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 of the Alliance

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 in July 2000. The last two programs—Molecular Engineering of Biological and Chemical Systems (MEBCS) and Computer Science (CS)—began in 2001. Each program has completed its five-year term.

In March 2003, MIT signed a memorandum of understanding to enter into the second phase of SMA. Internally, this phase is referred to 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 the others to start in July 2006. SMA-2 allows for 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 greater collaboration in both research and teaching through increased and significant participation by the Singapore partner universities. SMA-2 continues to refine face-to face and extensive distance interactions to create and sustain a close, pervasive relationship between the core faculties and students. Fifty MIT faculty members now participate in the SMA-2 program.

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. 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 respective host departments or host academic units are:

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

- Chemical and Pharmaceutical Engineering (CPE)—MIT host department is Chemical Engineering
- Computational Engineering (CE)—The CE program has interdepartmental host support within the School of Engineering
- Computation and Systems Biology (CSB)—MIT host department is Biological Engineering
- Manufacturing Systems and Technology (MST)—MIT host department is Mechanical Engineering.

SMA-2 Graduate Fellowships

A unique feature of the SMA-2 program is that students accepted into the program receive an SMA-2 graduate fellowship. The fellowship 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 AY2010 and AY2011 Classes

Four of the five SMA-2 programs (AMMNS, CE, CSB, and MST) had their final intake of new students in AY2010. The fifth program, CPE, had its final intake of new students in AY2011. All five programs continue to have engagement with PhD students.

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

Distance Learning

MIT's Academic Media Production Services (AMPS) 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, and 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 other 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 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, comprises 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 impact, 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 (IME), as well as all three university partners: NUS, NTU, and MIT.

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

Computational Engineering

The CE degree program is collaborative between MIT, NUS, NTU, and the research institutes IME, 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 (micro-machined 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 micro-machined 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. The importance of computational engineering and optimization in the global industrial economy cannot be overstated, particularly as the systems used 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 in the billions of dollars, and 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, and it is expected 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, and a myriad of technological tools will be integrated to explore biological systems and sub-micron devices, which will have a major impact on daily 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 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 CE 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 inter-university 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 professor Jaime Peraire. Faculty members involved include professors Alan Edelman, Robert Freund, Nicolas Hadjiconstantinou, Jongyoon Han, Pablo Parrilo, Anthony Patera, Georgia Perakis, Gilbert Strang, Joel Voldman, Jacob White, and Karen Willcox.

Chemical and Pharmaceutical Engineering

The CPE 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 master of science degree: one from NUS and one from the chemical engineering practice program in the Department of Chemical Engineering. The dual degree 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. The 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 professor Bernhardt Trout. Faculty members involved include professors Daniel Blankschtein, Patrick Doyle, T. Alan Hatton, Kenneth Smith, Gregory Stephanopoulos, and Daniel Wang.

Manufacturing Systems and Technology

The MST degree program is a comprehensive education and research effort that concentrates on enabling manufacturing systems and technologies for emerging industries in a global context. Emerging industries are defined as those based on new technologies that are 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 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, 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, the manufacturing issues for this emerging industry will have manufacturing process, systems, and business issues that are common with many yet-to-emerge industries, such as fluidic devices computation, advanced drug delivery systems, and advanced health maintenance systems. 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 professor David Hardt. Faculty members involved include professors Lallit Anand, Duane Boning, Jung-Hoon Chun, Jérémie 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 Computational and Systems Biology Initiative (CSBi) at MIT and the visionary biology, bioengineering, and biotechnology programs at NUS, NTU, and the research institutes of the Agency for Science, Technology, and Research.

Students with backgrounds in biology (and with strong mathematics skills), physics, chemistry, mathematics, computer science, or engineering are encouraged to apply. They 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 at MIT, including five MIT/CSBi courses beamed live from the Institute—a signature feature of the high degree of integration between the Singapore and MIT/CSBi PhD courses. CSB courses cover topics in computational biology, systems biology, genomics, proteomics, and imaging theory and technology, and some 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 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 professor Peter So. Faculty members involved include professors Jianzhu Chen, C. Forbes Dewey, Harvey Lodish, Subra Suresh, Roy Welsch, and Jacob White.

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