1.1 Degree programmes and requirements

The School offers two graduate programmes by research:

- Ph.D. in Chemical and Biomolecular Engineering
- Ph.D. in Bioengineering

Candidates enrolled for a graduate programme by research pursue independent but supervised research in an approved topic on which a thesis must be submitted for examination. The award of the research degree is based solely on the thesis submitted. Candidates are also required to fulfill coursework requirement of a minimum of six courses. The minimum period of candidature for a Ph.D. degree is two years while the maximum is five years.

Curriculum structure of Ph.D. (CBE)	
Coursework requirement	• Four CH core courses • Two elective courses (one has to be CH/BG elective courses offered by the School and the other can be suitable postgraduate courses approved by the School)
Coursework courses	CH core courses • Advanced transport phenomena • Advanced mathematical methods for chemical engineering • Advanced reaction engineering • Advanced chemical engineering thermodynamics Elective courses • Nanotechnology and its applications • Cell therapeutics engineering • Downstream processing in pharmaceutical engineering • Formulation and quality aspects of active pharmaceutical ingredients dosage forms • Nanotechnology and its applications in pharmaceutical engineering • Advanced physical characterisation methods • Foundations of biomechanics • Bionanotechnology • Bioelectrochemistry • Molecular dynamics modelling of biological systems • Systems biology • Molecular biophysics • Advanced cell biology
Possible areas of research	• Nanotechnology catalysis and reaction engineering • Process systems engineering • Industrial chemistry

Curriculum structure of Ph.D. (BIE)	
Coursework requirement	• Three BG core courses • Three elective courses (two have to be elective courses offered by the Schooland the other can be suitable postgraduate courses approved by the School)

Curriculum structure of Ph.D. (BIE)	
Coursework courses	BG core courses • Bionanotechnology • Molecular biophysics • Advanced cell biology Elective courses • Advanced physical characterisation methods • Foundations of biomechanics • Bioelectrochemistry • Molecular dynamics modelling of biological systems • Systems biology • Nanotechnology and its applications • Cell therapeutics engineering • Downstream processing in pharmaceutical engineering • Formulation and quality aspects of active pharmaceutical ingredients dosage forms • Nanotechnology and its applications in pharmaceutical engineering • Advanced transport phenomena • Advanced mathematical methods for chemical engineering • Advanced reaction engineering • Advanced chemical engineering thermodynamics
Possible areas of research	• Biomaterials • Molecular and cellular engineering • Computational biology • Biophysics • Bioimaging / Biomedical imaging • Bionanotechnology • Bioinformatics

Minor in Bioprocessing Technology

In the post-genomic era, there is a great interest to develop treatments and vaccines that target the molecular underpinnings of diseases. There is an urgent need for engineers to be equipped with the basic knowledge of biotechnology to accelerate the transformation of scientific discoveries to economical therapeutic and clinical products. The objective of this minor programme is to cater to the urgent demand for engineers with biotechnology training and background.

Minor in Pharmaceutical Engineering

The goal of this minor programme is to give full comprehension of the development, support and management of large-scale manufacturing operations in the pharmaceutical industry.

Centre for Chiral and Pharmaceutical Engineering

The Centre of Chiral and Pharmaceutical Engineering (CCPE) was established to be a chemical discovery and development partner to the pharmaceutical, biochemical and chemical industries that are considered as key engines of growth for the Singapore economy. The centre aims to forge multidisciplinary research between science and engineering to provide the 'one-stop chemical solution'. A unique range of innovative research projects are on-going to improve and to develop novel technologies for upstream and downstream processing of active pharmaceutical ingredients.

Through its multidisciplinary projects, the centre aims to develop R&D personnel, scientific knowledge and technological capabilities to support the chemical, biomedical and pharmaceutical industries as well. It plays an active role in enhancing the competitiveness of Singapore's chemical and pharmaceutical industries through its function as an R&D entity, a platform for NTU to collaborate with A*STAR research institutes, various Institutes of higher learning and technology start-up companies and as a coordinating party integrating scientists and engineers. CCPE also

nurtures a critical pool of talents that is needed by the various industries through the undergraduate programme offered by the Division of Chemical and Biomolecular Engineering. Some of the focus areas of the centre are:

1. Asymmetric synthesis of chiral compounds
2. Chromatographic separations through simulated moving bed technology, integrated reactor separators and preparative supercritical fluid chromatography
3. Crystallisation based separations with special focus on applying state of the art process modelling and control tools for turning particle sizes
4. Hybrid separations process such as integration of chromatography and crystallisation
5. Use of ionic liquids for chiral separations
6. Enantioselective extractions
7. Application of nanotechnology for enantioseparations

Centre of Biotechnology

Chemical engineering principles including chemical kinetics, reactor design, transport phenomena, thermodynamics and unit operations are critical to transform the molecular principles generated from molecular biology to the realisation of novel bio-therapeutics. Chemical engineering can play critical roles in cell culture development, bio-catalysis and downstream unit operations which are key processes in the R&D and manufacturing operations of biotechnology companies.

The Centre boasts of excellent infrastructural facilities, including confocal microscope, 2D gel electrophoresis, reflectance interference contrast microscopy, PCR, orbital shaker, ultracentrifuge, refrigerated centrifuge, CO2 incubators, bio-safety cabinets, UV-Vis spectrophotometer, chemi-luminance imager, fluorescence microscopy, gel documentation system, densitometer, deep freeze refrigeration system, electrochemical analyser, bio-sensors, Langmuir monolayer balance, optical tweezers, HPLC, complete laboratory set-up for intensive research on molecular and cell biology and virus-host interactions, Two-Dimensional SDS-PAGE system for proteomics analysis and ImX viral antigen measurement for investigations on cell-based HBV replication.

Some of the projects include:

1. HBV-Host Interactions: Applications for Antiviral Strategy
2. Liver Cancer Proteomics
3. Internalisation of Receptor-Associated Protein into Human Hepatocellular Carcinoma Cells
4. Investigation of Pro-apoptotic HBV Viral Proteins
5. Reorganisation of Cellular Cytoskeleton in Response to HBV InfectionChiral Drugs and Cellular Signaling Pathways
6. Biophysical and Biomolecular Investigations on Cellular Cytoskeleton Remodelling
7. Mechanochemical Transduction of Cells
8. Genetic Engineering and Biosensors
9. Biomaterials and Bio-inspired Materials