Clinician students are to undertake MD9001 The Ethics and Practice of Research and MD9101 Biostatistical Methods and Basic Epidemiology as core courses.

Non-clinician students are to undertake MD9001 The Ethics and Practice of Research as a core and another core relevant to the student’s area of research, in consultation with her/his supervisor.

Courses Offered to LKCMedicine PhD Students

<table>
<thead>
<tr>
<th>S/No</th>
<th>Type</th>
<th>Course Code and Title</th>
<th>Semester</th>
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<tr>
<td>1</td>
<td>Core</td>
<td>MD9001 The Ethics &amp; Practice of Research</td>
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<td>2</td>
<td>Core</td>
<td>BS7107 Computational Biology and Modelling</td>
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<td>MD9104 Introduction to Neuroscience: Cellular and Molecular Neuroscience</td>
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<td>11</td>
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<td>MD9108 Neural Systems and Behaviour</td>
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<td>Elective</td>
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<td>BS7001 Foundation Course in Molecular &amp; Cell Biology</td>
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<td>Elective</td>
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Brief Introduction of the Courses:

Courses Available as Core

1. **MD9001 The Ethics & Practice of Research**
   This core course aims to introduce fundamental issues in the fields of history and philosophy of science and practical ethics. It enables students to critically evaluate key arguments in these fields. This module examines the fundamental issues of scientific research. Designed as a core module for PhD students with or without training in critical thinking. It aims to provide young researchers a general grasp of foundation of science from a range of theories and case studies. In addition, it offers an opportunity for students to reflect upon their own roles in a team work or a research project before they enter a laboratory. Students will discern the motivation and objectives of scientific research. Eventually, they will be able to distinguish good and bad scientific practices and the philosophical concerns in lieu of or against them.

   - Philosophy of Knowledge and Scientific Revolution
   - Science in Society
   - Sampling methods & sample size calculation
   - The loss of knowledge in the information age
   - Research Application and Commercialisation
   - Research Involving Animal Subjects
   - Research Involving Human Subjects I
   - Research Involving Human Subjects II
   - Responsible Conduct in Research
   - Writing Workshop of Research Proposal for IRB and IAACUC
   - Ethics in Practice
   - Panel Discussion and Debate
   - Student-led Seminar presentations

2. **BS7107 Computational Biology & Modelling**
   In this course, basic ideas for understanding biological phenomena using principles from underlying physical and chemical foundations used in computer modelling approaches are introduced. Emphasis will be on how these computational tools are applied to biological areas
such as protein folding, membrane fusion, enzyme activity, drug-target interaction. These methods are illustrated with modern computer-based laboratory practicals with graphical display of biological molecules. A variety of computational methods and modeling strategies are introduced, such as classical force field based on quantum theory and coarse grained models. Basic sampling techniques, such as Monte Carlo, molecular dynamics and Langevin dynamics simulation will be described.

Courses Available as Core or Elective

3. MD9101 Biostatistical Methods & Basic Epidemiology
This course will provide students with a strong understanding of the basic principles and measures used in epidemiology. The course will cover the fundamental concepts and statistics in epidemiology including important topics such as causality and disease surveillance. Real-world cases and data will be used to illustrate key principles, concepts, and techniques.

- Exploring data
- Measuring health & disease
- Sampling methods & sample size calculation
- Statistical estimation and hypothesis testing I (parametric methods)
- Testing of hypothesis- II (non-parametric methods), and correlation analysis
- Introduction to regression analysis (linear, logistic and survival regression)
- Epidemiological study designs
- Communicable and chronic non-communicable diseases, and preventive epidemiology
- Clinical epidemiology and health services research
- Epidemiology in health policy & planning

4. MD9104 Introduction to Neuroscience - Cellular and Molecular Neuroscience
A general introduction into the concepts, principles and technologies of contemporary cellular and molecular neuroscience. This course is a core course and is intended to be the first part of a two-course introduction to neuroscience. It will be offered in Semester 1; the second course, MD9108, will be offered as an elective in Semester 2 and will focus on systems neuroscience.
5. **MD9105 Systematic Reviews and Evidence Synthesis**
This course will take a blended learning approach and consists of lectures, small group working sessions and focused discussions. Its aim is to provide knowledge and skills needed to perform a systematic review. The skills gained though this course will also prove to be useful when undertaking research other than systematic reviews, e.g., developing an answerable research question, knowing what information sources are available and how to search them or understanding the principles of research quality assessment and reporting.

6. **MD9107 Latest Development in Infectious Disease Research**
This course is intended to students interested by the latest development in infectious diseases research. Learning objectives: critical assessment and debate on cutting-edge articles; analyse diagnostic approaches and new therapeutic strategies for viral, bacterial and fungal infections; discuss the global danger and challenges of antimicrobial resistance; discuss and propose solution for current global health challenges in communicable diseases; develop and defend research global health challenges; analyse the clinical relevance of microbiomes and redefine the Koch postulates.

A project-based learning approach will be followed that includes team-based analysis of cutting-edge papers; team-based development and defence of solutions for medically relevant problems; elaboration and presentation of research proposals to solve global health issues.

- Infectious Arboviruses: research towards a cure
- New drug development for tuberculosis: progresses and application to other bacterial infections
- Emerging superbugs in Asia
- Fungal Infections (aspergillus, candida)
- New approaches to viral and bacterial diagnosis
- The microbiome as a source of infectious diseases: redefining the Koch postulates
- Vaccines/host-directed therapies
- Alternative to antibiotics for controlling bacterial infection
- Regional field research on neglected tropical diseases
- Infectious Disease in the Clinical Setting
7. **MD9110 Advanced Genetics in Diseases, Ageing & Cancer**
   The main aim of this module is to explain the key principles of human genetics, ageing and cancer genetics to the graduate student. This module will make them better prepared to contribute to the research and development of this trend, as well as research in other basic science and biomedical applications in general.

_Courses Available as Elective_

8. **MD9102 Bio-Entrepreneurship**
   Started in 2016, LKCMedicine’s 13-week Team-Based Learning Bio-Entrepreneurship module provides post-graduate students with an understanding of the entire drug discovery and development process starting from basic and translational research to creating viable partnerships with BioPharma companies or establishing Spin-Offs. The course is open to students from diverse backgrounds ranging from medicine, life sciences and engineering to humanity and social sciences.

   The overall course structure is as follows:
   Topics include target validation, drug discovery, drug development, design and execution of clinical trials, intellectual property, technology transfer, biotech investing, market analysis, business development.
   We draw on experts from Singapore’s ecosystem to teach specific topics. Lectures will be provided each week in advance of classroom learning.
   At the beginning of each classroom session, students will be examined for their understanding of the topic using MCQ/short-answer questions (individual Readiness Assurance or iRA; 25% weightage in assessment).
   Students will be grouped into teams (“Biotech companies”). Each team will be assigned a lead therapeutic. Each week, teams will analyse their lead in the context of the topic to be covered in the classroom session, and present their strategy for advancing their lead. Innovation, thoroughness and clarity will be assessed (team Readiness Assurance or tRA; 25% weightage in assessment).

   Team presentations will serve as the nucleus for a lively discussion by students, faculty and visiting experts. Individual student participation in these discussions will be assessed by faculty and visiting experts (25% weightage).
Each team will prepare a final presentation on their lead that covers the entire gamut of drug discovery and development to a viable business (25% weightage in assessment).

To understand biotech investing, each student will be assigned virtual USD 500,000. Each student will use online analytic tools (e.g. Morningstar) to evaluate BioPharma companies from a list we provide, and then use the USD 500K to create an investment portfolio. Students will track their portfolio during the course, buying and selling shares on a weekly basis. Students with the top three most productive portfolios will receive prizes.

9. MD9103 Biological Imaging
This module will provide introduction to optical microscopy, as well as the wide variety of non-optical imaging modalities in use in modern laboratories. Optical microscopy was invented by Antonie van Leuwenhoek in the 17th century in Holland. By making tiny spherical glass lenses obtained by melting fine glass rods, he was able to observe the mineral and living world with unprecedented detail, and is attributed to be the first to recognise the existence of single celled organisms. Better understanding of the physics of light has led to the definition of optical resolution in terms of the wavelength of the light. Understanding of reflection, refraction, polarization, diffraction and interference phenomena led to understanding a range of defects such as chromatic and spherical aberrations and how to overcome these.

Developments in Physics, including the description of light in terms of its quantal properties led to new microscopy techniques based on fluorescence phenomena. Further progress led to new ways for studying matter and for imaging: Positron Emission Tomography and X-ray imaging. Developments in spectroscopy using X-rays or Nuclear Magnetic Resonance also provide new high resolution techniques for imaging, such as Functional Magnetic Resonance Imaging (fMRI). Some scientific applications of the medical imaging techniques like fMRI, X-ray, CT-scans, PET and ultrasound, will be discussed. Students will be acquainted with the most prominent modern imaging techniques, such as confocal, fluorescence, NMR/MRI, PET and X-rays. The students will have a chance to expose to various imaging techniques during the theoretical and practical sessions.

The course might evoke a passion for imaging among students or prepare them for the laboratory by giving them a grounding in the principles, concepts, applications and language of Biological Imaging.
Light microscopy
Confocal microscopy
Fluorescence microscopy
Advanced light microscopy: Light sheet microscopy, two-photon microscope, FRAP, FRET, OCT, etc.
Magnetic Resonance Imaging (MRI)
Nuclear Imaging (PET & SPECT)
Electron microscopy
Raman spectroscopy

10. MD9106 Emerging Omics Technologies for Systems Biology & Personalised Medicine
All biological organisms, whether prokaryotes or the human body comprise a highly complex system of networks that are tightly regulated to maintain physiological and biochemical health. Factors contributing to this complexity are inter-individual differences of genetics and epigenetics, the microbiomes, as well as the external environment. Understanding how these complex networks are controlled is the goal of systems biology, and elucidation of individual variation and pathogenic perturbations could lead to personalised medicine. Advances in technologies that enable systems-scale analyses of biomolecules, from genes, to proteins and metabolites (omics) as well as big-data biocomputational approaches and tools have allowed us to derive novel insights into biological networks, leading to identification of alternative therapeutic approaches or biomarkers for a wide range of human diseases.

11. MD9108 Neural Systems and Behaviour
This course is offered as a follow-up elective course to MD9104 with effect from Semester 2, AY2017-18. Students are encouraged to first take MD9104 but this is not a prerequisite. For students whose research interest is in neural systems and behaviour, they are encouraged to take both courses. The course aims to give students an introduction to systems neuroscience, including sensory and motor systems, behaviour, memory and cognition. Students will understand conceptual foundations of systems neuroscience via textbook readings, lectures, class discussions and in-depth analysis of important research papers in the field.

- Somatosensory System and Pain
- Visual System
- Auditory and Vestibular Systems
- Motor Neuron Circuits and Motor Control
• Modulation of Movement: Basal Ganglia and Cerebellum
• Eye Movements and Sensory-Motor Integration
• Brain Plasticity
• The Association Cortices
• Language and Speech
• Sleep and Wakefulness
• Emotions
• Sex, Sexuality, and the Brain
• Memory

12. MD9109 Professional Skills for Researchers
This course aims to enhance the soft skills and careers of graduate students. It is developed using the non-profit Vitae programme which supports the professional development of researchers globally. Vitae provides a library of training materials and institutional case studies, especially designed for researchers. Our syllabus is based on the Researcher Development Framework (RDF) which defines the knowledge, behaviour and attributes of successful researchers. Graduate students will learn to use the RDF Planner for professional development, to identify strengths, action plan, review achievements and create a portfolio of evidence. This course is also enriched with Vitae practical resources for team-based activities in class.

13. BS7001 Foundation course in Molecular & Cell Biology
The aim of this course is to ensure graduate students have fundamental knowledge on topics of molecular and cell biology. Topics covered include: molecular and cellular mechanisms, genomic manipulations, control of gene expression, molecular immunology, virology, cancer biology, and hereditary diseases.

14. CH7102 Cell Therapeutics Engineering
This course introduces students to Tissue Engineering, and covers topics on Tissue Engineering fundamentals, practical Tissue Engineering and case studies. It also provides a forum for discussion on papers in literature and current issues in Tissue Engineering. The objective of this course is to provide students with a good foundation upon which cell and tissue-based therapy can be explored.