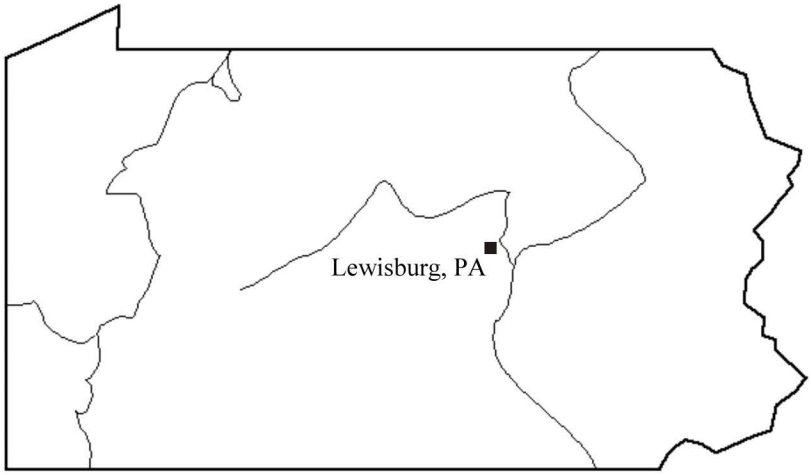
*ChE at…*




# Bucknell University

## CELEBRATING 100 YEARS

JEFFREY CSERNICA
MICHAEL GROSS
ERIN JABLONKSI
TIMOTHY RAYMOND
MARGOT VIGEANT

Bucknell University began as "The University at Lewisburg" in 1846, during a time when transportation advances in the region—a bridge crossing the Susquehanna River, a "turnpike" to the west, and a vibrant canal system providing an easy link to east coast cities—were transforming the area from what Philadelphians called the "wilds of Pennsylvania" into a goods trading and transport hub. The original charter describes a small liberal arts university, offering a curriculum including ancient languages, logic, and rhetoric, as well as geology, trigonometry, and astronomy.

In response to the industrial revolution and a rapidly growing and increasingly urbanized U.S. population, trustee **William Bucknell** and others sought to expand the scope of the university in the late 1800s. The free-standing Chemical Laboratory dedicated in 1890 ushered in a period of increased attention to instruction in the physical sciences, and paved the way for the B.S. in chemical engineering, first offered in 1909. Four graduates received the degree four years later, and the currently enrolled class of 2012, our 100th, contains 29 students. In 1923, chemical engineering graduate **Katherine Owens** became the first woman to receive an engineering degree at Bucknell. Women have maintained a strong presence in the program, and make up 35% of the current student population.

**John Harris**, university president during the early 20th century, was a supporter of the new engineering programs but actively discouraged them from seeking formal college or even department status. He instead argued that engineering courses were "part of a liberal education, which rests upon the substrata of mathematics, physics, drawing, and chemistry." While department and college standing eventually came, the concepts of integration and synergism between engineering and the liberal arts and sciences that Bucknell embraces today (and which are now publicly recognized at many other institutions) clearly had their roots in those early days. The university remains primarily undergraduate (a small master's program exists within the department), and advantages of Bucknell's liberal arts atmosphere have been stressed in engineering recruiting brochures since the 1920s. Currently such materials state that Bucknell's "liberal arts environment offers diverse learning opportunities, encourages critical thinking, and supports engineering problem solving in a societal context."

In 1922 the first wing of the Charles Dana Engineering Building was constructed, although most chemical engineer-

***Building Montage***

*Evolution of the engineering facilities on campus. Upper left (1925): first wing of the Dana building marks foray from primary campus into adjacent farmland; upper right (1945): a second wing and connector complete Dana's horseshoe geometry; bottom (2005): the current complex includes a renovated Dana Building (now seen with a complete third story) and the attached Breakiron Building.*

ing laboratory activities remained in the Chemical Laboratory until 1939, when the second wing and connecting central section of the Dana building were completed. Many elements of the new chemical engineering laboratories were based on the recommendations of the Engineers' Council on Professional Development, the engineering accreditation body at that time, and the chemical engineering program was formally accredited two years later. A major renovation and further expansion of this building was completed in 1984. In Fall 2004, space for engineering studies was further increased by 45% through the construction of the Lauren Breakiron Engineering Building, which is connected to the original Dana building.

## CURRICULUM

Consistent with former President Harris's "substrata," the current chemical engineering curriculum contains a broad required science base of mathematics, chemistry, physics, and biological and materials sciences. The program's general education component is based on that of the arts and sciences college, and contains a "global and societal perspectives" requirement. While engineering course titles and sequences would be largely familiar to those in the discipline, particular emphases throughout the curriculum are placed on realistic open-ended problems, project management, experimental practice, professional and interpersonal development, and independent learning, as illustrated in the elements discussed below.

*Laboratories* Almost all core chemical engineering classes contain a concurrent laboratory component, and students are thereby continually relating theory and practice throughout their four years in the program. These multiple laboratories create many added opportunities for practice and formal training in teamwork, communication, and the solution of open-ended problems.

Dedicated instructional laboratories currently exist with the following topical specializations:

- Analytical
- Bioprocess
- Fluid Flow
- Heat Transfer
- Kinetics
- Materials Science
- Polymer Science
- Process Control
- Unit Operations

*Exploring Engineering* Bucknell requires all incoming engineering students to take the introductory Exploring Engineering course in their first semester. The course is taught by a team of nine faculty, two of whom are chemical engineers, and has an enrollment of approximately 200. Since 2002, the course has been taught in a modular fashion based on a seminar format. Students take three discipline-specific, three-week seminars in groups of approximately 25. The seminars are student-selected and use a specific topic to introduce engineering concepts and provide windows into the specific disciplines. Each seminar contains a laboratory component in which students complete an open-ended design project. In 2009 there were two seminars representing chemical engineering—one based on producing a modified ChemE Car, and the other on designing and mass producing a superior material for sneaker soles.

*Introductory ChE Course* In the first-year Chemical Engineering Principles course, students immediately get their hands dirty in the unit operations laboratory and begin their exposure to pilot-scale equipment. The course is centered on a team-based cooperative-learning environment. Five two-week projects are proposed to teams of students, where they are expected to address a problem with hand calculations, simulation software, and a complex laboratory experiment. In addition to formulation and presentation of a solution to the open-ended problems, course objectives include formally developing teamwork and professional skills.[1]

*Senior Design* In the past decade, the department has moved from a traditional two-semester design sequence (in which both semesters focused on a single simulation-based design) to one in which the second semester is spent in a practical design experience, working on real problems posed by external clients.[2] Building on the earlier senior design work, this second-semester course, "Project Engineering," requires students to solve a problem with a more narrow focus and produce a tangible result for an actual client. Students work with problem definition, project management, genuine budget and time constraints, and real deadlines and expectations that are meaningful beyond the classroom. Project work can include product or process development at the bench- or pilot-scale, prototyping, or implementation in an industrial setting. For example, students have designed novel coatings for a producer of athletic mats, specified equipment for a pharmaceutical manufacturer to improve process flexibility, designed portable heating equipment for U.S. Army MREs ("Meals Ready-to-Eat"), and optimized fermentation performance for a start-up microbrewery.

*Seminar* The mid-1990s saw the initial development of the department's spring seminar course—weekly visits and presentations by practicing professionals—into which each student in the department is automatically enrolled. Beyond coverage of various technical topics, the exposure to careers, assignments, and problems of practicing chemical engineers enhances our students' understanding of professional growth and development beyond their college years. Many of these benefits are realized through the seminars themselves, but are supplemented through networking that occurs at associated speaker lunches with student sub-groups, and informal speaker visits to classes and laboratories. In conjunction with newly articulated program outcomes associated with EC2000, we later targeted and arranged speakers over time to explore specific "perspectives," such as those associated with ethical, environmental, and societal issues.

*Specialization* Beyond the core curriculum, students can tailor their experience to their interests, which may include study abroad (see below), a five-year dual degree (second degree in liberal arts or management, or a combined B.S./M.S. in chemical engineering), or pursuit of a concentration within the major (biological, environmental, materials, process).

*Research* Undergraduate research opportunities are considered a vital element of the program, and about 2/3 of graduates will have spent at least one semester conducting an "independent study" research project, working directly with a faculty mentor. Many such students are encouraged to serve as co-authors on archival publications, and to present their work professionally at AIChE meetings and other venues.

*Department faculty: (left to right, front row) Tim Raymond, Ryan Snyder, Jeff Csernica, Bill King, Kat Wakabayashi; (back row) Mike Gross, Erin Jablonski, William Snyder, Mike Hanyak, Brandon Vogel, James Maneval, Margot Vigeant, James Pommersheim; on sabbatical and not pictured: Mike Prince.*

## FACULTY

Currently the department carries 12 full-time faculty lines. Consistent with expectations of a predominantly undergraduate liberal arts institution and with responsibilities as described in Bucknell's faculty handbook, our faculty are committed to teaching excellence, and provide close personal attention to students in the classroom, laboratory, and beyond. Many faculty are both close followers of and contributors to developments in engineering education and pedagogy.

At the same time, however, Bucknell espouses a teacher-scholar ideal, and faculty are expected to remain on the cutting edge of their discipline through active research programs. In the past four years, major outside funding has been obtained for: development of a nanofabricaton laboratory; study of atmospheric aerosols (NSF CAREER); enhancing engineering education; and special instrumentation (atomic force microscope, polymer extruder and pulverizer). Research activities are conducted primarily with undergraduate students, and this feature brings its own set of special challenges as well as rewards.

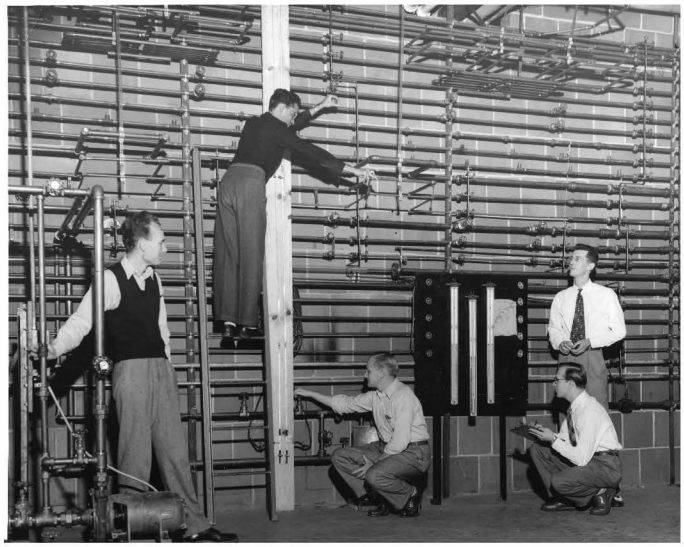
**Jeff Csernica** joined the faculty in 1989 after receiving his Ph.D. at the Massachusetts Institute of Technology. His work on transport in polymers with Colgate-Palmolive led to a cosmetic composition patent. He has acted as coordinator of the college's first-year Exploring Engineering course, and is currently serving as department chair.

**Michael Gross** joined the faculty in 2007 after receiving his Ph.D. at the University of Pennsylvania. His research currently focuses on the development of solid oxide fuel cell electrodes. He is a member of the CAChE task force developing modules that bring fuel cell technology into the traditional chemical engineering undergraduate curriculum.

**Michael E. Hanyak, Jr.**, holds a Ph.D. from the University of Pennsylvania and began teaching at Bucknell in 1974. Computer-aided engineering and courseware development have been the focal points of his professional career, and accomplishments include publications and federal grants in the area of systemic engineering education reform.

**Bill King** joined the department in 1983 and served as department chair from 1986 to 1998. His research interests are in biotransport related to cancer treatment, and he currently holds a dual appointment with the new and recently accredited Biomedical Engineering Department at Bucknell.

**Erin L. Jablonski** came to the department in 2004, following a Ph.D. from Iowa State and a post-doctoral position



*Above, Chemical Engineering's "fluids wall," circa 1950, which was dismantled during the 1984 renovation of the Dana Engineering Building. Right, students working in 1939's new unit operations laboratory.*

at NIST. Recently, she has used microfluidic techniques to study diffusion in hydrogels, and has reported on novel ways of integrating classroom and laboratory instruction through project-based design activities.

**Jim Maneval** joined the department in 1991 after completing his Ph.D. at the University of California, Davis. His research focuses on the use of NMR methods in systems of engineering interest and the development of models for transport processes in complex and multiphase materials. His teaching interests include design and applied mathematics.

**James Pommersheim** retired in 2007 after teaching in the department for more than 40 years. Early in his career he introduced the applied math and transport theory courses into the curriculum. Research leaves include time at NIST, NASA, Penn State, ExxonMobil, and Occidental. In 2005 and 2006 he taught the senior design course at Syracuse University.

**Mike Prince** came to Bucknell in 1989 after receiving his Ph.D. from U.C. Berkeley. His research examines the connection between instructional practices and student learning outcomes in engineering programs. He is co-director of the National Effective Teaching Institute and active in a number of initiatives to improve engineering education.

**Tim Raymond** began his time at Bucknell as an undergraduate in 1993 and returned in 2002 as a member of the faculty after completing his Ph.D. at Carnegie Mellon University. He is active in both research and teaching of the physics and chemistry of atmospheric aerosols, and is heavily involved in AIChE local and student sections.

**Ryan Snyder** joined the faculty in 2009, following industrial experience at Air Products, a Ph.D. from U.C. Santa Barbara, and a post-doctoral position at Eli Lilly. His research focuses on product and process design of structured (often crystalline) products, such as those commonly found in pharmaceuticals, foods, and nanomaterials.

**William J. Snyder** came to Bucknell in 1968 after completing a Ph.D. at Penn State and a post-doctoral assignment at Lehigh University. His research focuses on thermodynamics, polymer solutions, and pedagogy. His primary teaching areas include chemical reaction engineering, fluid flow, thermodynamics, and design.

**Margot Vigeant** is in her 11th year on the Bucknell faculty, and has an active research program in chemical engineering pedagogy, focusing on misconceptions in thermodynamics. She was honored with the 2009 Fahien Award from the Chemical Engineering Division of ASEE, and is spending this year as a part-time associate dean.

**Brandon M. Vogel** received a Ph.D. from Iowa State University and was an NRC postdoctoral fellow at NIST before coming to Bucknell in 2007. His teaching interests are in biomaterials, bioprocess engineering, and applied statistics, and his research focuses on the synthesis of new materials to detect, target, and treat disease.

**Katsuyuki Wakabayashi** became a member of the faculty in 2007 after his Ph.D. work at Princeton and post-doctoral position at Northwestern. His research focus in polymer hybrid processing provides for hands-on student work in both class and independent-study settings. He is currently the coordinator for the department's graduate program.


*The 29 students of Bucknell's 100th chemical engineering class (2012), with insets of the four inaugural class members (left to right, Joseph McKeague, Alexis Keen, Herman Zehner, and Hartley Powell).*

## STUDENTS AND SPECIAL ACTIVITIES

Bucknell students and faculty are engaged in many program activities beyond those associated with formal curricular and scholarly pursuits. The sampling below highlights the program's ideals regarding broad student experience and professional involvement, and its commitment to engineering education.

In 2007, Bucknell's AIChE student chapter organized and hosted its second Mid-Atlantic Regional Student Conference. One year later, they co-hosted the National Student Conference associated with AIChE's Centennial Annual Meeting in Philadelphia. Bucknell's then-student chapter president **Danielle Woodhead** was chosen to speak on behalf of the entire national student body at the black-tie Centennial Gala Banquet. AIChE selected Bucknell as an Outstanding Student Chapter for 2008-2009.

Also regarding AIChE, Bucknell's ChemE Car teams have distinguished themselves by including students from electrical and mechanical engineering and chemistry, and they recently placed first at the Mid-Atlantic regional competition in 2009. Also of note, students **Damon Vinciguerra** and **Ben Aldrich** both became heavily involved with national planning activities, and as juniors now serve as regional liaisons for AIChE representing the Mid-Atlantic and the Western regions, respectively.

During February, the engineering college at Bucknell celebrates National Engineers Week through a spirited yet lighthearted competition among its six degree programs. Many events highlight creativity outside of the technical norm, and include creation of departmental banners, poetry, and videos that often poke fun at engineering majors and their stereotypes. The chemical engineering department has won 11 times in the last 20 years of competition.

Students in the department are strongly encouraged to have a study-abroad experience while completing the degree program. In the mid 1980s, Professor (and long-serving department chair) **Robert Slonaker** was instrumental in establishing the study-abroad programs in the engineering college. Year-long and semester programs are now well established for chemical engineers, all of which allow students to finish their degree in the standard four-year time frame. Currently about 25% of our students participate in these programs during the academic year, and locations include England, Ireland, Australia, New Zealand, and Spain.

*Near right, AIChE Student Chapter President Danielle Woodhead addresses the audience at the 2008 AIChE Centennial Gala Banquet in Philadelphia. Far right, ChemE Car team members at the 2009 Mid-Atlantic regional competition. Bottom right, Professor Mike Prince at Bucknell's "How to Engineer Engineering Education" summer workshop, which draws faculty from around the country.*

Students interested in studying abroad but who choose not to pursue a semester-long program can elect a summer course called "Engineering in a Global and Societal Context." This three-week course, conducted abroad and led by a team of Bucknell engineering faculty, was modeled after a similar successful program in Bucknell's humanities division. While the course location, topical specialization, and instructors change yearly, the course's common denominator is a focus on foreign local infrastructure, economies, and culture, and how these affect engineering practice and technology policy. Typical are visits to universities, manufacturing sites, and government project locations, as well as talks from leaders of industry, government, and academia. Recent sites have included countries in both Europe and South America.

Under the direction of Erin Jablonski and funded in part through her recent grant from the National Science Foundation, Bucknell in 2008 began hosting a summer Engineering Camp for pre-college students interested in engineering. In July 2009 the camp hosted 52 students (8th – 11th grade) from eight states and the District of Columbia, and instructors included faculty from each engineering department at Bucknell. The week-long residential camp gives students a unique on-campus experience, and activities include presentations, hands-on experiments, and mini-design projects on topics ranging from nanotechnology to urban planning to biomechanics.

Bucknell has recently completed its 8th consecutive summer offering of the teaching workshop, "How to Engineer Engineering Education." The event is directed by Mike Prince with participation by several Bucknell engineering faculty including Bill Snyder, Mike Hanyak, Margot Vigeant, and Tim Raymond. It draws approximately 30 engineering faculty each year from around the country and overseas. This hands-on workshop introduces faculty to cutting-edge issues in instructional design, active learning techniques, and best assessment practices.

## SUMMARY

Bucknell's chemical engineering program was born and continues to thrive at the unique intersection of technology and the ideals of a liberal education. We look forward to continuing to build on those principles of the program founders, and the subsequent 100 years of dedication and refinement by many, as we embark upon our second century of commitment and contributions to chemical engineering education.

## REFERENCES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2.. Vigeant, M., J. Maneval, W. Snyder, M. Hanyak, and M. Prince, "Hands-On Chemical Engineering Senior Design: the Evolution from Paper to Practice," *Proceedings of the ASEE Annual Conference*, American Society for Engineering Education (2008) ❐