



# Arnold L. Demain

1927-2020

BIOGRAPHICAL

# *Memiors*

*A Biographical Memoir by  
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NATIONAL ACADEMY OF SCIENCES

# ARNOLD LESTER DEMAIN

April 26, 1927 – April 3, 2020

Elected to the NAS, 1994

Arnold “Arny” Demain’s transformative research in industrial microbiology spanned nearly seventy years. He usually classified his broad scientific expertise under the term “fermentation microbiology.” Well before the entrepreneurial transformations surrounding recombinant DNA and the first modern biotechnology companies, he was an effective spokesman for the commercial applications of microbiology. Under his leadership, members of his group discovered many innovative ways to harness the chemical virtuosity of microbes for applied purposes in agriculture, industry, and medicine. Moreover, throughout his distinguished career, he never forgot his roots in the pickle industry.



*By Joan Wennstrom Bennett*

In addition to his scientific contributions in industrial microbiology, Arny was an exceptional mentor, organizer, and volunteer leader. He nurtured several generations of students, postdocs, visiting scientists, as well as befriending a large cohort of national and international collaborators. He was uncommonly active as a conference organizer, book editor, committee chair, keynote speaker and reliable source of advice for young scientists. He was generous with his time and his connections. The former members of his group valued the way he fostered excellence in their research and his special mentoring style engendered singular affection and respect. In his later years, current and former members of his lab identified themselves as “Arny’s Army” and developed a series of symposia, essays, and other memorials in his honor. The biographical material given below is extracted from some of these sources.<sup>1,2,3,4,5</sup> This author also benefited from decades of Arny’s professional friendship and has written a previous paper titled “On being an honorary member of Arny’s Army: some musings about fungal fermentations, secondary metabolism, and scientific communities,” which gives details about Arny’s love of secondary metabolism, his gift for bringing together scientists from different backgrounds, his patience with beginners, and his proficiency at social dancing.<sup>6</sup>

## Education and Early Life

Arnold L. Demain was born on April 26, 1927, in Brooklyn, New York. His father was of Hungarian descent and his mother's family was from Ukraine. Throughout his life, he remained a true New Yorker and—until he moved to Boston—an avid Yankees fan. When he got older, Arny liked to joke that he could always remember that 1927 was his birth year because that was the year that Babe Ruth hit sixty home runs. Arny was a public-school kid and attended five different elementary schools and three different high schools in Bronx and Brooklyn before graduating, at age sixteen, from Midwood High School in 1943. Other well-known graduates of Midwood include geneticist Maxine Singer and movie director and producer Woody Allen.



Figure 1: Vintage jar from the Demain family pickle business.

Arny's grandfather, Joseph Demain, sold pickles in New York and his uncles Ben and Seymour Demain ran a pickling operation in Auden, North Carolina, named "Demain Foods Company." Arny's father, Henry Demain, worked for Vita Foods Corporation and established a pickling and canning plant for Vita in Chestertown, Maryland. Henry Demain convinced his son that he should continue in the family business and become an expert in food fermentation. Henry knew Frederick W. Fabian, a professor at Michigan State College (now Michigan State University) who conducted an annual one-week summer course called "The Pickle and Kraut Packer's School." So Arny was sent off to study with "the pickle professor." In March 1944, with World War II raging, both of Arny's parents

accompanied him on a train to East Lansing, Michigan, to begin his freshman year to study bacteriology, with long-term plans to work for his father after graduation. Arny studied for four quarters, but when he reached his eighteenth birthday, he dropped out of school and enlisted in the U.S. Navy. He was called up in June 1945 and joined the Hospital Core as part of the so-called "Fleet Marines," who were expected to accompany the invading U.S. Marines to enemy islands in the Pacific. During his basic training, however, the war with Japan came to an end. Instead he was sent for supplemental medical training at the U. S. Naval Hospital in Philadelphia, where he was stationed on the



Figure 2a: In naval uniform, circa 1945.



Figure 2b: Graduation from Michigan State College, 1949.



Figure 3: Arnold and Jody celebrating their 25th wedding anniversary. (Courtesy Demain Family.)

from farmers in the Carolinas and then shipping them by truck to his father's pickle factory. It was during this time that he met two people who would change the trajectory of his life. The first was Jack Lincoln Etchells, a professor of food science at North Carolina State University who became an influential mentor. The second was an undergraduate named Joanna (Jody) Kaye, who became “the love of his life” and the emotional ballast that anchored his subsequent intense and travel-filled career. While Arny was still courting Jody, he attended a Pickle Packer's Convention in Chicago, delivered a paper on his work, and told Etchells that he was planning to stay at Michigan State for his Ph.D. Etchells took interest in Arny's career and put the “Old Boys' Network” in action: without any transcripts, exams, or interviews, with nothing but a few well-placed phone calls, Etchells made sure that Arny was re-directed to, and accepted by, the Food Science Department at the University of California, Berkeley. Arny and Jody changed their plans and moved together to California, where he continued his graduate work first at the Berkeley campus and then at the University of California, Davis. It was a smart move. Etchells had guided him well. At the time, The University of California was one of the best places on earth to study microbiology.

Once at Davis, Demain came under the tutelage of Herman Jan Phaff. Like Arny, Phaff was born into a family that had strong roots in the business of commercial fermentation: the Phaff family ran a winery. Moreover, Phaff was a scion of the “Delft School of Microbiology” and a direct scientific successor of the traditions of Martinus Willem Beijerinck. The Delft School had elevated environmental microbiology from a niche

U.S.S. *Consolation*, a hospital ship later renamed the U.S.S. *Hope*, and spent two years ferrying overseas war veterans back to the United States.

In 1947, Arny was honorably discharged from the Navy and immediately returned to student life at Michigan State, where he finished his undergraduate studies and as promised signed up for independent research with Fred Fabian on the ways in which pickles lost their crunch and “softened.” He completed a bachelors' degree in bacteriology in 1949 followed by a master's degree in 1950. His master's thesis was on the microbial softening and spoilage of pickles during fermentation. During his summer breaks, he worked for his uncles, buying cucumbers

field into a robust academic discipline. Phaff had done his doctoral studies under Albert Kluyver, a prominent Delft microbiologist who had championed the concept of ‘the unity of biochemistry’ and also developed the use of submerged fungal fermentation to produce microbial products.<sup>7</sup> Students and faculty at the Delft University of Technology had strong ties with the Dutch Yeast and Spirits Factory, now part of Dutch State Mining (DSM), a company that had produced food ingredients including yeast, yeast extracts, and enzymes since the nineteenth century.<sup>8</sup> The remarkable traditions of the Delft School of Microbiology—and Phaff’s approach to research and to life in general—made a strong impression on Arny during his graduate years.

Phaff worked on the ecology and taxonomy of yeasts.<sup>9</sup> When Arny first joined Phaff’s laboratory, he was tasked with maintaining the viability of Phaff’s famous yeast collection and got lots of practice in media preparation, sterile transfer techniques, and careful record keeping. In addition to being an outstanding scientist, Phaff was an accomplished cello player and an urbane and deeply cultured man. Phaff impressed upon his students that they should not only be good scientists but that they should have a meaningful life outside the laboratory, be involved in the arts, and make sure to take time for relaxed social activity.<sup>10</sup> Perhaps more than any other of Phaff’s many students, Arny absorbed his example. Arny became a champion of applied microbiology in all its forms. Simultaneously, he recognized the importance of human-centered activities and personal relationships in enhancing the scientific enterprise.

Demain’s dissertation was on the enzymes responsible for the softening of pickles during fermentation with a focus on the extracellular polygalacturonase from *Kluyveromyces fragilis*. Demain and Phaff were the first to use affinity chromatography using a pectic acid gel to selectively absorb the enzyme from culture filtrate and showed that the hydrolysis of pectin was accomplished by a single enzyme. Later, Etchells was able to show that the softening of pickles was caused by unwanted yeast contamination that infected fermentation tanks.<sup>11</sup> The dissertation work itself appeared in four papers, one of which was published in *Nature*. In a biographical essay Arny wrote thirty years later: “I learned later in life—after receiving many rejections from *Nature*—that for a graduate student to publish one of his/her first papers in *Nature* was an unusual feat.”<sup>12</sup>

As Arny was writing his doctoral thesis, Jody was carrying their first child. She gave birth to Pamela Robin Demain just before Arny received his Ph.D. in 1954.

## The Merck Years

Arny did not do any postdoctoral research. Shortly after completing his Ph.D., he accepted a position at the Merck Sharp & Dohme company. Thus, in March 1954, Arny, Jody, and baby Pamela moved to Danville, Pennsylvania, where Arny started at the Merck penicillin factory, charged with improving the titer of penicillin production. Almost immediately, Demain displayed his facility for fermentation microbiology. After about a year and a half at the penicillin plant, Merck management transferred him to their research facility in Rahway, New Jersey, where he spent the next thirteen years. He and Jody bought a nice house in nearby Westfield, where their son Jeffrey was born. While at Merck, Demain found yet another outstanding mentor in the person of H. Boyd Woodruff, who had been one of the leading figures in the establishment of industrial microbiology as a modern discipline.<sup>13,14</sup> Woodruff was the founding editor of *Applied Microbiology* (now *Applied and Environmental Microbiology*), one of the flagship journals of the American Society for Microbiology, and had served as its editor-in-chief from 1953–62. By example, he taught Arny the importance of working with professional societies and of taking on editorial responsibilities. In the laboratory, Woodruff gave Arny intellectual encouragement with respect to his research, and within the Merck administrative structure he directed ample resource support toward nurturing Arny's management skills and scientific output.

Soon, Demain perfected a research strategy that was to characterize his whole subsequent career. He used experimental approaches based in the basic sciences to address practical problems in applied microbiology. He understood that you could use fundamental or theoretical research to solve real-world problems. For example, he was the first to establish that lysine caused feedback inhibition of penicillin production. He went on to study the effect of using selected primary metabolites, or starved resting cells, to enhance the production of the antibiotic. Importantly, he confirmed what had been a controversial claim by Koichi Kato that he could isolate the “penicillin nucleus” (later identified as 6-aminopenicillanic acid or 6-APA). This nucleus became the central molecule used for the production of all semisynthetic penicillins.<sup>15</sup>

By 1964, Arny was asked to form a new Merck department, Fermentation Microbiology, that would be devoted to the improvement of product biosynthesis as well as the development of fermentation methods for new bioactive metabolites. In biochemistry, the term *fermentation* is defined narrowly to refer to an anaerobic metabolic process in which a carbohydrate or related compound is partially oxidized with the release of energy in the absence of any external electron acceptors. In contrast, Arny was not too picky

about the definition of fermentation, and like many microbiologists broadly applied the term *fermentation* to describe a wide array of microbial processes that convert carbohydrates to alcohol or organic acids. Fermentation biology encompasses the production of alcoholic beverages such as beers and wines; traditional food preservation processes for preserving milk (cheese and yogurt), cured meats (sausages), and vegetables (kimchi, pickles, sauerkraut), but it also includes early industrial processes that were used to produce bulk chemicals such as citric acid, and solvents such as butanal.<sup>16</sup>

In the late 1960s, with encouragement from Boyd Woodruff, Demain was pivotal in establishing the Fermentation Division of the American Society for Microbiology, where the rubric was used to cover a broad umbrella of just about any operations that use living microorganisms to carry out chemical changes. It was also during this time that his Merck laboratory found that methionine could enhance the production of cephalosporin in *Cephalosporium acremonium*. The Demain group also worked on the production of L-glutamic acid for monosodium glutamate (MSG) by *Corynebacterium glutamicum* and vitamin B12 from *Pseudomonas denitrificans*. Arny was comfortable simultaneously directing projects on all kinds of different bacterial and fungal metabolites. The focus was always on improving a given fermentation system. Industrial microbiologists continue to improve titers using methods that were forged by Arny and are rooted in physiological and molecular sciences. Moreover, to this day,  $\beta$ -lactam antibiotics (penicillins and cephalosporins) are of major clinical importance and contribute a large share of the total antibiotic market. Demain's research in industrial microbiology has provided a lasting foundation.

### The MIT Years

In the late 1960s, Arny had the opportunity to move from industry to academia. He joined the Department of Nutrition and Food Science at the Massachusetts Institute of Technology (MIT). The Demain family moved to Wellesley, Massachusetts, in the summer of 1969. The change in geography was hard on his wife and children, who had established deep roots in New Jersey. Nevertheless, the disruption was part of a pattern of the professional-over-personal choices that characterized the careers of many men of his era. Decades later, when Jody was asked about her husband's enormous professional success, she would quip: "Arny does the science. I do everything else." There aren't many pictures of the whole Demain family together, but Fig. 4a shows Arny and Jody at their daughter Pamela's wedding, and Fig. 4b shows them at their son Jeffrey's wedding.

Once at MIT, Arny also had a lot of adjustments to make. He later described his initial ignorance about the workings of the academic world<sup>12</sup>

“I must say that I was quite naïve about academia. When I was offered a salary of \$25,000 per year, I thought that meant that they would pay me \$25,000 per year. No, it means that they would pay me \$4000, i.e., 20% of my nine months’ salary and 0% of my summer salary, and I would be expected to raise the rest via grants. Thus, I soon learned what ‘soft money’ meant.”



Figure 4a: The Demain family at daughter Pamela’s wedding, 1983. Left to right: son Jeffrey, Arny, Pamela, and Jody. Figure 4b: The Demain family at son Jeffrey’s wedding, 1985. Left to right: Jeffrey, Lauren Brener, Jody, Arny and Arny’s mother.

Nevin Scrimshaw was chair of the department at MIT and made sure that his new professor had a year without teaching so that he could get his research up and running and have time to write lots of grant proposals. Arny quickly adapted to academic life and flourished. His first two graduate students were Stephen Drew and Prakash Masurekar. Not long after, Arny hired Nadine Hunt (later Solomon) as a technical assistant. Nadine helped supervise the lab. During the early years, there was a strong focus on the  $\beta$ -lactam antibiotics. Arny had observed that lysine interfered with penicillin production. Masurekar found that the effect was not due to enzyme repression but to feedback inhibition. Masurekar developed a method for the isolation of nutritionally

deficient mutants in *Penicillium chrysogenum*, which in turn led to a theory paper that asked how it was that microbes could produce so many antimicrobial products without killing themselves, or as Arny put it “without committing suicide.” In work with Yoshida and Konomi, the Demain group went on to produce cell free extracts for studying cephalosporin biosynthesis.<sup>17</sup> During the ensuing years, Demain continued the path he had forged at Merck, whereby he did basic research on organisms that produced economically valuable products. The interests of members of his lab spanned many fields. They studied  $\beta$ -lactams antibiotics in *Penicillium chrysogenum*; cephamin C synthesis in *Streptomyces clavuligerus*; cyclic peptides by *Bacillus brevis*; malformin C from *Aspergillus niger*; secodolonic acid from *Aspergillus aculeatus*; mollicellins from *Chaetomium*; riboflavin from *Ashbya gossypii*; and mollicellum and simitoxin from *Penicillium islandicum* (see Demain’s autobiography review<sup>12</sup> for citations on these papers, and the names of Arny’s numerous students and collaborators). The producing organisms and their biochemical products were heterogenous, but the research was united under the rubrics of the “secondary metabolism” and “fermentation microbiology.”

Secondary metabolism is a difficult-to-define rubric. The term *secondary metabolite* encompasses a huge number of chemically dissimilar compounds, often with bizarre chemical structures, that are produced from a few common precursors of intermediary metabolism. In microbes, these metabolites usually accumulate after active growth has ceased and tend to be species or genus specific. The most famous secondary metabolites function as antibiotics (penicillin), toxins (aflatoxins), blood pressuring lowering agents (statins), immunosuppressants (cyclosporin), or antitumor agents (actinomycin). During his years at MIT, Arny’s lab did research on many different secondary metabolites. Many were of medically relevant importance, but numerous others were not. During the 1990s, Arny even persuaded NASA to sponsor experiments to probe the effects of simulated microgravity on secondary metabolism. Moreover during those years, in addition to his experimental papers, Arny wrote numerous elegant and wide-ranging review articles about these microbial metabolites, and he became a major theoretician of secondary metabolism. He also introduced some jargon terms including *idiotroph* (a mutant requiring a special nutrient to produce a particular product) and *mutational biosynthesis* (new secondary metabolites produced by feeding analogues that contained missing moieties). Moreover, the Demain lab’s work in fermentation microbiology sometimes extended beyond secondary metabolism. For example, with collaborators during the 1980s, his lab formed a subgroup to study the molecular biology of cellulases from *Clostridium thermocellum* that led to the elucidation of the extracellular organelle which had

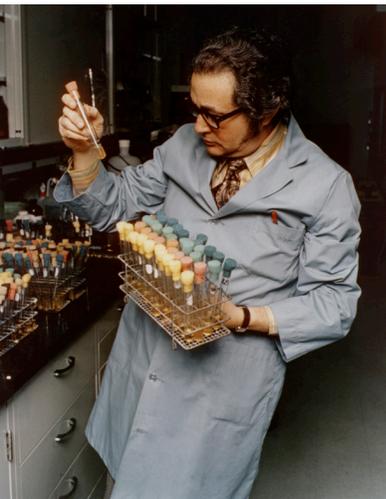


Figure 5: Demain in his M.I.T. laboratory.

earlier been named a “cellulosome.” Figure 5 shows Arny in his MIT laboratory during the late 1970s.

Demain’s leadership style and his capacity for hard work brought in plenty of funding and yielded a robust publication record. As a former industrial scientist, he championed the value of bringing industrial scientists together with their academic brethren. MIT had a long tradition of faculty members who performed similar hybridization in engineering and physics. The Demain laboratory was an early example of doing the same thing in the biological sciences. Arny’s first independent scientific success had come at Merck, where he used approaches garnered from basic research to improve production of  $\beta$ -lactam antibiotics. He knew that industry needed to become more like academia. At MIT, he reversed this insight and led his laboratory in the opposite way to ensure that academic research became more like industrial research. In his biographical essay for *Annual*

*Review of Microbiology*, he wrote: “It’s clear that those who understand basic biology are the ones most able to apply it.”<sup>12</sup> Along the way, he taught his students a great deal about the way economics drives research decisions within companies and how the ability to solicit outside funding drives science within universities.

### The Big Picture

Arny entered professional life about twenty years before the recombinant DNA revolution transformed biology. When he was a young scientist, many microbiologists still drew a firm line between pure and applied science. Famously, the team of Oxford scientists who won the Nobel Prize for their work on penicillin never applied for patents. There was a sense that it was unethical to make a profit from scientific discoveries. Industrial microbiologists often were disparaged as “money grubbing,” and academics had an in-group snobbery in viewing themselves as “above” profit.<sup>15,18</sup> Arny would have none of this. He understood that the production of antibiotics, commercial enzymes, and the like were honorable manifestations of the ancient arts of fermentation. As Arny’s scientific success grew, he increasingly crusaded for applied microbiology. He began his proselytizing before the advent of recombinant DNA and the concomitant changes in

industrial microbiology that came to be called modern biotechnology. When he was given the opportunity to write an autobiographical essay for the 2004 volume of *Annual Review of Microbiology*, he titled his paper “Pickles, Pectin, and Penicillin,” giving credit to the way his youthful interest in a humble cucumber fermentation led to his career in the production of a wide array of profitable microbial natural products.<sup>12</sup> His essay gives careful citation to decades of published work from his group and details the contributions of the many people who worked with him. High on the list of Arny’s many commendable qualities was the way he always shared recognition for the accomplishments of the people who worked in his laboratory.

Another one of Arny’s great strengths was his ability to use professional societies to amplify his ideas. Scientific meetings are where theories are exchanged and new hypotheses are formed. Arny was a master at putting together symposia, meetings, special committees, and other societal mechanisms for sharing the latest data in applied microbiology. He tirelessly organized social events. He leveraged his work with the American Society for Microbiology and the Society for Industrial Microbiology and Biotechnology to foster cooperation across the profession. He served as president of the Society for Industrial Microbiology from 1990-91 and was elected to the board of governors of American Academy of Microbiology in 2000.

Arny had a natural ability make fast personal connections with other microbiologists. He was in his element at a scientific meeting and a master at the art of getting the most out of the new contacts he made. Where some people go to social events and talk mostly to people they already know, Arny would seek out new people. He’d notice when individuals looked nervous or left out and with great ease and charm, talk to them, introduce them to others, and gradually draw new people into his scientific circle. Groups would form around him, and soon people would be sharing hypotheses, suggesting interesting approaches, and having a good time. Former student Randy Greasham described it this way, “Arny had a special way of making everyone around him feel important. No one was left out.” Arny’s sociability, and his skills at giving an enjoyable public lecture, meant that over the years he gave hundreds of invited lectures at



Figure 6: Demain at the lecture podium, 1990s.

venues across the world (Figure 6). His talks almost always mentioned the long history of microbial fermentation in the preparation of beer, cheese, koji, pickles, and wine, as well as the more recent historical developments with drug development research in the era before recombinant DNA and genomics where researchers had developed high yielding antibiotic producing strains employed a combination of brute force screening, mutational analysis, and nutritional supplementation. Arny had a “big umbrella” view of secondary metabolites that embraced not only antimicrobial compounds, but also antitumor agents, mycotoxins, and pesticides. His lectures almost always included slides in which he presented data on the economic value of the major fermentation products as they moved from multi-million-dollar industries to multi-billion-dollar industries. As the recombinant DNA revolution and advances in genomics transformed biology, he immediately recognized the enormous untapped genetic resources that could be identified with molecular techniques and advised companies to take advantage of the new approaches.

We scientists like to quantify things. For Arny, the numbers are impressive. Over his career, he published more than 575 papers; edited or co-edited seventeen books; was a member of thirty-eight different editorial boards; was awarded twenty-two U.S. patents; and mentored some 125 students, postdoctoral associates, and visiting scientists. Ten different national or international symposia were convened especially in his honor. In addition to his many academic achievements, Arny had a “second career” as an expert witness in patent cases. He was proud to have been a founding consultant with what was arguably the first biotech company, Cetus Corporation.<sup>19</sup> Over the decades, he held positions on dozens of important national and international committees and delivered hundreds of invited lectures, often as the plenary speaker.

Arny received many honors during his lifetime. They included several teaching awards: Outstanding Teacher Award in Bioengineering and Food Science, MIT (1971, 1974) and the Graduate Student Council Award for Outstanding Graduate Teaching, MIT (1974) as well as the Waksman Outstanding Teaching Award, Society for Industrial Microbiology (1995). He was elected a Fellow of the American Academy of Microbiology in 1981, the Society for Industrial Microbiology in 1985; the International Institute of Biotechnology, Kent, United Kingdom, in 1987; and Membre d'honneur, Société Française de Microbiologie in 1983; Honorary Member, Croatian Society of Biotechnology in 1998; and Honorary Member, Czechoslovak Society for Microbiology in 1998. In 1994, Arny was elected to the National Academy of Sciences in Section 61 (Applied Microbiology, Animal and Nutritional Sciences), for which he served as chair from 1997–99; and later chair of the Section Memoirs Committee from 2003 until his death. In 2002, he was elected to

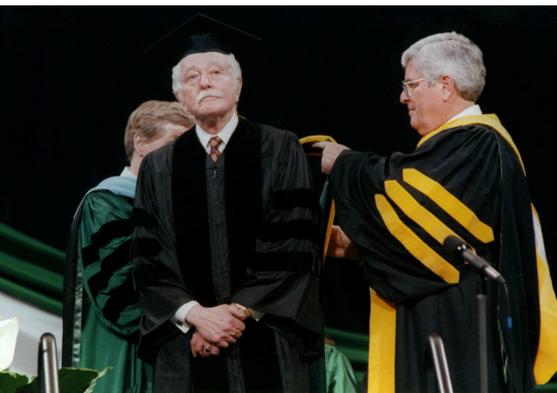


Figure 7: Honorary Doctorate from his alma mater, Michigan State University, 2000.

the Hungarian Academy of Sciences. Other major honors include the Charles Thom Award, Society for Industrial Microbiology, in 1978; Microbial Chemistry Medal from the Kitasato Institute and Kitasato University, Tokyo, in 1988; Medal of the Order of the Rising Sun, Imperial Decoration Award, Japan in 1999; Distinguished Service Award, American Society for Microbiology in 1994; and the Arima Award in Applied Microbiology from the International Union of Microbiological Societies in 2005. In addition, Demain received honorary doctorates from Michigan State University (East Lansing, Michigan) (Figure 7) and Drew University (Madison,

New Jersey) as well as the University of León (Spain); Ghent University (Belgium); Technion (Israel); and Muenster University (Germany).

When we honor our peers, we scientists tend to focus on their scientific discoveries, publications, and the formal honors they received. We pay less attention to the ways in which the person conducted his or her science. Yet it was Arny's remarkable capacity for making, and keeping, professional friendships and for maintaining a large network of collaborators and friends that made his influence extend far beyond the laboratory and the boardroom. Many members of the Demain lab came from outside the United States. His global network positioned him to put together strong programs for international conferences and solicit chapters for edited books. Almost every member of "Arny's Army" retains a fierce loyalty to him and carries good memories of the time they worked with him. His unstoppable curiosity and his rare social gifts generated a geeky, social glue that continues after his death.

### **Retirement and Years at Drew University**

At age seventy-five, Arny took what he called an "early retirement" from MIT and moved to Madison, New Jersey, to be near his daughter and grandchildren. He soon joined the Charles A. Dana Research Institute for Scientists Emeriti (RISE) at Drew University in Madison. RISE is an organization founded specifically for retired industrial scientists, who are given an office and a small laboratory and who, in return, are expected



Figure 8: Demain at Drew University with undergraduates.

to train undergraduate science students in how to do wet lab research. Because Arny's career had started during at the tail end of the "golden age" of antibiotics discovery and continued through the recombinant DNA revolution, he was ideally suited to being at RISE. The position at Drew University allowed him to continue research, mentor students, edit books, and publish extensively. He maintained close working relationships with the young students in his lab and created an atmosphere that encouraged accomplishment. In particular, he cultivated independent-minded undergraduates and encouraged them to follow their own ideas (Figure 8). He continued working at Drew and mentoring his wide network through his ninetieth birthday (Figure 9).

During the years following his retirement from MIT, an informal group of former undergraduate and graduate students, postdocs, and friends held the "Arny's Army and Friends Symposia" every three years in locations around the world. This tradition, carried out by members of "Arny's Army," has influenced a large cadre of young biotechnologists who to this day advance Arny Demain's vision of food and fermentation microbiology as a cornerstone of an ever-growing edifice that continues to rise with progress in cell biology, cellular therapeutics, and various forms of "-omics."

Demain made a crucial impact during his years at Drew University, and in honor of his ninety-first birthday, the university solicited gifts and then established a fund named in his honor that will support undergraduate research. Just a year later, shortly after his ninety-second birthday in May 2019, Arnold



Figure 9: Arnold Demain's 90th birthday party in 2017 with birthday cake.

Demain finally took a formal retirement. His health was failing and after several bad falls, he had to move into an institutional nursing facility. The timing could hardly have been worse. He contracted and succumbed to Covid-19 early in April 2020, shortly before his ninety-third birthday. In 2021, members of Arny's Army dedicated the December issue of the *Journal of Industrial Microbiology and Biotechnology* in his honor, including personal testimonials.<sup>20</sup>

### Summary

Arny never forgot his roots in the pickle business and always asserted that his early experiences with a traditional fermentation process inspired his later career. His lifetime of scientific work played an essential role in transitioning the old industrial microbiology into the new biotechnology.

Arny enjoyed being with people, and people enjoyed being with Arny. Arny brought out the best in those of us lucky enough to have known him. He was approachable. He was a good listener. He knew when to give realistic praise and was kind when scolding colleagues who had screwed up. His former student David Wu described him this way:

“Arny was more than a research mentor or a thesis advisor. Despite his fame and accomplishments, he was humble and compassionate. He cared about people around him and the world.”

A big part of Arny's success with science and with people had to do with his attention to personal happiness. His style had a profound impact on the way a whole generation of scientists approached the study of natural products for drug discovery. He provided social, scientific, and moral leadership. While Arny's formal education had shaped his scientific character, it was his native temperament and *joie de vivre* that informed his social triumphs. His supportive spouse enabled him to work long hours and travel extensively while raising a family. His uncanny ability to catalyze concepts from his mentors, his co-workers, and his students spawned a unique scientific camaraderie. During his MIT years, his wife Jody remembers that he regularly said, “I ought to be paying them to have this job.” Arny *loved* being a microbiologist.

It seems fitting to finish with a quote from Arny's memorial to his own most important mentor, Herman Phaff. Arny wrote: “He taught us how to work hard, be professional, ethical, and, above all, to enjoy our chosen careers!” and then, in a conclusion directed directly to Phaff, Arny said, “You were a great scientist, human being and friend, and you will continue to inspire me as long as I live.”<sup>24</sup>



Figure 10: With granddaughter Megan, and great-grandchildren Grant and Parker.

Many of us feel the same way about Arny Demain. His rare humanistic legacy lives on among members of “Arny’s Army and Friends.”

Arny died of COVID-19 on April 3, 2020, just a few weeks shy of his ninety-third birthday. He is survived by his wife of sixty-eight years, Jody; his daughter Pamela Demain, his son Jeffrey Demain and daughter in law Lauren Brener; his granddaughter Megan Neilson (and her husband Michael); and grandson Andrew McCloskey (and his wife Hillary). At the time of his death, he had two great-grandchildren, Grant and Parker Neilson (Figure 10).

Since then, two new great-grandchildren have arrived, both named after him: Brody Asher (A for Arnold) Neilson and William Arnold McCloskey.

### ACKNOWLEDGMENTS

This essay would not have been possible without the help of Jody Demain, Arny’s widow, and his daughter Pamela. Other individuals who made important input include Richard Baltz, Brendlyn Faison, Randy Gresham, Prakash Masurekar, Juan Martin, and David Wu. Personally, this author is grateful for decades of Arny’s mentorship and friendship.

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