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 extension of its global impact, enhancement of its curriculum, and improvement of its infrastructure

Overview

SMA was initiated on January 1, 1999, with the first two of its five programs, Advanced Materials for Micro- and Nano- Systems (AMM&NS) and High Performance Computation for Engineered Systems (HPCES), beginning 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), got under way on July 1, 2001. Each program has had a five-year term. To date, AMM&NS, HPCES, and IMST have concluded their terms, and MEBCS and CS will conclude their five-year term on June 30, 2006.

The academic calendar, course content, and grading method in this phase of SMA follows MIT practice and standards to a large extent. Degrees are conferred by the host university (NUS or NTU), along with an MIT–cosponsored SMA certificate confirming completion of the program of study.

Subjects are taught primarily by distance education. MIT's Academic Media Production Services (AMPS), under the direction of executive director Amitava Mitra, has assumed responsibility for the technology and operation of the distance learning aspects of SMA. 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 rooms 1-390, 3-370, 8-404, and in the three SMA research interaction rooms.

MIT faculty fellows also spend several weeks per year in Singapore, and some faculty have spent (or will spend) a half to an entire semester engaging in face-to-face lectures, discussion, and research collaboration in Singapore. SMA students spend three weeks at MIT during their matriculation; doctoral students spend an additional full semester in residence at MIT.

Research comprises an important aspect of the research master's and doctoral degrees in all five programs. An MIT and a Singaporean faculty member jointly supervise a research student's thesis. As part of the professional master's curriculum, through specific industry-sponsored research projects, students have the opportunity to work with some of the most technologically advanced companies in the world.

In March of 2003, MIT signed a memorandum of understanding to enter into the second phase of SMA, denoted SMA-2.

In response to a request for proposals, nine MIT and Singaporean teams submitted plans for participation in SMA-2, of which four proposals were selected. A second call for proposals was issued in December 2004. From these new submissions, a fifth and final program will be selected in August of 2005. SMA-2 will allow for students to obtain a dual (not joint) degree—a master's degree from MIT and either a master's degree from NTU or NUS or a PhD from NTU or NUS.

SMA-2 is characterized by greater collaboration in both research and teaching, with increased and significant participation by the partner universities. SMA-2 will continue to refine face-to-face and extensive distance interactions to create and sustain a close and pervasive relationship between the core faculties and students.

Dual-degree students will be in residence at MIT for one semester and in residence in Singapore for the second semester. While in Singapore, students will take MIT classes for credit at a distance.

Students accepted into the program receive an SMA-2 Graduate Fellowship that provides full tuition at MIT and either NUS or NTU, a monthly stipend, travel to MIT, and a monthly housing allowance when in residence at MIT.

SMA-2 will offer graduate degrees in three engineering disciplines and one life science discipline: advanced materials for micro- and nanosystems (the MIT host department is Materials Science and Engineering); computational engineering (this program has interdepartmental host support within the School of Engineering); computation and systems biology (the MIT host is the Computational and Systems Biology Initiative); and manufacturing systems and technology (the MIT host department is Mechanical Engineering).

Over 50 MIT faculty members will participate in the SMA-2 program.

Student Enrollment

SMA-1 Entering Class

A total of 320 applications were received for the two programs operating in academic year 2006. To date, 85 offers have been made and 65 applicants have accepted the offers. Of these, 28% were from Singapore, 39% from China, and 19% from India, with the remainder coming from other Southeast Asian countries.

Graduate Record Examination (GRE) scores were waived for students from top schools in Singapore. Nonetheless, the student scores that were obtained compare favorably with those of students being admitted to graduate school at MIT. Both GRE and Test of English as a Foreign Language scores for the Class of 2005 are comparable to last year's SMA class.

SMA-2 Entering Class

A total of 273 applications were received for SMA-2 Graduate Fellowships. Of these, 81 applicants were offered a fellowship and 53 accepted.

Eligibility criteria for admission to the programs in the SMA-2 Program of the Alliance Universities are stringent. Applicants must be admitted separately and independently to MIT and to either the National University of Singapore or Nanyang Technological Institute; then and only then will a student be considered for an SMA Graduate Fellowship.

SMA-1 Program Descriptions

Molecular Engineering of Biological and Chemical Systems

The MEBCS program offers two innovative courses of study (SM and PhD) that integrate a molecular understanding of biological and chemical phenomena with advances in process engineering for the life sciences and fine chemical industries. Through a combination of cutting-edge research and advanced coursework in molecular engineering sciences, graduates are poised to accept high-level professional or research positions in thriving industries, new start-up companies, academic institutions, and research centers.

The professional master's (SM) degree program prepares graduates for the shaping and solving of complex problems, resource management, teamwork, and leadership. The PhD program prepares graduates for advanced careers in industrial research and development centers, research institutes, or academic departments interested in biological and chemical engineering processes with emphasis on synthesis skills, engineering design, and interdisciplinary approaches.

The SMA program in MEBCS provides a unique and bold educational opportunity for graduate students interested in pursuing careers at the frontiers of life science and fine chemical technologies. Students attending this program have ample opportunity to work with some of the most technologically advanced companies in the world through specific industry projects. The MEBCS program is designed to prepare future leaders for positions in knowledge-driven industries poised for global economic growth in the new millennium.

The MIT program chair of MEBCS is Gregory N. Stephanopoulos. MIT faculty members Robert A. Brown (program advisor), T. Alan Hatton, Paul E. Laibinis, Harvey F. Lodish, Kenneth A. Smith, Daniel I.C. Wang, and Jackie Y. Ying are SMA faculty fellows; MIT faculty members Subra Suresh and Bernhardt Trout are SMA associates.

Computer Science

The SMA program in Computer Science provides a unique educational experience for graduate students interested in careers in industry and research establishments. The students are exposed to the broad foundations of computer science, encompassing computer architecture, software systems, algorithms, and advanced applications.

The SM in computer science is a one-year professional degree program based on coursework that prepares graduates for careers in the development of advanced computer systems. It is aimed at training students to apply their knowledge of computer science to industrial problems, particularly in the development of large software systems and embedded computing. The PhD degree program in computer science is a research program that provides the necessary depth to equip graduates for careers in industrial research and development centers, research institutes, or academic departments interested in cutting-edge research in all aspects of computer science.

The MIT program chair of Computer Science is Tomas Lozano-Perez. MIT faculty members Saman Amarasinghe, Alan Edelman, Leslie Kaelbling, Charles Leiserson, Stuart Madnick, and Martin Rinard are SMA faculty fellows, as is research scientist Larry Rudolph. MIT faculty members Fredo Durand and Jovan Popovic are SMA associates.

SMA-2 Program Descriptions

Advanced Materials for Micro- and Nano-Systems

The AMM&NS 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 a particular 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, comprise the core of the multidisciplinary coursework that prepares students to lead in the development and exploitation of new materials for future micro- and nanosystems. The AMM&NS degree program also promotes a practice-based understanding of the paths through which critical advances in the fundamental science and engineering of materials impact, and often pace, the rapid evolution of information processing, communication, and sensing technologies, especially those based on systems of micro- and nanoscale devices.

AMM&NS 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 will 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 program chair of AMM&NS is Carl V. Thompson. MIT 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 CE degree program is a collaboration by 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, etc.) as well as man-made systems (distribution networks, telecommunications systems, transportation systems, etc.) 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, etc.). 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 an 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, for example, 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 point 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—methodology that is of growing importance—while also providing tools for overcoming the manufacturing yield issues that have hindered BioMEMS commercialization. Finally, our 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 program chair is Jaime Peraire. MIT 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.

Innovation in Manufacturing Systems and Technology

The IMST program is a comprehensive education and research effort that concentrates on enabling manufacturing systems and technologies for emerging industries. 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, 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 micronscale 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 that the manufacturing issues for this emerging industry will have manufacturing process, systems, and business issues that are 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 these industries.

The MIT program chair is David E. Hardt. MIT 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.

Computation and Systems Biology

The SMA 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 will 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 MIT/CSBi PhD courses. The CSB program courses will cover topics in computational biology, systems biology, genomics, proteomics, and imaging theory and technology, some of which will be team-taught by faculty members from Singapore and MIT. As part of the CSB degree program, concepts emphasized in the classroom will be applied in research projects that are tightly linked to the education program.

CSB research projects will focus on the development of advanced technologies in biological probes, imaging, and computational biology and 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 program chair is Paul Matsudaira. MIT faculty members involved include Jianzhu Chen, C. Forbes Dewey, Harvey Lodish, Peter So, Subra Suresh, Roy Welsch, and Jacob White.

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