

SYLLABUS

BMS 894 Demystifying the RNA World

Location and meeting times: Center for Medical Sciences, Bioinformatics Conference Room,
1:30 to 3:20 pm on Wednesday

Course Directors:

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Course Description: RNA has emerged as a molecule of major importance throughout biology. Interest in RNA has exploded over the last decade, fueled in part by the discovery of microRNAs and RNA interference. In this course, students will be introduced to the diversity of RNA molecules and their functions in the cell. An interdisciplinary approach to understanding RNA structure and function will be taken. Topics will include: RNA secondary and tertiary structure, ribonucleoprotein complexes, noncoding RNAs, parasitic RNAs, catalytic RNAs and RNA interference.

Learning objectives for BMS894:

- You will be able to describe the major roles of RNA in biology.
- You will be able to present a cross-disciplinary view of the multifaceted roles of RNA in cell function.
- You will learn about the structure of RNA and how that influences function.
- You will be familiar with computer programs to predict RNA secondary and tertiary structures.
- You will learn about RNA as a primordial molecule.
- You will understand how different RNAs are encoded in the genome and how they mature into their functional forms.
- You will learn about the role of RNA in regulation of post-transcriptional gene expression.
- You will learn about the emerging fields of small non-coding RNAs, including bacterial sRNAs and eukaryotic miRNAs, siRNAs and piwiRNAs.
- You will be able to explain mechanisms of enzymatic RNAs.
- You will know how RNA has shaped eukaryotic genomes.
- You will be able to describe how an understanding of RNA functions is changing the way we do and think about research in biology.
- You will be able to explain how the basic aspects of RNA biology are shaping science and human health.

Grading Type: S/U

Students will participate in peer-evaluation of group projects. The instructors will base grades on class participation (50%) and evaluation of projects (50%).

Projects: The course directors will assemble small groups to work on two projects. One will be on the structural analysis of an RNA molecule. The second will be to design and present an NSF-style proposal to study the biological function of an RNA molecule.

Suggested Reading: Selected Chapters of The RNA World, 3rd edition (available online).

Attendance Policy:

Participation in the course is expected and will be considered in the final grade.

Lecture Schedule

SEPTEMBER 2

Lecture 1 – Overview of the course; Overview of the Biology of RNA (Laederach and Pata)

- The Central Dogma and beyond
- Properties of RNA
- Types and functions of RNA (coding RNA, non-coding RNAs, regulatory RNAs, catalytic RNAs, parasitic RNAs)

SEPTEMBER 9

Lecture 2 – The RNA World (Ferris and Laederach)

- RNA as the primordial molecule
- Evidence for the RNA World hypothesis

SEPTEMBER 16

Lecture 3 – RNA secondary structure part I (Theimer)

- Chemical composition of RNA
- Base pairing (including non-standard Watson-Crick base pairing)
- Hyperchromic effect
- Introduction to thermodynamics and the RNA Turner rules

SEPTEMBER 23

Lecture 4 – RNA secondary structure, part II (Li and Laederach)

- 2° structure diagrams
- Structure of tRNAs and ribozymes
- The hard way to predict an RNA structure: minimizing a free energy function to obtain a structural prediction

SEPTEMBER 30

Lecture 5 – RNA secondary structure, part III (Zuker and Laederach)

- The easy way to predict RNA secondary structure: dynamic programming algorithms for finding the minimum free energy structure
- In class demonstration using M-fold

OCTOBER 14

Lecture 6 – RNA tertiary structure (Theimer)

- Simple helices
- A and B form
- Major and minor grooves
- Triplexes
- Quadraplexes
- Pseudoknots
- Tetraloops
- In class demonstration using 3D structural prediction program (e.g., Pymol)

OCTOBER 21

Meeting 7 – Student presentations (Theimer and Laederach)

OCTOBER 28

Lecture 8 – RNA-binding proteins, post-transcriptional gene regulation and ncRNAs (Tenenbaum)

- The role of RNA-protein interactions in the regulation of gene expression
- Untranslated regions (UTRs) of mRNA
- The ENCODE project: an explosion of non-coding RNAs
- The role of RNAs in translational regulation
- non-coding RNAs in gene dosage regulation

NOVEMBER 4

Lecture 9 – RNA-small molecule and RNA-protein interactions (Shi and Tenenbaum)

- RNA Aptamers
- The RNP world: RNA binding domains
- RNA motifs
- RNA kinetics

NOVEMBER 11

Lecture 10 – The discovery, biogenesis, genomics and functions of tiny RNAs (Conklin and Curcio)

- RNA interference and siRNAs
- miRNAs
- piwiRNAs

NOVEMBER 18

Lecture 12 – Parasitic RNAs (Belfort and Curcio)

- Group I and Group II self splicing introns
- Retrotransposons and Viral RNAs
- Telomerase, Pseudogenes, Retrosequences and the Retrogenome

NOVEMBER 25-THANKSGIVING BREAK

DECEMBER 2

Lecture 13 – Large RNAs and Technology (Contreras and Curcio)

Date TBA

Meeting 14 – Student presentations (Tenenbaum and Curcio)