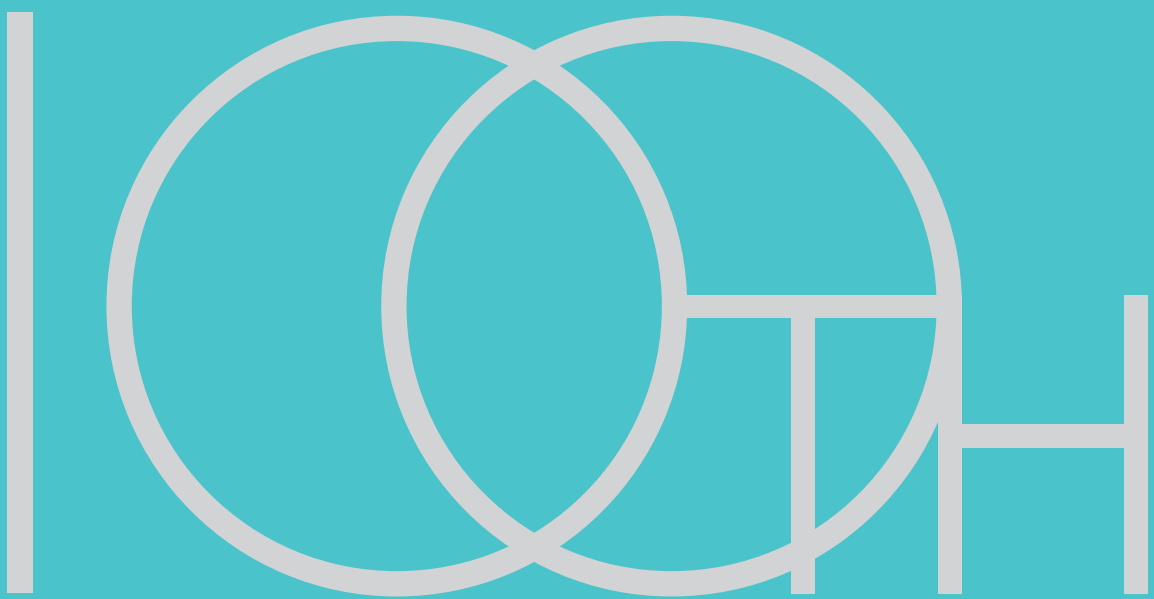
IN PRACTICE

VOICES OF THE PRACTICE SCHOOL EXPERIENCE

100TH

THE MIT SCHOOL OF CHEMICAL ENGINEERING PRACTICE 1916-2016



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We will not be here to see where the Practice School is one hundred years from now. We can all project, however, that the program will continue to train highly successful cadres of new chemical engineers using the well-tested and proven methods honed over the past century, no matter where technology leads us. It promises to be a wonderful journey.

Introduction

One hundred years in practice.

Life has changed a lot since 1916, but the core of the Practice School experience for students and hosts hasn't. For a century, MIT chemical engineering students have worked with industry partners to help solve real problems in pharmaceuticals, energy, food sciences, materials, the biomedical field, and other areas.

The venues have changed–back then they were confined to the Northeastern US, while today students travel to stations around the world–but the fundamental tenets of the Practice School have remained the same: Step out of the classroom and address real-world problems through communication, teamwork, and initiative; and focus intensely and apply fundamentals to deliver value to the host company. As a result, the Practice School has instilled in generations of students critical thinking and analytical skills, tenacity, cultural sensitivity, confidence, and a desire to do right by the company that has opened its doors to them.

As alumni, you know better than anyone the singular rigors, wonders, and lessons of life offered by the Practice School. With this book, we share a cross section of those experiences. Whether students are working with carbon black at Cabot, re-engineering Golden Grahams cereal at General Mills, or analyzing the surface qualities of an antacid pill at Merck, they are contributing to the success of their team and host company, while learning skills one can only earn through such a dynamic and intensive experience.

One reason for the School's persistent success is that students recognize its value. They are drawn to the program by the opportunity to better themselves in so many ways, encouraged by the tales of those who have gone before them. They keep coming, taking time away from doctoral research and postponing careers to benefit from the Practice School experience.

But also, the School's success can be attributed to its evolution. The School has become more diverse, the stations more far-flung,

and the challenges more modern. In Australia, for instance, student groups recently tackled problems in the liquified natural gas arena using computational methods and 3-D printing in a remote production facility.

Without a doubt, that evolution will continue. As we begin the second century of the Practice School, we confront new challenges. New technologies are changing the way students work and, in some ways, changing the boundaries of chemical engineering. This has happened before. We met the challenge then, and we are doing so again.

We will not be here to see where the Practice School is one hundred years from now. We can all project, however, that the program will continue to train highly successful cadres of new chemical engineers using the well-tested and proven methods honed over the past century, no matter where technology leads us. It promises to be a wonderful journey.

T. Alan Hatton
Ralph Landau Professor, and Director
David H. Koch School of Chemical Engineering Practice

There are really two kinds of chemical engineers: Those that have gone to Practice School, and those that should have gone to Practice School.

Jefferson Tester ’71
Former Director of the Practice School (1980-1989)

100TH

THE EARLY YEARS

Paul Ammann

Degrees: BS ’57, MS ’58

Station: Oak Ridge National Laboratory, Carbide and Carbon Chemicals Division, Oak Ridge, TN

Current position: Engineering Consultant

About: Paul Ammann lives in East Orleans, Massachusetts. He and his family have been enjoying time on Cape Cod since the 1960s. Today he spends some of his time there evaluating the health of coastal water bodies and fresh water ponds.

We all had job offers when we got our bachelor’s degrees. Offers were pretty good in ’57. But I thought, *Well, I might as well go on and get another year of school while I have the chance.*

I was not somebody who liked to absorb endless education. I like to use it. The Practice School appealed to me because it wasn’t just more classwork.

In one project, we had to find out how neutrons behaved. We were measuring the absorption of neutrons in metals. We had these hemispheres of metal—silver, gold, platinum—half a dozen of these rare metal two-part spheres. They were like big grapefruits with hollow middles and must have weighed 20 or 30 pounds. I mean they were heavy to carry. We could not drive our cars into the Oak Ridge National Laboratory, so each of us would carry one of these heavy metal things and we’d walk right out through the gate. The guards never said anything to us.

There was an abandoned church outside the Oak Ridge National Laboratory where we did our measurements. Hanging down through a pipe in the ground was a wire attached to a golf ball-sized source of neutrons. It was very, very radioactive and hot. We would put half of one of these grapefruit things on a machine on the right, and the other on the left and then with a motor we would pull up this golf ball until it reached the center of the table. With the motors, we would move the two hemispheres together to enclose the source. Outside, behind lead shields, we would take measurements of how many neutrons would get through these metals over time.

We did actually have an accident. One time, when we pressed the button to drop the source down, it got hung up on the pipe. It was just sitting out there in the room. The health safety guy came with his radiation detectors and stood there while my colleague grabbed a narrow board, maybe 10 feet long, so long and thin that it bounced up and down as he held it. He jumped out from behind the lead barriers and batted the wire so the ball would drop down through the hole. The health safety guy said, *Well, you got some radiation, but maybe it wasn’t that bad.* That was life in those days. That’s the way it was.

Work then was a big contrast to students now doing everything on a computer. We had to do the drawings for our reports not in pencil, but in ink with a T-square on vellum paper. If you remember, vellum is this sort of transparent paper that you could make copies of blueprints off of. I remember I would draw and get about eighty percent done, and then I’d smear it. Hah! So I’d start all over again.

In ’58 there was a downturn and a lot of businesses contracted. I had a position with an engineering firm, but a few weeks before graduation, I got a polite letter from them saying that they weren’t able to honor the offer. It turned out that one of the three plants in Oak Ridge had an opening. They almost immediately offered me a job.

After graduation, my wife and I loaded the car and we were driving back down to Tennessee. **Somewhere around New Jersey, the radio announced that one of the biggest nuclear accidents had occurred in Oak Ridge.**

I was immediately assigned to the accident investigation. Some solutions had mysteriously gotten from one side of the plant to another side and an employee had filled up a drum and it actually fissioned, like a nuclear reactor. When that happens, there’s Cherenkov radiation, a bright flash through this huge building. But at the same time, there were three or four welders working in that area. The employees thought the flash was from the welding, so none of them left. Eight men were very severely irradiated, but they all survived.

My task was to figure out how the stuff got from a safe area to an unsafe area, which I was able to do. I don't want to go through it, but it was all engineering applications. **That was my introduction to the real world.**

Practice School was embedded in me throughout my career. At the Kennecott Copper Corporation, we had co-op students from Northeastern who would work with us. I asked one student to write a memo summarizing his project and findings. Normal Practice School reporting. When I got it, I rigorously marked it up and gave it back to him. He was in total shock. I ran into him ten years later and he told me that project was one of the best learning experiences he ever had. That was good.

"The Practice School appealed to me because it wasn't just more classwork."

Harris (Pete) Bixler

Degrees: SB '53, MS '58, ScD '60

Stations: Oak Ridge National Laboratory, Carbide and Carbon Chemicals Division, Oak Ridge, TN; Station Director 1960-1962, American Cyanamid, Bound Brook, NJ

Current position: Retired CEO, Ingredients Solutions

About: Pete Bixler lives in Maine and for years was an avid hiker and mountain climber. He still has a taste for adventure. At the age of 82, for the first time in his life, he started taking piano lessons.

My dad lost his job during the Depression. He was a mechanical engineer, so he strongly recommended that I not go into mechanical engineering. Chemical engineering looked like a better situation. In those days, you sort of did what your father wanted you to do.

I come from a little town in Pennsylvania called New Buffalo. Seventy-five people. Seventy-four when I left to go to MIT. I was at a small military school that was not a strong science school. It was mostly a disciplinary school, but I managed to get into MIT.

I was interested in practical experience. If you look at my record, I was not a sterling scientific student. MIT wouldn't accept me for graduate school, so I went to the University of Toronto and found myself. A professor named Woodruff showed me that I really had some capability in thinking. Not just hands-on. I found I was good at material engineering. I did very well at the University of Toronto. So that was a changing moment.

I came back to Cambridge all puffed up. I went to see Glenn Williams, who was the graduate school registrar for Chemical Engineering. He said, *Well, you did very well, Bixler, but we don't think very much of the University of Toronto. Go and get a year of Practice School and see how that goes.* And so I did.

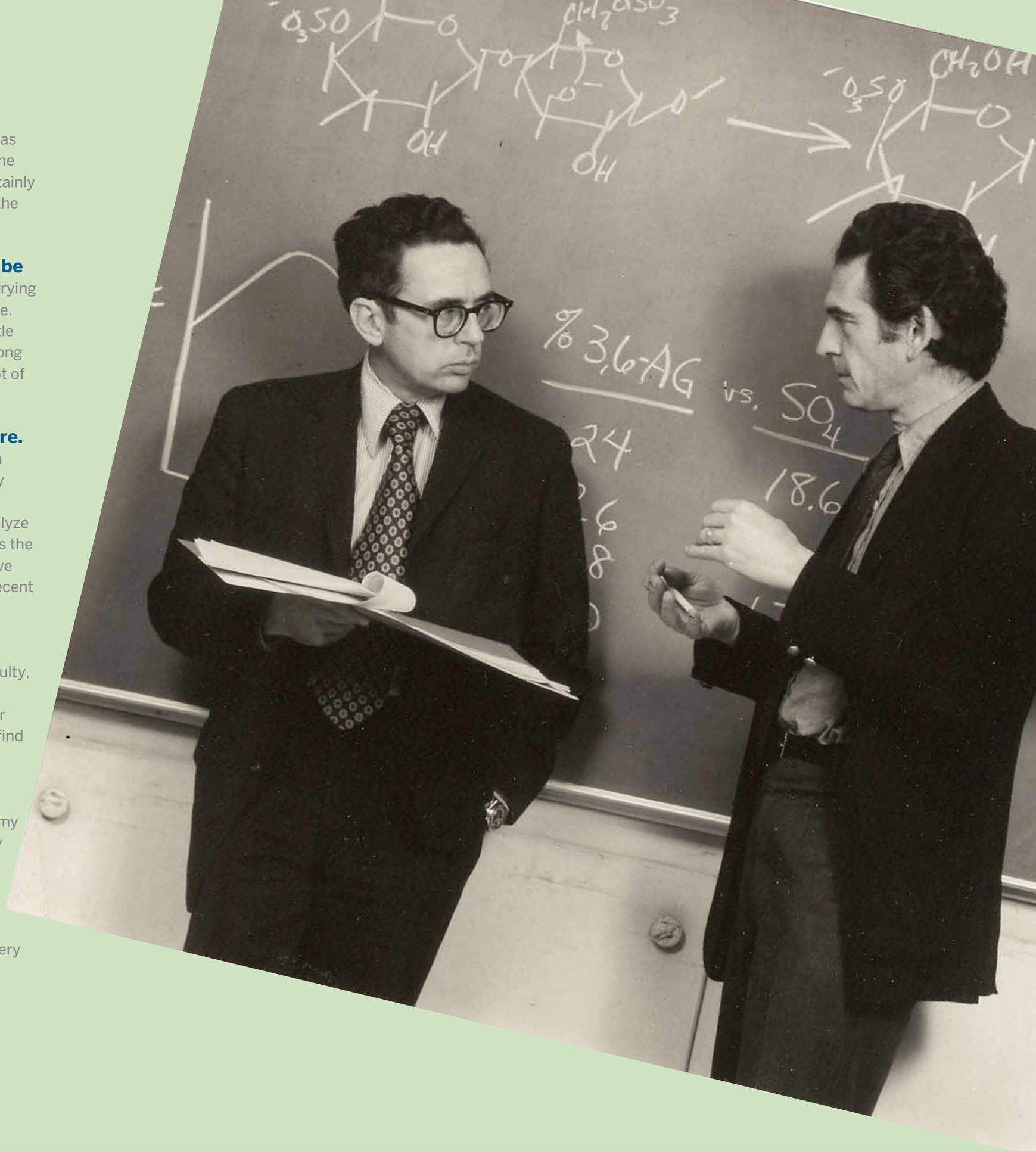
I wanted to be a hands-on chemical engineer. The primary thing I remember from Practice School at Oak Ridge was that we were learning computer code. We spent most of our time analyzing non-linear equations. I look back on it, and it was certainly worthwhile, but what I wanted to do was get my hands dirty in the plant.

By today's standards, American Cyanamid would be closed down. They made a black dye called nigrosine by carrying out high temperature reactions in a 2000-gallon cast-iron kettle. The recovery of the product was to open the bottom of the kettle and let it dump out on the floor. Then some guy would come along with a wheelbarrow and a shovel. At that time, there wasn't a lot of concern, but it was later clearly determined to be a carcinogen.

You'd prefer to have a success rather than a failure. Two organic chemists and two chemical engineers at American Cyanamid took the students and me under their wing and really wanted us to achieve what the whole principle of the Practice School was, and that is to be able to go out into a plant and analyze a situation and report on it in such a way that the company sees the advantage of doing it. Sometimes they knew we couldn't achieve what was in the proposal, but they worked with us to make a decent project out of it.

My career has been as a successful businessman rather than as a high-tech man. After I went on the faculty, Al Michaels and a few of us formed a company called Amicon. Our claim to fame was developing ultrafiltration membranes for concentrating proteins. You can still Google ultrafiltration and find Amicon membranes on the market.

During my career, I was the one smart enough to see what was worth supporting. A shining moment of my activity as president of Marine Colloids was when we financially supported a professor at the University of Hawaii who was showing you could cultivate seaweed. That is, you could tie a piece of seaweed onto a nylon line, stick it in the ocean, and it would grow by just pulling in nutrients from the seawater. That has been the savior of that industry. It also turned out to be a very successful livelihood for families who lived along the shores in tropical islands.



I still work because of my wife. She says **I married you for better or worse, but not for lunch.**

My family likes Maine very much. **In fact, I went back to Boston for two years and they almost got rid of me.** But fortunately I had an opportunity to come back to Maine and we've stayed here ever since. You might ask why my company is here. The product never comes here, but I set it up here because the work ethic is so good in Maine. That's why we've been able to do so much business with so few people.

I've been in the botany/biology business most of my career and I've never taken a formal course. About two years ago, I took a course of biology from the MIT Open Courseware. I took about four of five lectures and something came up that got in the way. I'd like to go back to that.

Robert Blumberg

Degrees: SB '64, SM '65, MBA '67 (Harvard Business School)

Stations: American Cyanamid, Bound Brook, NJ; Esso Standard Oil, Byway, NJ

Current position: Management Consultant, Blumberg & Company

About: Bob Blumberg lives in San Diego, California, with his wife and enjoys spending time with family, including two sons and five grandchildren. When he's not busy working, with family, or on the golf course, you might just find him kicking back on the porch with his banjo.

Chemistry was so easy for me that I couldn't believe it was difficult for anybody else. I couldn't say that about physics or other disciplines. Chemical engineering was a challenge because an education at MIT is a challenge, but conceptually it just all made so much sense to me.

To my surprise, I was awarded a Scott Paper fellowship, which paid for a year to do a master's degree. I had been an active undergraduate and so I was considered for it without my even knowing about it. It seemed to me a very obvious decision because I enjoyed the field and I had a paid-for education at the finest institution in the country.

I'd grown up in New Jersey on a farm very close to American Cyanamid. But arriving at Cyanamid for Practice School was like something out of Charles Dickens. There were many buildings and you could walk around the corner and a cloud of purple gas would be coming at you. You had no idea what you were going to be breathing.

One incredible thing happened at American Cyanamid. There were several teams of us working under the station director Mike Modell. One of the other teams, in the course of their project, discovered that this factory produced—I'm going to make up a number—close to 865 different products. Many small products, chemical

intermediaries, dye stocks, et cetera. They discovered—again I'm making up the numbers—that product number 862 was the waste stream they were throwing away from product number 3. Nobody had put two and two together. It wasn't my team, but I think we as a group saved the company some money.

There wasn't as much memorable about Standard Oil. It was in Bayonne, New Jersey, on a piece of land that looked like the end of the Earth. It was near a spit of land across the harbor from New York, and it wasn't far from a trash dump. There were seagulls flying in and out of the trash dump all the time. It looked pretty desolate.

The Practice School gave me some very good industrial experience. The lessons were intangibles. What does an industrial organization look like? What does it mean to report to somebody? What does it mean to be a peer of somebody? How do you relate to people in the organization who are either supportive of your projects or are not particularly interested at all?

I also learned about cultural differences at Practice School. Even if you talk freely and think you understand each other, people sometimes come from very different places, with very different traditions. Unless you have some grasp of that, you can't be nearly as effective.

For example, if I put forth an idea to my project team, my American colleagues at Practice School would not hesitate to tell me if it was a terrible idea. Well, my team also had one fellow from Italy and one from Brazil, and their cultures are very different. They would never dream of saying in a meeting, *That's a lousy idea.* It would be insulting. So they'd leave the meeting with an assignment, and they just wouldn't do it. They'd do something else. I would find out a couple of days later when I checked in. In private, they'd let on very delicately that they didn't think the idea was the right direction to go in.

Those kinds of lessons are useful in life when you're dealing in any context with people from different cultures. Later in my career I dealt extensively with Japanese, Chinese, Korean, and other cultures. Based on the Practice School I was more open to understanding them quickly and therefore figuring out how to deal with them.

After business school, it was the time of the Vietnam War, so I served in the army. **After that, in 1970, I went into what at the time was a very little known field called venture capital.** We were evaluating business proposals from startup companies, many of which were technology based. In 1981 I became an entrepreneur myself, joining with three other MIT graduates to start Spectrographics, which I ran for 30 years. At the end of 2010, we sold the company. About a year later, I set up my own one-person management consulting firm. I consult for the CEOs of small and midsize companies in various technology niches. I'm comfortable talking about the technology, but I help them more on the business side.

I decided that retirement was a course I wouldn't take. There's something about the energy of MIT alums. I'll bump into somebody there that I haven't seen in 20 years or 30 years, and I'll say, *Hey, what are you doing now?* I can't tell you how many times the answer I got was prefaced by, *Well, it turns out I flunked retirement and now I'm doing X, Y, and Z.*

"There's something about the energy of MIT alums."

Thonet C. Dauphiné

Degrees: BA ‘35, MS ‘36, ScD ‘39

Station: Eastern Manufacturing Company, Bangor, ME

Current position: Retired.

About: Thonet Dauphiné was born in Saskatchewan, Canada, to American parents. He grew up in Minnesota and attended the Shattuck Military School before coming to MIT in 1931. As an MIT undergraduate in chemical engineering, he also competed on the fencing team, participated in ROTC, and played the trombone in a dance band.

According to a resume that covers his career until the 1960s, Thonet’s Practice School experience included four months of work in “pulp and paper mills, a sugar refinery, and the Merrimac division of Monsanto Chemical Company.”

Thonet has four sons, six grandchildren and four great-grandchildren. He currently lives in Acton, MA, near a son kind enough to share the following stories about his father.

After eighty years, dad’s Practice School memories aren’t always forthcoming. He kept a trove of photographs, but few are annotated, so some mystery remains. Most show a variety of extracurricular group activities in Maine. They climbed Mount Katahdin, hiked, went deep-sea fishing, and sailed in a classic coastal schooner.

They were pretty mobile. Dad had a new Ford [A brand new 1936 5-door, Thonet told us later]. He was there at the infancy of skiing, learning jump-turns on long wooden skis. They’d put them on their backs and hike all the way up Mount Washington to Tuckerman Ravine.

Here is my dad standing on a waterborne log with a logger’s pike. His classmates appear in similar photos. I don’t know if this was part of the work at the paper mill or just students having fun.

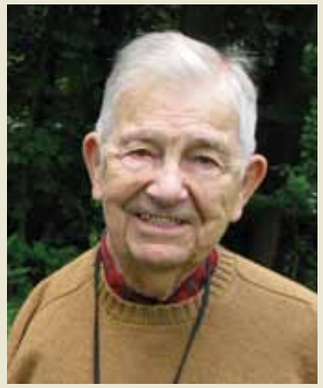
What's amazing is the deep social and professional bonds these guys formed during Practice School. Classmates T. J. Suen, John Demo, John Roberts, Kelley Woods, Lew Garono and Reed Ewing were frequently mentioned in our house, along with other MIT friends like Bill Rousseau. He's got bundles of correspondence. As a group, the Practice School kept together up until the early 2000s. An alumnus collected letters addressed to the whole group and regularly dispersed them with a cover page. The last one was 2003. Seventy years of correspondence. There probably aren't too many of them still around, or they're like my dad, not corresponding much.

My dad earned three degrees at MIT.

He also met Nathalie Boland, a master's student in public health at MIT. She was one of the few coeds on campus. They married in '38, after a courtship that included skiing Tuckerman Ravine and sailing Tech dinghies on the Charles. After finishing his ScD in '39, a job with Standard Oil of California took them west. They bought a house in Berkeley and had their first two sons there. He worked on aviation fuel processes at Richmond during the war. They returned east in '46 to open the office for a subsidiary called Oronite Chemical Company in Rockefeller Center. He's really proud of that.

In '51 a sales development position for Hooker Chemical brought them to western New York. We settled on a small farm, a perfect environment for keeping four sons busy. Between agricultural experiments, he helped introduce Tech dinghy racing to the Niagara River. In '62 he took a job as vice president for production and engineering at Nease Chemical in central Pennsylvania. That's where the resumes end. After a few years at ChemPro in Stamford, Connecticut, he returned to Cambridge to work for E. B. Badger Company, a subsidiary of Raytheon. It was a welcome homecoming for both of my parents, who had fond memories and many friends in the area.

The last chapter of his career was the creation of his own consulting company called Design Enterprises. He worked with Badger, Raytheon and Texaco on oil shale technology before the fracking revolution. They set up a pilot plant in a remote part of Utah to experiment in extraction using microwaves, a clean alternative. This was in the 80s. Even then the emphasis on shale was heavy. They knew there was 300 years of energy buried in shale. It was just a question of the relative market price of a barrel of oil, the same game as today.



After a fulfilling marriage my mother died in 2013, months before their 75th anniversary. None of us chose engineering as a career. There's a wildlife biologist, a surgeon, a chiropractor and an architect. His great-grandchildren have yet to choose. They're coming to visit in July from California and North Carolina. My dad continues to be an amazing guy, especially as he approaches his 103rd birthday.

He's going with the flow.

Sam Fleming

Degrees: BA ’59 (Pennsylvania State University), MS ’61, ScD ’70

Stations: Oak Ridge National Laboratories, Oak Ridge, TN, Assistant Director, ORNL Station, ’61-’62, Station Director, ORNL Station, ’66-’68, Director of the School of Engineering Practice, ’70-’74.

Current position: President, Global Resources Development and Management Company

About: It’s been 55 years since Sam Fleming first got wind of the Practice School, yet speaking with him, it is as if he attended just last week. He remembers EVERYTHING. His career took him from Boston to California, but he now lives and works back in his hometown of Huntingdon, Pennsylvania.

There had been some doctors in the family and I wanted to be a doctor. My mother had graduated from Juniata College in 1931 in Latin and Greek, and Juniata College, which was in my hometown, had a wonderful premed program. It also had a compulsory chapel service at 8 o’clock every weekday morning. I lived at 5th Street and the chapel was up at 15th, so it would have been a ten-block walk every day at 8 AM. My sister had gone on to Penn State, so I decided to go to Penn State, too.

I was a cheerleader at Penn State. I had a good time. My sister was in the May Queen Court. I was always Susie Fleming’s little brother. I was very proud and very happy to be Susie Fleming’s little brother. That was true then, and it’s true now.

I picked chemical engineering because I knew it to be the hardest or second hardest course at Penn State. It was a challenge. One of the reasons it’s hard is that you have to know both the chemistry and the physics. I’ve got to tell you I had no idea what a chemical engineer does. But it turns out it was a very happy choice for me.

I learned that chemical engineers do all kinds of things. I went up to work for Sun Oil company between my junior and senior year. I was in the refinery in the automotive lab. We had a pump with seven grades with different blends and used it to test their stuff against the competition. After that, I went back and made the Dean’s List the next year and went on to MIT.

I didn’t even know they had a Practice School at MIT. I went there and got a research assistantship at MIT under Alan Michaels. Pete Bixler was finishing his doctorate on the topic of the solubility and transmission of gases through polymers. So I was measuring the solubility of gases in polymers. It was very precise work. Pete came into the lab one day and he said, *Fleming, we’re going to send you to the Practice School and teach you how to talk.*

Pete, I think it worked. I think probably I had not yet acquired the skill, you know: Line up what’s important to say and say it convincingly in short sentences in order of decreasing priority of importance. That by the way is a skill we learned just listening to the faculty in the doctorate seminar program. It hit me after a while. My God, these guys are asking the most important questions in the order of decreasing importance. Pretty soon, you start to think that way. A lot of that was Practice School.

There’s a Practice School contract. Now or in the future, you and your fellow students will enable and encourage and when necessary prod and provoke each other to excellence. The goal is excellence. There’s nothing in second place. That philosophy of always going to the top, of always trying to make the campsite better, that’s it, see.

There’s nothing wrong with being first. That meant you delivered a result and hard work. My dad had me working in a machine shop from the time I was a freshman in high school—3 to 5 every weekday, 8 to 10 on Saturday morning—to make money for college. In those days of low in-state tuition at Penn State, I paid for my entire college education with the exception of about $400.

I was in one of the last groups in the first version of the Practice School at Oak Ridge. It was called the Engineering Practice School at Oak Ridge and it was open to engineering students from many disciplines. Mechanical engineers

had gone through, nuclear engineers, et cetera. The director was Jim Laramore and he was a nuclear engineer. And the assistant director was Jim Motley, who'd gone to Princeton. There were two problems at Oak Ridge and in the second problem there was a group of six of us. They usually break it into two teams of three, so I was given a tougher problem and all six people were on the team. That was a really early indication to me of, *Gee, these guys really think I can do this. Now how do you spell those second and third words of the problem statement?*

We learn from our errors as well as our successes. As a station director, I once felt I had to give an F grade to three good people, all MIT men then completing simultaneous bachelor's and master's degrees. It was their last presentation in Practice School. It's the director's job to see to it that every student succeeds. Part of this is rehearsing them before oral presentations. So these guys go through the thing and are making claims that aren't justified by what they've done. So Hank Cochrane and I spent until 11 o'clock helping them restructure. But the next day, the team leader reverted to his original, incorrect version. I called him out in front of everyone. I would never do that again. Thanks to the wisdom and counsel of Professor Glenn C. Williams, the department's graduate registration officer at the time, we identified a way out. He suggested we change the F to Incomplete, have the three do a problem for him over the summer, and if the work were acceptable, the Incomplete would be changed to the lowest grade required for graduation in September.

The point is, when I failed them, I knew immediately that I'd failed too. My job was to see to it that they succeeded. There are a whole bunch of errors I made in the assignment that I wouldn't make again.

Happiest of all to me is that a year later, back in Cambridge, the team leader sought me out. With tears in his eyes, he grabbed my hand with both of his big paws, and thanked me profusely. He said, *Because of my experience at Oak Ridge I know I am far ahead of others who joined Procter and Gamble when I did.*

My reaction as station director at American Cyanamid was, *it's perfect.* They made aniline dyes. One of the most important is called nigrosine blue. The chemical reaction is classic and goes right back to the dye industry in Germany at the turn of the 20th century. The problem is, aniline dye is a cyclic nitrogen compound and it has carcinogenic properties, which we didn't appreciate then. But it was a place where you could make a contribution. The equipment was old, the chemistry was sound, and if you went in there and had a problem, you could probably do something and help fix it. Cyanamid was very appreciative. They had a cadre of really smart kids come down from MIT. Their professional staff helped the students and the students helped the staff. Everybody wins.

Between 1970 and 1974 I took two trips to the Birla Institute of Technology and Science in India. We helped them start a Practice School that was open to every discipline in the Institute, including the social sciences. I went out in two trips. Ed Vivian came out in between. We helped them plan the curriculum and started the first Practice School station at Hindustan Aluminum. This was sponsored by the Ford Foundation. Today the Practice School program is still a requirement for students in BITS.

Practice School 101 is: What's the real problem? What do we do about it? How do we do it so the campsite's better off for my having been here?

We stand on the shoulders of giants. I can name them going back to high school. At MIT, I went to do research with Michaels, and then Michaels was gone. Wolf Vieth was my next supervisor, and then he was gone. So I'm four years into this pretty complicated experimental problem and Ed Gilliland comes in and says, *How's your thesis going? I'd like to be on your committee. Would that be acceptable to you?* Acceptable? It brings tears to my eyes just thinking about how he reached out. I've been really lucky to have the privilege of being educated by people like that in a very friendly way.

I went from MIT to Badger. The guy who recruited me was Bill Rousseau, vice chairman of the Badger Company, all the way over at One Broadway in Kendall Square. I became director of technology. Then I went to Fluor in Southern California, and then to Bechtel in San Francisco.

When you know what the problem is, and you've been to the Practice School, you figure it out: Here's what we do. Bing. Bing. Bing. Bing. I was program manager at Bechtel for CargoScan, a very large X-ray used to verify part of the 1987 Intermediate Nuclear Forces treaty with the USSR. It was built to X-ray Soviet missiles coming out of a missile factory

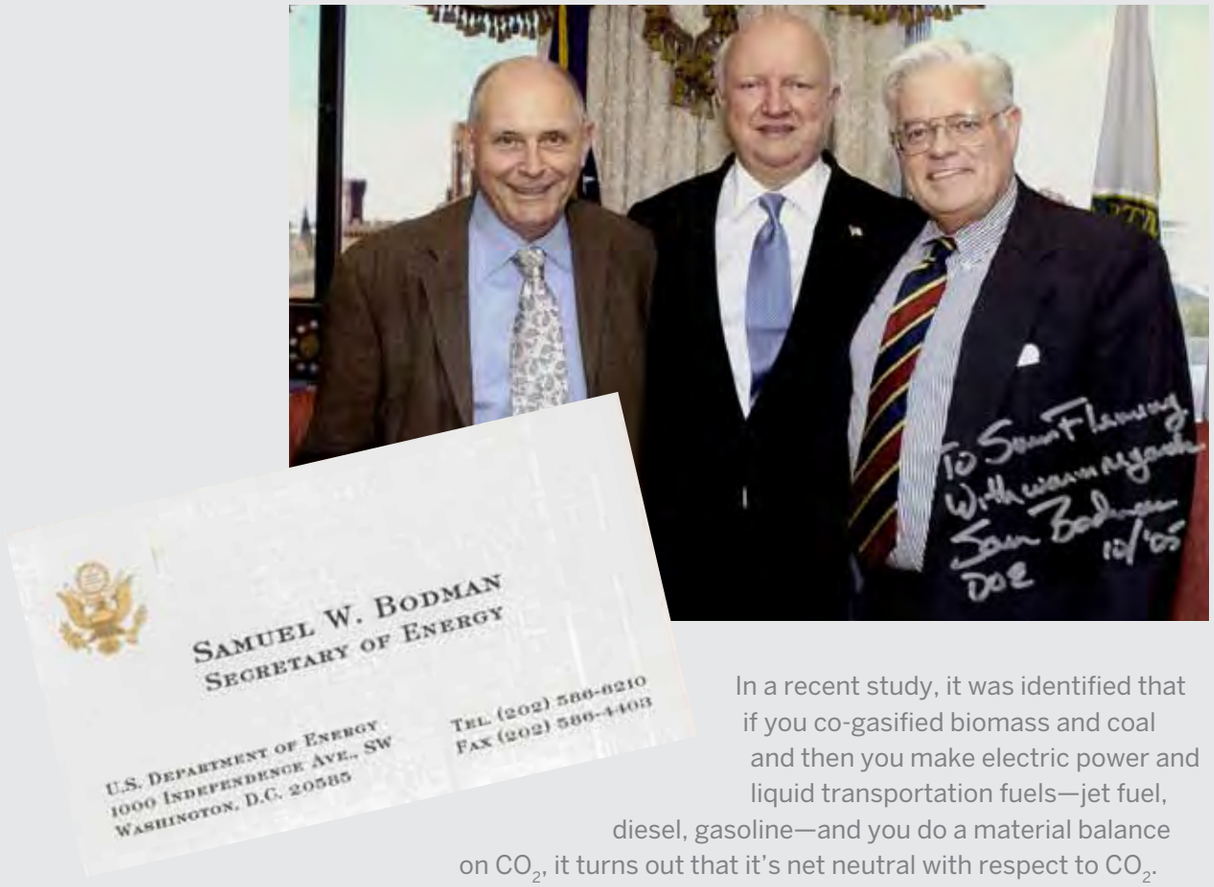
to confirm there wasn't a banned item under the treaty hidden inside an allowed strategic missile. We knew the system was going to work. We'd demonstrated it to them on some prototype equipment we had of air cargo on US Minuteman II missiles at Hill Air Force Base. That was the ICBM at the edge of the defensive shield of the US. We used radiography to find flaws in the rocket boosters. You want to find flaws because they can cause the rocket to burn too fast in certain places and when that happens, the rocket blows up. For CargoScan, what we did is use their X-ray source and put in our detector. We had that equipment out of the warehouse in Palo Alto, installed in Hill Air Force Base, got verification quality images, and had the equipment back in the Palo Alto warehouse in ten days.

I don't know why anyone would call a nice mild mannered guy like me with no opinions Bulldawg. A guy at Bechtel laid that on me. We were in research and development together. He was an aggressive guy. I named him Rocket and he nicknamed me Bulldawg.

If you don't know, a good honest *I don't know* is the best answer. I learned this from the Socratic method. I'd ask my Dad a question and he used to say, *What do you think? Pick a side, any side.* We'd talk about it for five minutes. Then we'd switch sides in the argument. Then five minutes later we'd say, *What did we hear that we liked? What's right? What don't we know? What do we do to find out?* That is the Socratic method. I've used it in industry and with my family. It's not particularly welcome with your family. By the way, my daughters hate the nickname Bulldawg. *Oh, Dad!*

We used to have a family tradition with the girls. On the last day of work for the year in San Francisco we'd go to Tadich Grill for lunch. **Everyone would take their calendars for the year and throw them off the roof, so it would be like a rain of confetti.** I'd always want to take a picture. It got to the point that the girls would say, *Oh Dad, you want a picture, don't you?* And so we'd go take the picture. And they'd say, *Make sure I get copies.*

Now I'm out in California and I'm shaving in the morning at five o'clock, getting ready to go to Bechtel, and the news comes on and says that the White House has announced that Sam Bodman is going to be nominated to be Secretary of Energy. Sam Bodman ran the Cyanamid station when I ran the Oak Ridge station. At the mid-term conferences in which students had to comment to the Director of the Practice School about it, they complained about how critical Sam Bodman was in his questioning of them. Bodman's response was, *You think this is bad, wait till you get down to Oak Ridge and Fleming goes after you!* **So when I heard the news report, I let out a shout.** My wife and two kids came in. They thought something was wrong with me. I said, *Sam Bodman is going to be Secretary of Energy!* The Senate later confirmed him unanimously.



In a recent study, it was identified that if you co-gasified biomass and coal and then you make electric power and liquid transportation fuels—jet fuel, diesel, gasoline—and you do a material balance on CO_2, it turns out that it's net neutral with respect to CO_2. You can make power and transportation fuels without a net addition of CO_2 to the atmosphere. That's vitally important relative to the Paris Accords, in which 160 countries and 30 industries pledged to triple their research budgets for mitigation of CO_2 emissions to the atmosphere from energy. **My company, which is modestly called Global Resources Development and Management Company, is aimed at doing exactly that.**

Today the world is under great stress. We're faced with situations of violence in the Middle East, spreading to Europe and the United States. So we're trying to take renewable domestic biomass and domestic coal and make electric power and liquid

transportation fuels without putting CO_2 into the atmosphere. If you've got this technology at scale, you are making what are now petroleum products from renewable domestic biomass and coal, so you reduce your dependence on foreign oil. It is transformative. Potentially transformative; we haven't done it yet.

I decided I would headquarter my company in Huntingdon, Pennsylvania, where I grew up. You need coal, biomass, water and transportation. That small town has all four. There's a big long family history. My grandfather, who died in 1921, was secretary treasurer of the Huntingdon Broad Top Mountain Railroad and Coal Company. They had coalmines in southern Pennsylvania and ran coal up to the Main Line and sold coal all over the country. I was going to incorporate in Delaware for tax purposes, because Pennsylvania taxes are high, but then I thought, the hell with that. I'm a beneficiary of the Commonwealth of PA. I went to Penn State. Why not pay the Pennsylvania taxes?

Some people say, Fleming you're 78 years old, when are you going to retire? I work pretty much through the 24 hours of the day. When I get tired I take a nap. Then I get up and do something else. I hope to have the best idea of my life the day I die.

Peter Spitz

Degrees: SB '48, SM '49

Stations: Eastern Corporation, Bangor, ME; Bethlehem Steel, Lackawanna, NY; Hercules Powder Co., Palin, NJ

Current position: Retired, but still an active member of Chemical Heritage Foundation's executive committee

About: Peter Spitz lives in Scarsdale, New York, with his wife, and when he's not keeping up with his family of three children and nine grandchildren or blogging about the latest chemical industry trends, he might be found playing golf or duplicate bridge.

I was born in Europe. My family came here when I was 13 because of Hitler. We lived with a Quaker family in Philadelphia. They sent me to the Germantown Friends School, where I had a chemistry and physics professor by the name of Professor Bennett. It was his influence that got me interested in chemistry and engineering. I dedicated my first book to Professor Bennett.

Even though I wasn't anywhere near the top student, I was a good student. I went to MIT because I got a small scholarship there. **I enrolled in Course X immediately and never thought twice about it.**

It seemed to me that advanced degrees are a good idea. I was in the army for two years and went back to MIT for my junior and senior year. Then I got the master's degree in Chemical Engineering Practice. The GI bill was still in operation, so the cost was very low. There seemed to be no reason not to do that. I didn't go for a doctor's degree, which some people did, because I was anxious to put what I had learned to work.

The first station, in Bangor, Maine, was a paper mill. They had some pollution issues and we had to figure out how to measure stuff coming out of the stack. Nobody told us how. **We had to do some original thinking.** We had to go up to the stack. But it's not as bad as it sounds. It wasn't a hundred feet up in the air. You just go on the roof and there's a stack. You make an opening and put your measuring instrument in. That's more or less what we did.

I was very interested in industrial chemistry: large plants, refineries, petrochemical plants. At the time, the industry had a lot to do with the Second World War. The US had to build a huge defense industry—refining and petrochemicals and synthetic rubber—in order to win the war. For maybe four decades thereafter, industrial chemistry was the real big deal. Then it began to be thought of as a smokestack industry.

I went to work for the engineering arm of Standard Oil in New Jersey. I spent about seven years there designing and starting up refinery units that take crude oil and refine it into gasoline, diesel, and other products. At one point, the division in Montana couldn't use some of the heavy oil anymore. You can't just let the heavy material build up. You have do to something with it. So we figured out a new technology at that time, brand new and patented, that would transform this heavy material into more gasoline and diesel oil. **This was a breakthrough kind of invention.**

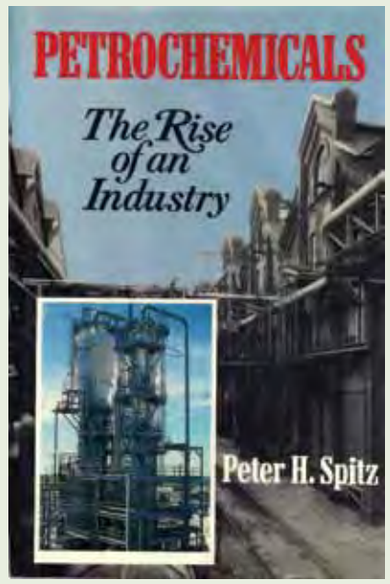
So we designed a new plant for our new technology and went out to Montana to start it up. **And the plant didn't work. It shook. We thought it was going to fall down.** It was the middle of winter in Billings. The plant was eight stories high and had no elevators. You had to climb up and down icy steps. It's pretty hard to start a refinery in the middle of winter.

We worked and worked on it and finally figured out how to make it run. We were so excited. But my real Eureka moment came when Standard Oil sent two executives there for the dedication. It was a very big moment, with the big shots coming there to congratulate us. When they showed up, we barely met them. They seemed totally disinterested and left as soon as possible. **My Eureka moment was this: I'm going to have to be promoted 15 times to get to that level. Is that what I have to look forward to? I'm getting out of here.**

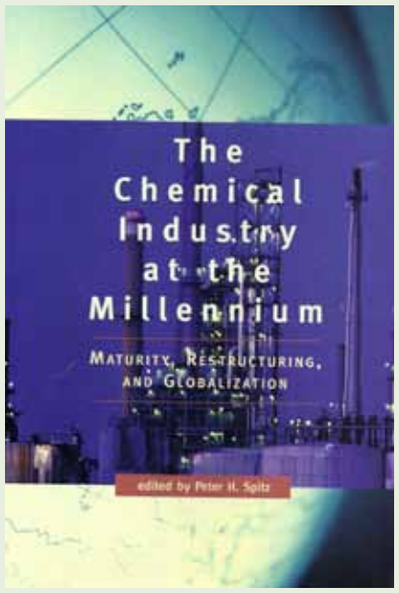
I spent another seven years at a company called Scientific Design Company, Inc. In '64, I was a vice president with a good salary and a good outlook. But my colleague Bob Davis, who also went to MIT, and I decided to quit and start a consulting firm. We had absolutely no experience in consulting, but we felt that we knew a lot about the industry and that we could somehow sell our knowledge. It was a pretty risky proposition. **We just sort of hung out a shingle and hoped for the best.** Eventually it became very successful.

One of the most memorable moments of my career was an OPEC meeting in Vienna in 1978. The OPEC nations had all the oil and we were importing a huge amount. They were making a huge amount of money, but said, *We're sick and tired of selling you oil and having no benefits of industrialization. We want to start building refineries and petrochemical plants. We want universities here that will teach our people how to be chemical engineers.* The rationale for the meeting was to find some meeting of minds between Western industry and the OPEC nations. They got three speakers from the West and three OPEC speakers, and one consultant. That was me. I was the moderator.

When I was picked to give a TED speech, I was very honored. I have given a number of speeches, but this was more difficult. It's a very stylized format. The speech has to be exactly 18 minutes. I was standing on a platform in front of an audience and the only way I could see my visuals was to look down at the floor. And there was a clock with a minute hand counting down to zero. It was pretty challenging.



For my second book I became a temporary fellow at the Chemical Heritage Foundation. They helped me write the book. I'm one of the senior members there now. **We look at the past, present and future of chemistry. I just love the whole thing.**



Bayard Storey

Degrees: BA ’52 (Harvard College), MS ’55, PhD ’58, (Harvard University)

Stations: Eastern Manufacturing Company, Bangor, ME; Hercules Powder Company, Parlin, NJ

Current position: Retired

About: Bayard Storey retired from the Obstetrics and Gynecology Department at the Perelman School of Medicine at the University of Pennsylvania in 2012. He spent most of his career studying mammalian reproduction, became an advocate for women’s reproductive rights, and still works to advance women’s rights and children’s health today.

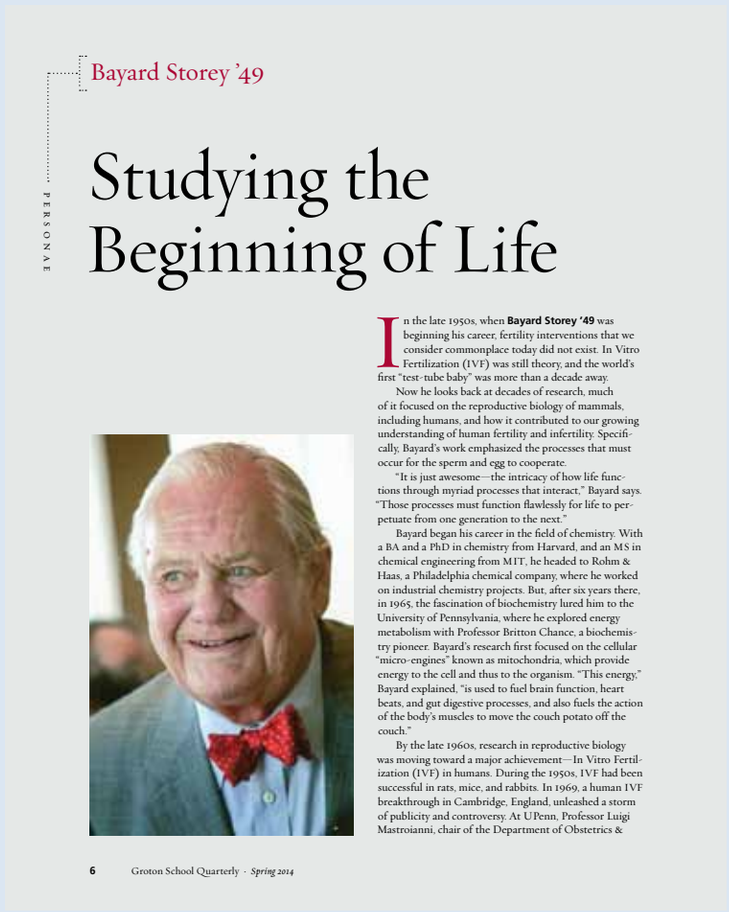
I asked my father, Should I go to Harvard or MIT as an undergraduate? I had gotten interested in chemistry in boarding school at Groton. My father was a graduate of Harvard; we’re all from Boston and the connection goes back to my great-great-great-grandfather. Before the war, my father had been with Kidder, Peabody & Co., which was one of the brokerage firms that was still functioning in the middle of the depression in the 30s. The only account that was doing anything was with Warren K. Lewis, an MIT professor of chemical engineering and consultant for Standard Oil’s research laboratory. So my father arranged an appointment for me with Doc. And Doc said, *Go to Harvard, young man, as an undergraduate. The MIT graduates tend to be a little boring, and you’ve got the proper background. But then come to MIT for graduate school*. That’s essentially what I did.

Those two years at MIT were very important. First, the coursework was very different from anything I’d had before. It made you think. Herman Meissner taught us a totally different brand of thermodynamics. When I look back on it, I would have been smarter to stay at MIT to get a PhD than go back to Harvard.

Also, those big beautiful mahogany and ivory-based slide rules from the MIT Coop were considered the *ne plus ultra* of calculating machines. Particularly the ones that were bigger and longer and had a complete natural logarithm scale as well as a regular logarithm scale. You could buy the little aluminum ones to put in your pocket to make you look like an engineer. I got one of those. They were cheap, but the big ones were expensive—40 or 30 dollars in 1955. But they were beautiful and they were incredibly precise.

Practice School just seemed to be an attractive thing to do at the time. Part of it was that I had had very little of what I would call true practical experience in any chemical firm of any kind. **Those years at MIT were really the most valuable I spent in my education.**

Practice School was particularly good at teaching you how to use your wits in very crude situations. We went to the Eastern Manufacturing Corporation, which was this antediluvian paper manufacturer in South Brewer, Maine. We learned to talk to the operators, who were old Mainers. Piping and plumbing and fluid movement is of course endemic to any paper manufacturing. We learned about slurries and this kind of stuff. But we also learned that you use very crude measuring methods, of which the bucket and stopwatch were the ultimate.



PERSONAE

Bayard Storey ’49

Studying the Beginning of Life

In the late 1950s, when **Bayard Storey ’49** was beginning his career, fertility interventions that we consider commonplace today did not exist. In Vitro Fertilization (IVF) was still theory, and the world’s first “test-tube baby” was more than a decade away.

Now he looks back at decades of research, much of it focused on the reproductive biology of mammals, including humans, and how it contributed to our growing understanding of human fertility and infertility. Specifically, Bayard’s work emphasized the processes that must occur for the sperm and egg to cooperate.

“It is just awesome—the intricacy of how life functions through myriad processes that interact,” Bayard says. “Those processes must function flawlessly for life to perpetuate from one generation to the next.”

Bayard began his career in the field of chemistry. With a BA and a PhD in chemistry from Harvard, and an MS in chemical engineering from MIT, he headed to Rohm & Haas, a Philadelphia chemical company, where he worked on industrial chemistry projects. But, after six years there, in 1965, the fascination of biochemistry lured him to the University of Pennsylvania, where he explored energy metabolism with Professor Britton Chance, a biochemistry pioneer. Bayard’s research first focused on the cellular “micro-engines” known as mitochondria, which provide energy to the cell and thus to the organism. “This energy,” Bayard explained, “is used to fuel brain function, heart beats, and gut digestive processes, and also fuels the action of the body’s muscles to move the couch potato off the couch.”

By the late 1960s, research in reproductive biology was moving toward a major achievement—In Vitro Fertilization (IVF) in humans. During the 1950s, IVF had been successful in rats, mice, and rabbits. In 1969, a human IVF breakthrough in Cambridge, England, unleashed a storm of publicity and controversy. At UPenn, Professor Luigi Mastroianni, chair of the Department of Obstetrics &

We didn't need a lot of fancy electronics. If you needed to measure a fluid flow, you did it by a mass fluid flow. It took three people to do this. You'd station one person on the downstream valve, you yourself were on the upstream valve with the bucket or barrel, and that was sitting on a scale. And then at time zero, you'd say *Go*. And I'd open the valve above the bucket and the other person would close the valve just downstream of that, and this filled the bucket. You'd need a third person on the stopwatch.

We learned to be skeptical about virtually everything. One of the things we learned fairly early was never to believe the diagrams you were given. You talk to the old guys who run the place. All those mills had valves all over the place. They never took a pipe out when they had to replace them. They just put one next to it. There were all sorts of extraneous dead pipes around. That was a revelation because you're kids and you assume the diagrams are all correct. That doesn't happen, for God's sake. People screw up in spades.

Our other station, the Hercules Powder Company in Parlin, New Jersey, was very sophisticated. There was a high-pressure nitric oxide absorption tower that we made measurements on and around. That was fairly state of the art in 1955. They also made dehydrated acetic acid, which is very useful for reacting with cotton to make cotton acetate. We did some work on that. In those days, that was pretty fancy chemistry and chemical engineering.

They also had these little wooden shacks out back. That's where they made nitrocellulose for guns. They looked like outhouses, little wooden shacks with a big cast iron pot in the middle. You'd get the hell out of there when they put on the heating element. Every so often they'd go *Boom*. When you have that kind of situation, you don't build something fancy.

When I was in Practice School it was strictly a male preserve. It never occurred to us that we could have girls involved. There were eight or ten of us and we all lived on top of each other and we never thought a thing about it. I mean, it was three males to a room and one bathroom. It wasn't exactly conducive to women. We wore funny hats, hats that would keep acid from dripping on your head. We looked like a bunch of scruffy bums. It was really very messy. It also required a degree of physical strength. We assumed the girls were too weak or too delicate to do this sort of thing.

Bob Richardson, I think it was, he knew how to deal with slurry. He was working with slurries and on equations for how to calculate slurry flow. I got interested in that on the side because it was a fascinating problem. Those things don't flow like water. Blood is a slurry. Ed Merrill, my thesis advisor at MIT, was the one who figured that one out. Years later he told us that Gilliland pushed him to do work on blood rheology while the rest of the department were appalled that anyone would take this on. It's an interesting question: Is this chemical engineering or isn't it? And Ed would say he thought it was. And Gilliland said yes. The others said no.

I was doing a PhD at Harvard and watching the faculty members of the chemistry department stab each other in the back. **I thought, *My God, I don't want to get involved with this kind of stuff.*** And then Rohm and Haas came along. The research division there was remarkably academic. Also I was engaged to my wife and her sister lived in Philadelphia so the idea of Philadelphia was very attractive.

My move into research got me into fighting for women's reproductive rights, which I've been doing for the last 30 years. Biochemistry was already all over the place down here and I got more and more interested in it. I applied for a geriatric post-doctoral fellowship at Penn, got it, then I wound up on the faculty at Penn in the biophysics department. They merged with biochemistry. One thing led to another, and I started looking at the physiology of sperm cells, which really hadn't been looked at in this particular way. So I got into that early and that just dumped me into reproductive biology in general.

It was basically our lab in conjunction with a couple other labs in the division of reproductive biology that straightened out the biochemistry and biophysics of the mammalian sperm's first interaction with the egg. **People thought they just go boom in the night, but oh, no, it's much more complicated.** Sperm, of course, its great characteristic is that it swims. It uses its muscle, so to speak, to get to the egg. The one that fertilizes it is the one with the strong flagellum. You want to know why. Is the egg telling it what to do or is the sperm telling the egg what to do? This is still up for grabs, but we certainly made a lot of progress. That body of work is what I'm proudest of.

Wolf Vieth

Degrees: SB ’56, ScD ’61

Station: Station Director 1962-1964, American Cyanamid, Bound Brook, NJ

Current position: Professor Emeritus, Rutgers University Department of Chemical and Biochemical Engineering (Department Chairman)

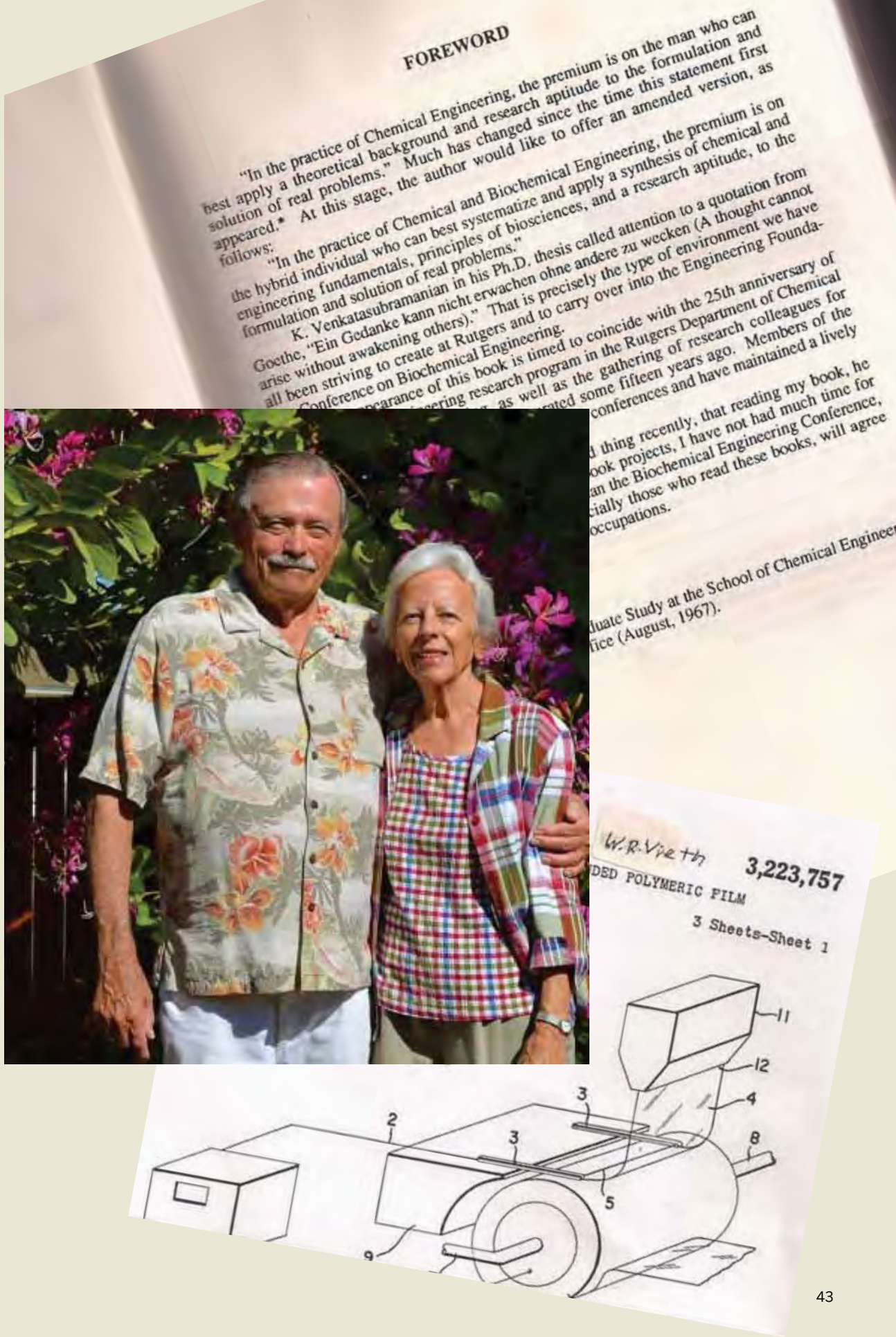
About: Wolf Vieth lives with his wife Peg on Maui, Hawaii, where he’s an avid fisherman. He designed the “ideal rod” for striped bass, which he catches locally and remotely, using Skype to join fishing trips with a son who resides in New Jersey.

My father said I should be a chemical engineer. He was an employee of Shell Oil Company. He knew how important chemical engineering was to Shell and saw how well the field had progressed.

When I was a post-doc, Professor Gilliland, who was the MIT Chemical Engineering chairman at the time, said I ought to go out and learn my profession and learn how to apply it. I resisted, but listened to him finally and went to the Practice School at American Cyanamid as station director. **Those are a couple of the best years I ever spent in my life.** You can’t imagine the scope of the activities in that place. It was just immense.

Fred Dorf was a first class plant technical man. He was the head of their chemical research section and was a plant technical liaison officer to the director of the Practice School. **I learned right away from Fred, there were no bones about it, as a project manager, you always have to follow up.** He followed up every project. And, oh my God, you couldn’t believe the coffee that that guy made. It was unbelievable. You could feel yourself being levitated up into the ceiling.

You run into all kinds of people at MIT. Anil Nehru was the nephew of the Indian Prime Minister and was in the Practice School. He didn’t put his weight around, but the one place where he showed off was that he didn’t do his own literature surveys. He had the US Library of Congress do this for him. His father was the ambassador, and I guess he just had somebody tell them to do it.

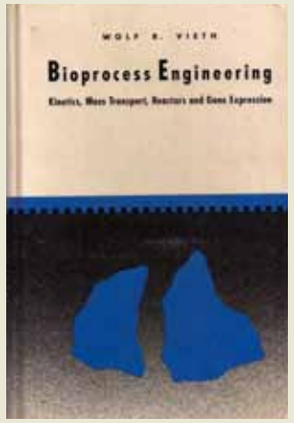


The people at Cyanamid were so kind to me. They adopted me like a puppy. One time they said, you know Wolf, if you're interested in biology, you ought to go to Lederle Laboratories and see what they're doing. So I went and they told me about folic acid. At that time, that was a triumph. Nobody'd ever seen it or crystallized it or isolated it, but they did it at Lederle.

But what I wanted to talk to them about was enzymes. I had started to learn that enzymes were biocatalysts. I had done the studies on the glassy polymer, and what came to my mind was why don't I find a biopolymer that will do the same sort of things with these enzymes? I did. I found collagen. I was ahead of the game in the polymers business, and I was ahead of the game in the bio business, and I put the two together and invented the collagen technology.

This is not going to be so romantic, but the first application that was especially meaningful for me was a job we did to purify urinous wastewater for the Army to make fresh water in the field. I had a guy named Bob Gilmore work on it. He did such a great job that later on it was sent on a space mission. Since that happened, I thought, *Hey man, this stuff works.*

We had a positive influence on the whole profession of chemical engineering, and it all came about because of what I learned about biocatalysts when I was in the Practice School. In 1970, we were doing research in biotechnology at Rutgers and we were flying, so we decided to change the department name. Rutgers became the first Department of Chemical and Biochemical Engineering. In the late 1970s, three of us Rutgers professors founded the Biochemical Engineering Conferences, which have continued successfully up to the present day. These conferences paved the way to the current state of affairs in chemical engineering, where most of the departments have changed their titles and their emphasis to chemical and biomolecular engineering.



I wanted to mature in the Practice School, but I always wished to have scope. Way later on down the line, I had it. I could go after interesting subjects and people didn't throw me out. They listened to what I had to say. I've been published in journals on neurotransmission, on how the heart beats, things like that. I've had a glorious time.

I stepped away from all this at the peak of my career. My grandfather died of a heart attack when he was 57. My father died of a heart attack when he was 60. I had high blood pressure—you get high blood pressure working in this kind of stuff—and I just said to myself, *I don't want this anymore. I've done enough. I want to enjoy my children.* I've been retired about 18 years. What's amazing is I haven't disappeared from technology. It's just catching up with me.

I sound like a blowhard but I believe in facts. I have a son who has fished with me since 1973. Forty-one years we've fished together. We've gone though five boats. Would you believe in our career we've caught four-thousand weakfish and two-thousand stripers?


POSTSCRIPT

To provide some further inkling of "where the author is coming from," the following is a profile of a surf fisherman, a member of a breed whose outlook on life he admires. It was fashioned from the writings of several authors, whose books have provided many pleasant moments to scores of readers.*

The surf fisherman is an action-oriented individual whose sense of achievement is fulfilled by taking gamefish which are sometimes large and powerful under difficult conditions, through the exercise of superior personal skills. Surf fishing in general is a sport of individualists who exult in battling wind, rain, sun, waves and bad weather. They may, for instance, be found along a stretch of windswept shoreline or on a crumbling rock jetty with huge combers breaking over it. Students of fish and the sea, they govern a part of their lives not by the clocks of civilization, but by the pulsing tide-clock of the moon and sun, in anticipation of the movements and feeding moods of the fish they seek. Consider for a moment a superb gamefish, the striped bass. The British Museum has pronounced its ties to the freshwater perch in the genus *Morone*. The perch was thus the evolutionary progenitor or genetic parent of the fish that now, long after the Ice Age, still prowl up the Atlantic coast each spring, returning southward in the fall, searching in vain for a homeland that lies far to the north, buried beneath an avalanche of glacial till, or under lakes the striper would have to cross mountains to reach.

It is never ending, this study of gamefish and their habits, which is why it appeals to members of a select fraternity. The feeling of accomplishment is second to none, right from the fabrication of a lure bearing the individual's personal stamp, to the selection of the scene and time, the presentation of the lure, the smashing strike, the ensuing struggle and, finally the supreme moment when a magnificent and unpredictable warrior is brought to rise, like a new idea, to the surface of its own element, the sea. All of this comes because of the decisions of one individual.

Even the old-timers along the coast will tell you the thrill never wears off completely. That heavy pounding of the heart returns as a reminder from time to time and a man's hands can shake with nervousness as he unhooks a prize. As a result of all this, surf fishermen, wherever they are found, stand out from the great mass of everyday pleasure anglers; they are a breed apart.

*The Complete Book of Striped Bass Fishing, H. Lyman and F. Woolner, A. S. Barnes & Co.: New York (1954).
Secrets of Striped Bass Fishing, M. Rosko, MacMillan Press: New York (1966).
The Lore of Sportfishing, Trc Tryckare, E. Cagner and Frank T. Hess (U.S.Consultant), Crown Publishers: New York (1976).
Striper, A Story of Fish and Man, John N. Cole, Atlantic-Little Brown & Co.: Boston-Toronto (1978).

Alfred Wechsler

Degrees: BS ’55, SM ‘58, ScD ’61

Stations: Eastern Corporation, Bangor, ME; Bethlehem Steel, Lackawanna, NY; Hercules Powder, Parlin, NJ

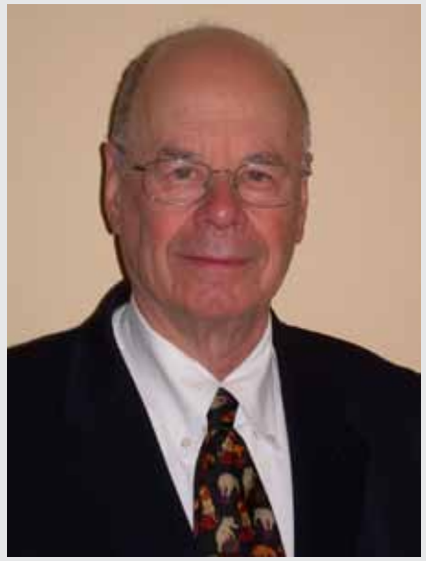
Current position: Retired after forty years at Arthur D. Little

Life Today: Al Wechsler now volunteers with the American Institute of Chemical Engineers and travels with his wife, whom he met during his graduate studies and married in the MIT Chapel.

In high school, I worked for Pfizer at a very early radio-biological lab in New Jersey. It extracted natural caffeine with benzene from tons and tons of waste tea leaves. We sold the powdered caffeine to Coca-Cola. The lab technicians were all pipetting radioactive materials. We all wore radiation badges, obviously, but this was back in the dark ages, and they did all the pipetting by mouth. But I was 15 or 16, and the women lab technicians were very protective of me. They would never let me pipette a radioactive material.

I was fortunate in going to three Practice School stations. The first was Eastern Corporation, a paper mill in Bangor, Maine. The second was Bethlehem Steel in Lackawanna, New York. Then we did a short portion at Hercules Powder in Parlin, New Jersey, a chemical plant that made some polymer precursor.

Paper mills are smelly places. The paper itself smelled a lot. You didn’t wear masks or anything like that. You just made sure you didn’t get in a confined room where it smelled too much. We did not have any courses in safety back at MIT at that time, so one of the first jobs of the Practice School director and assistant director was to help you understand what you should do and shouldn’t do in terms of safety at that particular plant.



A number of projects at the Bethlehem Steel plant involved sampling stack gas, gas that comes off of various furnaces. How do you do that? **You strap on some equipment, and you climb up to the top of a two-hundred-foot stack.** You were given enough talks on how to climb up a stack and measure something: Don’t do this, and don’t do that, and climb safely, and wear your safety belt, and wear your hard hat—and don’t look down.

The Bethlehem Steel plant in Lackawanna was a huge plant, with big overhead cranes that carry giant slabs of metal on big magnets. We all wore hard hats all the time. Our students all wore bright orange hard hats, and everyone else in the plant wore blue hats and green hats. **A favorite game of the crane operators was when they saw a student walking along the floor in an orange hat, they’d come along behind you with a giant slab and chase you.** Though of course they’d never drop it on you. Sometimes it was a warm slab and you could feel the radiation coming from it.

Another thing that was extremely valuable was just seeing the magnitude of processes and the size of equipment and how it’s not easy to turn things on and off. You do a heat transfer project on paper in your class, and yes, you’re heating this material to fifteen hundred degrees, and the flow rate is so much, and how long does it take if you’re heating it with combustion gas, et cetera. But you don’t realize the size and complexity of the equipment that is actually used to do this.

Bethlehem Steel was in Lackawanna, but we lived in Buffalo. Sometimes it would take us a couple of hours to get to the plant in the wintertime. A few times, we had to overnight it at the plant because you just couldn’t get back in all that snow, so we had sleeping bags, and we found a control room somewhere that we could use to sleep.

Arthur D. Little was unusual for a consulting company, because it was really a technology-based company. Since I had done research, I started in the Engineering Division, which did engineering research and development.

Around the early 1960s, people started thinking about the moon. Arthur D. Little had a number of contracts with both the NASA Huntsville and NASA Johnson Space Centers, and the Air Force Cambridge Research Laboratory, who were interested in knowing what the moon was made of. They wanted to create simulated lunar materials, so that astronauts could walk on it and we could know how it would affect the temperature of their boots, and things of that sort. I must have spent a couple of years measuring the thermal properties of simulated lunar materials.

We measured stuff in sewers around the country, looking for priority pollutants. I wouldn't ask anybody to do anything that I wouldn't do or hadn't done, regardless of what it was, so as part of overseeing the job, I would go and help take samples down in the sewers in Atlanta and Cleveland and everywhere else. Not fun!

We created a lot of new food products. A client had the idea to make a lettuce chocolate bar. We took lettuce, shredded it, did all kinds of things to it, fused a little bit of chocolate into it, and made a wholesome lettuce chocolate bar. It never sold, but those difficult kinds of things were the ones the staff really liked to do, because it was a way to have fun and use their ingenuity.

"Climb safely, and wear your safety belt, and wear your hard hat–and don't look down."

Comfort doesn’t enter into it. Get comfortable with being uncomfortable, because that’s how you challenge yourself.

Sam Fleming ’61 SM, ’71 ScD

60TH

THE MIDDLE YEARS

Benson Aghazu

Degrees: BS ‘69 (University of Leicester), MS ’70, ScD ’72, MBA ‘73 (Northeastern University)

Stations: American Cyanamid, Bound Brook, NJ; Oak Ridge National Laboratory, Oak Ridge, TN

Current position: Retired

About: Ben Aghazu lives in Nigeria with his wife, Chinemerem, and is the father of nine children and grandfather of fourteen grandchildren. He is an active Rotarian working to promote peace in the world through Rotary Peace Centers of Rotary International and is also helping to establish the Pentecost University in Nigeria.

I grew up in Nigeria. In 1966, **I escaped the Nigerian Civil War.** The Shell-BP Oil Company was interested in indigenous manpower in Nigeria, so they sent their officers to pick out the top students from select secondary schools. I was fortunate to be selected to go to the University of Leicester in England on a scholarship to study engineering science.

I came to MIT with an inflated idea of my achievement. In Leicester, I’d graduated top of my class. I thought I was very smart. So I get to MIT and the first quiz that I took, I got 33 percent. The highest score on that quiz was also in the 30s, but for me it was a shock. I learned that I really didn’t know much.

I wanted to get a doctoral degree, because whatever I’ve done in life, I like to get to the apex. My parents wanted me to study medicine. They wanted a child who would be called “doctor.” When I finished my doctorate in ’72, I said to my dad, *Well, you now have a son who is a doctor.*

I thought the Practice School route was a good one, so I could have the hands-on experience of the profession before I left MIT. I was planning on going back to Nigeria and possibly getting into the oil industry.

Thank God for the seatbelt. I remember January of 1970, driving west on the Massachusetts Turnpike in my brand new Volkswagen Karmann Ghia. I skidded on black ice and my car spun out of control and I hit the highway barrier. My car was badly smashed. They found me unconscious with my seatbelt strapped on. They said I was smiling. I recovered, and a gentleman came and towed my vehicle to a workshop. He said, *Nothing is wrong with your engine. You can be on your way.* By now, it’s nine at night. I drove the car all the way to Oak Ridge. Then I drove it to New Jersey. I didn’t repair it until I returned to Massachusetts three months later.

The experience in Oak Ridge was out of this world. It’s a very high security establishment of the American government. To be allowed to go there, into the labs, some underground inside the mountain, was quite a privilege for me. When I tell my life story, I say, *Ah, I’ve worked in the Oak Ridge National Laboratory.*

My Practice School experience at American Cyanamid inspired my doctoral thesis. We worked on an industrial-sized fluidized bed dryer, which dries liquid to produce drugs in powder form. It was chemical engineering in practice, not just the laboratory. The vision came that maybe I can use this same method to turn abundant raw materials in Nigeria, palm kernels, into protein rich flours that can be used as food supplements for babies. At that time in Nigeria, we had pictures of little children with matchstick legs and big tummies because of malnutrition. I thought my work would help to produce a product that would be useful to people. The title of my thesis is studies in...um...I am trying to think of the title. Age is catching up with me!

I carry the influence of Professor H. P. Meissner. He supervised my doctoral work. He said to me, *Ben, you ride too close to the wind.* I didn’t sail, so I didn’t know what he was talking about. I had to go to research it. He was telling me to have more focus. I took on too many things at the same time hoping to excel in all of them. That admonition did me a lot of good.

At that point in time, I was thinking of going to medical school. My wife didn’t find it funny that I wanted to remain a student forever. She wanted to go back to Nigeria. I didn’t.

I wanted to study as far as I could in the United States. In December 1973, after getting an MBA from Northeastern, I went back to Nigeria.

Titles do not really impress me. I like to be remembered by what I have done. So Ben. Ben is what I like to be called. Ben Aghazu.

I was given a wonderful opportunity to influence the development of education in Nigeria. I was asked to take the MIT standards back to help create this new institution called IMT — not MIT, IMT — the Institute of Management and Technology in a town called Enugu, the capital of what was Biafra during the Nigerian Civil War. That to me was very fulfilling.

I'm so happy to be a Rotarian. Rotary is a worldwide organization of business and professional persons who are anxious to give back to society. I've received so much from society I feel I must continue to give back.

In the year 2004, I made a deliberate decision to become a born-again Christian. I found that my life took a brand new meaning. I have no anxiety in my life anymore. I have no doubts. I serve beyond self. God has made it possible for me not to worry about many things in life.

My son was kidnapped here in Nigeria about three years ago. I was in a meeting when my wife called to tell me. I called a friend for help. He said, *Ben, all they need is money.* I said to him, *Sorry, there is no price you can put on my child's life.* When we hung up, I felt sorry because I had gone to the wrong source. I should have gone to God first. So I knelt down and I cried out to God. I said to Him, *I don't know what to do in this matter. It's up to you.* When the kidnappers called, they asked me to produce 20 million Naira [about $100,000] within three hours or they would kill my son. I laughed at them. I said, *I don't have 20 million Naira to give to you. Please release him. He's done nothing to you.* They hung up. Do you know what I did? I went back to the meeting. I forgot all about the problem. Truthfully. After that prayer, I had left the problem at the feet of God Almighty. I spent six hours in that meeting. At the end, I looked at my phone and found a number had called ten times. So I called it. Do you know what I heard? *Daddy! I escaped!* It was my son.

I can now tell you the title of my thesis. It has come back. It is called "Studies on the feasibility of obtaining protein rich extracts from tropical palm kernels." Somebody in Indonesia or Malaysia carried on my work. I think they built a plant somewhere based on what they found.

"When I tell my life story, I say, Ah, I've worked in the Oak Ridge National Laboratory."

John Austin

Degrees: BS ’74, MS ’75

Stations: American Cyanamid, Bound Brook, NJ; Oak Ridge National Laboratories, Oak Ridge, TN

Current position: Retired, Certified Ironman Triathlon Coach

About: John Austin competes in one or two Ironman triathlons each year and has run the Boston Marathon ten times. In 2015, he ran the race with his daughter, who is also a chemical engineer.

I didn’t go to MIT with the thought of majoring in chemical engineering. On the application, I said I was interested in aerospace engineering and architecture. A couple of upperclassmen in my fraternity were in chemical engineering and they seemed to enjoy it. I had to say I was in some major, so that was what I picked. **The fact is, I kinda liked it.**

For Practice School, we went to American Cyanamid first and then to Oak Ridge. **The most interesting thing was the contrast.** Oak Ridge was pretty modern. But American Cyanamid was basically a dye plant using First World War-era chemical technology from Germany. More than once clouds of something would get released and drift across the plant site. Things were pretty theoretical at MIT. So when we got there and saw the buildings, it was a real eye-opener.

One of the projects at American Cyanamid had to do with reducing emissions in one particular building. They made hundreds of different dyes there. Just trying to figure out what was actually being processed was a huge undertaking. They had all these recipes, with file cabinets of paper showing operating instructions to make different dyes. **The papers would be red or yellow or blue depending on what the last operator had been making when they pulled it out.** You’d walk through the building and go through an area that was blue, then an area that was pink; maybe next week it would be yellow and red depending on what was being made.

They made one chemical, a black dye. Nigrosine. I remember that place because it was totally black. For some reason there was an open flame—maybe it was a pilot light—but it was totally black with a flame. **It was a vision of Hell.**

At Oak Ridge, we had to run tests all day and night. I worked the night shift with Bob Train. It would take ten minutes to set the tests up, and then you had to wait an hour and a half to allow it to come to steady state. **So we had a lot of free time at night.** MIT was housed in a building that was a museum, the American Museum of Atomic Energy. If you went downstairs they had a mechanical glove box where your hands grip a couple of levers to operate sticks inside to move around a series of blocks. Bob would get on one arm and I'd get on the other and we'd play hockey in there.

We were free to wander around the place. We could just go into buildings where there were research reactors. You could never imagine that in today's environment. I wouldn't say the security was lax, but it was a different era back then.

There was a fair amount of learning about what to do when things don't go right. Practice School forces you to be creative when an experiment doesn't work because the piece of equipment doesn't fit or for some practical reason. That never happens when you're doing theoretical coursework, but in the real world that happens all the time. You've really got to force yourself to get out and find the resources you need to get something done.

At MIT, you pretty much rely on yourself, but Practice School taught you to rely on other people. You see it in sports a lot, but Practice School was a work setting where you had to deal with team dynamics. In the end, it's a lot more rewarding that way.

I finished Practice School just before Christmas and started at DuPont January twentieth. **Forty years later, I retired.** That's pretty rare these days.

My first assignment was a pilot plant for a new material. When they authorized the project, I spent a year on the engineering team designing the commercial facility and then became a production supervisor for part of the operation. I spent a lot of my career in project management, taking projects from early on, the technology end, all the way through the operations end, building and starting new facilities. **I was fortunate to spend more of my career adding jobs than subtracting jobs.**

My first exposure to distance running was walking out to Kenmore Square from my fraternity on Patriot's Day and watching the marathon runners come in. I started running Boston in the early 90s. I used to be fast enough to get in the first corral and watch the pros come out. Those days are long gone. I started triathlons about 13 years ago. I didn't do my first Ironman until 2011. The training's pretty onerous when you're working 50 to 60 hours a week, but by 2011, work wasn't quite as time consuming, so I did it.

I've toyed with the idea of doing some engineering or project consulting, but I haven't done anything yet. What I am doing is running and triathlon coaching. I've gotten Ironman coach certified and I've got a couple clients next year. It's a great way to spend time. **I enjoy giving back some of what I've gotten out of these sports for the last quarter century.**

"You've really got to force yourself to get out and find the resources you need to get something done."

Ulrich Bühlmann

Degrees: dipl. Ing. ‘72 (Swiss Federal Institute of Technology (ETH)), MS ’74

Stations: Oak Ridge National Laboratory, Oak Ridge, TN; American Cyanamid, Bound Brook, NJ

Current position: Retired

About: Ulrich Bühlmann lives outside of Basel, Switzerland and enjoys spending his time gardening, playing the piano as well as the alphorn, and mountaineering with his wife (ice picks required at times).

I was most attracted to the exact sciences and I had the choice of math, physics or engineering. It was a pretty difficult decision but I decided to go for engineering. Math and physics are more research or teaching related, which I didn’t like too much. **I can now look back through my life and say it was the right choice.**

After my diploma, I was in the airplane flying to Boston. ETH had a student exchange program with MIT for two students. I applied for it, I was elected, and I got one of the tickets to go to MIT.

I kept some documents from Practice School. I have my memory, in my head, but what’s funny is I found all the letters I wrote from MIT to my parents. They kept all the letters and at one time they gave them back. I didn’t throw them away. **I discovered a lot of things I had forgotten, including all the reasons why I chose to go to Practice School.** It’s the shortest but by far not the easiest way to get the master’s degree. It’s one term and it’s hard.

Practice School was a pretty hard start. Right when we arrived in Oak Ridge, there was the problem assignment. The assistant director explained the four problems. The last one was, I’ll read you the title: “Immunological activity of biospecific proteins immobilized on polyacrylamide matrices.” I didn’t understand what it was. It’s biochemistry. I have no idea of biochemistry. I just was praying, *Please, not this group. Please, not this group.* I was in this group. And it’s hard to believe, but I was group leader.

Jeff Tester was the station director. He made an excursion to the Smoky Mountains, which are close to Oak Ridge. It was early March, with a bad weather forecast: one to two inches of snow. Jeff was afraid of the situation. He arrived fully equipped for this hike—with a rope and an ice pick. Ha! It was just normal hiking trails. **He was taking care of his students.**

Outside of Practice School, Jeff Tester was a friend. That was so important, again, because life was tough. You had to work a lot. With his approach, he really made life at Practice School much easier. More bearable.

Ten years ago, I was on a business trip to Cambridge. Of course I went back to MIT. In particular I wanted to know if Jeff Tester was still around. I went to his office, but it was empty. I walked around and suddenly I heard a voice in a room down the corridor. It was him! I went in. He looked at me and said, *Ueli!* **It’s funny, you know, how after thirty years you can recognize a voice.**

The last experience I had at Practice School, I forever will remember. At American Cyanamid, it was the last round of problems. We were getting tired. There was a double-group project in this last set of problems to be solved, with seven

students in total, two group leaders and one guy heading the two groups as the project leader. Guess who was project leader? Ha! It was me again.

I still have the Practice School manual. I have it in front of me. It has 75 pages. It's like a cooking book. How you have to prepare your investigation memorandum, how you have to organize your work, how you have to prepare your progress report, a large chapter on how to prepare the final report, and how to prepare your oral presentation and make a good slide. You have to follow the procedure. It's tough but it's very helpful later on to make good presentations and to have good slides.

I liked the US way of life, but I probably would not like to have it for the rest of my life. I knew the longer I would stay, the likelihood to stay forever is just increasing with time. So after Practice School I said, *It's time to go back to Switzerland.*

I'd had enough of university. I wanted to go to industry, so I chose a job with Sulzer, a well-known Swiss mechanical engineering company with a chemical engineering division. It was the right decision because I got to know a nice girl who turned out to be my wife.

After three years, I changed to a small-medium sized enterprise called Kühni. It's a specialist process engineering company. **I led this company as a managing director, or CEO as you would say in the US, for almost 30 years.** When I joined the company it was mostly a restricted market in Switzerland. I opened the market field worldwide.

Kühni was small, so I did not have only managerial problems. My professional life was devoted to chemical engineering. Until the end I was involved in chemical engineering and separation technology, all that I learned at ETH and MIT. **But now being retired I must say there are other things outside chemical engineering.**

I have been walking around with a jacket from Practice School for forty years. In Bound Brook you have to wear work jackets at work, blue work jackets. The one I got, I took with me. It's nothing special, but I took it with me as a souvenir. It served me practically all my life as my work jacket at home. While gardening, when I worked in my small workshop, I wore this blue work jacket from American Cyanamid. Last year, it finally fell apart. I had to part with it. Forty years of service!

Laurent Burelle

Degrees: dipl. Ing. ‘74 (Swiss Federal Institute of Technology (ETH)), MS ’75

Stations: American Cyanamid, Bound Brook, NJ; Oak Ridge National Laboratory, Oak Ridge, TN

Current position: CEO, Compagnie Plastic Omnium SA

About: Laurent Burelle lives in Paris, France, with his wife (and college sweetheart), Régula, a pharmacist, and his four daughters. He is uncertain about the meaning of the word “retire.”

My brother studied chemical engineering, my father studied chemistry, my grandfather studied chemistry, and my great grandfather studied chemistry. **So I was free to choose any specialty, as long as it was chemistry or chemical engineering.**

When the answer came from MIT, I accepted. For a French boy from Paris who studied in German in Switzerland, **arriving in Boston was like landing on the moon.**

I was very much in love with a Swiss girl. So the real target was to pack a master’s into one year. I studied the rules. I said, *If I do that, that and that and then I go to Practice School, then <clap> in 12 months, my master’s is done and I’m back.* It could have been space science. It could have been chemical engineering, medicine, agriculture; anything that would bring me back to my love was good for me.

At Oak Ridge I realized for the first time what foreign policy and security standards were. There were three security classifications. The first group was US citizens. Then you had the so-called friendly nations. Canada, England, Australia. The whole world but France. Then there was “Others.” The Others was France. I was very shocked. They thought we were communists. (They were not wrong. Haha!) We were not a *friendly* nation.

Practice School is a way to develop a young personality. The station director at Oak Ridge was a young and enthusiastic PhD. I don’t know if he taught me anything in science, but he taught me communication, teamwork, multicultural projects, and working together. That and the army afterwards, one year in Germany, has been the greatest help in my job to become the boss of a corporation today.

Army was more fun. I was an officer. I had a group. I had tanks. I was free to go right and left. I enjoyed it.

I was quite sad at Oak Ridge. I was very much alone. I was not really integrated in the American social life of TV soccer and beer. **I wanted to get married.**

I learned that in the States, when the policeman asks you to stop, you don’t get out of the car. I went with my friend Shingo Ishikawa with his VW Beetle visiting the Smoky Mountains. We loved it. On the way back, we did something absolutely wrong on the highway. We stopped and we pulled back. A police car came by and said to us to stop. We made the huge mistake of getting out of the car. And the guard, I don’t know what he thought. He did not shoot us, but it was not far.

American Cyanamid. That’s something. American Cyanamid at that time was a rich powerful company with a beautiful building in downtown Manhattan. And they had a really dirty ugly teardown plant in New Jersey. They had not invested a dime in it for the last hundred years.

Air pollution from this plant was dramatic. The plant was fabricating a product called nigrosine to clean shoes, if I remember well. A dirty product. It was made in huge—I would say 1000 or 2000 gallon—wooden buckets, like wine barrels, but 10 or 100 times bigger. Wood. It is a 19th century product. And the process was...my goodness.

The project they assigned us was very good training for me that I have applied during forty years afterwards. It was around that time that the Environmental Protection Agency started in America. The EPA said, *You have to protect the air and environment, gentlemen from American Cyanamid. You have to measure the concentration of bad toxic product in the air in your plant.* Instead of taking the question straightforward, to measure the concentration of pollution, American Cyanamid asked us, *How much land should we buy*

around the plant so that the concentration of bad toxic product becomes legal at the boundaries of the plant. They turned the question around because the law said that at the boundary of the plant the concentration should be low enough to be legal. My conclusion, I said, *Well, you have to tear down the plant.* They were angry as heck with me.

At that time, you were not looking at environment and social responsibility. Compared to profitability, the fight was over. Today, you would never dare to ask that question.

I am a capitalist, but this taught me about investment. American Cyanamid is dead. They died because they underinvested and they killed their company. I have 115 plants today worldwide. I know that investment, automation and environment are key. Very often I push my teams to invest more than they wish.

This Practice School experience also taught me how to behave. Some years ago, we developed a product that was legal within the technical frame. One day, I asked my daughter to come to the office and use the product. It sounded to her exactly as it sounded to me, and she was afraid to use it. Everybody was afraid. And I said to the team, *Now, do you want to put this legal product on the market and your children to use it?* Everybody bowed their heads. They said, *You just canceled the project.*

Industry is a fantastic adventure. I started my career as a young engineer on the plant floor. My family and me, we own a company that was small at that time, a couple hundred employees, and today we have more than 25,000 employees. We have plastic plants around the world to supply the automotive industry. I've quite an interesting life. A very rewarding life. And I married the girl of Switzerland I wanted to marry back in '74.

If I said to my wife I plan to retire, she's going to kill me. She would think that that is horrible news. I'm still very active, fully operational. I have started to promote people around me. My daughter, Felicie Burelle, is working with me now, so it is exciting to try to hand it over to her.

Arun Chetty

Degrees: BS '85 (Princeton University), MS '86

Stations: GE Silicone & Noryl Products, Albany, NY; Brookhaven National Laboratories, Upton, NY

Current position: Director, Intel Capital

About: Arun Chetty lives in Saratoga, California, and has spent his spare time over the years volunteering at his children's schools, teaching math and science and coaching Math Olympiad teams.

I was heavily influenced by engineers as I grew up. My father was a chemical engineer. My brother was a chemical engineer. We've got a lot of chemical engineers in the extended family. Also electrical, mechanical, et cetera. Engineering was a natural path for me.

After I came to MIT and I learned more about Practice School, I decided to sign up for it. And it was amazing. **It was one of the pivotal points that opened up my mind to other possibilities.**

At GE, the projects weren't research projects; these were immediate problems that needed solutions. They trusted these students from MIT to attack these problems and they wanted to hear what the proposed solutions were. There was a technical aspect to it. But there was also a business aspect to it. I got the inkling that the business side of things might also be interesting.

We had the opportunity to go beyond just doing the work for GE, which was really great. One problem had something to do with modeling a chemical process for a polymer that GE was making. We had to do computer simulations and so we had to work not just with the resources that GE had but also with the company that GE was sourcing the software from. We told them, *Hey you know, if you structure the software this way, it may be easier to model certain things.* What was really satisfying was that we were actually able to improve the software itself.

Practice School was pretty intense. We'd be working probably twelve to fourteen hours a day. It is like boot camp. It builds

character, as they say. **But it was invaluable in that short timeframe to get that amount of work done and to learn that much.** You don't get something like that often in life.

At GE's silicone manufacturing facility, we had to map out the factory. This was an old factory with lots of pipes and everything going everywhere. The maps were all physical maps that people had rolled up and stored in some closet somewhere. As changes were made to the factory, the drawings weren't being updated. So the first thing we did was map out all the pipes and all of that. We had to just keep hustling and walking around the factory. One of the silicone manufacturing processes wasn't going right, so we had to figure out how the reaction was taking place. We were walking around in hardhats and using all kinds of markers and dyes to measure the flow of fluids through those pipes.

We presented to senior management what we were proposing. They told us, *Okay, if you modify the reactions as you guys are proposing, tell us what the economics of that would be. What are the costs? How long would it take to recover the cost? What is the impact on the product costs?* So then I was like, *Oh, there's a connection between the technology we're proposing and the business implications. It's all connected.* That was a great experience.

Practice School was the first time that I got the experience of putting a case together and having a structured discussion with senior management. **That principle, that thought process, is relevant throughout life.** Even today, whether it's in business or outside of business, even in personal life, having that structured logical thinking process has helped a tremendous amount. It is relevant even now when I'm having business discussions with senior folks in my company.

I've been at Intel Capital, which is the venture capital arm of Intel, for about eleven years, about half my time here at Intel. **Every week I meet at least five to six new companies that are developing interesting technologies.** My technical background is helpful in my current job, but also my business background and combining the business aspects with technology is extremely relevant here in this job.

I've identified a handful of companies that have become a key part of Intel's larger ecosystem and have been relevant to helping Intel's products be successful in the market. They have also been very successful investments for Intel Capital. That's what I feel good about. That's the reason I've been here eleven years. **I enjoy doing this work and hope to continue doing it.**

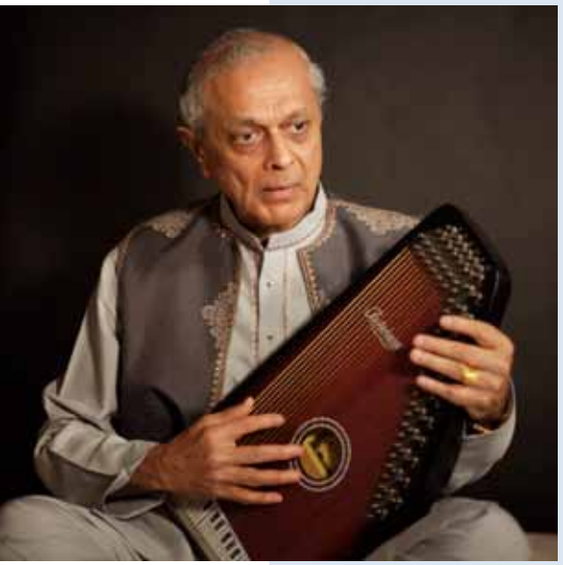
Arun Dravid

Degrees: BA ’66 (India Institute of Technology Bombay), MS ’67, ScD ’70

Station: American Cyanamid, Bound Brook, NJ

Current position: Retired, Chairman Emeritus, Jacobs Engineering, India

About: In addition to his engineering career, Arun Dravid sings Indian classical vocal music. He still performs and has students in Pasadena, California, and Mumbai, India.



The musical part of my career probably came first. I started developing a keen interest in it from the raw age of ten or eleven. I had serious training in parallel with my studies at IIT Bombay, and it almost grew to a level of being able to perform as a professional. I did not quite treat it as my profession because I never did it for a living.

I was deeply influenced by a wonderful professor and teacher of inorganic chemistry. I was scientifically inclined anyway, and he ignited my interest in chemistry, but my inclinations towards physics and math made me think, *Well, you know, what about chemical engineering? Wouldn’t that be a good blend of the two?*

People like me, graduating from good renowned institutes of learning like IIT, had MIT in their vision. MIT had a very special name and fame. So I called for the big fat catalog. It came by sea mail, believe it or not. It took about six weeks for it to reach my place in Mumbai. I went through it and looked at the chemical engineering literature and was very fascinated by the faculty, the research areas, and everything.

I made up my mind to say that MIT would be my first choice. MIT gave me admission right away, but they withheld financial assistance. Other good schools offered me financial aid, so I was of two minds. For us in India, an MIT education was not exactly cheap.

Upon graduation, IIT Bombay had a system of recognizing the top ranked student in the Institute, not only within chemical engineering but all the undergraduate disciplines of engineering. **I happened to be the top one.** I earned a very coveted honor of the President of India Gold Medal for that performance. I said, *Well, why don’t I make that a selling point?* I sent a telegram to Glenn Williams, who was in charge of admissions at MIT, saying, *For such and such performance I have been awarded President of India Gold Medal by IIT Bombay.* He right away wrote back another telegram to me saying, *Assistantship awarded. Please come.*

I thought the Practice School experience would be valuable to get a feel for real-life situations in chemical engineering. I had always planned that I would go on to do a doctor’s degree. I knew I was going to have ample research opportunities during my doctoral program, so I didn’t have to do yet another small research project to get a master’s.

I stayed both quarters of Practice School in Bound Brook at Cyanamid; I did not go to Oak Ridge. That was partly my choice and partly because I was not a US citizen. If I had really wanted, I think I could have gone to Oak Ridge. But I was quite happy. I liked the Cyanamid environment.

Cyanamid designed the projects very nicely. There are oftentimes tendencies of these big industrial companies to look at the Practice School type of intrusion into their plants and factories as some kind of a social obligation and sometimes there is a tendency of giving some superficial type of work projects to the students. I found Cyanamid was not that kind of a company. They spent a lot of time devising real problems they were facing in their plant where our limited student experience might be put to good use. The projects were fit for a one or two-month duration for a group of three or four. And there was a fair balance between applying the theory and getting their experts to tell us how the theory would fit. It was a good learning experience.

One person who was a great motivator and help was our assistant director, Joe Sie. He had a considerable amount of plant experience before he came to MIT. He stands out in my mind even today, how helpful he was in explaining and challenging us and getting us to think. He was a good mentor and a good educator.

The best Practice School lesson was the ability to be faced with a hell of an unknown situation and just approach it boldly. I have to give credit to some of the courses that I had at MIT, such as Bob Reid's thermodynamics course and Herman Meissner's course in industrial chemistry. I was beginning to get used to being totally flabbergasted and not having a clue about where to start thinking. But that situation began to repeat in real-life projects in Bound Brook. Many of the challenges seemed like course problems. I tell you, this is what stuck in my mind: The Practice School challenges you to not get drowned and say *Hey, this is not for me.* However hopeless it might look on day one, however clueless you might be, you learn persistence. *Hey, this can't be unknown. This can't be that bad. Come on. Think, think, think!*

Practice School did influence me to not seek a research career after having finished my ScD. The Practice School experience was one factor and my early inclination to apply hardcore engineering to real-life problems drove me not to seek that academic career. Instead I went to work for Shell Oil company.

After seven years, first at Shell Oil and then at Chevron, I thought I would like to apply all this knowledge and experience and training back to my home country, back to India, where it was badly needed. I had a green card, so it wasn't an issue to remain in the US, but I was driven, shall I say, by what many people considered a foolish desire to be patriotic. In my career in India, I went to work for what today has become probably the world's second or third largest design and construction company, Jacobs Engineering. I got into a technical job there and for the first ten years, it was so exciting.

I ended up heading a team of people in our company who developed a very rare technology that was not available for license in India. There was a feeling that this technology was badly needed by India, so we ended up developing it from scratch in a project together with the National Chemical Laboratory of India. I spearheaded that effort and we produced the world's eleventh and Asia's first plant to produce these specialty chemicals called chloroxylenes, which are specialty solvents that are used as additives in manufacture of certain high performance polymers. That has stuck in my mind as a very rewarding experience and a culmination of my MIT days, my Practice School days, and applying all those periods of long training into something concrete and vitally important for the country.

After thirty-five years with Jacobs Engineering, I have recently retired. My last position with the company was chairman of the Indian arm of our company. They now made me chairman emeritus. I don't have any full time responsibility, but I do have a small consulting contract with the company so if they need a piece of my wisdom I can share it.

My singing career has never stopped. I still perform professionally and I do concerts back in India and here in the US.

"However hopeless it might look on day one, however clueless you might be, you learn persistence."

Bulent Eczacibaşi

Degrees: BS ‘72 (Imperial College London), SM ’74

Stations: Oak Ridge National Laboratory, Oak Ridge, TN; American Cyanamid, Bound Brook, NJ

Current position: Chairman, Eczacibaşi Holding Co.

About: Bulent Eczacibaşi lives in Istanbul, Turkey, where he and his wife actively cultivate the contemporary arts. His wife is the founder of Istanbul Modern, Turkey’s first museum of modern art, and he is the head of the Istanbul Foundation for Culture and Arts.

I was influenced by my family history. In the early 1900s, my grandfather ran a small-scale pharmaceutical business in Izmir, where he prepared pharmaceuticals and personal care items in a laboratory. At that time there were no large-scale pharmaceutical plants in Turkey and very few pharmacists of Turkish/Muslim origin. Following in my grandfather’s footsteps, my father completed three degrees in chemistry and did post-doctorate research at the Kaiser Wilhelm Institute in Germany. Less than a decade after he returned to Turkey, he established Turkey’s first modern pharmaceuticals manufacturing plant. From a young age, my ambition was to get a solid technical education, gain practical experience by working in our family company, then take over the business one day from my father.

In the old times of the Ottoman Empire, there were no family names in Turkey. It was the old Arabic system where everybody was called by his father’s name, like Ahmad son of Mahmed. Then in the 1930s the law of family names was introduced in the new Turkish Republic. At that time, my grandfather, my father’s father, had the honorary title of “head pharmacist” in Izmir. **So he took his honorary title as his family name and became Eczacibaşi.**

I chose MIT for two reasons. The first was its wide recognition as the world pioneer of chemical engineering. MIT essentially created this branch of study. Secondly, MIT had the School of Chemical Engineering Practice. I was sure that this program would be invaluable for my professional career—and I was right. It gave me the opportunity to work on real engineering projects and problems in companies unrelated to our own business, something I was never able to do again once I began my career in the Eczacibaşi Group.

M.I.T. CLASS and instructors are, front row, l. to r.: assistant director Prakash Dhargalkar; director, Prof. J. E. Vivian; Larry Krussel, Makoto Yamazawa, and Ronald Leenhouts; back, l. to r.: Kris Kudmac, and Miss Elsa Kam-Lum, who plan to be married in January; Jerry Toman (rear), Bulent Eczacibasi, Raymond Mayer (rear), assistant director at the Oakridge Practice School; Rafael Solares, John Donohue (rear), John O'Neill, Karl Londgraf, Ted Bush (behind Mr. Londgraf); Paul Koppel, and Eric Sunberg.

I went to Oak Ridge, Tennessee, and to Bound Brook, New Jersey. **They were very well-chosen stations.** They represented the two extreme worlds chemical engineers could be exposed to in their professional lives. One was a super-advanced research lab at Oak Ridge, the other was an ancient chemical plant producing dyes and intermediates in Bound Brook. They were really very different environments and very different experiences for us.

I believe that the four months I spent at Practice School were the most productive of my graduate studies and even my professional life. Probably the most valuable lesson I learned at Practice School was that not having enough information or data about a problem and having to use estimates instead to solve a problem was more often the rule than the exception in real life. Virtually all of our projects at Practice School had very short deadlines and very little data, which was so different to what we had become accustomed in the classroom. You didn’t have the luxury of backing away from a project just because there wasn’t enough hard data. It’s been 42 years since Practice School, but I can still hear my professors saying to us, *Use your engineering judgment.*

I also learned the importance in real life of good communication techniques. Standing up in front of an audience, it was a new feeling for most of us. Up to that time, I'd never had to do it. We had to deal with the excitement and also the stage fright. It's a skill one must learn at some stage because in professional life, you have to do it all the time.

Another experience that was entirely new was teamwork. Up to that point I always had worked on my own, working in the library or in the labs. I never had worked in teams before Practice School. Team members were assigned by our supervisors, with no control over it by ourselves, so we had to get to know the team members very quickly. We had to figure out the division of responsibilities within the team and try to attack the problem with the maximum efficiency with the available talent in the team. We had to make sure that everybody was doing what he or she did best. That was a very valuable experience.

I honestly don't know how we found time to travel around the region we lived in during our incredibly strenuous work schedule at Practice School, but we did. On the weekends, I visited areas of the US that otherwise I never would have seen. Jeff Tester introduced us to the Smoky Mountains. He managed to give us time to explore the area while at the same time working on projects with extremely tight schedules. He'd organize brainstorming sessions in the mountains and the forest. It was very enjoyable.

Bound Brook and the immediate surroundings were not as impressive as the Tennessee and Smoky Mountains area. **It was a good place to concentrate on work.**

The experience of a US college campus was something very new to me. Studying in London, you are a Londoner. You take the Underground to go to lectures and labs and you live in the city. Whereas, on the MIT campus, you live in a different world, a self-sufficient world.

In 2017 we'll celebrate the Eczacıbaşı Group's 75th anniversary. **I'm proud to say that we're far more international than we were two decades ago.** We have several brands that are European leaders in their own segments, numerous manufacturing operations abroad, and international sales accounting for a third of our sales overall. In Turkey, we've maintained our leadership in our core businesses, expanded into new fields and maintained our position among Turkey's most admired companies.

Culture and arts top my list of favorite activities unrelated to business. I chair the Istanbul Foundation for Culture and Arts, which was founded 42 years ago on the initiative of my father. This foundation organizes international festivals and biennials. I love the work involved so I am fully engaged in all the foundation's events and projects. I try to attend as many different types of culture and art events as my time allows me.

Kim Kao

Degrees: BS ’83, MS ’84, MBA ’92, (UCLA Anderson School of Management)

Stations: GE Silicone and Noryl Products, Albany, NY; Bethlehem Steel, Bethlehem, PA,

Current position: CEO, LogicLink

About: After a whirlwind career as a chemical engineer during his 20s, Kim Kao became a computer services entrepreneur who sold, bought back, and rebuilt his company, LogicLink, more than once. Now, he and his wife and business partner Amy Hsaio are slowing down and taking time to enjoy family life in southern California.

As a high school senior, I took the initiative to ride my bike to UC-Irvine to take organic chemistry. I grew up in New York in Scarsdale and came out to California for my last year of high school. Since I’d finished all my prerequisites and some AP classes, I had an opportunity to be more advanced. Back in those days, organic chemistry was touted as being one of the hardest classes in college. I saw that as a great challenge and an opportunity for me to leapfrog other students.

The minute I walked into the UC-Irvine science lecture hall, everyone knew I had arrived. Irvine is well established now, but back in those days, Orange County was orange groves and farmland. During the ten-mile bike ride to campus, I picked up a lot of agricultural manure and fertilizer.

Anybody who thinks outside the box wants to be in an environment that’s unfettered. At MIT, as long as it’s not illegal, you get to pursue what you want to do. That’s why we have a lot of hacks at MIT. MIT allows kids to be able to explore the limits of what they’re capable of.

I was fortunate to graduate from MIT in two and a half years. When I showed my transcript from UC-Irvine to the professors at MIT, they said, *Well, UCI just can’t meet the standards of MIT.* They would not give me credit. So I went back to the professors and challenged them. There’s a policy at MIT where you can place out of certain classes by taking the final. I said, *Why don’t I take the final and if I do well, you should give me credit.* It turns out that the curriculum at MIT was a little different in organic chemistry. I spent IAP relearning it, came back, and took the test. I’m happy to say the professor gave me more than the requisite credits.

It was an intense two and a half years. There were times where I would go into a lab or the library and when I came out later the leaves would be gone or the whole weather pattern would have changed. I realized I was missing out on some of the experience on campus. That’s why I applied to Practice School.

I had a car, an old jalopy. It was a Ford Maverick. I loved that car. It was very useful and served as a social focal point. We used to sneak around those towns during Practice School whenever we had a chance.

In Practice School, you really start to learn about politics. When you’re in the academic world, it’s very objective. You do well on tests. Practice School gives you a whole different psychological perspective on how to approach a career and work.

One of my biggest regrets is that one of the participants in Practice School left. He left because of conflicts amongst the team members that had to do with working hard but not being acknowledged. I regret it because when the guy asked me if I could take him to the airport, I did. I was the youngster of the group and didn’t know any better. Professor Tester gave me a hint later that perhaps we could have worked a little more to make sure there was a binding, cohesive group. I understood what the conflicts were, but I didn’t have any tools at the time to help him.

We were supposed to carry gas masks at GE, but we would never wear them. There were sirens when there were releases of gas and you’d have pockets of clouds moving around. You had to carry your gas mask with you. Safety was starting to be emphasized, but the irony of it was that it was emphasized from a corporate standpoint, but not from a personal liability standpoint. We only carried them because it was required.

I was exhausted after Practice School. I recall it was a warm, wonderful May day when we finished in Albany. I was driving my jalopy back to Boston on the Mass Pike. The leaves were just starting to come out and I was eating oranges. It was wonderful. The next thing I knew, my car was entangled in the high-speed barrier right around Sturbridge. I’d fallen asleep, so I didn’t suffer any injuries. I was an avid cyclist—I’d had a bit of a bike-racing career—so my bike was on the back of the car. I jumped down from the car, got the bike off the back and rode to the next exit to get a tow truck.

After that I realized, maybe I needed to change my venue. I went back to California.

The same group dynamics I saw in Practice School, I saw in the corporate world. I was at Avery for two and a half years. It was quite an exciting time. I was the research manager for the Avery laser printer labels. Our claim to fame was that we did the development work with Microsoft to incorporate templates into Microsoft Office. Today, when you're printing labels, it still gives you Avery SKUs. We did that in the mid 80s.

One of the first real lessons I learned in business is: If you want to be compensated properly, you've got to go ask for it. When I joined Armor All, there were a lot of rumors about cracking of plastic dashboards with their protectant. The US Attorney General, the Feds, were onto it. I told the Attorney General we needed to do some testing and get some real facts. We knew about the problem but also had a new formulation that fixed the problem. After about six months of testing, I told them, *Yup, you're right. All these terrible things are happening. But here's a new formula and everything's hunky-dory.* The CEO came down and personally thanked me, shook my hand, and gave me a good bonus. Then they gave me more responsibility. I was just a young kid, but I really should have asked for more.

One of the things that people should thank me for is Gak from Mattel. It's a variation of slime. I'm the one that refined Gak for Nickelodeon. Remember how they'd Gak people? With the old formula, once it gets in your clothes or carpet, you'll never get it out. Never! I'm the one that formulated it so it was a little more solid, so it dries as a clump. It doesn't sink into all the fabric.

My wife and I get enamored by new business ideas. At first we started renting computers here in Orange County. We became pretty big in the western US. We combined that with LCD projectors and then I came up with the idea of self-serve business centers. I put together a touch-screen interface where you'd swipe your credit card, select the equipment you want, and basically have at it. When you were finished, you'd log off and get your receipt. We were the biggest provider of that in the late 90s and early 2000s.

Right now I'm incubating new ideas, but my focus is more on family life. I have a son in high school, so we spend as much time with him as possible. As you get older and later in your career, it's very important to slow down and enjoy the journey.

Tom Mo

Degrees: BS '80 (National Taiwan University), SM '83, ScD '88

Stations: Brookhaven National Laboratory, Upton, NY; Bethlehem Steel, Bethlehem, PA

Current position: Finance Manager, Exxon-Mobil

About: Tom Mo is currently commuting between Houston, where his family lives, and Dallas, where he applies the problem solving skills he learned as a chemical engineer to financial management.

My parents were on the losing side of the civil war in the late 40s. When the communists took over China, millions, including my family, were subject to bad consequences. It was fortuitous that both my parents left their hometown and went to Taiwan. They never returned.

When I was a little kid, I always went to my mother's lab. She was an oenologist, which is the word for people who study making wines. Her background was agricultural chemistry. **My objective was looking for wine samples older than I was.**

At that time a generation of young Chinese people were inspired to be physicists and engineers. My uncles and one of their wives were all PhDs in physics. I happened to be reasonably good in math and I found that my inclination was more on the pragmatic side rather than the pursuit of ultimate scientific discoveries. **So I chose engineering as my major.**

My interest in chemistry almost vaporized in college. My interest in math and physics grew stronger. But chemical engineering was really more math and physics than chemistry. It turns out to be a terrific fit. If I did my college major all over again, I would do exactly what I did.

One of my professors, who had been an MIT undergrad, told me not to bother with MIT. He said no one ever directly applied to the school from Taiwan. Students were able to get scholarships at MIT only if they went to another

school to get a master's degree first. That way, MIT knows what the transcript really means.

He was discouraging, so I definitely had to do it. I made my application to MIT based on reputation. I could not interview overseas. I was not able to leave Taiwan until I finished my compulsory military service for two years. I got admitted and they gave me a scholarship, completely dropping out from the sky, totally unexpected. I found out later that MIT awarded four foreign students full scholarships without being able to interview them. My thesis advisor told me later that they just happened to change their admission policy that year. So for me, it was sheer luck.

My thesis advisor at MIT, James Wei, told me he thought the Practice School program was truly unique. He worked for 15 years with Mobil, so he had extensive industry experience and he thought this was something that really added value for the students.

I picked Practice School because I always wanted to get practical experience in what the real world looks like. My decision was also utilitarian. I can get a master's degree in the fastest way. I'd be able to work on real world projects with a bunch of students on a team rather than bury myself in the lab working on a thesis. It seemed to be a no-brainer to me.

The first two months in Bethlehem, Pennsylvania, was a real world experience way more than I bargained for. The steel industry in the early 80s was in big trouble. We worked in the lab, a spic and span beautiful building that had been completely emptied out. All the people were gone. We were roaming the empty lab space, no people, some equipment. It was a dose of reality that we didn't expect.

Every time we drove to the parking lot, we tried to avoid employees. A person on our team had a Japanese car and the employees had snipey comments about it. It was quite an experience. I had spent two years in the army forgetting everything I learned about differential equations and fluid mechanics. Then I came to MIT and survived one year to get on with my degree and I'm looking for some idea of how industry really works. But as I saw in the army, real life is not the well-protected cocoon college students encounter.

We think we made useful value-added suggestions to the company, but the reality of that time was that the people running the plants had more weighty issues on their minds. I remember one project that Bethlehem Steel was trying to figure out was how to make use of an old part of the plant to clean up wastewater. They needed to clean it up with minimum costs. We would climb on top of the old, rusted out sanitation tank, and fill it up with water and drop some chemicals in there and see if it cleaned up the metal content down to the level we needed to be. It seemed to be within the parameters we needed, so we made the recommendation and gave the presentation. I don't know if they ever implemented it.

We spent four weeks at Brookhaven National Lab. **We published a paper in the AIChE (American Institute of Chemical Engineers) Journal from that one-month exercise.** We studied a corrosion chemistry process. Anything with chemistry in the subject I usually have a phobia about since my interest was really on physics and mathematics. But we had a tremendous team and we were very successful. It's a short paper with eight authors. Most people are curious about why it took so many people. The reason was it was only three weeks of work.

Like choosing chemical engineering as a major, Practice School is in the same category: Knowing everything with perfect hindsight, I wouldn't hesitate to go back. I saw quite a few things and did way more than I could ever have expected. We had a great time. The very nature of working closely with a small group of fellow students and being dropped into deep water again and again is truly a unique opportunity. It's a shared experience that's one of a kind and that you really treasure.

We always joke among ourselves that a chemical engineer can do anything. What I learned is the discipline in problem solving, which I got my first hands-on experience with in Practice School. Being able to have insight into a problem and being able to quantify and provide a feasible solution is the heart and soul of engineering; it's the heart and soul of chemical engineering. And it's the heart and soul of Practice School.

I've always had a wide range of interests in many topics. MIT and Practice School offer a wide range of opportunities and I learned so many things at MIT and Practice School that benefitted me for my entire career. Let me put it this way. I had a theoretical problem in my thesis that I couldn't solve. I went all over the school looking for an answer. I didn't solve my problem and applied an approximation to wrap up that part of my thesis. But in that process, I learned a whole lot more mathematical and statistical skills. Even though I started, like many PhD students, by working in the R&D department for Mobil, one day I took a complete turn into finance. I didn't miss a beat.

My work today is a bit far afield for a chemical engineer. I work in the Treasurer's group and at this moment I'm in the tax department. Earlier I spent five years in Hong Kong as a company's treasurer. I was negotiating loans for a joint venture in China. In this process the bank needs an expert opinion about the technology in the plant, so they hire outside experts. Typically these are people with my background—engineers, people with PhDs. They were jolted out of their skin when they realized I understood everything they were talking about.

Everyone's interests and opportunities change. It's really a benefit to students to spend at least one semester at the Practice School to get a glimpse of what the real world looks like. It may not be exactly the same but it's a glimpse. It's a good start. You never know what you're going to get into eventually.

Sandy Roadcap

Degrees: BS '79 (Princeton University), MS '81

Stations: GE Silicone and Noryl Products, Albany, NY; Oak Ridge National Laboratories, Oak Ridge, TN

Current position: Cost Engineering Systems Manager, Chevron

About: Sandy Roadcap lives in the San Francisco Bay Area with her husband, Steve Sciamanna (MS '81). The two met at Practice School. Now thirty-five years later, their daughter Kate Sciamanna will be starting Practice School in the fall.

I've always had an interest in science. I had a high school physics teacher that I really liked. He said if he couldn't sway me to go into physics, the next best thing was engineering. **He would tolerate that.**

My parents encouraged me to do what I wanted. When I was in high school, very few girls were in science. There were no role models in engineering. It was odd enough if you did well in math. People kind of looked at you like there was something wrong with you.

When I applied to Princeton, my choices for a major were biochemistry first, English second, and my third choice was engineering, almost on a lark. Once I got on campus, I walked down to the engineering quad, and saw the concrete boat the civil engineers were building. I saw the guys playing Frisbee out on the courtyard. **People seemed to be happy and curious and having a lot of fun.** I thought, *This is for me.*

Princeton had just gone coed three or four years earlier, so it was kind of a male club, but I found people were very welcoming. In the chemical engineering department, there were forty-eight in my class and nine of us were women. That wasn't all that different from the ratio elsewhere, even in English. I found that the campus experience was supportive and it was no big deal.

The reason I liked physics was because I like to draw. People think those two things are very different but I think sketching is so connected to what physics is all about. That goes right into engineering and being able to draw a system and show the ins and outs. I got to use pencil and paper to draw how things worked, and then optimize them. I liked the focus on efficiency in engineering.

I heard about Practice School from my Princeton professors. My thermo professor was a good friend of Bob Reid at MIT. Practice School stood out among all the places you could go for graduate school because it had a focus on industrial practice and getting used to the workplace. **I thought it was the perfect combination of an internship but with a rigorous academic frame for it.** I'm such a believer in the Practice School. That combination has carried with me ever since.

At Oak Ridge, my team kidded that we were the North American team. It included me, Rodrigo from Mexico, and Sam from Canada. We were working on a wastewater treatment application in the bio and environmental part of Oak Ridge. The biggest challenge was figuring out the chemistry. We got to climb around on the equipment. There was a distillation unit in a tall bay, and you had to climb metal stairs, like a fire escape, to get to the top. We took samples and tried to correlate what we were measuring with what we thought was going on. And we tried to improve it.

The housing was government barracks. It wasn't fancy. I learned about cockroach traps. But who cares. I also remember a place called the Toad Stool, a little hole in the wall with a grassy area and a pond in back. We got to take a break and go there a couple times. It was cheap. Student pricing.

There were only two women at Practice School in Oak Ridge. The kind lady who was the administrative assistant for the program didn't know what to do with us. She was used to setting up mixers for the guys with the local girls.

At General Electric, I learned the hard way about union rules. I did something that was reserved for union work. I was used to doing everything myself as a grad student. But in a highly unionized environment, you can't touch anything. Union work is by design constricting. You just have to get creative with how to work with people who might have a different agenda and different characteristics than you. You have to honor that. You have to learn the rules but also, just like anything else in life, engage people and try to find a way that you can be on the same side solving the problem and still respect your differences. You won't learn that in a book, but it's probably one of the most useful things I learned in my career.

The General Electric engineer who was our advisor was a fabulous example of a good leader. We were used to an academic environment where you had the Gods, meaning the professors, and then us peons, the students. This advisor treated us more like colleagues in a workplace. He was a pretty high up guy, but he had good relationships with the machine shop, with the glass shop, with the union. He didn't let his position get in the way of trying to solve a problem together. He also took the time to teach us how you get things done. That's what stuck with me at General Electric.

I met my husband my first day on campus in Building 66. We started with coursework in the fall of '79. He was at the Xerox machine and so was I. I was having trouble and he showed me how to press the buttons. It all started from there. After Practice School, I was very interested in Chevron because it was on the west coast and, being from Chicago, I'd never been west of the Mississippi. Also my boyfriend was going back home to California. So the planets aligned.

I'm proud of helping my employer manage environmental liability. I help frame the problem, apply engineering and science to it, and convince them that the same principles that apply to making money with oil also apply to minimizing our footprint on the environment. If we do it well, that helps the bottom line. I can't take credit for making environmental management a part of how we do business, but I was part of it on the ground floor and got to apply engineering to something quite different from what I expected back in graduate school.

Just like me 30 years earlier, my daughter was looking at graduate programs and found that the Practice School has this wonderful and unique combination of both academic rigor and industrial experience. We're all going to get together at the Centennial celebration in the fall.

My big hobby is playing the violin. I'd do that no matter where we are. I have a great community group nearby that I've been in for most of 33 years. I also enjoy skiing in Tahoe. The Bay Area is a little like Boston. There is a sense of energy and new ideas and new ways of doing things and new efficiencies and new products. The area has a character that is tolerant and energetic. I like that.

Jocelyn Scott

Degrees: BS ’80 (Stanford University), MS ’82

Stations: GE Silicone & Noryl Products, Albany, NY; Oak Ridge National Laboratories, Oak Ridge, TN

Current position: Retired from DuPont

About: Jocelyn Scott did things in reverse. She had her career first and then started raising a family. She’s now home with two school-aged kids and loving it. “I’m not really retired,” she says.

I was encouraged by my parents. They knew there were a lot of opportunities in engineering. In high school, I hated physics but I loved chemistry and biology. I always said if I was going to be an engineer, I could only be a chemical engineer. I hated mechanical, I hated electrical. It was either major in ChemE or switch to economics.

I grew up outside of Chicago, in the boring Midwest where everything is flat. Being the youngest child, I had flexible parents. They’d been worn down by my older brother and sister. They said, *Fine, you can go anywhere in the country you want for college.* So I went to Stanford.

I accepted before I even went to California. My sister and I went out that summer before I started. You drive down Palm Drive and you see all these palm trees. It’s like, *Is this a college or a country club?* It was wonderful, going from the Midwest to the Bay Area and that whole lifestyle. It was fun.

As an undergraduate I thought I was more the research type. I was a white lab coat type person. I loved doing organic chemistry lab. I wanted to do research, and was sort of interested in the biomedical side.

What got me first started thinking about grad school was a scholarship for minorities in engineering. Somehow I got an application as a junior. I thought, *This application looks easy. Just fill it out.* When it came back, I had a scholarship. I thought, *Oh, someone must think I should go to grad school.* That really started me thinking about it. The following year, I applied for a National Science Foundation award and got it. That really drove it.

I didn’t know what I wanted to do for my specialty in ChemE, so I knew I needed to go to a larger school. I looked at the typical larger schools. There were three of us who were friends coming out of my ChemE class at Stanford. The class was small compared to MIT, like twenty people. All three of us were looking at grad school and all three of us independently chose MIT. So I had two friends come from Stanford to MIT with me.

After I got to MIT I realized that I’m not a specialist, I’m really more of a generalist. I started rethinking R&D. I liked the Practice School option for a master’s because it was different. I liked the practical side of it, the hands-on experience.

Living in the South was different. I remember sitting there in the Oak Ridge National Lab lobby waiting to get signed in. None of my other friends there were from the South. We’re sitting there, and they’re calling our names. One of my friends was named Jeff. And the receptionist says, with this southern drawl, *Jayyyeff?* We all just sat there. We don’t know what she’s saying. And finally we realize: *It’s Jeff.*

In my Practice School group there were three women. That was probably a lot more than earlier. I could see it was still a male culture. MIT in general was still very male. It helped that there were two other women in that summer rotation with me, but when you looked at the whole class, it was a small number. And then you had the additional factor for me that there weren’t very many African Americans. My friend and I were the only two African Americans in the ChemE class of about ninety.

Our project at Oak Ridge was simulating an oil spill on a quiescent surface, like a pond. We were looking at the transfer rate, the evaporation rate of the oil. It was nice having this environmental project. I did a lot of the experimental work. My partner did a lot of the modeling. We split it up. That’s what I remember.

We all had to stay in apartments together. There were three women, and I was the odd woman who shared an apartment with a guy. There was this cute little four-year-old girl who was our neighbor next door. She just assumed we were married. We kept saying, *No, we’re not married.* It was funny. There were no issues with the arrangement. That’s the nice thing about being nerds and engineers; you just don’t get involved with much else.

You've just got to be tough. I felt out there on my own in terms of safe space and mentoring being a woman and being black. I felt that the station directors were a lot more in tune with the guys. They probably thought, *Why don't you feel comfortable here? I'm fine.* They maybe didn't recognize the subtle entitlement as males, and that there are other things going on that might make it more challenging for us.

The whole summer we took one day off. That includes Sundays. It was very intense. Practice School really taught me how much you can do. The summer session was compressed and with the quality of work they demand at MIT, it seemed an impossible feat to get it all done. But if you really put yourself to it, it's just amazing what you can accomplish. It was a grind, but we did it.

We had to practice using the pointer for our final presentation. I'm serious. For the final presentation at Oak Ridge, we used overheads. The screen is huge because it's projected for a large audience. Back then there were no laser pointers. The pointer stick was literally about eight feet long. I remember trying to use the thing, trying to wield it and not impale anyone.

Practice School confirmed for me that I didn't want to do research. I wanted to do product development work. So I switched and got the master's degree instead of the PhD. I was interested in biomedical work, so I looked at pharmaceutical companies and healthcare companies. I felt a little unsure at the time what I really wanted to do. DuPont had a program that allowed you to do different kinds of work as two-year rotations. I liked that. I could try out different things and really see what it was like working in research and product development and tech service. I ended up at DuPont my whole career.

I never had the aspiration to get to senior management, but to make it was an accomplishment. When I retired, I was Vice President of Engineering Facilities for the corporation. I was the first black woman to be a corporate officer or a vice president in DuPont. It ended up that one of the fields that I was responsible for was construction. If you want to talk about a field where there aren't many women, just walk into a construction industry conference. I hosted one once. It's just funny.

Paul Wood

Degrees: BS '66 (Purdue University) MS '68, ScD '73

Station: Oak Ridge National Laboratories, Oak Ridge, TN

Current position: Senior Partner at Cycla

About: Now semi-retired (and semi-still working), Paul Wood lives in Naples, Florida, with his wife of 46 years.

I was sort of attracted to chemistry, but didn't want to be a scientist. **I wanted to be an engineer.** My father, although he was not college educated, always did technical work. He always had a high degree of regard for the engineers he worked with, and not a high degree of regard for everyone he worked with.

In college I'd had a couple of summer jobs in the chemical industry, which were…boring. I was looking for something a little bit more entertaining for graduate school. I didn't know a lot about what nuclear engineering was, but there was clearly new technology being developed. It seemed interesting. At MIT, the people who ran the nuclear engineering program were chemical engineers. I was in the nuclear engineering department, but because of my background, I decided to take courses in chemical engineering, too.

At some point I got tired of going to school and wanted to close it off. I had enough credits for both chemical and nuclear master's degrees, so I looked for a way to end up with a master's degree in both. The Practice School was a vehicle for doing that. It was a callous, opportunistic decision purely. I remember American Cyanamid was the other Practice School station at that time, but since I was nuclear, I just stayed in Oak Ridge for the entire semester.

In Oak Ridge there were lots of small experimental reactors and you could do things to those that you couldn't do to a big power reactor. Sam Fleming may remember it better than I do. He seemed really excited about the possibilities. We hypothesized how the molten salt reactor would behave under a certain disturbance caused by the jiggling of the control rods. Then we mathematically modeled that disturbance and ran experiments to see whether or not the mathematical model and the response of the actual physical reactor matched.

Sure enough, they did. Frankly it was a simple enough reactor that I wasn't terribly surprised, but Sam was thrilled.

Sam called me a few years ago about the Centennial event. **He wanted to see if I could dig up the report from that project.** Unfortunately I couldn't find it. Maybe I'll look again, but those ancient records seem to have found their way into the graveyard of ancient records.

Sam had a major impact on me because of his enthusiasm and because of his strong feeling that engineering was about making a contribution to the engineering world and to society in general. That kind of value stuck with me. If you've met or talked to Sam, his voice and mannerisms are still the same as they were when he was a young professor. I was always grateful for having encountered Sam that early. He got the idea of commitment embedded in my mind.

Sam was probably less enthusiastic about me. He got a new MG GT while we were down there in Oak Ridge and he let me drive it. He blames me for the oil leak that it experienced for the rest of the car's life. Let's just say I was aggressive as a driver.

The experience in Oak Ridge was the first major step down the path of evolving to a management consulting role. One of the major things we learned in Practice School is how to take a semi-clearly defined work scope and flesh it out so you can finish it in four weeks. That's a pretty invaluable skill that you just don't learn in class. Every problem can be solved at a whole variety of different levels of detail. The amount of money you have and the amount of time you have define what you are able to do. In the case of the Practice School projects, the challenge was to develop and refine the scope of the project so you could actually get something constructive finished in the four-week time period. That learning process was probably more important to me than the actual projects.

During the Second World War, my dad worked at Oak Ridge. He worked in the power plant that supplied electricity for the electromagnetic separation process that separated the isotopes of uranium that could be used in the bomb from those that couldn't. It was a pretty austere life down there during the War. The whole thing was fenced, maybe the original gated community in the negative sense. While I was there, I drove around and saw where my parents had lived.

I don't think I believed that I was a great writer, but I didn't believe that I was a terrible writer. I wrote our first Practice School report totally myself. Then I gave it to a team member to edit. When it came back, I hardly recognized it. It was definitely a learning experience about technical writing. He did a good job as a student to a fellow student in helping me to see the deficiencies in my writing and to figure out how to communicate better in technical writing.

After Practice School, the first risk assessment project I did was at Westinghouse. They were designing the first experimental breeder reactor that was actually going to be licensed by the Nuclear Regulatory Commission. There were no standards for that type of reactor. One of the things Westinghouse decided to do was to develop a risk assessment for that program to support their licensing activity. That was unique. Risk assessment had been developed as a technology but it had been applied more as a public relations device. We were the first ones to apply it and to use what we learned to influence the design and operation of that reactor.

I started consulting in 1978 and we started our company in 1981. **We did risk assessment of nuclear plants.** We used a modeling technique that looks at the way the system is designed and operated and quantitatively characterizes the risks. Then we developed management processes to help managers figure out how to better manage safety. After the accident at Three Mile Island, the industry had to figure out a way to improve safety by dealing with the facts of the accident instead of just dredging up all the stuff that people had wanted in the past. Our risk assessment tools and the management systems that went along with them were very valuable in helping them identify things that needed to be done to improve safety, communicating those needs to the regulatory community, and getting acceptance.

Around the time of the Chernobyl accident in Russia, the Department of Energy community got really concerned about whether they were keeping up with commercial nuclear industry standards. The Department of Energy operated a lot of facilities, production reactors, experimental facilities and cleanup operations, many of which were related to the nuclear weapons program. They were going through the same internal turmoil the nuclear regulators had gone through following Three Mile Island. We basically took the same kind of techniques that we'd been applying in the nuclear power world into the Department of Energy complex.

Virtually every major evolutionary improvement in safety is a result of a big accident. After we got really sick of working for the Department of Energy—you can include that if you like—we moved over into the oil and gas pipeline industry. They'd had a bunch of major accidents killing a lot of people. Basically, we introduced risk assessment and risk management to the oil and gas pipeline business. It's an ongoing process, but it's something I feel pretty good about. I feel like it has made a difference in the safety of that business and will continue to make a difference.

It's rare that you find someone who looks ahead and says, *We might have this problem. Let's work on solving it in the operation of the industry.* What you usually find is, *We have had this problem. Let's think about how to deal with it.* It's after the fact rather than an anticipatory style of management when safety is concerned.

"Every problem can be solved at a whole variety of different levels of detail. The amount of money you have and the amount of time you have define what you are able to do."

Success in Practice School is learning something new, even if it’s learning why something won’t work.

Ramin Haghgooie SM ’03, PhD ’06

THE LATER YEARS

Gerald Adler

Degrees: BS ’07, MS ’08, MBA ’18 (Boston College)

Stations: Cabot Corporation, Billerica, MA; Cargill Research, Minneapolis, MN

Current position: Engineer and Project Manager, Cabot Corporation

About: Jerry Adler lives in Charlestown, Massachusetts, near the Bunker Hill Monument. But if it’s a Saturday, he’s more likely to be found on a peak in the White Mountains, hiking or skiing, or somewhere off the Maine coast, sailing.

My father went to MIT. He was my role model. I view him as an extremely successful individual. I wanted to be as successful or more, so MIT seemed like a good place to start.

I honestly had no idea what chemical engineering was when I first started. My father was an electrical engineer and my mother was a chemistry teacher. I guess you could say I took the middle path. I knew it made the most money of any engineering disciplines, so I went with that.

German was always my toughest class at MIT. It was never an engineering class. Crazy, huh? I got a whole mess of Bs in German. I really suck at it. I can speak it fluently now, so it eventually worked out, but it was a struggle along the way.

Practice School gave me the confidence to go after almost any problem. When I started working at Cabot as a Practice School student, I did not know what carbon black was. It’s the stuff that goes in tires and makes them tough. It’s Cabot’s primary product. We were asked to go figure out why there was a difference in the manufacturing yield between a pilot-scale unit and a large unit. They’d been asking this question for 30 years and didn’t have a satisfactory answer yet. *Fresh eyes*, they said. *Let’s have these kids look at it and see what happens.* We took a very transport-heavy approach to it and we were able to make good headway. My understanding now is that the approach we took has spawned eight years of additional research and understanding.

My Practice School director was Bill Dalzell. He worked in industry forever and he knows his stuff. **He pushed us hard to think about fundamentals.** He said, *The difference between a PhD and a non-PhD is a PhD will ask, What is fundamentally happening here?* I figured, *okay, I'll just make sure to always ask that question.* It's served me well.

I went into engineering consulting. **I thought Practice School was tough, and I thought that MIT was tough. This place was tougher.** It was a nice continuation of Practice School, taking these specific skills and putting them to use in industrially based problems. The first report I wrote, I was told by the fellow I wrote it for: *If you turned this in to a partner, you'd be fired on the spot. So I'm going to help you learn how to write, because you don't know how.*

At some point I got bored, so I started a hedge fund. I did that on the side for a couple years. It was fun and I made a ton of money. But in the end, I didn't like it. You're not actually making anything. You've made a bunch of money, but there's nothing else. There's no product.

I was working in northern Virginia for the consulting company, but I grew up in the Northeast. I wanted to come back here. **This is home.**

I feel very fortunate to have made connections through the Practice School. I'd stayed in touch with the folks at Cabot and let them know that I was looking to make a move. They found a position for me. The guy who hired me was the guy whose product I was staffed on while I was here during Practice School. Just a few months ago, I met him for dinner. I said, *Hey Fred, thanks for giving me a job.* And he said, *Jerry, it's the best decision I've ever made.*

My first project with Cabot was successful because of one question: *What the heck is fundamentally happening here?* I was project sponsor for a Practice School project looking at mixing dynamics in a configuration that had not really been studied before. We built a mockup of our plant in one of the buildings onsite and had the students run it for a month. That improved our fundamental understanding of what the heck was going on, and through that we were able to design next-generation technology and sell it for a very large amount of money.

I'd like to have a greater influence over the company's direction. I see getting an MBA as an avenue for doing so. If you have an MBA, you can present a more complete business case. You have that marriage of technical expertise and business acumen and the ability to quantify the financial value for a project.

My work has shifted from, *Jerry, go do this task*, to me going to management saying, *Hey, I think there's real value in pursuing this line of work.* You pitch your case to management and they award you time and funding. **It's almost like a venture capital fund internal to the company.** It's unique. I really value that about this company.

I feel good about working here. Cabot is an extremely safety-oriented company. I've had the opportunity to work in plants all around the world. It doesn't matter where the plant is; you walk in, and feel like, *Yeah, I'm going to leave here in one piece.*

Gregg Beckham

Degrees: BS ’02 (Oklahoma State University), MS ’04, PhD ’07

Stations: General Mills, Minneapolis, MN; BP Chemicals, Kingston upon Hull, UK

Current position: Staff Engineer, National Renewable Energy Laboratory

About: Gregg Beckham lives in a small community about an hour from the Rockies called Golden, Colorado, where, he says, “getting outdoors is great.” But for fun? He heads to the lab. “Our research group is amazing. They love what they do and so do I, so I really enjoy being here.”

I grew up in a farming community in central Oklahoma. I went to a math and science high school for junior and senior year. I really loved math and chemistry and wanted to do something to combine those. It was a very traditional path to chemical engineering.

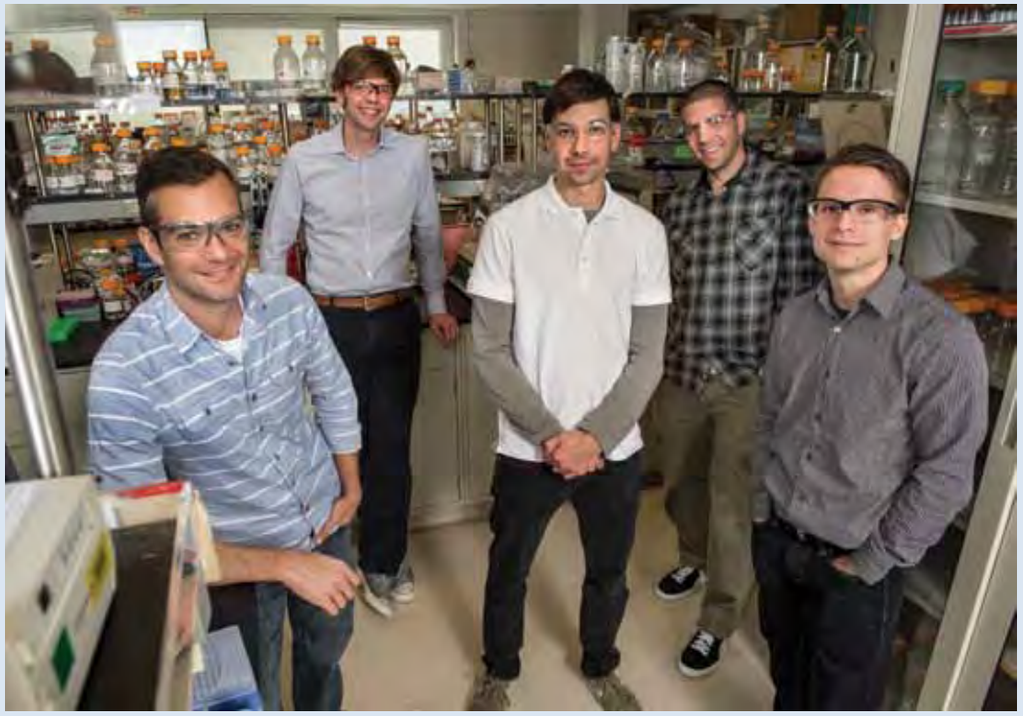
At MIT, I had the same concerns as other students about Practice School. That is: *This is six months away from my PhD thesis. It’s going to delay my graduation for six months.* Alan Hatton had excellent quantitative data to show that indeed it does not on average distract from one’s PhD. He had charted the average resident time of PhD students who went to Practice School and who did not go, and it was essentially the same. There are pretty large bands and they significantly overlap. It was very Alan. He really is an amazing salesman for the Practice School—and I don’t mean that in a bad way, I mean it in a very good way. He can and did describe the benefits to us really nicely, and so I thought that it would be a fun thing to do. It was a blast.

We took Cereal School at General Mills. Our Practice School group spent three or four days in Minneapolis and got to learn all about how cereal is made. That was exciting, super different and really fun. After that we went for three and a half weeks to Buffalo, New York. General Mills has a large manufacturing facility there.

We worked on Lucky Charms. We were looking at how there were no marshmallows in the last bowls of Lucky Charms. I’m sure you know this problem. So we worked on process engineering to help ameliorate that issue. For several hours at a time, with adult supervision so to speak, they would let us run the packaging line and modify parameters. We would literally make multiple pallets full of Lucky Charms boxes. With a bunch of temp workers that General Mills hired for us we would go one box at a time and pour those bad boys out bowl-by-bowl. It was crazy.

Then we went to West Chicago to work on Golden Grahams. They’d let us take cereal boxes off the line, or take a little scooper and get warm cereal off the line. **I’m not going to lie; it was pretty magical.** There are very few things better to eat in this world than warm Golden Grahams that have just had sugary syrup sprayed on them and then been dried in the heater. Golden Grahams have a pattern on them, and that pattern will impact how it cooks and what its bulk density is. So we modified some of the features on Golden Grahams to help improve bulk density such that when you pull the bag out of the box it doesn’t look like it’s only half full.

After that, we moved to Hull in the UK to work at BP. When we got there, we went to a bookstore and there was a little book that had just been published in the UK called “The 50 Crappiest Towns in England.” **Hull was Number One.** It was grey and rainy and we spent lots of nights in the pub, lots of rainy grey cold nights listening to Tom Waits and drinking scotch with our UK colleagues. It was pretty wonderful.



The engineers at BP were all brilliant and supportive of what we did. They told us later that they changed designs in plants around the world based on what we did. I think we had a pretty significant impact in terms of energy efficiency and processing efficiency.

At BP the project was all ASPEN simulations and techno-economic analysis, all computer based. But they did take us out to look at the unit we were modeling. We all wore hardhats and very bright orange Nomex coveralls. At General Mills, we also wore hardhats out on the lines. And steel-toed shoes. **I remember buying steel-toed shoes at the Mall of America in Minneapolis, a slice of Americana that can't be missed.**

We had to work really hard at Practice School. **It wasn't so much that we were being pushed but we were pushing ourselves to get the work done for the station companies.** We had wonderful clients who made us feel like we were actually helping them and engaging with them at their level.

I loved Practice School so much that I wanted to go back again. Alan asked several of us to help out in Singapore as part of the Singapore-MIT Alliance to work with students from the National University of Singapore who were going through a master's degree modeled after the Practice School. I attempted to run it the way I had experienced Practice School. I went several times. But I went back to Singapore the last time for the food. It's the best food I've ever had collectively, integrated over time, in one given place.

One of the coolest things about Practice School is that the students don't have the same filters as the clients. We got the Practice School out here at NREL and we get to meet with the students and to answer questions as the client. We definitely get entrenched in our ways and we have our own filters and our own bias. It's nice to bring in students who are go-getters and can come up with solutions that don't have our filters on them.

Biomass isn't very glamorous. But we have a really cool mission to work on making fuels and chemicals from renewable resources to offset petroleum use and reduce greenhouse gas emissions. It's about moving and converting a diffuse resource that's literally dirty. It has a lot of dirt and other things in it, like mold and bailing twine. These are very real engineering challenges. We need to move an enormous amount of material around and be able to feed it to a very large refinery system to make biomass a realistic solution. There are problems that we don't always think about as engineers, but they are incredibly important problems.

"It's nice to bring in students who are go-getters and can come up with solutions that don't have our filters on them."

Dhananjay Dendukuri

Degrees: BS ’99 (Indian Institute of Technology Madras), MS ’00 (University of Toronto), SM ’04, PhD ‘07

Stations: Novartis Pharmaceuticals, Basel, Switzerland; Cargill Research, Wayzata, MN

Current position: CEO & Co-Founder, Achira Labs Pvt. Ltd.

About: Dhananjay Dendukuri and his wife, Mithila Azad (MS ’06), live in Bangalore, the *de facto* tech capital of India. They miss the walkability of Cambridge and Boston, but enjoy being close to family and working towards their dream of building something significant in India.

What drew me to chemical engineering was more a matter of chance than any active choice. The way things are in India, it depends on how you rank in your college entrance exam.

Chemical engineering has this whole unit operations type of approach. You break down a complex process, like you’d have in a petroleum refinery, into little individual reactors or whatever, and then study each of those and build a system out of it. It could be applied even in biology to break down different processes inside a cell. A lot of chemical engineers are trained in this and it’s a useful methodology for studying complex systems.

Everybody I spoke to said Practice School is a taste of reality outside MIT, so you should absolutely do this. I chose Alan Hatton as one of my PhD advisors, and Alan Hatton of course is a strong supporter of Practice School. He highly recommended it. I do not know a single student of his that did not go to Practice School.

Practice School was one of the most distinctive and unique experiences at MIT. For people who are pursuing an academic research track, Practice School might end up being the only four months where they experience directly how industry works and what a realistic problem is.

At Novartis in Basel, the first thing that hits you is that there are people who take their weekends very seriously. At MIT we’re used to planning what experiment we’re going to do in the lab, but there people are planning what skiing trip they’re going to do, what trek they’re going to go on. America is a pretty work obsessed society overall, especially a place like MIT. What you see in Europe is there’s a much clearer distinction between work and play.

The European working hours are for the Europeans, and MIT Practice School’s are different. You just really have to get a lot of stuff done as fast as you can.

The Novartis cafeteria stands out in my memory. They had lots of European breads. Baguettes every day.

People expect to see serious input from you during Practice School. Novartis has a massive campus in Basel, but clearly we were interacting with quite senior management given that we were a bunch of interns, effectively. You could see that they took it very seriously. I think that comes along with the tag of MIT and the Practice School reputation.

One of the things for me was learning that there are lots of constraints. You want to do a lot of tweaks and make everything efficient tomorrow if possible, but there are company policies and budgets and various other constraints. What’s equally important is how you negotiate, how you present it, all of that, as opposed to just proposing a technical solution to a problem. Understanding that is great for someone who is in their early 20s to see practically how a company operates.

The first thing that hits you going from Switzerland back to America is that the room size quadrupled. **Everything seems much bigger, American sized.**

Cargill is a little outside Minneapolis. I forget the name—Wayzata—oh, wow, I haven't heard that name in so long. Yeah. Wayzata. **So we were in Wayzata, where there is not a whole lot to do.**

Cargill was a real experience, my first and only exposure to what's close to the heart of America. In a place like Minneapolis you have to have a car. That was quite striking for me. Driving in America was unbelievable. For me it was quite a frightening experience to begin with because I was not used to driving at those speeds and freeways and so on. But I got used to that. I'm not scared of driving anymore.

What drove me to return to India was a larger vision in terms of myself. India has lagged behind in building really world-class innovative engineering companies, something MIT is so good at doing. So I felt this is part of my giving back a little bit. I should make my own individual effort to seed something in India based on all of my experiences, including MIT Practice School, to create something that's world-class in India.

A big unmet need in India and many parts of the world is for lower cost and easily available blood tests. There's a lot of chemical engineering that goes into that. So in late 2009, I co-founded Achira, a company dedicated to making technologies for making blood testing affordable and closer to patients.

Achira is the first company to pioneer the use of woven textiles as diagnostic sensors. It's given me a lot of personal satisfaction to use a very local technology and local skill to make a differentiated technology product. We call it FabChip, short for fabric chip. We've done it with the support of Grand Challenges Canada and the Gates Foundation, another link to North America in my effort to drive technology development in this part of the world.

I'd say that a little seed of MIT has come now to Bangalore and been planted here. I'm hoping it grows into something bigger. I maintain connections with my advisors at MIT. My PhD co-advisor, Pat Doyle, is an advisor of my company. I try to keep my connections with MIT very strong.

Jose Alberto Gómez

Degrees: BS '11 (Technologico de Monterrey), MS '14

Stations: Corning Glass, Corning, NY; Alcon, Fort Worth, TX

Current position: PhD Candidate, MIT

About: Jose Gómez is enjoying living in Boston and activities like skiing, playing tennis, hiking, and sailing on the Charles.

When I was in high school, I started to study economics. Then I took a physics class and decided to try engineering instead. I didn't know what engineering to choose, so I chose chemical engineering because my dad is a chemical engineer. Once in there I just stuck with it and decided I liked it.

I grew up in a small city called Saltillo in northeastern Mexico and did my undergrad in Monterrey. I did two summer research experiences in Wisconsin. It was during those that I got interested in research, which drove me to apply for a PhD. **I chose to apply to MIT because back then I thought it was the best engineering school in the world.** I still think that.

When I came in, I was interested in going into industry after my PhD. I didn't see myself as being a full-time professor. I am interested in research, but industrial research. Professor Hatton, the director of the Practice School program, does this presentation about Practice School for all incoming students. I thought it made sense to get some relevant industrial experience, so that's why I decided to do the Practice School.

The way I got to know my classmates in the Practice School was a very good thing. I got to know everyone in a different way, especially the people I worked with. But it was also a valuable experience living with them and hanging out together and seeing how everyone deals differently with stress.

At Corning, the important people in the company were interested in what we were doing. It was memorable. Top executives and senior researchers actually showed up at the meetings and tried to help us achieve something. That was very motivating.

Every final presentation was memorable on its own. It was closing a job and sometimes a painful chapter in the Practice School because those projects are tough.

We got a lot of mentoring from our station director, Bob Hanlon. He's a very interesting character and he's very driven, very enthusiastic, and he really knows how to get the best of people. He's very detail-oriented. I do remember him carrying his small notepad and taking notes about everyone he meets. I assume he has in his computer some file with the details of everyone in it.

I learned a lot of good techniques from him, like presenting better information. He really knows how to set an objective and organize a presentation. He's very structured. Your goal is to send this message to the company people, so how are you going to send that message? That skill has been pretty useful for me after Practice School. I see a before/after in the way I prepare my presentations.

Going through the Practice School makes you realize you can do anything if you put in the effort. Now that I'm back in my PhD, sometimes I feel as if I'm going nowhere. But then I remember the Practice School program. If I was able to go through those things, I can go through this. I definitely use it to keep pushing forward. Practice School was a confidence boost.

At Practice School, running experiments at the same time that the production site was running was a very interesting and valuable experience. For instance, we were stationed in Wilmington, North Carolina, for our second project at Corning Glass. We were in the fiber optic cable production facility. Our experiments were run on the production site and sometimes to run our experiment we would actually have to ask the operators for permission. For my project it wasn't too bad; we were not really perturbing what was going on that much. But one of the other projects was modifying the way things were being produced. A mistake on their part could cost a few thousand dollars.

When we were in Corning, New York, we did some day trips to Cornell, to the Finger Lakes area. Then we drove all the way from Corning to Wilmington. We stayed a couple of nights in Washington, D.C. That was nice. In between Corning and Alcon we had a week in between, so a few of us decided to go to Mexico. In Fort Worth, Texas, we went to a rodeo. In Atlanta, I don't remember doing anything special. It was the last station. **By the time you get to the last project, you're pretty much done.**

Not everything is work. We're in a field that tends to value technical skills and knowledge. We tend to neglect the soft skills. Practice School is a chance to practice your soft skills and realize how important they are. You might have a lot of knowledge and you might be doing amazing stuff, but if you don't communicate it well, it's meaningless.

Networking and socializing with company people are also valuable experiences. A couple of my Practice School classmates were very good at it. I found my own way. The two guys who were good at it are American, so it's easier for them to socialize with American people. It's a bit harder for international people to understand the inside jokes and things like that.

At Practice School you get to meet a lot of people that maybe can help you later, to provide good mentoring. I've been going to conferences, in particular the AIChE (American Institute of Chemical Engineers) conference. Corning sends people, so my Practice School classmates and I go out to lunch with the Corning people. As I get nearer to graduation, I might contact a few of the Corning people to ask about the job search. I think these people could mentor me and give me good advice.

My research is one-third chemical engineering, one-third mathematics and one-third computer science. I'm in a process modeling and process optimization lab. We come up with a process and then we try to model it using mathematics,

then find a way to improve the way the process is run using mathematical optimization. My specific process is growing algae for biofuels production. I'm more interested in the mathematical and optimization side of things.

When I came here I was set for industry but now I'm a bit confused. I have a year and a half left of my PhD. I'm getting to the point where I need to decide what I'm doing next. I think I'm going to pursue, at least initially, an industrial research career aiming to move towards management.

I grew up in Mexico and did my undergrad in Mexico, but I was born in the US. I'm a citizen here, too, so I can stay if I want to. I have the flexibility. There are opportunities in Mexico, but they are different opportunities. If I want to do something that's related to my PhD, it's a no-brainer. I have to stay in the US. But if I'm more flexible about what I want to do with my future, if I want to move towards management, I think the opportunities are about equal. Mexico is really investing in technology and research. They are trying to create this research capability, so probably in the next five to ten years, Mexico is going to have very interesting research opportunities.

Saeeda Jaffar

Degrees: BS '01 (Boston University), MS '02, PhD '05

Stations: Mitsubishi, Tokyo, Japan; Cargill Research, Wayzata, MN

Current position: Managing Director, Alvarez & Marsal

About: Saeeda Jaffar lives in her native Dubai, UAE, with her husband and three-year-old son. She received the email invitation to be a part of this book while walking the halls of Building 66 on her first visit back to the MIT campus since her graduation in 2005.

I've always loved math. I love the simplicity, the beauty, the discipline…the purity. From a very young age I was good at it and loved it. I attribute that to my mom and dad. They supported and nurtured that in me.

My brother was a medical doctor and I was going to medical school. But I did not want to go into premed. I wanted to do something that was a little bit more stand-alone in case I changed my mind. Boston University had an amazing biomedical engineering program, which I thought was a great fit.

By sophomore year, I knew: I'm an engineer. I'm a biomedical engineer, but the emphasis was on engineering, not the biomedical. It became abundantly clear to me that I did not want to continue with medicine and I did want to go into engineering.

The question was which engineering field. I debated between biomedical and chemical engineering for graduate school. I chose chemical because of the versatility. As a chemical engineer, you can do biomedical engineering. But as a biomedical engineer, you cannot necessarily do chemical engineering.

What really sealed the deal for me was going back home. My parents are telling everyone, *My daughter graduated with a biomedical engineering degree!* My uncle turns to me and asks, *So what do you do with biomedical engineering? Are you*

going to fix hospital beds? I was like, *Okay, I have to do something that's more easily understandable and applicable.* That was chemical engineering.

Practice School is absolutely a no-regret move. I knew I needed a milestone along the way to a PhD. Also, I wasn't sure yet if I was going to stay in academics or if I was going to go into industry. Practice School gives you a chance to experience industry like nothing else can.

At Mitsubishi in Tokyo, we used to bike to work. Except that I don't know how to bike. I come from a traditional Arab family, and girls don't ride bikes. That was something boys did. So I had to get on the back of somebody's bike and go all the way there—a fifteen minute bike ride—sitting on the back on the metal rack. I had to bring a little cushion. At first they thought I was lying. Nobody could fathom that a person wouldn't know how to bike.

To top it all off, I'm now married to a Dutch man. He's from a place with the highest number of bikes per capita in the world.

My first project in Japan was exceptionally bad. Most Practice School projects are good, one is exceptionally good and one or two are exceptionally bad. Ours was just a nightmare of a project. Do you know the cellophane wrapping? We were trying to make it thinner while increasing the tensile strength. It was just ha-a-ard. I don't think we were successful.

Cargill was frankly a lot easier. It was a lot more comfortable. There was no culture shock involved. It was a very enjoyable experience. It wasn't as defining a moment as Japan, though, for sure.

We figured out our Cargill project pretty early on. We were trying to change something in the way they developed a sugar substitute. The projects were usually four weeks and just about two-and-a-half weeks into it, we got it.

The Practice School experience is technical consulting, and I switched to consulting because I loved it so much. As I went through Practice School, I realized how much I loved the consulting aspect. Not so much the technical aspect, but the consulting aspect. After I came back from Practice School, I'd made up my mind about where I wanted to go next.

I joined McKinsey in their New York/New Jersey practice. **At the same time, there was a question of whether I wanted to move back to Dubai or not.** I knew that if I didn't then, I probably wouldn't ever move back. I wasn't quite ready to commit to not ever moving back. So with McKinsey I had the great opportunity to work in the Middle East without actually transferring there, just to see whether I liked being back or not. When I went there, I really and truly enjoyed it.

In the 15 years I was away, the country had changed a lot. When I left, the concept of coffee didn't exist beyond what you made in the kitchen. Today, Dubai probably has more Starbucks per capita than every other city except Manhattan. Say what you will, but it's an indicator. You can get anything anywhere anytime in Dubai. It's absolutely the best place to live.

Also when I left, the UAE was still a very young place with a limited knowledge-based economy. Today I feel that there is tremendous focus on that. MIT actually has a program with one of the local colleges. The country has become more global, and more appreciative of knowledge and talent. And it's much easier to work here as a woman and as a professional.

I've recently joined Alvarez & Marsal, leading the UAE Financial Services consulting practice. It's a profession that I love and I'm having a wonderful time. In the last three years I also have another job. It's a much more demanding, never-ending job. I have a three-year-old son. **That is absolutely the most wonderful thing.**

Gabriel Li

Degrees: BS ’89 (University of California, Berkeley), MS ’91, MBA ‘95 (Stanford University)

Stations: Chevron, Richmond, CA; Merck, West Point, PA

Current position: Managing Partner, Orchid Asia Group

About: Gabriel Li lives in Hong Kong, which he finds to be one of the most dynamic and culturally mixed cities in the world.

I spent my time in chemical engineering because it was challenging. It taught me how to solve problems. The analytical skills are quite good.

I chose MIT because I wanted to go to the best school. I wanted to be with the best students and with professors who are leaders in their fields. I was told about the Practice School by one of my professors at Berkeley. The Practice School was more in line with learning what’s going on in industry than learning about theory and concepts, more towards applying those concepts and theories in real life. I thought that would be really interesting.

Turbulent flow, laminar flow—these are all things I don’t remember that well. In Practice School at Merck, we worked together as a team to measure laminar flow characteristics of the clean rooms that they had. We were basically applying fluid dynamics to a real life situation where we would not want to have turbulent flow because it would blow all the particles and viruses and bacteria all over the room. You want to have a very smooth flow of air to make sure that all of the dust and bacteria and viruses will flow out through the vent. So we would do experiments to test how you could achieve that.

Practice School helped me find my first opportunity. The Practice School at Chevron is at the research center near the refinery. You could actually walk across the street and be at the refinery. We had a chance to learn from some of the people who were ten- and twenty-year veterans who were solving problems at the refinery as engineers. I ended up working there for two years.

The best thing was working with my classmates. I remember one person on my team taught me a lot about how to organize the experiments properly to make sure they were done in a way that was methodical and clear. In the classroom, my classmates were very competitive in terms of exams and grades. But at the Practice School, it was much more collaborative. There’s no competition there. You have to work together. I thought that was pretty good.

In practice, it’s never like the equation or the concepts that you learned in the textbooks. Practice School taught us how to think and analyze and be critical about how we solve problems. Because there’s always something that is imperfect, you have to accommodate for those imperfections. Whether it’s chemical engineering or experiments in the lab or a real-life situation, you always have to use those skills.

While at Chevron, I lived with several people, one of whom went to business school. That person influenced me to apply for a Stanford University MBA. I didn’t know anything about business and I never thought I would get in. But they took a chance on me. In business school I met a lot of different people from all over the world and different industries, including another housemate from China. **He said, *You’ve got to come back to Hong Kong. China is going to be the future.*** I was born in Hong Kong but came to the US when I was seven and hadn’t been back for eighteen years. That made it a big change.

I was able to use my analytical skills from chemical engineering at MIT and Berkeley to get a job at McKinsey in Asia. That was a great experience. After a few years, I decided to jump into investments.

Over the last 20 years, we've made several investments that have changed the lives of people in China. We invested in Ctrip International, which is similar to Priceline and Expedia in the US, and in an internet company that helps people buy cars, and in online learning. These companies have made a huge difference in China. I want to do that going forward if I can, to make investments and help companies continue to make improvements in people's lives.

I don't think I would have been able to go to MIT without the stipend I got. It would have been difficult. MIT was the first school that gave me financial support to be able to receive an education. I support the school every year now. That is a system in the US, especially at MIT, that made a difference in my life.

"Practice School taught us how to think and analyze and be critical about how we solve problems... Whether it's chemical engineering or experiments in the lab or a real-life situation, you always have to use those skills."

Philippe Matthys

Degrees: BA '87 (Rice University), MS '89, MBA '93 (Harvard Business School)

Stations: General Electric, Albany, NY; Dow Chemical, Midland, MI

Current position: Self-employed

About: Philippe Matthys lives in London with his wife and son because it is easy (at least, somewhat easy) to get from London to his family in the US and his wife's family in Spain, and to anywhere else they might want to travel.

I was drawn to chemical engineering basically because of the family influence. My grandfather had a grease factory in France. He sold the grease factory in the 1950s or 60s. My father then built an oil recycling plant in the north of France and then my family moved to Texas in the early 80s.

My father's boss in France had a son who had gone to MIT. Ever since I was about ten years old, my father put in my mind that this person had gone to MIT. It kind of became a thing. It became ingrained in my head that I wanted to go to MIT. Seriously. I decided, *One day, I will go there.*

For college, I didn't even apply to schools outside Texas. I grew up in France but went to high school in Corpus Christi, Texas. When I got to the US, I couldn't speak a word of English. I was only speaking French. MIT seemed too big a step for the little French kid who just got to the US. I wanted to stay in Texas, so that's why I went to Rice.

I'm much more of a business guy than an engineering guy. I went to MIT enrolled in the chemical engineering PhD program. But when I started talking to people, I heard stories of people staying there and doing stuff in the lab for eight years and that just freaked me out. I realized that this was not for me. I thought, *I'm not going to be 32 when I get out of here having done just stuff in beakers all my life. I've got to regroup. I love it here, but it's just not the program I want to be in.* When I came in I didn't even know about the Practice School, but it turned out to be really good. You have some very hands-on experiences. I loved it there not only because I liked the program, but also I just loved the people I worked with.

I don't like big bureaucratic companies. As a Practice School student, I ended up at Dow working on a project that made the Dow equivalent of aspirin. Then during the summer Dow hired me to keep on working there. I really liked the company and the people there, but the experience confirmed to me that long term, I'd never succeed at a large company. It's too political for me and I just don't like it.

One of the tricky parts of Practice School is finding interesting projects for students. After I finished my degree, I was associate director for the Practice School for a year and a half. The job of the associate director is to try to find projects in the plants and factories, and that can be quite a challenge. The students come every term and you need to have interesting projects. If there are five teams you have to come up with five different projects. They have to be doable in six weeks, and when the students give you reviews, they have to like them. Otherwise they'll give you a crappy review. The students don't really understand that finding amazing projects at exactly the same time every five or six weeks is a very difficult task.

That experience as associate director gave me confirmation that I wanted to work in small companies and be entrepreneurial. I ended up really liking going out there and saying, *Okay, what are the potential critical issues here? What are the potential solutions?* You got to know the important people at these plants and then you were able to speak to them and they would give you ideas. You'd try to figure out with them what the students could accomplish. We had to get things done quickly and it was action packed. The small team entrepreneurial environment is what I really love and that's what I've tried to do for the rest of my career.

I realized after the Practice School that what made it so much fun was the people. I learned that it is important to work not only on something you like, but also with people you like. I'd never recommend someone being at a job surrounded by people they don't like. It's just no fun.

People are going to think it's crazy to say that investment banking is like the Practice School, but the team structure is not so different. Investment banks in general work in very small teams, whether you want to conclude an M&A transaction or something else, it's usually quick, like the Practice School. It's done within four or six weeks as a project. You have a small team of five or six people working on that project and you work twenty-four hours a day to get it done. Finally at the end you've got the reward and the transaction gets done. So I'm not surprised since I liked the Practice School environment that I ended up liking investment banking.

What got to me about investment banking was that, after awhile, it just got to be big bureaucratic organizations. Dealing with the bureaucratic stuff was not fun. So in 2008 I set up my own company.

My hobbies are traveling and eating good food. London is an amazing city. We don't go to shows much but we go out to restaurants, plus Heathrow is close, so we can take off and go anywhere in Europe at a moment's notice. I love it here.

"The small team entrepreneurial environment is what I really love and that's what I've tried to do for the rest of my career."

Anna Pisania

Degrees: BS ’01 (University of Patras), MS ’03, PhD ’07

Stations: British Petroleum, Kingston upon Hull, UK; General Mills, Lodi, CA and Cedar Rapids, IA

Current position: Staff Engineer, Acceleron Pharma, Cambridge, MA

About: Anna Pisania lives in Arlington, Massachusetts, with her husband Ramin Haghgooie, MSCEP ’03, PhD ‘06, and her children.

In Greece, you need to know what you’re going to major in before you enter the university, so that was a decision I had made before I was 17 years old. I really liked chemistry, but I wanted to do something hands-on. **The two merged into chemical engineering.**

During my undergrad, chemical engineering was more like old traditional chemical engineering. But the department was starting to introduce more biology. That was what drew me in. **It was not just chemistry; different sciences could be combined in chemical engineering.**

I had support from my professors and also my family to apply and come overseas and pursue my graduate studies. A couple of my professors had studied in the states, two of them at MIT. They were encouraging good students to come to the states for graduate studies. Also my father had done his PhD in physics in the 60s in the States.

I applied to a couple of universities. I got a scholarship and I was accepted into MIT for my PhD program. **I wouldn’t say no to that.**

Why Practice School? **Have you met Alan Hatton? He’s very convincing.**

For me, the appeal of Practice School was the experience of working in industry and seeing what that means. Practice School is not just to get another degree. It’s about having the opportunity to work on different projects at different places and to be able to travel and learn.

I think British Petroleum was pretty pleased with the results. We were the first Practice School group to work with British Petroleum. We spent two months in a small facility. In the years after, they moved the station to a bigger facility.

The director that we had in England, Barry Johnson, is amazing at his job. He would not give us answers or say, *You need to do this or that.* But he would pose questions that would make the team think critically. The team would make the decision to go down a certain path, but he would prompt those discussions and the thinking.

We did a lot of fun stuff. We were overseas, so we wanted to explore. Between the two projects, the whole team went to Scotland. The other weekends we visited local areas. We had with us some locals, three or four students from Cambridge University in the UK doing a joint program with MIT. We had a real tea experience and visited some castles. It was a lot of fun.

In Sacramento, we were making the square cereal... Cinnamon Toast Crunch. It was so delicious. We did a mass balance project, what goes in, what comes out, and what are the operational parameters that would make the product have a certain consistency or quality. They wanted to measure how much water is evaporating, but they hadn’t thought through how. Our team developed a way. It was very hands-on engineering.

We worked with the operators, the people who actually do the work and operate the equipment, which was also very interesting. They were very curious about the work we were doing. They could have been like, *Oh, what are these kids doing in my facility?* But they were open and did a really good job showing us around the facility and supporting us.

So after all this lovely time, the fall in England and November in Sacramento, California, we spent December in Iowa. All we could see was cornfields. That was it. It was pretty tough. We worked in the facility where they were making fruit roll-ups, gummy bears, basically candy. There were

some inconsistencies with the amount of sugar being used in the manufacturing facility, and our project was to understand where the sugar is going.

Practice School helped me be more efficient. You have a project to finish and you have a limited amount of time to finish it. It streamlined the way the project should be addressed. You state your objective, your assumptions and your path forward, and then you execute the project and wrap it up. At MIT, even with my long graduate research project that lasted five years, it was the same process. At work now I still apply it to projects.

Now I work at a biotech company in Central Square. We develop protein therapeutics, and my group is responsible for figuring out the process by which we grow the cells and we purify the proteins. We're also responsible for manufacturing the drug that we use in clinical trials and for transferring the technology to bigger facilities for phase three and commercial production.

My husband and I are still tied to MIT and keep up with social events and alumni events. But our kids are young. Our fun is spending time with them.

Lea Poquerusse

Degrees: BEng '10 (McGill University), MS '12, MBA '16, (Stanford University)

Stations: Cabot Corp., Billerica, MA; Novartis Pharmaceuticals, San Carlos, CA

Current position: Graduate Student, Stanford University

About: Lea Poquerusse grew up in France, went to college in Canada and graduate school in the US—on both coasts—and has worked in France, Canada, the US, the UAE, and the Philippines. "I love exploring new countries and see myself having more of an international career," she says.

My father is an astrophysicist. He, my sister and I spent a lot of time running experiments either in the kitchen, the garage, or in the garden. From a very young age my father was able to instill in us a curiosity around science.

As I got older, I realized I really liked science. In France, you have to specialize in high school. I chose to specialize in science. That led me to engineering. I was driven to chemical engineering because I was looking for a field of engineering that would combine biology, chemistry, physics and math. I saw chemical engineering as the only field that would do that.

I'd always thought I'd get some kind of graduate degree in engineering. I wasn't sure whether that would be a PhD. My father is an academic with a PhD. My sister is going to be starting a PhD in neuroscience. After I graduated from McGill, I applied to PhD programs as well as master's. What it came down to is realizing, after going to admit weekends, that there wasn't one field of research in chemical engineering that I felt passionate enough about to spend five years on. I really liked solving real world problems. I liked the applicability of the MSCEP program at MIT, the fact that we do internships in two different companies over the summer that are directly relevant to real world problems.

Practice School was a lot more intense than other internships I'd had. We worked six days out of seven. Part of the intensity too is the team orientation. I'm still really close to the people I went to Practice School with. The people component of it is just huge.

At Cabot Chemicals, in Billerica, I think they saved a bunch of money thanks to the project we worked on. I was in a team of four people. We were working on optimizing the mixing of two fluids for the production of rubber. At the operating conditions that Cabot was using, there was cavitation, the formation of bubbles, which meant that the fluids were not properly mixing. It's a problem they had tried to solve in the past. So we put together an experimental setup and then ran a series of experiments. We varied the geometry of the setup and the flow rate of the two fluids. We provided them suggestions on operating conditions that would allow for better mixing and no cavitation.

Our professors were incredibly supportive. Our project wasn't easy. The two professors helped us out and when things got tough, they were there to support us.

Practice School is not only a good chemical engineering experience, but it's also a really good team experience. That's something in engineering school that there isn't that much of. You have to adapt to the environment and to new people, you have to understand a complex project and work with individuals you may not have worked with in the past.

I learned that getting buy-in from the people you're working for or with is critical. We had multiple stakeholders, whether they were MIT professors, the peers we were working with, or various units within the company. Working with teams and leading others is a huge focus of mine in business school. I think that I have an edge up compared to engineers who didn't have the Practice School experience.

At Novartis, we used a model of a little infant's mouth. We were trying to develop a process to get surfactants into the lungs of infants that suffer from infant respiratory distress syndrome. These infants are born too early and their lungs are not fully developed so they don't have the surfactant in their lungs that allows for the easy transfer of oxygen between the air and the body. So we tried to input an exogenous surfactant. We essentially developed an experimental setup that would allow us to optimize for the greatest retention, to get the most surfactant to stay in the lungs.

From Practice School, I learned confidence. It was a really big challenge, especially at that age, a year after undergrad. I remember feeling distressed about it. Making it through successfully breeds a lot of confidence.

One weekend at Cabot—and by weekend I mean a Sunday—we went up to Maine. We took a boat tour, went to an improv show, and had lobster rolls. It was a gorgeous day. Bob Fisher was there with his wife and all of us. It was a really good time.

I'm pretty outdoorsy, and I organized some hikes while we were in California. We went hiking in Pacifica, we went up into San Francisco, we went to the De Young museum, crossed the Golden Gate Bridge on foot, and spent some time in the redwoods.

After Practice School I went back to MIT for the fall and helped to organize the MIT Energy Night. I was the managing director and led an eight-person team. I started doing it while I was at Practice School. That contributed to the craziness. Sometimes on Sundays I had to work on the organization of this event. It turned out to be a really great experience. It confirmed in my mind just how much I love meeting people, co-creating a vision and then motivating people to work towards successfully accomplishing that vision. That's when I first became aware that business school could be something I'd be interested in.

I did well at MIT, and my professors encouraged me to stay, but I decided that a PhD still wasn't right for me. I'm very much a people person, so I decided to go into industry. I worked in energy consulting, specifically on new energy technology, such as renewable energy, energy efficiency, and smart grids. I don't think I could have gotten the job had I not been at MIT and the Practice School. It was critically important.

I can't emphasize enough just how complementary business school has been. My focus has been more on psychology, organizational behavior, accounting and finance. Those aren't things I'd focused on before, so I will be leaving with a much more expanded skillset. I'm still at a very early stage in my career and my hope for what's next is to learn from people who are a lot more experienced than I am.

I've been giving talks at McGill, sharing advice with students on what I wish I'd known when I was in their shoes. I have a list of Lea's 10 Tips. They're more soft things: the importance of having a team of cheerleaders around you; having mentors; the importance of working really hard for what you want; and setting stretch goals for yourself. When you're not quite sure you can do something, that's a good time to go out and do it.

Lea's 10 Tips

1. Set **Stretch Goals** for yourself – you can accomplish more than you think you can.
"Whether you think you can or you think you can't, you're right." – Henry Ford

2. Work Hard for what you want – don't miss a chance to be extraordinary.
"We are what we repeatedly do. Excellence, then, is not an act, it is a habit." – Aristotle

3. Find yourself a **Team of Champions.**

4. Know Yourself, listen to yourself and **Trust Yourself**.

5. Don't be confused by what is objectively "right" vs. **What Is Right for You.**

6. It's A-OKAY to Make Mistakes and to fail - makes you stronger.
"The greatest glory lies not in failing but in rising every time you fail." – Nelson Mandela

7. Focus on your friends and the quality of your friendships – they contribute to your happiness.

8. Quiet the inner critique in you. Remind yourself of **Your Past Successes** *(especially when feel the imposter syndrome!).*

9. Go after and **Seize New Opportunities** as they come your way.

10. Assess your life regularly and **Change** whatever is not working for you.

Lori Shen

Degrees: BS '94 (Tsinghua University), SM '00, PhD '00, MBA '06 (Lehigh University)

Stations: Merck & Co, West Point PA; Molten Metal Tech., Inc., Fall River, MA

Current position: Senior Director, Pfizer

About: For relaxation, Lori Shen runs the trails of Valley Forge National Park near her home. She also travels. Her most recent trip took her to Italy to visit Florence and the Amalfi Coast.

I enjoyed chemistry the most in high school. I was very practical-minded. I wanted to do something with my hands. So that's a natural path to chemical engineering.

To choose MIT was not a difficult decision. Several schools offered scholarships. MIT was one of them. It seemed to be a very natural choice. The five years I spent there, even today when I talk about it, I still feel that's the best experience I have had.

I had in my mind I wanted to stay in academia. I worked in Alan Hatton's lab on magnetic nanoparticles. It's a fluid; the particle size is so small you can disperse it really well in suspension. We were able to use magnets to move it around. We were exploring bioseparation. If you coat the surface of the magnetic nanoparticle with certain types of materials that selectively bind to another type of material, then you can fish out whatever you want to fish out from a solution using a magnet.

I learned about the Practice School right away. I immediately thought it was a great program. Not only do you get exposure to practical industrial problems, but also for me being from China, you get exposure beyond academic study, to actually work with people in corporate America. It's a no-brainer. **I want that experience.**

At Merck, I worked on a Pepcid AC formulation development project. They gave us little packages of it when we were done with the project. The problem was with erosion on the surface of the tablet. The surface coating makes it pink. If the conditions are not right, the pills stick together and the surface is not uniform. We developed a model, we did some experiments, and we made a recommendation that if you

adjust two rates then it will reduce the occurrence of erosion. I cannot believe I remember this after 20 years!

Security had to make special accommodations to let us in and out of the facility afterhours. We were really excited to work on our projects. It was pretty intense. In a few weeks, you have to narrow down to a specific objective and deliver your final results to pretty senior people at Merck. That was a great experience for me.

Another team was working on a vaccine project. Even though I was not directly involved, I got a lot of exposure. Wow, you can use a vaccine to save lives. I got a general understanding of the pharma industry. I liked what was going on in the life sciences field.

Practice School was exponential in terms of the learning. When I first came here to the US, the struggle was not academic. Academics are difficult, but not that difficult. What was hard was: How do you fit in? How do you adapt to the culture, to all the dimensions of life? Even how to order food, to understand what the food was. Being very new to the US, I went through a lot of adaptation.

The sponsors at Merck and also Molton Metal Technologies were very supportive. Help from the industry sponsors is really important in the program. Now that I have spent time in industry, I think it's a big commitment from the company.

Molten Metal Tech was very different compared to Merck. Very high temperature, high pressure processing conditions. We had to understand the metal technology, where you see melt, where the dust forms, how its going to affect the process conditions, those sort of things. It's a much smaller company than Merck. I could get easy access to their very senior people.

I feel strongly about spending some time in the real world after undergraduate study. You really develop a different perspective about how you want to approach different types of research or work. When I decided to go into industry after graduation, Alan was a little disappointed, I think. I'd gone to various conferences and presented my work. A lot of schools were interested and wanted to talk. I still remember the conversations. But I started feeling like I wanted to get out into the real world.

What I had seen in Practice School really resonated with me. In the life science industry, you are part of that community making drugs to help people. So I decided to go to Bristol-Meyers Squibb. It was really simple.

The practical thinking of chemical engineering—we are very results driven—had a lot to do with what I was able to do when I moved to Pfizer. I have been able to move around a lot during my career. I moved from R&D, where

I started, into manufacturing. I spent time in the plant on the tech transfer process. Then I moved to strategic sourcing. I have a team doing global strategic sourcing work. We have suppliers located in 70 to 80 countries. It's exciting.

Last year I actually went back to look at my thesis. Google is doing a project in the healthcare area that is using magnetic nanoparticles with certain binding relationships, the same technology I was exploring twenty years ago. The project is to detect early cancer biomarkers. That's a very interesting application.

I'm keeping the idea of going back to China open. I'm pretty happy here at Pfizer. I think it's a great company. But when my daughter gets a little older—we don't want to disrupt her education—I'm keeping it open. Pfizer has a significant operation in China.

I'm a pretty active runner. I was looking at my MapMyFitness app. I ran over 500 miles last year!

"Not only do you get exposure to practical industrial problems, but also for me being from China, you get exposure beyond academic study, to actually work with people in corporate America."

Neda Vukmirovic

Degrees: BS '97 (Oregon State University), MS '00, PhD '07

Stations: GE Plastics, Mt. Vernon, IN; Alkermes, Cambridge, MA; Cabot, Corporation, Billerica, MA

Current position: On sabbatical pursuing new business and social impact ideas.

About: Neda Vukmirovic lives in Zurich, Switzerland. After working for BCG in Zurich and leading new product development for Straumann in Basel, she is now looking for a new business opportunity in the Zurich area. Her life outside of work is filled with activities, including yoga, cooking food that follows gluten-free and Ayurvedic principles, attending a Bible study fellowship, and learning to act.

I was born in Serbia and lived there until I was 17. I was an exchange student in Oregon for my last year of high school. It was just a chance I ended up in Oregon. It's one of the most beautiful states in the Union and people there are kind and open. It was a very nice place to be.

I knew I was interested in engineering even before university. My uncle was an engineer and my father was an engineer. From a child's point of view, everything looked very interesting. Also engineering is a useful profession. You could get a job after four years of college, or at least you could back then when I was studying.

I really didn't plan on doing chemical engineering. **The people in the chemical engineering department at Oregon State were friendly and welcoming and cared about me as a student.** Mechanical and electrical engineering, which I considered as alternatives, were bigger and I didn't get the same impression. Also I could combine ChemE with pre med easier.

I wanted to go to MIT, but it was not based on me wanting to go but on me being caught by other people's ideas. They were contagious. A friend of my

father's was a professor at Boston University. He thought very highly of Boston, and he said, *Boston is the Athens of the United States.* Like in the old times, Athens was the place to be for the latest thoughts and ideas. Also, I had a very good friend from Serbia who was an undergrad at MIT and he thought that academically it was the most amazing place to be. Another one of the reasons I came to MIT was the Practice School.

I also applied to medical schools before MIT. But then luckily when I came to MIT I found out about the HST (Health Sciences and Technology) program. I did a master's in chemical engineering and applied to HST. I was happy to get in and went through the program, taking medical school classes and internships at the hospitals and doing my doctoral research. I decided not to pursue a medical degree in the end because the return on investment was simply too low.

Not everybody who is good at something can teach it well. At our first Practice School station in Indiana, I remember one classmate organized a weekend to go waterskiing. None of the other students had ever done waterskiing before and yet this particular classmate was able to get everybody from the water onto the skis. I was really impressed. He was pretty good at teaching waterskiing, but probably other things as well.

My favorite book when I was growing up was Tom Sawyer. I was really excited when I went to Mt. Vernon, Indiana, for Practice School because it's on the Mississippi River.

At Cabot, I don't remember the project but I do remember that what I was supposed to be doing was not working. I was doing some HPLC (high performance liquid chromatography) analysis and it was just not working and not working and it was driving me crazy and my project leader crazy.

I got the most amazing feedback letter from my project leader at Cabot afterwards. I think this was the most mature, insightful and candid feedback I've ever received. He identified patterns in our communications. Even though it wasn't pleasant, I was so impressed. He must have put in a lot of effort to put it in kind words, to be to the point and not hurtful. Only years later I could see the value. The pattern was that if things were not working, I would not communicate right away. It took me a long time to accept that it's much better to communicate the bad news sooner rather than later.

My time at Practice School happened to be one of the most difficult times in my life. There was a civil war in my country. Exactly during these years, the Clinton administration was bombing my hometown. That was really difficult. It minimized the experience I was getting at MIT and has left a permanent mark in my life. Today, 17 years later, people there are still struggling economically and politically. I hope that in my lifetime, I will contribute to peaceful resolution of conflicts in some way.

It's amazing how different things are when you live in a certain country versus what the government of that country is doing. It's like two different worlds. I really had a good time living in the United States for 15 years, especially in terms of the people and their openness to me.

The reason many people get a PhD is a career in academia, but I don't think I ever considered academia as a career. I was interested in the biomedical field. In '97, the biomedical field was rapidly developing, but in the university setting. If I wanted to learn it, the best place to be was a university.

After MIT, I was interested in learning more about business.

I was also interested in getting to know Europe, where I'd never lived as a grown up. I got a job with the Boston Consulting Group in Zurich, Switzerland. After consulting, I moved to a medical technology company where I led new product development for bone and tissue regeneration products used in dental medicine.

When I was in primary and high school in Serbia I learned English and German. I was one of the top students in German nationally, but after 15 years in the US, my German got really bad. After landing in Switzerland, I put in a lot of effort to relearn German, which was made more difficult by people here speaking Swiss-German, which is considered a separate language by the Swiss. At work, I can also speak English. Both work.

You’re not looking for the perfect answer. You’re looking for good enough to make it work. I think that was a really good lesson.

Mariah Mandt SB ’08, SM ’12

Closing Remarks

The School of Chemical Engineering Practice (SCEP), without exaggeration, molded and transformed me. I believe it to be because we were trained and enabled to address the most important and complex issues, and where possible to help point to the way ahead and forge consensus for positive action and results.

My transformative experience seems to be just yesterday, and it remains highly germane today. I am not alone in such an introspective personal assessment. The pages of this volume attest to that.

In 1968 at Oak Ridge, when Hank Cochran and I updated and revised "The Practice School Manual," I went to the MIT Archives, and found and used as an introduction the following quote of Professor William H. Walker:

"It is the man [today, read 'person'] with experience in industry who is best equipped to identify and solve the challenges of that, or perhaps even any other, industry."

There you have it, from the very outset in 1916. The three core elements of what we frequently call "The Practice School Experience": (a) very smart people, (b) practical experience solving real problems and communicating results and recommendations for action, and (c) the general applicability of that experience in identifying and solving challenges…including those far into the future, when we presently cannot even know what those challenges will be.

I believe this to be the essence of the pedagogy of the School of Chemical Engineering Practice.

The pages preceding this one capture that essence through the stories of the School's graduates, all told honestly and in their own words. Their distilled experiences and take-away perspectives represent just a handful of those of alumni, but that handful ranges from the most recent to as far back as 1936–when the Practice School was just 20 years old.

You cannot make this up. *We are merely facing the facts*, as Warren K. "Doc" Lewis taught us.

Thanks to everyone who participated. I also want to acknowledge the giants upon whose shoulders we stand: Arthur D. Little and William H. Walker. We have them to thank as we celebrate the Centennial of the Chemical Engineering Practice School. Today we are all legatees of those who came before us, encouraged and enabled to confidently but modestly stand and solve real problems.

As we think both retrospectively and prospectively, the grand challenge question is:

What will the Practice School look like 100 years from now?

If only we knew, we'd do it today! I defer once again to Lewis: *We've got to teach people to attack from the fundamentals because they're going to have to solve problems, decades from now, that we presently can't even imagine.*

—Sam Fleming SM '61, ScD '70

A Few Words from the Editor

When Bob Hanlon approached me with the idea for this book, he had an example in mind. He said, *I want to do something like this book by Esquire called "The Meaning of Life."* So I flipped through the book. It's full of in-your-own-words interviews with people like Albert Einstein. Al Pacino. Sting. E.O. Wilson. Julia Child.

In my head I thought, *You're kidding me, right?* But what I said was something like, *Hmmm. That's interesting.*

What I didn't know then but I do know now is that graduates of the MIT School of Chemical Engineering Practice are an interesting lot. Their stories convey the same messages as those of the more famous. Like Julia Child and Philip Glass, Practice School alums value practice. Like J. Craig Venter and Chuck Close, they know that getting out into the world and doing something makes a difference.

Plus chemical engineers know about a wild range of stuff. Nuclear power? Check. Carcinogenic dyes? Check. Cinnamon Toast Crunch? Check.

I have now had the pleasure of speaking with dozens of Practice School alums, each with his or her own unique stories to tell and lessons learned. If I learned one thing from this experience, it is that when a small team works very hard and intensely on something, it changes them. Each person comes away more confident and more capable and ready for what's next.

My first few interviews were with folks from the early days: Pete Bixler and Wolf Vieth, who were part of the Practice School when it was just 45 years old. The men—and during this era, they were all men—had and still have about them a genuine sense of wonder about chemical engineering and problem solving.

Their recollections of their Practice School experiences are told in rich detail and full color. They recall the names of supervisors and plant operators, along with other fun facts. They recall the titles of their projects, the way things smelled, the pithy pieces of advice they received. I can't help but wonder if the world was simpler then, giving people more time to notice the good stuff and more space to hold onto it.

It was pretty special for me to have had the chance to speak to these older alums. Little did I know that I would also have the chance to meet the wonderful Thonet Dauphiné, who attended Practice School in 1936, when the program was just 20 years old. I like to imagine his time, a time when students journeyed over primitive roadways to the distant woods of Bangor, Maine, to get an in-depth work experience. A time when an adventure like hiking to the top of Mt. Washington wasn't the grand goal of a lifetime, but rather a necessary step to get to the real fun of skiing down it.

At the start of this project, I worried that Practice School alums wouldn't be forthcoming with me, a stranger. Again, I was pleasantly surprised. People welcomed my questions. They told me their stories, from professional to personal, and humbling to bold.

I have the special honor of being trusted with these stories. They are treasures, and I am so happy to have heard them and to be sharing some of them in this book. It's not called "The Meaning of Life," but it could be.

– Elizabeth Dougherty

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The Middle Years

The Later Years

Do it. Go to Practice School. Travel the world or maybe Minnesota; it depends on your luck. It's a great experience to see companies from the inside and understand how in the real world our skills matter.

– Aly Eltayeb SM '12, current graduate student

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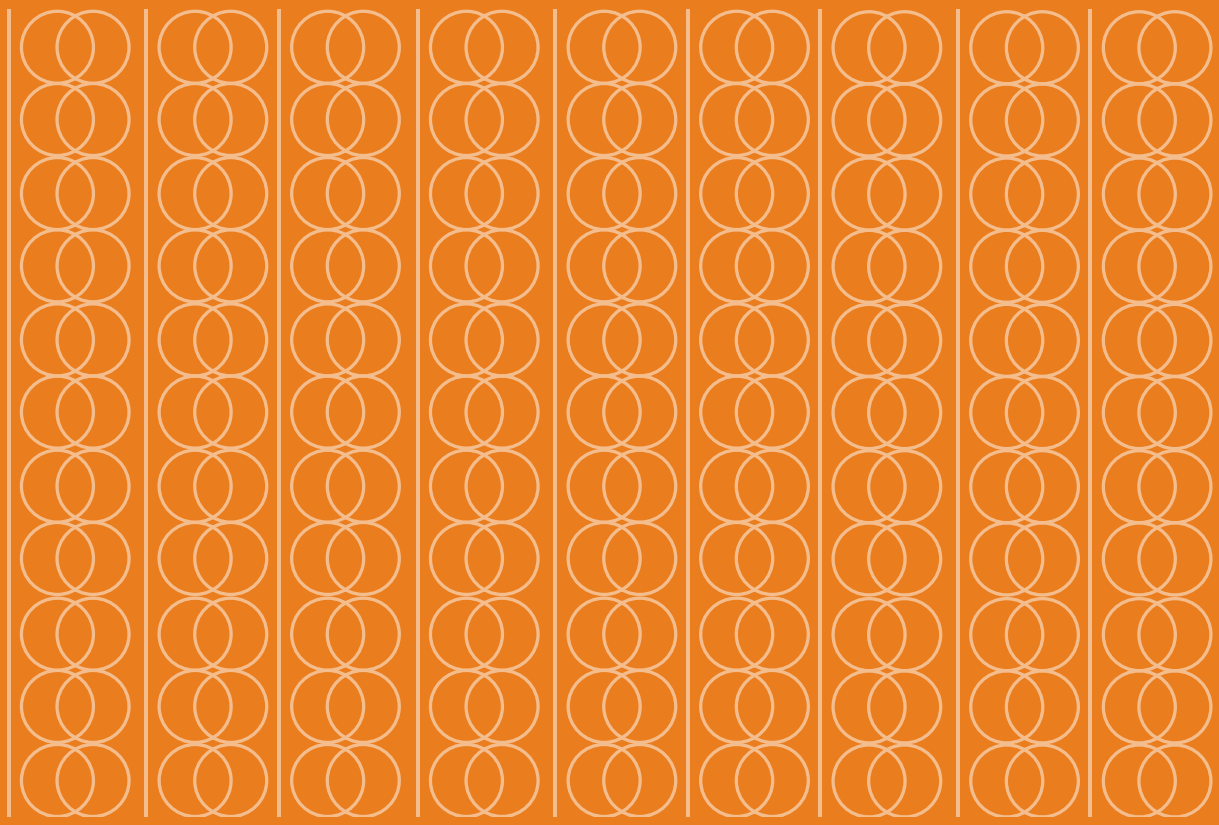

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