long discussions, and a lot of prodding by Nigel, we assigned Carl a lovely office overlooking the IGB plaza, the "Walk of Life" DNA-in-brick mosaic, and the Morrow Plots. The views were gorgeous from the west-facing floor-to-ceiling windows of the South Wing. But that was not to be, because of the one great disagreement I had with Carl.

Nearly a year before the institute opened, I began work with a campus committee on selecting the artwork for the institute. I had decided that we needed a major art piece on the plaza, rather than inside the institute. The Illinois "Art-in-Architecture" program required by statute that a significant fraction of the building costs be devoted to public art. In all, we had about \$370,000 to spend! I wanted to do something to honor Carl's discoveries with symbolic trees, and we invited a state-wide competition on that basis. The finalist in the process was Tony Tyson, an irreverent award winning artist from Chicago. I invited Tony for a discussion with Carl, which the institute has on videotape. It was a fascinating discussion. Carl walked away feeling that Tony really "got it" and would produce something to his liking. The problem was that Carl absolutely detested Tony's concept. At first, I did not like it much either, but Jonathan Fineberg, the chair of the art-in-architecture

committee, took me out after work, and with a good bottle of red wine, changed my mind. Rosane also loved the concept, which helped sway me the other way. I found that people either loved it or hated it—with no gray zone at all. In the end, I decided to go with the whimsical three pieces, all identical except for color and size, and to Carl's great chagrin, I named the area and piece "Darwin's Playground"—a name I found far better than "The Blobs" given by Tony (see Fig. 3). The pieces became somewhat of a local tourist attraction because of their size, color, and otherworldliness in the context of all that glass, masonry, and metal, but for Carl, they were blasphemous. He refused to have an office that overlooked the plaza and avoided walking through the front entrance so he would not see them. In the end, Carl moved to an interior office with no windows, which suited him just fine. Eventually, he forgave me, but I received a few good fatherly lectures along the way. I felt awful, but the decision had been made, and in the end, I think it was the right one for the institute and the university. But it was never easy to have a disagreement with Carl, and he had a long memory for people whom he felt were plain idiots, phonies, or had disrespected him in some way.

During the next few years, I began to see many changes in Carl. Although clearly thriving in the IGB, he was deeply frustrated by his inability to formulate evolution in its proper scientific terms. It seemed as if he was heading down the same road as Einstein, with his Unified Field Theory. Carl believed that evolution was a property of all living and non-living systems. He postulated that evolution extended beyond the "Darwinian Threshold" before cellular life began. Was molecular evolution all thermodynamics or were there evolutionary processes guiding pre-cellular life as well? Was there a broader role for evolution, writ large, in the universe? These questions haunted Carl. In our frequent discussions, Carl was able to explain his thoughts in evocative terms, but he was unable to formulate the evolutionary processes in mathematical terms, for which he looked to Nigel and his fellow physicists for inspiration. Carl deeply believed that there was directionality to evolution, that evolutionary processes were not merely the result of random genetic events, and that there was indeed a force in the universe that created it all. It will come as a surprise to many, but Carl believed in God, and was quite a spiritual person. However, Carl was deeply suspicious of religion and religious people. And he detested those like Richard Dawkins who used science and evolution as a tool to deny the existence of God. In Carl's mind these things were never to be mixed, faith and science, because he felt God was truly unknowable and science depended on factual evidence. He never discussed these views publicly to my knowledge, but he freely shared them with me, especially toward the end of his life. I was surprised and moved by his deep sense of spirituality, which I believe helped him to bridge the untimely short gap between his life and his death.

Hard Goodbyes

In the Fall of 2010, I decided to leave the University of Illinois to return to my Ph.D. alma mater at UC Davis as Vice



Figure 2. Carl and Gay enjoying a Fighting Illini Basketball game with me and Rosane, Illinois vs Iowa, February 25, 2006.

Chancellor for Research. When the time came, and I had made up my mind, it was time to face Carl with my decision. It was the most difficult discussion we had ever had. I dreaded having to tell him what he had obviously already figured out for himself. When I finally laid out the reasons for my decision, I could see how deeply disappointed he was. This was treason of the highest order, especially to someone who had spent near half a century at Illinois. Carl voiced muted understanding for my reasons, but made an incredibly prescient comment that he thought "the move would be good for Rosane," never saying what he thought lay in store for me. Carl was extremely gracious and participated in most of the farewell celebrations before I left for Davis mid-March of 2011. We had a bitter-sweet goodbye before we left town in which he wished me luck and success. We pledged to talk every weekend, which we almost managed to honor, but I could tell that something had changed in Carl. We shared a wonderful exchange on an early morning in May of 2012 when I learned that I was elected to the National Academy of Sciences. Carl had always wanted this for me, and predicted that one day it would happen. On that morning, in his inimical way, Carl warned me to be careful of the "shit kickers" in section 61! Sadly, over the next few months, it seemed that Carl's physical vigor was waning and his mental state was slipping. He was resigned to an evolutionary end point that he disconsolately was abandoning.

Soon after, Gay had an accident and Carl seemed really blue. Then during the summer of 2012, from his home in Martha's Vineyard, Carl shared the news with me about his diagnosis of pancreatic cancer and emergency surgery. His health deteriorated steadily and he refused chemotherapy. Nigel and Elbert Branscomb made heroic efforts to have him treated with personalized therapy at Washington University in St. Louis. His many friends and admirers did whatever they could to stabilize Carl's situation, which was very problematic given Gay's condition and his difficult family circumstances. I was involved in the efforts to help Carl, but with the distance now between us, my

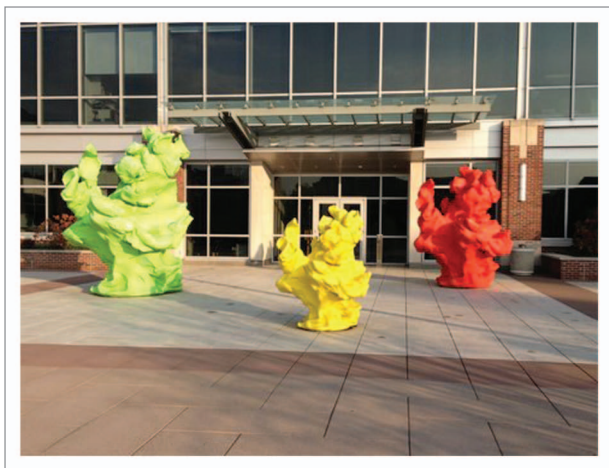


Figure 3. Darwin's Playground, the artwork at IGB detested by Carl. A couple of years later, I spent most of the remaining funds for artwork for an exhibit on the third floor of IGB, near his office. This piece, which spans two walls, forms an illustrated timeline of great discoveries in science (including Carl's) and in cybernetics at the University of Illinois, overlaid with historical context. Carl really liked this piece and it was my way of making it up to him.

effectiveness was limited. When Debbie warned me that the end was near, Rosane and I decided to return to Urbana to visit Carl and Gay after the Thanksgiving holiday. We arrived in Urbana late in the evening on December 1. The next day, Rosane and I spent the entire morning with Carl and Gay, and returned later that evening for dinner. We brought him his favorite Timponi's pizza to cheer him up, and as a tribute to our many wonderful dinners at Ray's place. By that time, Carl had lost a great deal of weight and was very sick. He must have mustered every bit of his strength to sit and talk with us that day, because Gay had commented that he had not been out of bed and had barely spoken for a week. After downing some pizza, which I probably should not have let him eat, he became sick and had to be excused for several minutes. Carl was stoic, but clearly intent on sharing what he knew would be our last evening together. I shall not reveal the details of our conversation, which I will forever treasure, but we talked well into the night, with Carl stretched out on the couch, nodding off, and returning to momentary lucidity when his strength permitted. Finally, with us both emotionally and physically exhausted, it was time to part. We shared a final tearful embrace in his kitchen, he walked us to the door, waved a long goodbye through the window, and we drove off, knowing that this was the last time we would see him. We caught the 6:00 AM flight out of Champaign to Dallas, and looking out the window flying over the Illinois prairie on that cold December morning, my heart was pulling me back to Urbana.

On December 30, we received a flood of emails and phone calls to tell us that Carl was gone. I don't remember who told me first, I think it was Gene, and although expected, the news hit us hard. Unfortunately, we were unable to make the memorial ceremony held in Urbana, but I heard about the moving speeches, particularly from Nigel's daughter Zoe. Until this day, I have Carl's picture on my desk in my Mrak Hall office. It's an amazing photograph that captures Carl's intensity and brilliance. Through his penetrating stare at the camera, every day I feel that Carl is watching me, judging my decisions, and helping me to stay the course during difficult times, as he had always done. With each paper I manage to publish despite the constraints of my current position, I tell him I have not given up on my promise to continue doing science, and I can hear his cheer. My final promise to him was that I would pursue remaking evolution as a science when my administrative appointment is done. With an academic appointment in a top ranked Department of Evolution and Ecology, surrounded by many outstanding evolutionary biologists, microbial ecologists, theorists, as well as other very progressive thinkers from across the campus, I do believe that the Woese legacy can be continued at UC Davis. Despite the improbability of it all, that would be my greatest tribute to Carl. Often after some wonderful accomplishment or sharing of a stimulating idea, Carl would part with me by saying "Long may you wave." And you too, my dear friend Carl.

Endnotes

^aI later learned that the ABI 370A machine in the sequencing core was donated by Carl after his lab was unable to operate it successfully. This was one of the first sequencing machines built (serial # 805264).

^bThe proof in the pudding came in 1996 when the group at TIGR led by Craig Venter sequenced *Methanococcus jannaschii*.

^cIt so happened that we were in Oslo for the CGTA-V (Comparative Genomics of Terrestrial and Aquatic Vertebrates) meeting that I co-chaired with Øystein Lie, and the Winter Olympics was our post-conference event.

^dThe term "phylogenomic" first appeared in the literature in a paper by Jonathan Eisen in 1998. Our collaborative group published a paper in the *Journal of Molecular Evolution* (Bouzat et al., 2000) that exemplified the approach that we had envisioned. Historically, that paper is the 5th published article using the term "phylogenomic" according to PubMed.

^eRegardless of who got what from whom, the now famous 1977 paper by Fox et al. correctly identifies the source of these rumen methanogens as Marv Bryant.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.