

Module Information

Module Code	Module Title	Semester	Mod. Credits
LSM3245	RNA Biology And Technology	1	4

Module Description

This module examines the roles of RNA, coding and in particular non-coding (ncRNA), in regulation of gene expression, host–pathogen interaction, and catalysis as well as their applications in research, diagnosis, and therapy of human diseases. The topics cover the ‘RNA world hypothesis’, the relation between structure and function of RNA, the mechanisms of regulation and dysregulation of gene expression by ncRNAs, selection and design of functional RNAs, features and usage of ncRNAs, the role of RNA in early stage pharmaceutical developments, and RNA-based drug development and FDA approval. The technologies discussed in this module include the antisense and ribozyme technologies, aptamers and Spiegelmers, RNA interference, RNA trans-splicing, CRISPR/Cas genome editing, mRNA vaccination, circular RNA and microRNA sponges, miRNA antagonists, functional genomics screens and high throughput sequencing, chemical modification and delivery vectors.

Eligibility and requirements

Prerequisites (prior knowledge required): LSM1102/LSM1106 or basic knowledge in molecular biology, cell biology or molecular genetics

Corequisites: NIL

Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:

- 1) Lecture
- 2) Tutorial
- 3) Seminar
- 4) Blended Learning
- 5) Inquiry-based or Research
- 6) Group work

Assessment modes

The following assessments will be employed:

40% Continuous Assessment:

- 1) Mid-term exam (MCQ quiz)
- 2) literature review (each 20%)

60% Final Examination: MCQ and SAQ

Contact information for Module Coordinator and other instructors

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Course content and syllabus

Introduction & Coding RNA

- The RNA world hypothesis - Molecular unit of genotype and phenotype
- The role of RNA in gene expression
- Structure and function of RNA

Naturally occurring non-coding RNA

- Antisense RNA and ribozymes
- Circular RNA
- Bacterial Cas/CRISPR systems
- Bacterial riboswitches
- RNA interference: miRNA, siRNA, and piRNA
- Non-coding RNA and human diseases

Artificial non-coding RNA

- Selection and evolution of RNA: in silico, in vitro (SELEX), and in vivo
- Aptamers and 'Spiegelmers'
- In vitro & in silico selection of antisense RNA
- siRNA and shRNA design
- mRNA design for enhanced gene expression
- mRNA and miRNA as targets
- RNA-guided genome editing (CRISPR/Cas9)
- RNA splicing (cis/trans)-based therapeutic approaches

RNA in early stage pharmaceutical development

- RNAi-based screens for target discovery & validation
- RNA-based diagnostics
- High-throughput technologies: Sequencing & microarrays of RNA

RNA as a drug – clinical applications

- Delivery and chemical modifications of RNA
- Clinical Trials, FDA approval, and RNA-based drugs
- mRNA vaccines (Covid-19 and cancer)

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the 'Intended Learning Outcomes' below:

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|---|-----------------------------|
| 1) Critical Reading & Critique, | 6) Inquiry-based Learning |
| 2) Debates | 7) Interactive Lecture |
| 3) Group Discussion or Discussion Forum | 8) Peer-Learning |
| 4) Group/Individual Presentation | 9) Problem-based Learning |
| 5) Group/Individual Project | 10) Self-Assessment or Quiz |
| | Student Generated Questions |

Group project, critical reading, group presentation: Teams of students are given a topic related to the lectures, a review article and an original research article which they have to complement by literature of their choice in order to extract and present a story. The literature reviews are presented by the teams in front of the class followed by an intensive discussion and debate. This exercise facilitates collaboration and teamwork, verbal/oral communication, digital & information literacy, efficient planning and organisation.

Interactive lectures and problem based learning: The lectures are very interactive and interdisciplinary and include problem-based learning activities facilitating interdisciplinary and creative thinking, quantitative thinking and ethics awareness.

Technology-supported three-stage classroom feedback system for promotion of self-regulation and assessment of student and teacher performance: Classroom feedback is essential to facilitate self-regulation and assessment of student and teacher performance. A technology-supported classroom feedback system is implemented which provides students with three different levels of feedback: First, a direct computerized quantitative feedback; second, a dialogical external feedback from peers; and third, a class-wide qualitative external feedback from the teacher. This easy to set-up three-stage classroom feedback system enables the application of several principles of good feedback practice, triggers measurable learner and teacher self-regulation and steadily improves the quality of learning and teaching.

Intended Learning Outcomes

Knowledge development

Having attended this module, students should have acquired fundamental and specific knowledge on the role of RNA in evolution of life, the mechanisms of ncRNA in regulation and dysregulation of gene expression in multicellular organisms, applications of RNA in drug discovery and development, and RNA-based diagnostics and therapeutics. They should be able to understand, critically evaluate, and review the literature in this area.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

The students will achieve a level of integrative understanding and are trained in knowledge transformation.

Very Good Opportunities	Good Opportunities
<ul style="list-style-type: none">1) Understand: Question, Connect & Explain2) Apply: Use, Execute & Implement3) Analyze: Differentiate, Organize & Attribute4) Evaluate: Review, Check & Critique5) Create: Ideate, Plan, Generate & Produce6) Verbal/Oral Communication7) Digital & Information Literacy8) Analytical & Critical Thinking9) Quantitative Thinking10) Interdisciplinary Thinking11) Creative Thinking12) Problem-solving & Decision-making13) Collaboration & Teamwork14) Planning, Organizing & Management skills15) Ethics Awareness16) Self-Efficacy17) Adaptability & Learnability18) Resilience	<ul style="list-style-type: none">1) Remember: Recognize, Recall & Know2) Written Communication

Required and/or recommended readings

Optional and not required:

Life's Indispensable Molecule, James Darnell, 1st Ed. (2011), CSH Laboratory Press

RNA Worlds, Atkins, Gesteland, Cech (2011), CSH Laboratory Press