Singapore–MIT Alliance

The Singapore–MIT Alliance (SMA) is a global partnership in graduate education between MIT, National University of Singapore (NUS), and Nanyang Technological University (NTU). The goals and aims of SMA are threefold:

- To set a new standard for international collaboration in graduate research and education
- To invigorate engineering education in Singapore
- To strengthen MIT through extension of its global impact, enhancement of its curriculum, and improvement of its infrastructure

History of the Alliance

SMA was initiated January 1, 1999, with the first two of its five programs, Advanced Materials for Micro- and Nano-Systems (AMMNS) and High Performance Computation for Engineered Systems, beginning July 1, 1999. A third program, Innovation in Manufacturing Systems and Technology, was introduced the following July, and the last two programs, Molecular Engineering of Biological and Chemical Systems (MEBCS) and Computer Science (CS) were introduced in July 2001. Each program has completed its five-year term, with CS and MEBCS concluding their terms on June 30, 2006.

In March 2003, MIT signed a memorandum of understanding to enter into the second phase of SMA. Internally, we refer to this as SMA-2.

In response to a request for proposals, 11 MIT and Singapore teams submitted plans for participation in SMA-2; four proposals were selected to start in July 2005 and another will start in July 2006. SMA-2 allows students to obtain a dual (not joint) degree: a master's degree from MIT and a master's degree from either NTU or NUS, or a PhD from either NTU or NUS.

SMA-2 is characterized by greater collaboration in both research and teaching with increased and significant participation by the Singaporean partner universities. SMA-2 continues to refine face-to-face and extensive distance interactions to create and sustain a close and pervasive relationship between the core faculties and students. Forty-nine MIT faculty members now participate in the SMA-2 program.

Students in SMA-2 are in residence at MIT for one semester and in Singapore for the second semester. While in Singapore, students take MIT classes for MIT credit at a distance.

SMA-2 offers graduate degrees in four engineering disciplines and one life science discipline. The programs and their host departments or hosting academic units are:

- Advanced Materials for Micro- and Nano-Systems (AMMNS)—the MIT host department is Materials Science and Engineering

- Chemical and Pharmaceutical Engineering—the MIT host department is Chemical Engineering
- Computational Engineering—this program has interdepartmental host support within the School of Engineering
- Computation and Systems Biology—the MIT host program is the Computational and Systems Biology Initiative
- Manufacturing Systems and Technology—the MIT host department is Mechanical Engineering

SMA-2 Graduate Fellowships

A unique feature of SMA-2 is that students accepted into the program receive an SMA-2 graduate fellowship, which provides full tuition at MIT and at either NUS or NTU, a monthly stipend, travel to MIT, and a monthly housing allowance when in residence at MIT.

SMA-2 2006–2007 Class

A total of 343 applications were received for SMA-2 graduate fellowships. Of the 343 applicants, 103 were offered a fellowship and 60 accepted.

The eligibility criteria are stringent for admission to the programs in the SMA-2 Program of the Alliance Universities. Applicants must be admitted separately and independently to MIT and to either NUS or NTU; then and only then will a student be considered for a SMA graduate fellowship. The MIT admissions review is done by the hosting academic units using the same criteria and procedures applied to any other applicant for graduate study at MIT.

Distance Learning

MIT's Academic Media Production Services (AMPS), under the direction of executive director Amitava Mitra, provides the technology support for SMA's distance learning activities. Each year, a service agreement and a corresponding budget are developed between SMA's leadership and AMPS. The SMA staff works closely with AMPS staff in selecting modes of operation and necessary equipment through a joint SMA Distance Education Working Group. This group assisted with recommending the distance learning equipment that is currently used in 1-390, 3-370, and 8-404 and in the three SMA research interaction rooms.

SMA-2 Program Descriptions

Advanced Materials for Micro- and Nano-Systems

The AMMNS degree program offers a comprehensive and intensive approach to a field of study that is rapidly defining the frontier of modern technologies. Students are exposed to the broad foundations of advanced materials that encompass processing, structure, properties, and performance, with an emphasis on applications in microelectronics and emerging nanotechnologies. Fundamental understanding of the structure and properties of materials, coupled with system-driven design, fabrication, and optimization of materials, make up the core of the multidisciplinary coursework that prepares students to lead in the development and exploitation of new materials for future micro- and nano-systems. The AMMNS degree program also promotes a practice-based understanding of the paths through which critical advances in the fundamental science and engineering of materials affect, and often pace, the rapid evolution of information processing, communication, and sensing technologies, especially those based on systems of micro- and nano-scale devices.

AMMNS graduate study provides an exceptional opportunity for collaborative research between SMA students, world-renowned faculty, and industry experts, both in Singapore and in the United States. Students have the opportunity to interact with scientists and engineers at a number of research institutes, such as the Institute of Materials Research and Engineering and the Institute of Microelectronics, as well as all three university partners—NUS, NTU, and MIT.

The MIT chair of the AMMNS program is Professor Carl V. Thompson. Faculty members involved include Dimitri A. Antoniadis, W. Craig Carter, Gerbrand Ceder, Eugene A. Fitzgerald, Nicola Marzari, Caroline Ross, Henry I. Smith, Francesco Stellacci, and Subra Suresh.

Computational Engineering

The Computational Engineering degree program is collaborative between MIT, NUS, NTU, and the Research Institutes for Microelectronics, High Performance Computing, and Defense Medical Environment. It is one of the most technologically advanced and critically acclaimed computational engineering programs available in the world today.

Intensive computation for simulation and optimization has become an essential activity in both the design and operation of engineered systems, where the terminology "engineered systems" includes (but goes well beyond) complex systems in engineering science (micromachined devices, guidance/control systems, imaging systems) as well as manmade systems (distribution networks, telecommunications systems, transportation systems) for which simulation, optimization, and control are critical to system success. In applications as diverse as aircraft design, materials design, and micromachined device design/optimization engineers need computationally tractable modeling systems that predict and optimize system performance in a reliable and timely manner. Effective computation allows for shorter design cycle times, better product quality, and improved functionality. One cannot overstate the importance of computational engineering and optimization in the global industrial economy, particularly as the systems we use grow more necessary and more complex (cellular telephone telecommunications systems, the electric power grid, the internet, air transport systems). Revenues from simulation and optimization software products for such systems are only in the billions of dollars, but the overall economic impact of these tools is trillions of dollars. Substantial improvements in numerical methods and dramatic advances in computer hardware have generated vast opportunities for computational engineering. We expect that the next decade will experience explosive growth in the demand for accurate and reliable numerical simulation and optimization of engineered systems. Computational engineering will become even more multidisciplinary than in the past, and a myriad of technological tools will be integrated to explore biological systems and submicron devices, which will have a major impact on our everyday life.

The customized numerical algorithms in the latest generation of commercial engineering design software points to a significant trend: researchers and professionals in computational engineering will need a strong background in sophisticated numerical simulation *and* optimization, but they must also be skilled in marrying the application formulation to the numerical methodology. In addition, the ever-accelerating rate at which new technology becomes available is generating an additional demand that computational engineers be discipline-flexible in their skills. Finally, the Computational Engineering educational program combines applied general methodology courses, discipline-specific electives, and industrial experience in a way that, in parallel, trains professionals for industry while preparing doctoral students to participate in the flagship and interuniversity research projects.

The Computational Engineering educational program is focused on educating the professionals who will model, simulate, optimize, and design the important engineered systems of the next decade.

The MIT chair of the Computational Engineering program is Professor Jaime Peraire. Faculty members involved include Dimitris J. Bertsimas, Alan Edelman, Robert M. Freund, Nicolas Hadjiconstantinou, Jongyoon Han, Thomas Magnanti, Pablo Parrilo, Anthony Patera, Georgia Perakis, Gilbert Strang, Joel Voldman, Jacob K. White, and Karen Willcox.

Chemical and Pharmaceutical Engineering

The Chemical and Pharmaceutical Engineering degree program offers a cutting-edge curriculum in the fields of molecular engineering and process science focused on the pharmaceutical industry. It provides a unique opportunity to obtain a dual MS degree—one from NUS and one from the Chemical Engineering Practice program of the Chemical Engineering Department at MIT. The dual degrees can be completed in three academic terms of coursework and an additional term of industrial internship. The industry internship at a practice school station is in lieu of a research thesis of a conventional master's degree program. This program comprises innovative courses of study that integrate a molecular-level understanding of biological and chemical phenomena with advances in process engineering for the pharmaceutical and fine chemical industries. Coursework presents advanced engineering concepts that unite multiple-length scales at the molecular, microscopic, and macroscopic levels through a close coupling of biological and chemical sciences. Students are exposed to state-of-the-art concepts in bioprocess engineering, biocatalysis, biochemical engineering, nanostructured catalyst design and organic synthesis, molecular engineering, molecular principles of colloidal and interfacial engineering, and metabolic engineering.

The MIT chair of Chemical and Pharmaceutical Engineering is Professor Bernhardt Trout. Faculty members involved include Stephen Buchwald, Patrick Doyle, T. Alan

Hatton, Kristala Jones Prather, Kenneth A. Smith, Gregory N. Stephanopoulos, and Daniel I. C. Wang.

Manufacturing Systems and Technology

The Manufacturing Systems and Technology degree program is a comprehensive education and research effort concentrating on enabling manufacturing systems and technologies for emerging industries in a global context. We define emerging industries as those based on new technologies that are just beginning to be considered for commercialization. Currently, this includes a host of new concepts in micro- and nanotechnology such as molecular diagnosis, advanced drug screening, new ideas for photonic devices, microrobots, nano-scale optical devices, and a multitude of potential products employing micro- and nano-scale fluidics. At the commercial manufacturing level, these industries will be characterized by micron-scale product dimensions, high value added, extreme quality requirements, mass customization, time-sensitive distribution, and entirely new business structures. In the immediate time frame, our research will focus on an emerging industry that is now at the point of large-scale commercialization—namely, microfluidic devices for chemical, biomedical, and photonic applications. While specific in nature, we also believe the manufacturing issues for this emerging industry will have manufacturing process, systems, and business issues in common with many other yet-to-emerge industries, such as fluidic device computation, advanced drug delivery systems, and advanced health maintenance systems. Our research themes focus on critical issues enabling high-volume, low-cost, high-quality products in the emerging industries of micro- and nano-manufacturing.

The MIT program chair of the Manufacturing Systems and Technology program is Professor David E. Hardt. Faculty members involved include Lallit Anand, Duane Boning, Jung-Hoon Chun, Jeremie Gallien, Stephen Graves, David Simchi-Levi, Todd Thorsen, and Kamal Youcef-Toumi. Senior Research Scientist Stanley Gershwin also participates.

Computational and Systems Biology

The Computation and Systems Biology (CSB) degree program is a partnership between the world-recognized CSBi program at MIT and the visionary biology, bioengineering, and biotechnology programs at NUS, NTU, and the A*STAR Research Institutes.

Students with backgrounds in biology (with strong math skills), physics, chemistry, mathematics, computer science, or engineering are encouraged to apply. Students must be attracted to the interdisciplinary nature of the CSB degree program and have a strong interest in systems and computational approaches to stem cell and tissue biology. Students accepted into the CSB track take a selection of modules offered in Singapore and MIT, including five MIT/CSBi courses beamed live from MIT—a signature feature of the high degree of integration between the Singapore and the MIT/CSBi PhD courses. The CSB program courses cover topics in computational biology, systems biology, genomics, proteomics, and imaging theory and technology, some of which are team-taught by faculty members from Singapore and MIT. As part of the CSB degree program, concepts emphasized in the classroom are applied in research projects that are tightly linked to the education program.

CSB research projects focus on the development of advanced technologies in biological probes, imaging, and computational biology and application of these technologies to medically relevant problems in tissue biology, including stem cell differentiation, tissue morphogenesis, infectious disease models, and tissue physiology.

The MIT program chair of the CSB program is Professor Paul Matsudaira. Faculty members involved include Jianzhu Chen, C. Forbes Dewey, Harvey Lodish, Peter So, Subra Suresh, Roy Welsch, and Jacob White.

Professor Steven Lerman
Acting Codirector

More information about the Singapore–MIT Alliance can be found at http://web.mit.edu/SMA/.