special feature

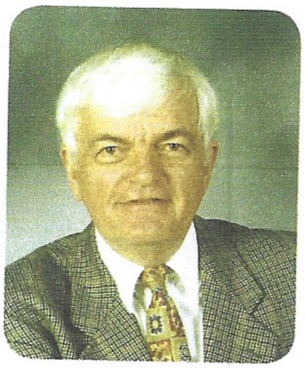
perspective on

coloring outside of the lines

an interview with D. C. Neckers

D. C. Neckers is one of the world's leading practitioners of pure and applied photopolymerization science, with many contributions to both mechanistic studies of photoinitiation and commercial applications. His record of service to the photochemical community, particularly in the development of the Center for Photochemical Sciences at Bowling Green, is equally impressive.

Inter-American Photochemical Society Award in Photochemistry, 1999



Courtesy of D. C. Neckers

In the 1990s, an American science journalist in the former Soviet Union was spending a weekend at the Russian Academy of Science (RAS) dacha outside Moscow.

Sitting in a lounge at 10 a.m. were some of Russia's elite scientists, dressed for relaxation in bathrobes and slippers, jogging outfits, sweaters and jeans. Over refreshments—those famous Krupskoi dark chocolates and Armenian cognac—the journalist mentioned that newspapers in Ohio were among those planning to run his story about RAS efforts to sustain science in post-Soviet Russia.

An assistant to Yuri S. Osipov, then RAS president, asked, "So, then, you must know Dr. Neckers?" As the journalist discovered later from visits to RAS institutes, universities, and other facilities, a surprising number of Russian scientists and students knew D. C. Neckers. Indeed, at times, Neckers seemed to be the most widely known American chemist in Russia.

How did a photochemical scientist from Bowling Green State University (BGSU) in rural Ohio get a name for himself in Russia? That's a good question. However, it is only one of many about Doug Neckers' remarkable career and influence on the photochemical sciences.

Rarely does a single research center become the identity in the scientific community for an entire university. For many a chemist, BGSU (which has an enrollment of 20,000 and offers 200 majors) and Neckers' Center for Photochemical Science (www.bgsu.edu/departments/photochem/general/overview.html) have become synonymous. One recent ACS Committee on Professional Training report showed Neckers' doctoral program graduating as many students as some Big Ten chemistry departments. The Center probably has trained more Russian photochemical scientists than any other non-Russian institution in the world.

How did a newly arrived faculty member at a school that never granted a doctorate or landed a major research grant start, fund, and develop a nationally renowned research and teaching facility? More good questions about Doug Neckers. In this interview with *The Spectrum*, Neckers addresses those and other questions. Doug Neckers' career began in the Golden Era of photochemistry, when the science was fostering new commercial and industrial products, industry and academe were discovering the mutual benefits of collaborating, and university education was in a period of enormous change. Neckers' role in some ways offers a road map for young scientists who are positioning themselves for similar changes that lay ahead in the 21st Century. D. C. Neckers received a doctorate in organic chemistry from the University of Kansas and joined Bowling Green State University in 1973, where he is the McMaster Distinguished Research Professor in the Department of Chemistry and Executive Director of the Center for Photochemical Sciences at Bowling Green State University. Neckers' publications include 10 books and almost 350 research papers. He holds 50 patents. Doug and Suzanne Neckers have two grown children.

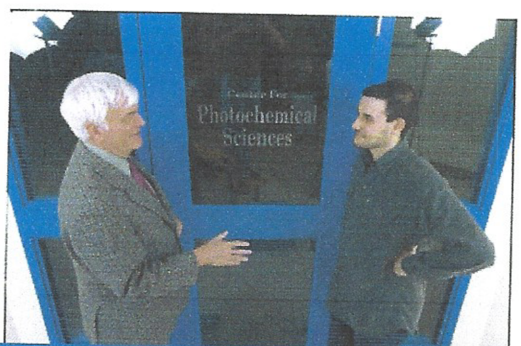
***The Spectrum:* How did Doug Neckers become one of the most widely known American chemists in Russia?**

Neckers: Really, that's an exaggeration. The relationship started years ago when Paul Olscamp, then BGSU president, asked if I'd like to go to Russia. Russia was an exotic place in those days. Only a few thousand Americans traveled to the Soviet Union each year. Why would I want to go to Russia? It turned out that Olscamp was going to Mendeleyev Institute of Chemical Technology in Moscow to sign an agreement to conduct a series of bi-lateral student dialog programs to be broadcast on state run television in Russia, and public television in the U.S., on the issue of global warming. The students would be undergraduate science students, and since Olscamp was a philosopher, he felt he couldn't go to Russia without an accompanying scientist.

***The Spectrum:* The old axiom says that travel changes people.**

Neckers: That trip made a huge change in me, in the students in my group, and most importantly of all, in the Ph.D. students at Bowling Green State University.

As of this fall, more than 100 Ph.D. students—mostly from Moscow but an increasing number from St. Petersburg—have studied for degrees in our Ph.D. program in the photochemical sciences. They are still coming and many are currently studying for degrees. About 50 have already finished their programs. One can actually take the written portion of the driver's examination in Bowling Green in Russian because of all of the students, families, and extended families that now live here because of our Moscow trip.



D. C. Neckers with former Ph.D. student Bassam Fneich outside the Center for Photochemical offices at BGSU.

Courtesy of D. C. Neckers

***The Spectrum:* Some of them have become successful entrepreneurs.**

Neckers: They've started companies and become presidents of companies. Alex Mejiritski is President of Spectra Group Limited (SGL) in Millbury, Ohio—a research and development company originating and selling products for the photopolymerization market. Several of our Russia students work for SGL. Alexei Gusev is President of UltraFast Systems, located in Tampa, Florida. UltraFast Systems markets spectrometers and other optics equipment. It spun off research in Professor Michael A. J. Rodgers' laboratories and only graduates of Mendeleyev are on its staff!

***The Spectrum:* How do you gauge the impact the Center is having on the photochemical sciences?**

Neckers: In a number of ways. Take one example. At a recent meeting in the energy cure sciences, Rad Tech 2006, 17 Bowling Green alumni presented papers, worked for companies that displayed their technology in the exhibition, or just attended. It was an amazing *tour d'force*. Our program has made that industry.

***The Spectrum:* You were a Ph.D. student yourself in the early 1960s, before many younger photoscientists came onto the scene. It must have been an exciting time, with the photochemical revolution in full swing, and the science behind commercial products slowly falling into place.**

Neckers: The photosciences of the 1970s and 1980s moved beyond xerography and silver halide photography. Those two technologies were mature businesses by the time the organic photochemical revolution began in the 1950s and 1960s. So in addition to tweaking the products that were cash cows, companies like Kodak and Xerox had turned their attention to technologies other than their basic core businesses by the time I entered the field.

***The Spectrum:* We've heard a lot in previous interviews about advances in the science during that period. How was the science being applied in industry?**

Neckers: Unbeknownst to but a few in the field, companies like DuPont were developing a large intellectual property position in reactions of small molecules with light that converted liquids to solids. When this work started in the 1940s, they didn't really know what it could be used for, but by the mid-1960s it was emerging as an important technology in proofing for color prints, as Rolf Dessauer discussed in his interview with *The Spectrum* (2003, *16* (4), 4). Color printing was also starting to become commercial.

Laundry soaps were packaged in colored boxes with the name of the soap printed in colors other than black or white. Plastic bottles were entering the market place and competing with glass containers. Plastic packages of all kinds were emerging. The field was growing rapidly.

***The Spectrum:* Photopolymerization was getting plenty of attention.**

Neckers: Very much so. At Kodak, for example, images were being made from liquids turning to solids with light. A liquid that could be photopolymerized was laid on a surface, covered with a mask, and irradiated with light of a particular wavelength. The areas on the surface that were not covered by the mask turned solid. The rest remained liquid and could be washed away.

***The Spectrum*: Was blue print technology mature then?**

Neckers: Well, it was improving. Hoechst used chemistry done in Germany during WWII to develop new methods to make blue prints and their American branch, American Azo plate, licensed the technology to a company called Shipley for applications other than blue prints. Charles Shipley's licenses were extraordinarily strong. So when he started selling small samples to IBM, and the size of these orders began to increase dramatically, he was in a position to control the market. That market became the positive photoresist market—a technology used still today to make images on silicon wafers that, when processed, leads to the computer chip.

***The Spectrum*: How much awareness in academe was there about the industry work?**

Neckers: All of these companies employed photoscientists. And many of these photoscientists traveled to meetings, hired academic consultants and interacted with other segments of the community. A back and forth of intellectual property developed and entire new commercial fields began to grow up.

***The Spectrum*: So what research was interesting to photochemistry doctoral students like Doug Neckers in that era?**

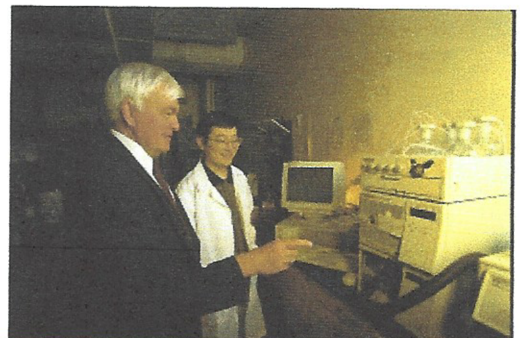
Neckers: I wrote my Ph.D. dissertation in 1963 on the photochemistry of aromatic carbonyl compounds. In the first part, I did some physical organic studies that mimicked the photoreduction of benzophenone. In the second, I studied and first proposed the mechanism for the photodegradation of phenyl glyoxylate esters.

***The Spectrum*: What came next?**

Neckers: After using benzophenone and some of its chemical relatives as photoinitiators, more as photosensitizers, I decided I was tired of separating products by laborious chromatography after the reaction was completed. So I used Bruce Merrifield's trick and chemically immobilized a photosensitizer (in this case a benzophenone) to a poly(styrene) bead. My thought was that the poly(styrene) bead that contained the sensitizer could catalyze the reaction and, when that was done, could be separated from the reaction mixture by a simple filtration.

***The Spectrum*: Did it work?**

Neckers: Yes—but poorly. Benzophenone, following light absorption, was too reactive. It degraded the polymer to which it was immobilized. So we switched to a less reactive series of photocatalysts—organic dyes that were being used then, and still are being used, as sensitizers for the formation of the reactive singlet oxygen. Polymer Rose Bengal went commercial in the 1970s and remains the staple in reactions of olefins with oxygen that produce highly energetic dioxetanes. Lumigen, for example, is still using it to make chemiluminescent dioxetanes such as those used in small molecule diagnosis in clinical chemistry.



D. C. Neckers with former student Shengkui Hu. Dr. Hu is currently a research chemist with PPG Industries.

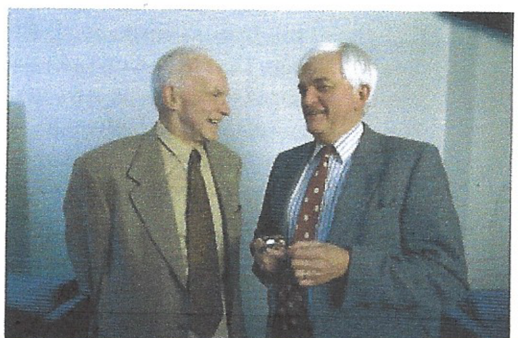
Courtesy of D. C. Neckers

***The Spectrum*: So more and more, your research involved photopolymers?**

Neckers: At Bowling Green, we began to publish our work on polymer immobilized photochemical reactants. I was soon speaking at conferences, and employed as a consultant, by industries beginning to explore the use of photochemical reactions in polymerization processes. The most important of these relationships developed with Ciba-Geigy Corporation first in Ardlsey, New York and later in Basel, Switzerland. In Switzerland I worked with Rudolph Kirschmeyer, Werner Rutsch, and Godwin Berner as they began developments that led to the Irgacure series of photoinitiators. My work wasn't that important to them at the time I don't think because they were already well along in developing the series of initiators that formed free radicals by photodecomposition—the so-called Norrish Type I photoinitators. But we had many lively discussions about their developing products and the objectives for their work. Years later, when the Center started and I got involved with the inventor of stereolithography, Charles Hull, and the company he had just formed (3D Systems), I helped my Swiss colleagues meet my new California friends and a very productive, commercial partnership evolved between the two companies in 1987.

***The Spectrum*: How did this affect your work at Bowling Green?**

Neckers: All of this attention to photopolymerization changed the work in my laboratories. I became a photopolymer chemist. The impact on Bowling Green was that these companies started looking to us for our graduates, they supported some research, but more they gave me the idea that there was a real need for an academic center that provided a basic education at the graduate level in the photochemical sciences. From this, and from the encouragement of other industrial friends, came the Center for Photochemical Sciences. We became one of the first university research units to truly interact at the academic industrial interface with our friends in the imaging, printing, painting, varnishing, proofing, and other businesses.



D. C. Neckers with Dr. George Hammond. Dr. Hammond was a Senior McMaster Fellow in the Center and a mentor for doctoral students over the course of 15 years.

Courtesy of D. C. Neckers

***The Spectrum*: And that interaction proved critical in starting the Center for Photochemical Sciences. How did it happen?**

Neckers: It happened gradually at first and then with more regularity. The first major consultancy that paid Bowling Green handsomely was my consultancy with Mead Imaging in Miamisburg, Ohio. Before we had a Ph.D. program in the photosciences Bowling Green had a successful masters degree program in chemistry. I say "successful" because it was one of the larger such programs in the country. However, as we all know, the masters degree isn't the terminal degree in chemistry so the program was necessarily limited in scope.

***The Spectrum*: Were any of those students attracted to Mead?**

Neckers: Yes, a masters student from Chris Dalton's lab took a job with Mead Paper Company in Chillecothe, Ohio, and before I knew it he was writing me continuously for some sample photolabile peresters that had been of interest in my labs in the late 1970s/early 1980s. We kept sending him samples but I'm not very patient with that sort of thing, and finally said to him "Mike—this is it. No more. If you want the peresters you'll have to make them yourself."

Later I got a phone call from his boss, Dick Wright, who said that Mead Corporation was developing a new program that involved photochemistry, and that he would like to interview some of our students for possible appointments in that project. As it turned out one of my students, Paul Davis, was just finishing a postdoctoral appointment in Colorado and he had a significant other who lived in Columbus. So Paul was anxious to get back to this part of the country. He got a job at Mead.

***The Spectrum*: On what project?**

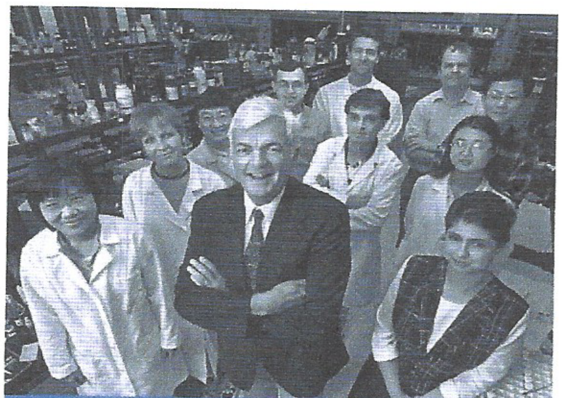
Neckers: Mead was beginning work on photopolymerization in microcapsules that eventually led to the near photographic imaging system called "Cycolor" and they needed to hire some organic chemists to make photoinitiators. Paul was the first or second hire into this project. After about a year, the project grew so large that Mead decided to set up a separate corporate division, which it called Mead Imaging, and it did this in Miamisburg, Ohio, which is a few miles south of Mead's headquarters in Dayton. Chris Dalton and I were invited there to give a short course on photochemistry and not long thereafter I was engaged as a consultant. Gary Schuster was also engaged as a Mead consultant at about the same time so together we worked with the small but steadily increasing number of chemists/physicists working on the "microcapsule" project. When Mead moved the Imaging division to Miamisburg in 1984, Gary and I were two members of the then formed Mead Imaging scientific advisory board.

***The Spectrum*: What effect did this collaboration have on Bowling Green?**

Neckers: Mead began accelerating their support of work at Bowling Green culminating in a gift of $300,000 from the Mead Foundation to the then very nascent Center for Photochemical Sciences which formed the basis of what now exists as the Endowment account of the Center for Photochemical Sciences. The expense of publishing *The Spectrum* has been largely born from interest income earned from this and other corporate gifts to the Center.

The Spectrum: Mead Imaging, however, has not fared quite so well, have they?

Neckers: Mead Imaging continued to grow—for a while. What its business charter evolved to was an attack on the color computer graphic-to-print market. This was in 1989. At the time the color original files were just aborning; color print in newspapers was at a very early stage; and the transportation of the computer graphic to an imageable technology through optics devices like HP digital light processors was at least five years in the future. Mead Imaging, for various reasons, had partners who drove corporation decisions to build for the big win. So coatings technologies far beyond the required capacity in the market were constructed and installed in Miamisburg. When the market for color copy failed to come close to the break-even demands, and the sale of paper products cycled soft in 1990, Mead Corporation said "Hold, enough." And Mead Imaging's run from startup to brilliant entrepreneurial success story failed. As too often happens, Mead Imaging's technology successes outstripped their business plan. The division was sold to Japanese investors and most of the employees were terminated.



D. C. Neckers with the students enrolled in graduate studies in the Center for Photochemical Sciences.

Courtesy of BGSU

The Spectrum: How did the Center originate and what was Mead Imaging's role?

Neckers: The management at Mead Imaging, and the scientists there, gave us the confidence to go forward. On October 8, 1985, Dean of Arts and Sciences Kendell Baker forwarded to Vice President for Academic Affairs Eloise Clark a proposal to establish a Center for Photochemical Sciences.

The purpose of the new center was "to prepare postdoctorals and other professionals in the principles of photochemistry, photophysics, spectroscopy as it relates to photochemical processes, and polymer photochemistry."

The Spectrum: Did you find that quite a few of the academic bureaucrats wanted to get their thumbprints on a good idea?

Neckers: Correct. As is typical for state universities, each point in the food chain wants to carve out a little piece of the pie just in case it becomes successful. Baker's stake hold on the Center was that centers were nominally research centers and therefore to be administered by the Vice President for Research and Dean of the Graduate College. By proposing first an institute, Baker, who was Dean of Arts and Sciences, could claim it as part of his administrative bailiwick because institutes were to be administered through the undergraduate college. If the end product was subsequently called a center it made no difference.

The Spectrum: How did you cope with all the wheeling and dealing?

Neckers: I was rather like Rhett Butler in *Gone With the Wind* and didn't give a damn as long as I got a way to differentiate what we did at Bowling Green in the chemical sciences from what was done in the chemical sciences all over the rest of the world. Bowling Green was now going to be photochemical science not chemistry and there was a big advantage to that locally, regionally, nationally and internationally. That was an especially important consideration in that era in American higher education.

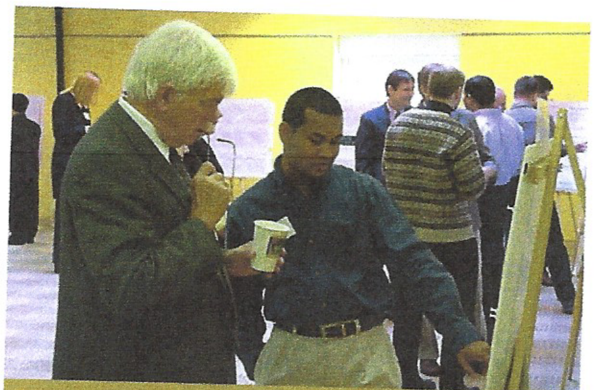
The Spectrum: Give us a snapshot of higher education at that point—a time when some of our readers had not yet appeared on the scene.

Neckers: American universities grew rapidly after WWII and into the mid-1960s. It's hard for us now to believe, but American higher education in the form of the state university to the extent that we know it today was virtually non-existent until after WWII. There was no New York State system of higher education until 1956; and many of the largest California universities, Irvine, Santa Barbara, La Jolla, Santa Cruz, didn't begin operations until the mid-1960s. Even universities like UCLA were barely out of the crib. The Bruins granted their first Ph.D. in chemistry in the early 1940s.

After WWII it became evident that returning GIs would benefit from education beyond high school and they took advantage of something called the GI bill to manage that. Every state saw its university system grow rapidly from 1955 or so to 1970.

***The Spectrum*: And in Ohio?**

Neckers: Virtually every university in the system either had a Ph.D. authority in place in chemistry before the Ohio Board of Regents was created in 1968 or they added one—often a paper program—just to say that such a thing existed when they were incorporated in the Ohio state university system. Bowling Green was asleep in chemistry the late 1960s. Though BGSU added programs in mathematics, English, history and biology, chemistry made no attempt to do so until it was too late. So we had no Ph.D. authority in chemistry when I took over as Department Chair in 1973. Adding such an authority would require the approval of all of the other state universities—more specifically all of their graduate deans. Given that by 1973 they all had their programs, and the American Chemical Society was starting to mutter about too many Ph.D. programs in chemistry anyway, we were told by the Chancellor that we didn't stand a chance of getting a new Ph.D. program approved. This was the best thing that ever happened to our program though it didn't seem that way at the time.



Former Ph.D. student, Tissa Gunaratne, discussing his research with D. C. Neckers at an annual meeting of the Center for Photochemical Sciences.

Courtesy of D.C. Neckers

***The Spectrum*: It must have been obvious that the U.S. didn't need another marginal graduate program in the physical sciences.**

Neckers: We had to take another path. We proposed, based on the advice and consent of our peers in the photosciences in the U.S., that we begin a graduate program in the photochemical sciences. The name was chosen selectively—we had no intention of just a graduate program that focused on a small subset of chemistry, or physics. We intended the program from the beginning to be collaborative and interdisciplinary. We set some simple admission standards. Namely that any admitted Ph.D. student would have to demonstrate competency in both physical and organic chemistry. But beyond that we felt we could admit students from undergraduate programs in physics, chemistry or biological sciences without difficulty and, if they had basic undergraduate chemistry courses sufficient to qualify at our level, they would fit in our program.

***The Spectrum*: And it obviously worked.**

Neckers: It worked better than I could dream. At the time the proposal was defended in front of the Regents' Committee on Graduate Studies, I was asked how many students I hoped we would graduate when we achieved critical mass and when would that be? I said that I hoped we'd be able to graduate 7 to 10 students per year in 10 years if the program met my expectations. In fact by 2000 we were already graduating approximately 7 new Ph.D.s per year and in 2005 graduated 12. When the ACS Committee on Professional Training's report appeared for 2003, the 10th anniversary of our first graduate, we were graduating as many students as some of the smaller Big Ten university's chemistry programs, and more than the entire rest of the Mid American Conferences' chemistry departments put together. We had almost 60 full time students in residence. The program far exceeded my dreams and the entire university was rightfully proud of its success.

***The Spectrum*: What were the keys to success of the program?**

Neckers: There were several. First, we maintained our interdisciplinarity and we built the program on fundamentals. Every student had to demonstrate competency in organic and physical chemistry and our courses built on this competency. Our core courses included quantum mechanics, introduction to chemical reaction theory, principles of photophysics and principles of photochemistry. We also required a single course in organic spectroscopic analysis. After a few years a course in solid-state physics was added as a core alternative. And students could take elective courses in the departments of physics, biological sciences and chemistry at Bowling Green as well as in chemical and biochemical engineering at the University of Toledo. Several students also worked collaboratively with the Department of Biochemistry at the Medical University of Ohio in Toledo.

Second, the Soviet Union fell and we were one of the first universities in America to recruit in the former Soviet Union. Third, the senior faculty in the program recognized that collaboration was the key to success. Instrumentation proposals were written collaboratively, and each of the groups was quite comfortable hosting students from the other groups. Finally, the Ohio Board of Regents offered financial incentives that could enable selective excellence. Our program competed successfully in each of these.

***The Spectrum*: Who were some of the key staff hires in those days?**

Neckers: The addition of Deanne Snavely in 1986 and M. A. J. Rodgers, the first Ohio Eminent Scholar in our area of the State, were absolutely critical to our early success. Also some of our colleagues were really supportive. Without their help we never would have made it. I think particularly of the late Elliott Blinn and Distinguished Teaching Professor Thomas H. Kinstle. We never would have managed had it not been for their support and cooperation.

***The Spectrum*: What did Mike Rodgers contribute?**

Neckers: I can't say enough about Mike. First he enthusiastically worked to develop the curriculum. He participated then, as he does now, in the teaching of quantum mechanics and a core course in photophysics. He also set up a laboratory in kinetic spectrometry that, in 2001, became the Ohio Laboratory of Kinetic Spectrometry. This laboratory houses some of the finest facilities for transient kinetic studies in the world and it is a testament to his genius. He's an extraordinary instrumentation specialist and developed some of the techniques in his laboratory both before he came to Bowling Green and just afterwards. Mike also was an excellent research mentor not only for his students but also for those of his colleagues. He took committee appointments seriously and made students from other groups recite for him on a regular basis. This meant that, in the main, when they finished their dissertations and it was time for their final oral examinations, the examinations became conversations between colleagues about common research interests, rather than examinations.

***The Spectrum*: We understand you relied on a high-profile recruiter to snare Mike.**

Neckers: Rodgers also became an example for what an Ohio Eminent Scholar could mean to a program. At the time he was being recruited, Governor Celeste had offered to call any candidate on behalf of any program if it was thought that a call from the Governor would help. Mr. Celeste called soon to be Eminent Scholar Rodgers to ask him what, if anything, we could do to encourage him to come to Ohio. Our successful appointment paid testament to his help.

The Spectrum: How did *The Spectrum* originate?

Neckers: Scientists don't communicate well with the public, and they communicate even less well across their own disciplines. Experts do pretty well with one another, but experts in one field do poorly with experts in other fields. When we started *The Spectrum* I decided that there were a lot of interesting things going on in the then photochemical sciences, but most photochemists didn't know anything about them. I was determined to change that. So we started almost 20 years ago with a four-page format that was distributed to 400 scientists. By trading lists with other organizations, and selling our lists on occasion, *The Spectrum* grew and grew. With the fall of the Soviet Union, scientists from states formerly in the Soviet influence found that they could get scientific information from our *Spectrum* that they were unable to get elsewhere. It has been distributed to over 10,000 people in 42 countries at no charge for all these years.

***The Spectrum*: Tell us about the decision to move from paper to online-only publication for *The Spectrum*.**

Neckers: That's a sign of the times. In the first place *The Spectrum* has grown to the point that is a small magazine, and becoming quite expensive to publish and mail. Secondly, the reading habits of the scientific public have changed enormously. Whereas hard copy used to be expected, now it is almost becoming a nuisance. For every scientist that complains because we have decided to go completely *electronic* five said "What took you so long?"

***The Spectrum*: You've had scores of memorable students over the years. Which individuals stand out most?**

Neckers: I've worked with so many wonderful students at all levels. I'm like Lou Gehrig and thinking I'm one of the luckiest persons in the world. Undergraduates at Hope College gave me my first introduction to what it meant to be a university teacher, but still I found out what it meant to work with them at formative stages of their young lives. I don't know how many students worked in my labs at Hope College then. Many did. And most, though not all, went on for graduate study in chemistry or biochemistry. Several went on to distinguished professorships at colleges and universities across the country. At one time I had three former undergraduates holding named, endowed professorships at two Big Ten universities. Admittedly this was the 1960s and early 1970s so there were lots of Americans studying chemistry. Some went to medical school.

Paul Schaap worked with me at Hope from 1964 through 1967 when he graduated. I remember the first time I saw him in the undergraduate organic labs that I was teaching. I asked him how he liked freshman chemistry and he said he liked it a lot; and "there was an independent section in the laboratory that was the *best* (and he emphasized best) part of the course." Paul spent a semester working in the laboratories of Hans Wynberg in The Netherlands in a program I arranged for him, enrolled at Harvard and worked in Paul Bartlett's lab. When it came time for him to find a job, I knew Wayne State was looking for an organic chemist so I encouraged Carl Johnson to take a look at Schaap. They hired him.

D. C. Neckers with undergradutae students at Hope College. Paul Schaap is standing behind Neckers second from right.

Courtesy of D. C. Neckers

***The Spectrum:* Paul helped launch the technology transfer enterprise.**

Neckers: Yes. He started Lumigen in the mid-1990s. Lumigen had some rocky times early, but has gone on to prosper. Hope College just announced that Schaap and his wife had given Hope $7 million and that the new Science Center would henceforth be named the A. Paul Schaap Science Center in their honor.

***The Spectrum:* What is the secret for successfully cultivating undergraduates like Schaap?**

Neckers: With undergraduates it involves much more than teaching core textbook principles, routine laboratory techniques used in research. The best undergraduates will get that part quickly. But it's the attention you pay to them as individuals that really makes a difference. Sometimes telling them chemistry isn't for them is the most important thing you can advise. I've had numerous former students discover themselves during personally difficult times in the courses or the laboratory. One of the major directors of pest control for the World Health Organization discovered what he really wanted to do was become a field biologist, because he got into small difficulty in one of my sophomore organic chemistry courses at Hope. He'd felt family pressure to be a doctor but I gave him the confidence to decide for himself what *he* wanted to do; not do what he thought his father wanted him to do. And I gave him the confidence to make that decision by telling him "that's all right." A few years ago that student, Rick Bruggers, was named a distinguished alumnus of his graduate university—BGSU.

***The Spectrum:* If you were teaching by example, what rule would you emphasize?**

Neckers: I had great teachers while a student (by the way I'm still a student!) and I learned something from each. Ironically several of my greatest teachers weren't chemists or even university professors but that's a different story. My great teachers were real role models. Cal VanderWerf was creative and energetic. Mel Newman loved chemistry more than anything else in the world. George Hammond was a rebel and critic. Harold McMaster was an entrepreneur. Paul Block was a writer and journalist—a man who stood for something and made sure that he told the world what that was. Each of them made a difference in my life. So to any young aspiring teacher/educator I would say, *Make a difference each and every day*. I'll never forget the response from a precocious high school student a few years ago when I asked about his career plans.

"So, Peter. What are you going to do for a living?" He replied, "I don't know. They haven't invented it yet." One doesn't have to invent a new curriculum or course or project every day. But Picasso made a living by coloring outside the lines. I like to think, in some ways, so have I.