MODULE DESCRIPTION

BN5101 Engineering Principles in Medicine I
Modular Credits: 4
Workload: 3-1-0-2-5
Pre-requisites: N/A
Preclusions: N/A

This course is designed to enable students to apply the fundamental principles of engineering to bioengineering applications. It aims to provide a good understanding of biomechanics and biofluid dynamics. An understanding of biomechanics is important as mechanical forces are constantly experienced not only at the musculoskeletal but also the organ, tissue as well as cellular level. Mass transport is also vital for cell, tissue and organ functions; and 60% of body weight consists of body fluid. In this module, topics include biomechanics of the human musculoskeletal system and tissues, mechanics of biological structures at the nano/micrometer scale, rheology of biological fluids, mass transfer in tissue, and reactor analogy of cellular activity.

BN5102 Engineering Principles in Medicine II
Modular Credits: 4
Workload: 3-3-0-1-3
Pre-requisites: N/A
Preclusions: N/A

This course is designed to enable students to apply the fundamental principles of engineering to bioengineering applications. It aims to provide a good foundation for signal measurements and processing. This is necessary since bioengineers are constantly required to handle electronic instruments, transducers and medical images for diagnostic and therapeutic applications. Topics covered include biomedical signal measurement, computer-based signal processing and medical imaging systems.

BN5103 Advanced Molecular Biology
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: Basic Chemistry or Biology
Preclusions: N/A

This course will focus on the major concepts in molecular biology providing the students with the background to understand and critically analyze scientific papers in this field. Starting with an introduction on the different molecules that make up the building blocks of cells, this course will emphasize on DNA as the basic unit of inheritance and how the next phase of the Human Genome Project will influence health care in the next century. The course will introduce various cutting edge techniques in molecular biology including bioinformatics focusing on how we can derive the function as well as structure of the protein from the sequence of the gene; genomics, functional genomics and pharmacogenomics.

BN5104 Quantitative Physiology Principles in Bioengineering
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: (BN5101 or BN5102) AND (BN5103 or MD5101) or permission from coordinator
Preclusions: N/A

This course will focus on three major systems (cardiovascular, endocrine and nervous system) and quantitatively described from both the cellular (membrane dynamics, ion transport, muscle and nerve, electric conduction and equilibria, wave propagation and intercellular communications, sensory receptors and others) and system physiology perspectives (regulation and control, homeostasis, specific functions of major organs). Problem-based approaches will be adopted for the students to integrate the life sciences and engineering principles to solve bioengineering problems relevant to human physiology.

BN5201 Advanced Biomaterials
Modular Credits: 4
Workload: 4-2-0-2-2
Pre-requisites: Basic materials science and engineering
Preclusions: N/A

Major controversial issues in the application of biomaterials to medical problems will be covered. Fundamental structure-property relationships and issues such as wear and structural integrity will be addressed. Subjects considered include introduction to biomaterials, host-tissue response, blood compatibility, control drug release polymers, bioadhesion, contact lenses, polyurethanes, biodegradation, protein adsorption, corrosion, orthopedic and cardiovascular implants, stress shielding, materials selection in artificial organs and medical device regulation. Format will utilise case studies, special invited lectures, discussion, literature research and problem solving.

BN5202 Cell, Tissue and Body Mechanics
Modular Credits: 4
Workload: 3-1-1-2-4
Pre-requisites: BN5101 Engineering Principles in Medicine (I) or Engineering Mechanics
Preclusions: N/A

This course is designed for students interested in the application of engineering mechanics to biological structures. Following the biological hierarchy, the course will begin at the cellular level, looking at Cellular Biomechanics, such as molecular and cellular responses to strains, and biomechanical transduction; then moving on to Tissue Mechanics, where we will look at viscoelastic deformation processes in biological tissues; and finally focusing on whole body mechanics, such as modeling of musculo-skeletal with examples in rehabilitation and orthopedic applications.

BN5203 Advanced Tissue Engineering
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: (BN5101 or BN5102) AND (BN5103 or MDG5101) or permission from coordinator
Preclusions: N/A

We will investigate various tissue engineering approaches for repair and regeneration of tissue structures and functions. In vivo approaches such as drugs, genes, and cell delivery to stimulate and regulate the biological repair and regeneration mechanisms, and in vitro approaches such as the construction of biodegradable scaffolds to build tissues outside bodies before implantation into patients, will be analyzed. A few model systems such as liver, heart, nerves, blood vessels, skin, cartilage and bones will be studied. Original literatures will be critically reviewed, presented, and mini-proposals constructed by students in place of CA.

BN5204 Membrane Science
Modular Credits: 4
Workload: 3-1-1-3-2
Pre-requisites: N/A
Preclusions: N/A

The course provides a description of membrane science for chemical engineers, chemists, biophysicists, pharmacologists, etc. The uniqueness of the course is that it will combine a lot of different aspects of the membranology, which is a new and quickly growing interdisciplinary area of science. It will cover fundamentals aspects such as membranes and transport processes, linear thermodynamics and kinetics of membrane transport,colloid chemistry and membranes; materials engineering aspects such as artificial membranes and membrane technology, polymer and inorganic membranes, asymmetric and composite membranes and membrane fabrication; chemical engineering aspects such as pressure driven processes (micro-, ultra-, nanofiltration), membrane fouling, concentration driven transport, gas separation, pervaporation, dialysis, osmosis, reverse osmosis, controlled release, liquid membranes and facilitated transport, electrochemistry of membranes; biological and medical aspects such as membrane biochemistry and biophysics, membrane electrodes and biosensors, biomimetics, membrane active drugs and pathology.

BN5205 Computational Biomechanics
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: BN5101 Engineering Principles in Medicine I
Preclusions: N/A

Learning objectives: The objectives of this course are to introduce students to the basic tools of biocomputation and to enable them to use these tools appropriately in the analysis of biomechanical and biological systems. Major topics to be covered: Basic biocomputational tools: finite elements and finite difference methods for steady state and transient problems. Description and modelling of biomechanical systems. Examples of biocomputational analyses in cardiovascular, musculoskeletal and mechanosensory systems. Advances and limitations in computational biomechanics. Target students: Those who are interested in modelling and analysis of complex biomechanical systems in research and application, using engineering computational methods and principles.

BN 5206 Biosignal Processing and Analysis
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: N/A
Preclusions: N/A

This module reviews the mathematical techniques that are needed for the processing of continuous and discrete signals and systems. It introduces important biological signals such as the ECG (electrocardiogram), EEG (electroencephalogram), and EMG (electromyogram) and the acquisition of these signals for use in the diagnosis of disorders and diseases. The module also discusses methods for the processing, analysis and classification of these signals.

BN5207 Medical Imaging Systems
Modular Credits: 4
Workload: 3-1-0-2-4
Pre-requisites: N/A
Preclusions: N/A

This module covers the physics and technology of the major branches of medical imaging, which include X-ray, computed tomography, magnetic resonance imaging, ultrasound, and single-photon and positron emission tomography. Topics that are important to developing a sound understanding of medical imaging technology, such as detectors, image forming processes, tomographic reconstruction methods, and clinical applications, comprise an important portion of the module. This module is suitable for students who may wish to undertake advanced studies and research or work in the area of biomedical imaging.

BN5208 Regulatory & Bioethical Issues
Modular Credits: 4
Workload: 3-0.5-0-1-1
Pre-requisites: N/A
Preclusions: N/A

Regulatory issues for medical devices: The need for regulatory approval; international regulatory guidelines, such as the Belmont Report and the Declaration of Helsinki, as well as Singapore regulatory requirements; design and production; safety and efficacy verification; clinical trial; marketing and post market vigilance. Bioethical issues: Nature of medical ethics; principles of biomedical ethics; Singapore legal system; patient care; patient's interest first; informed consent for clinical trials; right to information; medical confidentiality; limits to freedom, medical ethics; clinical research.

BN5209 Neurosensors and Signal Processing
Modular Credits: 4
Workload: 2-0-1-0-7
Pre-requisites: N/A

Preclusions: N/A

This module teaches students the electrical and magnetic field of the human brain in relation to the brain activities and methods for sensing the electrical and magnetic field of human brain in relation to brain activities. Major topics include: the electric and magnetic field of the brain in relation to brain activities, sensors for measuring the electric field and magnetic field of the brain in relation to brain activities, digitization of brain activities - neural waves, characterization of neural waves – neural power map and neural matrix brain activity pattern recognition using neural power map and neural matrix, and applications of brain activity monitoring. The module is designed for students at Master and PhD levels in Engineering, Science and Medicine.

BN5210 Biosensors and Biochips
Modular Credits: 4
Workload: 2-0-1-3-4
Pre-requisites: N/A
Preclusions: N/A

Biosensors have been a research object since several Decades with blood glucose biosensors for accurate and quick glucose home tests as the most known example. Nowadays Biochips, Microarrays, BioMEMS, Lab-on-a-chip and µTAS are attracting researchers and industry. Together with advances in life science and fabrication technologies Biochips may become reality with applications in medicine, diagnostics and environmental monitoring soon. The course will give a detailed insight into biosensors and biochips, their working principles, biocompounds and immobilization methods and how an electrical signal is generated.

CROSS-FACULTY ELECTIVES

The following is a list of approved elective modules offered by other faculties to NGS' GPBE candidates. These modules will also be offered to candidates from the Division of Bioengineering subject to the approval of their supervisors and the Head of Department. For more information, please refer to the respective faculty curriculum books.

BL 5201 Structural Biology and Proteomics
Administering Department: Biological Sciences, Faculty of Science

The module will focus on recent advances in topics related to structural biology and proteomics. It will provide a strong foundation in these new areas of biology and biochemistry. The topics to be discussed will include structure-function relationships, protein-protein interactions, protein folding, protein design and engineering and proteomics. Students will be required to participate actively in the form of presentations/discussion as well as analyses of recent research articles in the area.

BL5202 - Biophysical Methods in Life Sciences
Administering Department: Biological Sciences, Faculty of Science

The module is concerned with biological macromolecules and complexes or arrays of macromolecules. The contents deal with conveying the major principles and concepts that are at the heart of the field. These principles and concepts are derived from physics, chemistry, and biology. The various topics to be discussed will cover some of the techniques used in studying structure and function of biological macromolecules, excitable cell membranes and ion channel activities. The emphasis is on a detailed discussion of a few techniques rather than an attempt to describe every known technique. Our goal is to demonstrate how techniques and principles are used in concert to gain an understanding of the behavior and properties of biological macromolecules. The lectures will be mostly in the form of orientation discussions based on selected lead articles. Subsequently, students will be required to participate actively in the form of presentations/discussion on the selected topics.

BL5203 Molecular Recognition & Interactions
Administering Department: Biological Sciences, Faculty of Science

This module will focus on recent progress in our understanding of molecular recognition that forms the basis of cell signaling networks that are used in various organisms to regulate their responses to extra cellular and intracellular stimuli. How are various signals integrated and regulated to ensure cell homeostasis? What is the mechanism for host cell defense? Particular emphasis on pathologies (in both plant and animals) related to signaling defect as possible targets of intervention will be stressed. A basic understanding of the mechanism of these protein-protein interactions should provide key insights on how a specific pathway can be inhibited or modulated as targets for the rational development of therapeutics in applied biotechnology.

BL5204 - Current Trends in Biotechnology
Administering Department: Biological Sciences, Faculty of Science

Biotechnology is a rapidly growing field encompassing many disciplines and the objective here is to give broad exposure to students to encouraging multi-disciplinary thinking. Four broad areas are identified to allow some flexibility in the choice of contemporary topics. A broad introduction to this module is given under Emerging Disciplines in Biology. Interfacing Biology and Engineering delves into some of these diverse topics in some detail. Biocomputing focuses on the central role of software tools that complement experimental approaches in many applications. Under Entrepreneurship, innovation processes and the characteristics of the various related industry sectors such as Pharmaceuticals, Biotechnology and Healthcare will be discussed.

BL5216 Advanced Genetics and Genome Sciences
Administering Faculty: Faculty of Science

The module is directed toward graduates with basic molecular biology and genetic backgrounds who are interested in conducting genomics-based research. The module will also introduce the unique aspects of different model organisms and approaches to understand their gene function. The module aims to equip the students with the latest knowledge on characterizing and understanding genomes in the broadest sense. Upon completion of the module, the students will be able to appreciate the strengths and weaknesses of large scale genomic studies. They will also be able to apply the modern genetic techniques across different model organisms.

BL5224 Special Topics in Biological Sciences
Administering Faculty: Faculty of Science

This module will focus on the topic of Systems Biology. The module is directed toward graduates with basic molecular biology and genetic backgrounds who are interested in the new field of Systems Biology. The module will also introduce the interdisciplinary nature of Systems Biology and the utilization of computation modeling to understand, dissect and predict biological responses.

MDG5101 Advanced Cell Biology
Administering Faculty: Faculty of Medicine (Please refer to the Faculty of Medicine Curriculum Booklet for more details)
Modular Credits: 4
Pre-requisites: BN 5103 or other basic cell biology modules
Preclusions: N/A

This module will focus on the study of some of the basic concepts in cell and molecular biology and bio-informatics. Starting with an introduction to the structural organization of the cell and various subcellular macromolecules, the main thrust of this module will be on the molecular basis for intracellular communication, signal transduction, genetic control of cell survival and death, and on the role of oncogenes and tumor suppressor genes in neoplastic transformation. In addition, a section on

bio-informatics will focus on information retrieval, internet protocols and searches, and visualization tools.

MDG5102 Techniques in Biomedical Research
Administering Faculty: Faculty of Medicine

This module will expose student to current techniques in biomedical research and basic research skills in literature search. The course will include techniques in molecular biology, protein analysis, cell biology, microscopy, and the use of animals for biomedical research.

MDG5205 Neuroscience
Administering Faculty: Faculty of Medicine

This module develops the foundations of neuroscience essential for further research and clinical application. It begins by introducing students to the morphology and cell biology of the nervous system. This is followed by discussion of the molecular events that occur during nerve conduction and synaptic transmission, and more complex levels of sensory, motor, and cognitive functions. The fundamental and clinical aspects of common neurodegenerative diseases and strategies to promote neural regeneration are then explored. Students will be introduced to common research techniques and shown examples of how these can be applied to solve problems in neuroscience. Suitable clinical problems will be introduced throughout the course to show the clinical context and application of scientific knowledge, as well as to integrate across disciplines.

ME 6301 Viscoelasticity
Administering Department: Mechanical Engineering, Faculty of Engineering

Introduction to viscoelastic fluids, their properties and microstructure; Basic results from Tensor Analysis, Cartesian tensor notation, covariant derivative, gradients, divergence and curl, Divergence Theorem; Kinematics, relation between velocity and deformation gradient, connection to Dynamical System theory, path lines, relative strain tensors, linear autonomous systems, Balance equations for smooth regions, concept of the stress tensor; Viscometric flows, circular Couette viscometer, torsional viscometer, cone-and-plate viscometer, capillary viscometer; Non-viscometric flows; Constitutive Modelling, general principles; Microstructure theory for dilute polymer solutions, Elastic dumbbell model; Suspension models, bulk suspension properties, dilute suspensions of spheroids, concentrated suspensions. Examples taken from a variety of materials, including soft solids (rubber-like materials, bread dough, soft tissues), dilute polymer solutions, and suspensions.

ME 5302 Computational Fluid Mechanics
Administering Department: Mechanical Engineering, Faculty of Engineering
Review of basic theory: governing equations, classification of equations, model equations, discretization theory, Consistency, Stability and Convergence; Solution of parabolic equations, elliptic equations incompressible Navier-Stokes and energy equations: stream function-vorticity formulation, finite volume method and/or marker-and-cell method; Special topics such as boundary integral methods, finite-element methods, spectral methods and multi-grid methods.

PC5213 Advanced Biophysics
Administering Faculty: Faculty of Science

This module focuses on theories and techniques used in some important areas of biophysics and life sciences. The topics covered are: quantum mechanical approach of light and transition; absorption spectroscopy; linear and circular dichroism of biological molecules; emission spectroscopy, fluorescence spectroscopy and applications to biomacromolecules; NMR; equilibria of macromolecular solutions; biomembrane structure and transport of macromolecules and transport across biomembranes; kinetics and techniques of protein crystallization; biomineralization/demineralization in human body. This module also includes a lab component. This module is targeted at both physics and non-physics students who already have a basic knowledge in physics, thermodynamics and molecular biology.

PR5216 Advanced Drug Delivery
Administering Department: Pharmacy, Faculty of Science

This course aims to provide an appreciation of the concept of optimized drug delivery, an understanding of fundamental principles governing drug absorption and drug bioavailability, and a critical evaluation of innovative systems developed to optimize the delivery of biopharmaceuticals and the targeting of drugs to specific cells. Target students are MSc and PhD students with a strong interest in innovative drug delivery systems. The major topics to be covered include: optimized drug delivery; pathways for drug absorption across epithelial cells; physicochemical and biological factors influencing drug bioavailability; biopharmaceuticals – opportunities and challenges in developing optimized delivery systems; therapeutic proteins – physicochemical properties, current dosage forms and innovative systems for non-parenteral routes of administration of insulin; gene therapy – fundamental principles, viral and non-viral systems for gene delivery; drug targeting – concept and strategies to target drugs to specific organ, cell or organelle

SMA5421-Nanostructured Catalysts Design & Organic Synthesis
Administering Programme: Singapore-MIT Alliance

Catalytic processes are critical to the synthesis of chemicals, materials, and pharmaceuticals. This subject describes the tailoring of materials with unique pore structures and nanocrystallinity to provide for designed functionalities in catalytic applications. Strategies for surface modification and compositional design targeted towards enhancing catalytic activity, selectivity and stability will be discussed. The characterization and use of nanostructured catalysts in organic synthesis will be presented; of particular interest are the synthetic transformations and catalytic chemistry underlying oxidation/reduction, hydrogenation, acid catalysts, polymerization, and symmetric synthesis of fine chemicals and pharmaceuticals.

SMA5422-Special Topics in Biotechnology
Administering Programme: Singapore-MIT Alliance

This course reviews current topics in biology and biotechnology with particular emphasis on technologies catalyzed by developments in the field of genomics. These developments are changing the landscape of the chemical and medical industries through the introduction of biology as the enabling technology of manufacturing operations and biomedical information upgrade. The course will provide an in-depth analysis of the scientific fundamentals and technological extension of topics like: sequencing and genomics, bioinformatics, expression phenotyping via DNA microarrays, rational drug design, proteomics technologies and analysis, drug delivery, and others.

SMA5423-Bioprocess Engineering
Administering Programme: Singapore-MIT Alliance

The use of animal cells is now the major way to produce biological therapeutics. This course will cover the pertinent concepts in the use of animal cells for production of recombinant proteins and monoclonal antibodies. Comparison on the use of bacterial hosts with animal cells for therapeutic protein production will be considered. Topics will include nutritional requirements for cell growth, kinetics of cell growth, cell death and product formation. Bioreactors for suspension and anchorage-dependent cells will also be discussed. Issues related to process validation and safety in the use of animal cells will be addressed from a regulatory point of view.

Compulsory Seminar Modules

BN5999 Graduate Seminars
Modular Credits: 4
Pre-requisites: N/A
Preclusions: N/A

The aim of this module is to enhance knowledge, broaden research outlook, and improve thinking and communication skills of graduate students. This module is required for M.Eng. candidates. It requires the candidates to attend at least 10 seminars and to give at least a seminar presentation by the end of the third semester. For each seminar attended, a 2-page report summarizing key points of seminar is to be written by the student in his/her own words. For the seminar presented by the candidate, the presentation material (such as PowerPoint file) is to be printed. These reports and presentation material shall be compiled together in a folder. The folder should have a table of content showing the dates, titles and speakers of seminars for easy reference. When the above requirement is completed, the folder is to be endorsed by the main supervisor before submitting to the Division Office for record. Unless otherwise stated or prior approval obtained from the Division, seminars attended should be those conducted within the university. The speakers include academic staff, research fellows and post-doctoral fellows as well as invited speakers from outside the university. Seminars given by students are not counted for this purpose, but graduate students are encouraged to attend such seminars for mutual benefits. If two or more presentations are scheduled within the same half-day (morning or afternoon), they shall be counted as one seminar. For seminar presentation, the candidate shall present his research work and the suggested duration is 30-45 minutes. Grading is on S/U on the basis of attendance, presentation and document submission.

BN6999 Doctoral Seminars
Modular Credits: 8
Pre-requisites: N/A
Preclusions: N/A

The aim of this module is to enhance knowledge, broaden research outlook, and improve thinking and communication skills of graduate students. This module is required for PhD. candidates. It requires the candidates to attend at least 20 seminars and to give at least a seminar presentation by the end of the sixth semester. For each seminar attended, a 2-page report summarizing key points of seminar is to be written by the student in his/her own words. For the seminar presented by the candidate, the presentation material (such as PowerPoint file) is to be printed. These reports and presentation material shall be compiled together in a folder. The folder should have a table of content showing the dates, titles and speakers of seminars for easy reference. When the above requirement is completed, the folder is to be endorsed by the main supervisor before submitting to the Division Office for record. Unless otherwise stated or prior approval obtained from the Division, seminars attended should be those conducted within the university. The speakers include academic staff, research fellows and post-doctoral fellows as well as invited speakers from outside the university. Seminars given by students are not counted for this

purpose, but graduate students are encouraged to attend such seminars for mutual benefits. If two or more presentations are scheduled within the same half-day (morning or afternoon), they shall be counted as one seminar. For seminar presentation, the candidate shall present his research work and the suggested duration is 30-45 minutes. Grading is on S/U on the basis of attendance, presentation and document submission.