ChE department

University of Oklahoma

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The Sarkeys Energy Center, home of Chemical Engineering.

Oklahoma defies the stereotypes made famous in the *Grapes of Wrath*. It has the second most varied terrain of any state in the country and contains a diverse range of fauna and flora. There are pine trees, mountains, alligators, and Spanish moss in the southeast; a Nature Conservancy tall grass prairie preserve with stalks as high as an elephant's eye in the northeast; cacti and canyons at the Wichita Wildlife Preserve in the southwest; and sand dunes and salt flats in the northwest. These sights and Native American culture captivate visitors today just as they did Washington Irving, George Catlin, and Theodore Roosevelt in the past.

Located in the center of the state, Norman and the University of Oklahoma (OU) lie 17 miles to the south of Oklahoma City. It has a lovely, 2000-acre campus covered with trees, flowers, fountains, and sculpture. There are 28,000 students from all 50 states and 108 foreign countries. Notable features of the University include the outstanding De Gollyer History of Science book collection, a leading meteorology program, the Neustadt Prize ("American Nobel" in international literature), the Weitzenhoffer Collection of Impressionist and Post-Impressionist Art, the Sam Noble Natural History Museum, and one of the top sites for sequencing of the human genome. On an absolute and per capita basis, the University regularly ranks among the top comprehensive, publicly supported institutions in number of National Merit Scholars.

Unprecedented growth has taken place under the dynamic leadership of President David L. Boren, a Rhodes Scholar and former U.S. Senator. The growth is evident in ongoing construction projects on the campus totaling hundreds of millions of dollars. Recent speakers on campus have included such dignitaries as Mikhail Gorbachev, Margaret Thatcher, and Desmond Tutu.

Located in a temperature and humidity-controlled floor of the main library, the De Gollyer History of Science collection (an 85,000-volume collection that includes books by Agricola, Galileo, Newton, and Darwin) is unique. Of the many volumes by Galileo in the collection, four are first editions containing Galileo's handwriting, including his own personal copy of *Dialogue Concerning Two Chief World Systems* (1632); this copy contains his margin notes for a never-published second edition.

The University of Oklahoma was founded in 1890—one year after the famous land run opened up Oklahoma for settlement. Its educational programs developed at the same time that chemical engineering was becoming a discipline, and with Oklahoma situated in the oil- and gas-producing region of the country, the chemical engineering discipline found fertile ground at OU.

Chemical engineering at OU (now the School of Chemical Engineering and Materials Science, or CEMS), enjoys a long and rich tradition. What chemical engineer hasn't used McGraw-Hill's *Perry's Chemical Engineers' Handbook*, probably the best-known title in chemical engineering? Robert H. Perry, editor of the fourth through sixth editions (and son of the original editor, John H. Perry), taught chemical engineering at OU from 1958-1964 and served as the department director from 1961-1963. Don Green, the current editor of the *Handbook*, received his PhD at OU under Perry's supervision.

Another chemical engineering standard, *Transport Phenomena*, was reviewed prior to publication by Jack Powers and undergraduates at OU in the late 1950s. Most chemical engineers know the BWRS equation, Ken Starling's modification of the Benedict-Webb-Rubin equation of state, for light hydrocarbon calculations, or the Carnahan-Starling hard sphere modification of the van der Waals equation of state. Those in the natural gas processing industry are familiar with the accomplishments of Laurance "Bud" Reid (the Laurance Reid Gas Conditioning Conference, held every year at OU since 1950, is the premier conference for the gas conditioning industry). Cheddy Sliepcevich has been dubbed "the Father of LNG" for his work on the first LNG carrier, the S.S. Methane Pioneer. Starling, Reid, and Sliepcevich were all long-time CEMS faculty.

The self-contained college town of Norman (population 100,000) is close enough to Oklahoma City to be considered a suburb of that city. The advantages of this city of 1 million are easily accessible. For example, Oklahoma City recently completed a $200 million dollar renovation of its historic Bricktown area, which now includes a navigable canal, restaurants, hotels, an art museum, a minor-league ballpark, a performance center, and a convention center. There is even scull racing on the nearby river.

THE DEPARTMENT BY THE NUMBERS

The ChE department has space in the Sarkeys Energy Center, a 400,000 square-foot academic building that has a 2.5 acre footprint and a 15-story tower. The building was completed in 1989 and has exceptional laboratory, office, and teaching facilities. Presently, there are 15 full-time faculty, 6 postdocs, 242 undergraduates, and 54 graduate students. Our diverse funding comes from NSF, NIH, DOE, DOD, American Heart Association, other federal and State agencies, and industry. In the last several years, our undergraduate students have consistently won prizes at regional AIChE conferences. Our classes are about 38% female, 7% Hispanic, 10% Native American, and 9% African American

. . . our department has shared in the excitement and turmoil of new areas such as bioengineering and nanotechnology. We have wholeheartedly embraced these new areas as natural extensions of chemical engineering, a discipline that is probably the broadest and strongest of all the engineering disciplines.

CHRONOLOGY OF OU DEPARTMENT

1910	Chemical engineering program was established as part of Chemistry Department
1913	First BS in ChE awarded to Albert Edward Gartide
1918	First masters degree in ChE awarded to Roy Clyde Mitchell
1937	Chemical engineering becomes part of College of Engineering with R.L. Huntington as head of Chemical Engineering
1943	First BS awarded to a woman (Freda Meyer)
1955	Cheddy Sliepcevich leaves Michigan to become chairman of chemical engineering; renewed emphasis on graduate program as well as undergraduate program
1961-63	Robert Perry (of Perry's Handbook) is chairman of department
1980-86	Carl Locke is department head. In a two-year period he hires Harwell, Scamehorn, O'Rear, Mallinson, and Shambaugh
1986	Department moves to newly-constructed Sarkeys Energy Center
2004	Stephenson Research Center nears completion; the building will provide additional space for bioengineering research

Undergraduates are very active in the student AIChE chapter, the regional AIChE competitions, and in the campus Engineers Club, and the graduate students have an active organization, the OU CHEGS. As far as student-faculty interactions, it is rare not to see a row of open doors in the faculty hallways—no appointment is necessary! A year-end highlight is the AIChE faculty/student roast, during which the faculty and students make good fun of each other.

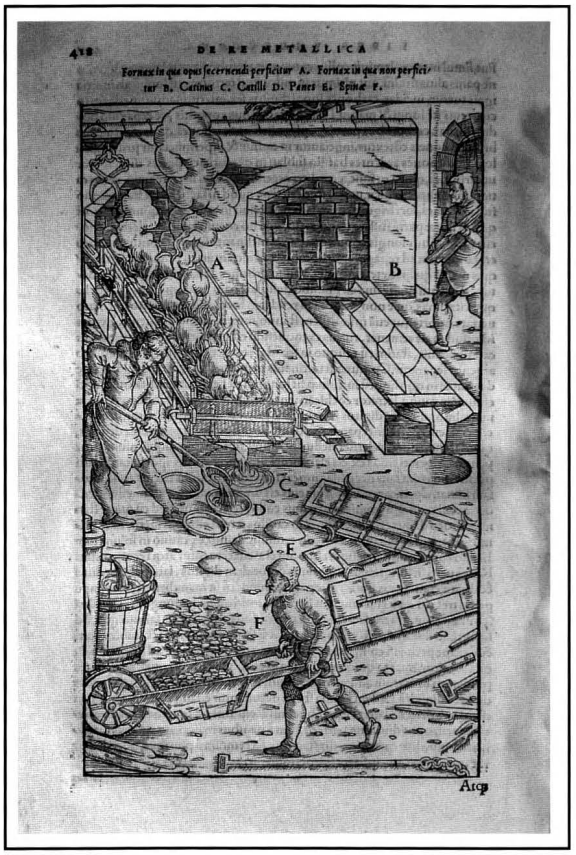
THE INDUSTRY-ACADEMIC CONNECTION

The department values and nurtures its relationships with industry. Past industrial experience is considered to be a valuable (although not required) asset for a prospective faculty candidate. Presently, 50% of the faculty have worked in industry. Also, all of the faculty have, or have had, industrial support for their research. The departmental faculty have 28 active patents, some of which are licensed to industry.

In 1987, the department negotiated with the University for the establishment of two industrial consortia. At the time, these consortia were unique to the University and, for that matter, to universities in general. For an established annual fee, the consortia gave the sponsoring companies access to research, access to prospective employees, and royalty-free rights to any university patents developed by the consortia. Both of these consortia are still in existence. The larger, the IASR (Institute for Applied Surfactant Research), does ground-breaking, applied research for the detergent, petroleum, health-care, and many other industries. The smaller, the CPFR (Center for Polymer and Fiber Research), concen-

trates on high-value fiber technology for use in nonwovens and composites. Over 35 Fortune 500 companies have been members of these consortia. More consortia have recently developed in the department, and the present dean in the College of Engineering (Skip Porter) has greatly furthered the cause of the industry-academic connection.

The department's industrial advisory board (OKChE), active since 1969, has served as a model for the development of similar boards in other departments of the College of Engineering. Program review, fundraising, student mentoring, and senior exit interviews are among the many valuable tasks they perform. Presently, Robert Purgason (Vice President, Williams Petroleum) is the board's president, and Larry Evans (CEO and founder, Aspen Technology) is the board's vice president.



A unit operations laboratory in the* really *old days. This is a page in Agricola's De re Metallica (1556) from the University of Oklahoma's "History of Science" Collection.

RESEARCH AREAS

Presently, the department has research strengths in bioengineering, nanotechnology, catalysis, turbulent transport, process optimization, fuels, surfactants, and polymers. In the bioengineering area, the department's history spans at least four decades. There was early work on an artificial liver, on artificial blood, and on confirmation of mass transfer correlations for large biomolecular species. Current research ranges from tissue engineering to approaches for treating cancer, heart attack, and stroke. At the turn of the millennia, faculty members in CEMS helped spearhead an initiative to coalesce diffuse activity in bioengineering across the College. Engineers teamed with biomedical scientists from the Oklahoma Medical Research Foundation (OMRF) and the Norman and Health Sciences Center campuses of the University of Oklahoma to write a successful application for a Special Opportunity Award from the Whitaker Foundation. As a result of growth sparked by this grant, 40% of the CEMS faculty now has research in bioengineering.

With highly regarded researchers in adhesion molecules and glycobiology and as one of the top five sites for the sequencing of the human genome, the University of Oklahoma has much to offer in tissue engineering (two of our new hires work in tissue engineering). In the fall of 2004, the bioengineering faculty will expand into the new Stephenson Research and Technology Building on the south campus. This building brings together researchers on the Norman campus in microbiology, zoology, biochemistry, and bioengineering.

In nanotechnology, one of our faculty (Resasco) has started a company for the manufacture of single-wall carbon nanotubes. This company, SWeNT (Southwest Nanotechnology) uses Resasco's patented Co-Mo catalyst system for producing nanotubes of unusual purity and selective chirality. Resasco's company presently provides nanotubes to more than 15 industrial giants, including three Fortune 50 companies.

Miguel Bagajewicz is director of the Center for Engineering Optimization. The main focus of this consortium is the development of new design methods to minimize overall cost. Other goals include the minimization of the energy consumption, the prevention of pollution, and the minimization of waste generated. Since doing research in this field requires strong relationships with industry, the students work on problems of practical interest.

In fuels, the department has a long history of research in natural gas, petroleum, and coal. Recent work involves natural gas storage, hydrogen production and storage, fuel cells, and other alternative energy sources.

As discussed above, research in the department's other two areas—surfactants and polymers—is heavily involved with two industrial consortia.

FACULTY

Recent faculty hires have greatly strengthened the department's bioengineering effort. Traditional strengths are not being short-changed, however. In fact, we contemplate growth in non-bio areas.

Vassilios Sikavitsas joined the department as an assistant professor in 2002. A native of Thessaloniki, Greece, he received his PhD in 2000 from SUNY Buffalo. Vassilios then did a postdoc at Rice University where his work with Tony Mikos on bone led to the discovery that shear stress promotes cell differentiation (marrow stromal cells to osteoblasts). Such results are important in preparing tissues and organs in the

A more modern laboratory scene than the one shown on the facing page. Graduate students Olga Rueda and Jose Herrera are shown operating the XPS in Resasco's well-equipped catalysis laboratory

Professor Cheddy Sliepcevich with a model of the S.S. Methane Pioneer, the first LNG carrier, which was developed at OU.

laboratory on a time scale feasible for clinical use. He has become somewhat of a star in the newspapers and on local TV, where his research on bone constructs using synthetic scaffolds provides visibility to the growing activity in bioengineering in the department.

Peter McFetridge also joined the department as an assistant professor in 2002. He was born in Rotorua, North Island, New Zealand (he is a "Kiwi"), and he captivates everyone with stories of his home country. He, like several others in our department, conducts research in tissue engineering, but with an emphasis on the production of vascular grafts that he began studying while receiving his PhD under the direction of Julian Chaudhuri and Mike Horrocks at the University of Bath. Pete's approach uses natural scaffolds prepared by decellularization of blood vessels isolated from umbilical cords. Recent results in his lab show promise for fully automating the dissection protocols, which has vastly improved the mechanical uniformity of these natural vascular constructs. Pete's background reads like a storybook. In one past job, he worked in the New Zealand hills laying high-pressure gas lines (in the beautiful locale where *Lord of the Rings* was filmed). After a list of other activities, including motorcycle racing and resultant broken legs, he left for the UK and took a job driving a dust cart, a 32-ton lorry (truck) used to transport industrial waste (and to pay for his European excursions).

David Schmidtke, who was born in Sheboygan, Wiconsin, became an assistant professor in the department in 2000. After receiving his PhD from the University of Texas at Austin (1997), he did postdoctoral studies at Penn with Scott Diamond. Although we did not know it at the time of his hiring, Dave already had an Oklahoma connection—his grandfather was the pastor of a Lutheran church in Oklahoma City fifty years ago. For his research, David focuses on the phenomenon of tether formation during leukocyte (white blood cell) adhesion, biosensors for diabetes, and microfluidics. His addition to the faculty builds on existing expertise in cell adhesion with Ulli Nollert and Rodger McEver, the Lilly Chair at the OMRF (Oklahoma Medical Research Foundation).

Dimitrios V. Papavassiliou joined the department as an assistant professor in 1999. A native of Karditsa, Greece, he received his PhD in 1996 from the University of Illinois at Urbana-Champaign. After receiving his degree, he gained valuable real-world experience as a Senior Research Engineer at the Mobil Technology Company Upstream Strategic Research Center in Dallas, TX. His research focus is on the fundamental understanding and modeling of transport processes with industrial and environmental interest. His group develops novel computational methods that are applied to explore turbulent transport of mass and heat, reactive flows, turbulent jet flows, turbulent drag reduction, and flow and transport through porous media. High Performance Computers are used to conduct the numerical experiments and to interpret the data.

Miguel J. Bagajewicz joined the department in 1995. A native of Buenos Aires, Argentina, he received his PhD from Cal Tech in 1987. Prior to coming to OU, he was a Staff Associate Member, Argentine National Research Council (Conicet) (1980-91), an Associate Professor at the Universidad Nacional del Litoral, Argentina (1987-91), a Senior Engineer with Simulation Sciences (SimSci) (1992-95), and a Visiting Professor at UCLA (1995). His experience at SimSci has been particularly valuable for integration into his teach-

ing of the capstone design course. As director of the Center for Engineering Optimization at OU, his research has focused on the design, operation, simulation, and optimization of process plants. In the area of process operation, his group focuses on data reconciliation technology. Since plant data are corrupted by noise and instrument malfunction, data reconciliation is used to filter this information.

Brian Grady, a Chicago native, joined the department in 1994 after receiving his PhD from the University of Wisconsin-Madison. He gained real-world experience as a Project Engineer with Procter and Gamble (1987-89) prior to attending graduate school. His awards include an NSF CAREER Award (1998) and an Alexander von Humboldt Research Fellowship (2000). The latter was awarded for a year's stay at the Max Planck Institute for Colloid and Interface Science near Berlin. Brian's research is focused on polymer systems with two different emphases: polymer systems with two different components such as polymer-matrix composites or phase separated copolymers, and polymer or surfactant nanostructures at solid-liquid interfaces. He is a Councilor for the Society of Plastics Engineers and serves on the Board of Directors in the Engineering Properties and Structure Division of that same organization.

Daniel Resasco, a native of Bahia Blanca, Argentina, joined the department in 1993. He received his PhD from Yale (1984) and has previous academic experience as a Professor (and Chairman for part of his stay) in the Chemical Engineering Department at Universidad Nacional de Mar del Plata (1983-90). He also served as a Visiting Professor at Yale University (1986-87, 1991). He received industrial experience as a Senior Scientist, Sun Company, Inc., Pennsylvania (1991-93). Recently (2001), he became an Associate Editor of the Journal of Catalysis. In his research in the area of heterogeneous catalysis he seeks to understand the relationship between the catalytic performance and the microscopic structure and composition of the material, in addition to the links between the synthesis process and the final catalyst. His work is applicable to industrial processes such as isomerization and dehydrogenation of lower alkanes, aromatization of paraffins, and nitration of aromatics. Another important application of his studies is in the area of environmental catalysis for the abatement of NO_x in the presence of O_2, H_2O, and SO_2. In the last few years, his work has progressed to an area of high impact and visibility—the controlled catalytic synthesis of carbon nanotubes in processes that can be scaled-up.

Matthias (Ulli) Nollert received his PhD from Cornell in1987. Although he was born in Luray, Virginia, his parents are from Germany. He joined the department in 1991 after a postdoc at Rice University. Ulli's work emphasizes the adhesion molecules in platelets and white blood cells and the measurement of adhesion forces. Leukocyte adhesion to the endothelial cells lining the blood vessels of the body is a key step to white blood cell function and the process of inflammation. There is good evidence that changes in blood flow characteristics may lead to the development of vascular disease. Only by studying vascular cells in a flowing system that closely mimics the environment found in the blood vessels can one truly understand how these cells behave in the body and why vascular disease occurs. His group is currently examining alterations in protein production in blood vessel wall cells that are exposed to fluid flow.

Roger Harrison received his PhD from the University of Wisconsin-Madison (1975) and came to OU in 1988. He is our "local" professor—he was raised in Altus, in the southwestern section of the State. Roger has a vast amount of industrial experience as a Research Engineer with Chevron Research (1968-70), a Research Scientist with Upjohn (1975-81), and as a Senior Research Engineer with Phillips Petroleum (1981-88). He designs hybrid proteins that are produced in *E. coli* using the techniques of gene insertion and expression. Around these methods, he has developed strategies for targeted cancer agents and for improved solubility and purification of expressed protein. For cancer, the hybrid or "fusion" protein contains a component selective for a tumor cell and a portion that will cause cell death. Fusion proteins for improved separations use a highly soluble species linked to the target molecule. Roger has recently published a textbook titled *Bioseparations Science and Engineering* (with P. Todd, S.R. Rudge, and D. P. Petrides). This well-written book fills an important need for a textbook on bioseparations. The text was first made available for adoption in courses for the spring 2003 semester. The text has already been adopted for use in courses at thirty universities, including Carnegie-Mellon, Princeton, Cornell, Imperial College (London), and Ohio State.

Lance Lobban, a native of McPherson, Kansas, received his PhD from the University of Houston in 1987 and came to OU the same year. As Director of our department, he has been instrumental in guiding us into the new millennium. His research focuses on catalysis and reaction engineering. His group studies gas phase reactions at temperatures up to 800°C, liquid phase reactions at room temperature and below, and reactions in presence of a strong electric field. One very active project is an investigation of methane oxidative coupling under a variety of conditions including cold plasma conditions and on different catalysts. A second project involves the synthesis and use of novel TiO_2 aerogels and binary SiO_2-TiO_2 aerogels as photocatalysts. The unique properties of these aerogels are hypothesized to allow more efficient use of UV light to activate the photocatalysts for the complete oxidation of air and water contaminants. Not only is Lance an outstanding director and researcher, but he also continues to maintain a teaching load. And he teaches extremely well—the students just gave him an outstanding professor award—for the fourth time!

Robert Shambaugh, a native of Youngstown, Ohio, came to OU in 1983. He received his PhD from Case Western Re-

serve (1976). Prior to coming to OU he gained nine years of industrial experience at Du Pont. Besides tours at two plant sites, he spent most of this time at the Experimental Station in Wilmington, Delaware. At OU, he has been heavily involved in the aforementioned CPFR, an industrial consortium that works in the fibers area. His research group is particularly interested in melt blowing, a process wherein a high-velocity gas stream meets a stream of molten polymer as the polymer exits a fine capillary. The result of this impact is that the polymer rapidly (in about 50 microseconds) attenuates into fiber strands as fine as 0.1 micron in diameter. Extremely interesting and potentially very strong crystal structures are formed under these high strain rate conditions.

Richard G. Mallinson, a native of Indianapolis, Indiana, came to OU in 1983. He received his PhD from Purdue (1983). He was Director of the Institute for Gas Utilization Technologies of the Sarkeys Energy Center from the mid-90s until 2003. He was integrally involved in the development of a curriculum for a new interdisciplinary Masters degree program in Natural Gas Engineering and Management that includes internet-based courses via streaming video and netmeeting. Rick's research involves the many aspects of energy and fuels. His energy-related research, which began with studies of coal and shale oil liquefaction, has more recently focused on natural gas conversion and gas vehicle fuel storage and gas transportation. These studies emphasize the understanding of the chemical and physical processes underlying observable thermodynamic and rate behavior. The efforts are directed toward applications of reaction engineering and other chemical process operations, including process development. Rick has also developed projects related to polymerization and catalytic reaction engineering.

Edgar O'Rear came to OU in 1981 after receiving his PhD from Rice. A native of the Appalachian hill country of Jasper, Alabama, Ed explains that in his hometown the term "runner" does not necessarily refer to someone who likes to jog. Ed has gained valuable experience in Japan as a Visiting Senior Researcher with Hitachi Central Research Laboratory (1988) and as a Visiting Scientist at RIKEN, the Institute for Physical and Chemical Research (1992). He was also Program Director, Interfacial, Transport and Separations Program, National Science Foundation (1993-94). Ed is currently the President of the International Society of Biorheology. As the Director of the University of Oklahoma Bioengineering Center, he has been a tireless driving force behind the bioengineering program at OU. Work in Ed's laboratory involves polymeric encapsulation of clot-busting drugs or plasminogen activators for heart attack and stroke. Recent results have elucidated the mechanism of accelerated thrombolysis, yielding as much as an order of magnitude reduction in the time for reperfusion with these agents and demonstrating a unique mode of action for a polymeric drug delivery system. Ed's other research interests include admicellar polymerization and novel surfactants.

Jeffrey H. Harwell, a native of Texas, arrived at OU in 1982. He received his PhD at the University of Texas at Austin (1983). Jeff's research concerns the use surfactants in controlling interfacial properties in engineering systems. His research ranges from environmental remediation (in-situ ground water remediation and ex-situ soil washing), to polymer composites (modification of silica fillers and reinforcers by admicellar polymerization), to the use of surfactants in creating novel adsorbents and catalysts. Applications of this research range from field tests of remediation technologies at hazardous waste sites, to new tire treads, disk drive lubricants, natural-gas-fueled vehicles, and indoor air decontamination. Jeff presently serves as Executive Associate Dean in the College of Engineering, but he still finds time to maintain an active research program and teach some classes. Jeff has an interesting, multi-talented background—prior to receiving his PhD, he received a divinity degree.

John Scamehorn, a native of Nebraska, arrived at OU in 1981. He received his PhD at the University of Texas at Austin (1980). His industrial experience includes time as a Research Engineer with Conoco (1974-77) and a Research Engineer with Shell Development (1980-81). Here at OU, he is the cofounder and Director of IASR (Institute for Applied Surfactant Research). Among his many other activities, he is Chair of the Surfactants and Detergents Division of the American Oil Chemists' Society. A primary area of his surfactant research is the use of surfactants in novel separation techniques for the cleanup of polluted wastewater, groundwater, and air streams. One approach he has taken is to dissolve surfactants in water under conditions in which contaminants associate with surfactant aggregates, which are easy to ultrafilter from solution in a subsequent step. Another technology he has developed is the use of surfactants to regenerate spent activated carbon beds. In addition, he also investigates the solution properties of surfactants relevant to improving detergent formulations.

THE FUTURE

We are now in the 21st century, and the department is only a few short years from celebrating its centennial in 2010. Like many other chemical engineering departments, our department has shared in the excitement and turmoil of new areas such as bioengineering and nanotechnology. We have wholeheartedly embraced these new areas as natural extensions of chemical engineering, a discipline that is probably the broadest and strongest of all the engineering disciplines. At the same time, we have not neglected our traditional departmental—and chemical engineering—strengths in such areas as transport phenomena, thermodynamics, and reaction engineering. Only by maintaining these strengths can we survive as a viable discipline whose graduates are sought by a wide diversity of employers. ❐