Singapore–MIT Alliance

The Singapore–MIT Alliance (SMA) is a global partnership in graduate education between MIT, the 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 the extension of its global impact, the enhancement of its curriculum, and the improvement of its infrastructure

History

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

In March 2003, MIT, NUS, and NTU signed a memorandum of understanding to enter into a second phase of SMA. Within the alliance, 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 a fifth to 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, a master's degree from MIT plus a PhD from either NTU or NUS, or a PhD from either NTU or NUS.

SMA-2 is characterized by substantial collaboration in both research and teaching, with increased and significant participation by the Singapore partner universities. SMA-2 continues to refine face-to-face and distance interactions to create and sustain a close relationship between the core faculties and students. Students in SMA-2 are in residence at MIT for at least one semester and in residence in Singapore for the balance of their time in the program. While in Singapore, students take MIT classes at a distance for MIT credit. Fifty MIT faculty members now participate in the SMA-2 program.

SMA-2 offers graduate degrees in four engineering disciplines and one life science discipline. The programs and their respective 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 (CPE)—the MIT host department is Chemical Engineering
- Computational Engineering (CE)—this program has interdepartmental host support within the School of Engineering
- Computation and Systems Biology (CSB)—the MIT host department is Biological Engineering
- Manufacturing Systems and Technology (MST)—the MIT host department is Mechanical Engineering

Graduate Fellowships

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

Class of 2010–2011

Four of the five SMA-2 programs (AMMNS, CE, CSB, and MST) accepted students to their final classes, 2009–2010. The fifth program, CPE, accepted 15 students to the 2010–2011 class. All five programs continue their engagement with PhD students.

Criteria for admission to the programs in SMA-2 are stringent. Applicants must be admitted separately and independently to MIT and either to NUS or to NTU; only then will a student be considered for admission to SMA-2 and for a 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) provides the technical 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 recommended the distance learning equipment that is currently used in the 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 frontiers of modern technologies. Students are exposed to the foundations of advanced materials, encompassing processing, structure, properties, and performance, with an emphasis on applications in microelectronics and emerging nanotechnologies. Fundamental understanding of the structure and properties of materials and of the system-driven design, fabrication, and optimization of materials constitutes 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 fundamental science and in materials engineering affect, and often pace, the rapid evolution of information processing, communication, and sensing technologies, especially those based on systems of micro- and nanoscale devices.

AMMNS graduate study also 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 with NUS, NTU, and MIT faculty.

The MIT chair of the AMMNS program is Carl V. Thompson. Faculty members involved include Dimitri A. Antoniadis, Karl Berggren, Yet-Ming Chiang, Eugene A. Fitzgerald, Nicola Marzari, Caroline Ross, Henry I. Smith, Francesco Stellacci, and Subra Suresh.

Computational Engineering

The CE degree program is a collaboration between MIT, NUS, NTU, and the Institute of Microelectronics, the Institute of High Performance Computing, and the Defense Medical and Environmental Research Institute. It is one of the most technologically advanced computational engineering programs available today.

Intensive computation for simulation and optimization has become an essential activity in the design and operation of engineered systems. "Engineered systems" includes (but goes well beyond) complex systems in engineering science (e.g., micromachined devices, guidance/control systems, imaging systems) as well as man-made systems (e.g., 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 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, especially as the systems we use grow both more necessary and more complex (e.g., 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 in the 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 see 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 myriad technological tools will be integrated to explore biological systems and submicron devices, which will have major effects on everyday life.

The customized numerical algorithms of the latest generation of commercial engineering design software point to a significant trend: researchers and professionals in computational engineering will need a strong background in sophisticated numerical simulation and optimization, but they will also have to be skilled in marrying numerical methodology with application formulations. In addition, the ever-accelerating rate at which new technology becomes available is generating increased demand that computational engineers be discipline-flexible in their skills. Finally, the CE educational program combines applied general methodology courses, discipline-specific electives, and industrial experience in a way that trains professionals for industry while preparing doctoral students to participate in flagship and interuniversity research projects. The CE 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 CE program is Jaime Peraire. Faculty members involved include Alan Edelman, Robert M. Freund, Nicolas Hadjiconstantinou, Jongyoon Han, Pablo Parrilo, Anthony Patera, Georgia Perakis, Gilbert Strang, Joel Voldman, Jacob K. White, and Karen Willcox.

Chemical and Pharmaceutical Engineering

The CPE degree program offers a cutting-edge curriculum in 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 is in lieu of the 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 the CPE program is Bernhardt Trout. Faculty members involved include Daniel Blankschtein, Patrick Doyle, T. Alan Hatton, Kenneth A. Smith, Gregory N. Stephanopoulos, and Daniel I.C. Wang.

Manufacturing Systems and Technology

The MST degree program is a comprehensive education and research effort that concentrates on implementing 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, photonic devices, micro-robots, nanoscale optical devices, and a multitude of potential products employing micro- and nanoscale 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 new business structures. Our research is now focused on an emerging industry that is at the point of large-scale commercialization: microfluidic devices for chemical, biomedical, and photonic applications. Although the immediate manufacturing issues are specific to microfluidic devices, we believe that this emerging industry will have manufacturing process, systems, and business issues in common with many other yet-to-emerge industries, such as fluidic devices 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 nanomanufacturing.

The MIT chair of the MST program is 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 and research scientist Brian Anthony also participate.

Computational and Systems Biology

The 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 Agency for Science, Technology, and Research (A*STAR) Research Institutes.

Students with backgrounds in biology (with strong mathematical 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 to the CSB program 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. 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 on the 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 chair of the CSB program is Peter So. Faculty members involved include Jianzhu Chen, C. Forbes Dewey, Harvey Lodish, Subra Suresh, Roy Welsch, and Jacob K. White.

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