



Course ID and Title: BISC 402: RNA Biology and Biotechnology

Units: 4

Class Time: Tuesday and Thursday 2-3:50

Location: RRI

Professor: Dr. Derrick Morton:

Office: RRI 104A

Office Hours: TBD

Contact Info: mortond@usc.edu

IT Help:

Hours of Service:

Contact Info: [Email, phone number (office, cell), Skype]

Course Description: The purpose of this course is to introduce students (upper level undergraduate/graduate students) to the fundamental concepts of RNA biology and to state-of-the-art biotechnologies that use RNA for medical and industrial applications. The course draws on the recent developments of utilizing RNA as medicine, providing a platform to discuss aspects of RNA processing, disease mechanism, steps taken to move from the bench to the bedside, and consider the socioeconomic implications of developing and delivering such a treatment. Topics will include treatment for the devastating motor neuron disease, spinal muscular atrophy (SMA), CRISPR/Cas genome editing and recent therapeutic advances that exploit RNA biology including the recent COVID-19 mRNA vaccines. It is now clear that most of genomic DNA is transcribed into RNA and only about 2% of genomic DNA is coding, while all the rest is transcribed into non-coding RNA. RNA has an ample spectrum of functions and many of its functions are yet to be discovered. RNA impacts almost every aspect of gene expression and regulation and its malfunction is associated with many types of human diseases, particularly neurological disease. RNA is also a catalyst, a scaffold and a guide for sequence-specific recognition and processing of other RNA and protein molecules. Moreover, progress in our understanding of RNA biology has made it possible to identify RNA molecules as targets of therapeutic intervention and to use RNA as a tool for functional studies, to treat human disease and for industrial applications. Understanding the biology of RNA is an essential investigation for basic, medical, pharmaceutical, and environmental research. RNA-based techniques (RNA interference, antisense RNA, CRISPR system, RNA nanotechnology etc.) are becoming more and more useful in gene therapy, applied research, and translational approaches. These topics will be covered in depth with lectures, journal clubs and debates building on the historical discoveries that led to the life-changing treatment for SMA.

Learning Objectives: Upon completion of this course, students will be able to:

1. Describe the processes involved in RNA metabolism, processing and function, and the basic concepts of major RNA technologies using the molecular basis and treatment of the neurological disease Spinal Muscular Atrophy (SMA) as a platform.
2. Describe how modern technology is leading to new treatments and personalized medicine.
3. Be familiar with theoretical foundations of the major technical approaches involved in RNA detection and quantification.
4. Understand molecular and cellular foundations of RNA biology and major approaches utilized in RNA biotechnology.
5. Appreciate the integrative interdisciplinary approaches to major biological problems.
6. Read, interpret, explain and discuss primary literature that concerns RNA biology and biotechnology.
7. Understand the molecular mechanisms underlying neurological diseases, which are often linked to mutations in genes encoding RNA binding proteins.

8. Increase their skills in the area of scientific discussion and analysis of current scientific literature.
9. Improve scientific writing skills and be familiar with scientific referencing.

Prerequisites: Molecular Biology and Genetics. Biochemistry strongly preferred.

Course Notes

Required Readings and Supplementary Materials

No textbook covers all the information in this course; however, some parts of the topics of the class are covered in the 'Molecular Biology of RNA' 1st Edition by David Elliott and Michael Ladomery, 2016 Oxford University Press, ISBN: 978-0-19-967139-7 The 'Molecular Biology of RNA' is a specialized and pertinent text for this class. Background information is from Lodish 7th Edition and is posted in Blackboard. *All of the information that you will be required to know will be presented in class or assigned as research papers.*

Grading Breakdown

For registered students, the grade will be based on quizzes, a final paper that is developed over the course of the class, and an in-class journal club presentation and in-class discussion and participation.

Grading Breakdown	Quiz (1-4)	Journal Club Presentation (1-5)	Class Participation	Final Paper/Presentation
	Points: 200	Points: 250	Points: 100	Points: 100
	40% of total grade	15% of total grade	15% of total grade	30% of total grade

Quizzes - 40% *Quizzes are taken in class. Before each quiz, a series of slides presenting the key points will be shown as an Exercise. Notes on the Exercise can be used during the quiz.*

Journal club presentation- 15% *Students will select a scientific paper from a provided list and work in small groups to present and lead a journal club discussion in-class. Students will be graded individually on presentations although they will work in teams.*

Class participation- 15% *Class participation will be assessed by level of engagement during class discussion and in-class case studies. Engagement includes asking questions (including in person, through the chat box on zoom, or through Blackboard discussion boards), collaborative teamwork in small groups and completed case study handouts both in and outside of class.*

Final Paper/Presentation – 30% *Final paper will be assessed by a provided rubric. An optional rough draft will not affect final grade.*

Course format: Classes will be comprised of introductory lectures, journal club presentations of recent papers on assigned topics, and case studies on assigned topics. This course places also a strong emphasis on developing the student's ability to understand and critically evaluate scientific literature. We also discuss recent exciting findings and challenging problems in RNA biology and biotechnology such as the COVID-19 mRNA vaccine. The lecture part of the course is intercalated with journal club presentations, where students will work in small groups to present on research papers chosen by the students, and two case studies, where students will collaboratively work through the assigned activity in class.

Table 1. Course Schedule

<u>Week</u>	<u>Date</u>	<u>Class Activity</u>	<u>Topic</u>	<u>Reading/Assignment</u> (material listed is for the next class period with papers on blackboard)
1	Day 1	Introductions	Course Organization/SMA as a Platform/ What does RNA mean to me?	RNA-Ch. 1: 7.11-7.13, Lodish Ch. 4: p. 124-142
	Day 2	Lecture 1/Discussion	Introduction to the RNA work & searching the literature	Lodish Ch. 4: p. 115-122 RNA-Ch. 2: 2.1-2.7 RNA-Ch. 13: 13.1-13.4

2	Day 1	Lecture 2	RNA structure and function	RNA-Ch. 11 (review)
	Day 2	Lecture 3	Central Dogma	
3	Day 1	Lecture 4	Central Dogma continued	Read paper for Case Study: MMA replacement and do part 1 before class
	Day 2	Case Study: mRNA replacement and MMA		Prepare for Quiz
4	Day 1	Exercise/Quiz		Lodish Ch. 7 p. 288-301 RNA-Ch.3: 12.1-3.13 (Bentley, 2014)
	Day 2	Lecture 5	Techniques in RNA biology and biotechnology	Wilson and Doudna, 2013 RNA-Ch.16: 16.1-16.3
5	Day 1	Lecture 6	Transcription/RNA processing/RNA-seq	
	Day 2	Journal Club/Presentation 1		
6	Day 1	Lecture 7	RNAi and RNAi in medical and industrial applications/RNAi biotechnology	Prepare for Quiz II
	Day 2	Exercise/Quiz II		Baum et al., 2017
7	Day 1	Journal Club/Presentation II	Antisense Journal Club Biology	Harrison & Hart, 2018
	Day 2	Lecture 8	The CRISPR/Cas9 system – history and intro	Corbett, 2018
8	Day 1	Lecture 8 and class discussion	Biology & applications of the CRISPR/Cas9 system CRISPR/Cas9 approaches to treat Myotonic Dystrophy	Gilmore et al., 2021
	Day 2	Journal Club/Presentation III	Use of the CRISPR/Cas9 system <i>in vivo</i>	
9	Day 1		One slide presentation of final paper topic	1) Prepare for in class presentation/350 word max description of planned project 2) Upload presentation for next class
	Day 2		One slide presentation of final paper topic	Moore and Proudfoot, 2005
10	Day 1	Lecture 9	RNA processing, splicing and alternative splicing (SMA as an example)	Chiriboga, 2017
	Day 2	Lecture 10	SMA: The Road to Treatment	Study for Quiz III
11	Day 1	Exercise/Quiz III		Read Journal Club Paper (Patient-Customized Oligonucleotide Therapy for a Rare Disease. <i>N. Engl J Med</i> 2019; 381:1644-52)
	Day 2	Journal Club/Presentation IV	Personalized Medicine to treat a N=1 disease (Milasen)	Work on final written assignment draft
12	Day 1	In Class Office Hours: Work on final paper draft		Read Case Study and complete part 1 before class

	Day 2	Case Study: Tazswana's story Splicing and ASOs		Review of mRNA vaccines (TBD)
13	Day 1	Lecture 10 Draft of Final Paper Due	mRNA vaccines	Read selected paper (Pho Teo et al., 2021)
	Day 2	Journal Club/Presentation V	mRNA vaccines for coronavirus	Prepare for Quiz V
14	Day 1	Exercise/Quiz IV		
	Day 2	Final Discussion/Implications and Ethical Discussion	RNA as medicine, personalized and global and its ethical implications	
15	Day 1	Final Written Report Due/ In-Class Presentations		
	Day 2	Final Written Report Due/ In-Class Presentations		

All lectures presented are based primarily on outside sources, which will be provided to the students. Some of the topics covered can also be seen in suggested book chapters. The specific books and book chapters are indicated and any material will be uploaded to Blackboard:

Lodish 7th Edition: Readings from Chapters 4, 7, and 8

RNA = 'Molecular Biology of RNA' 2nd Edition by David Elliott and Michael Lodomery, 2016 Oxford University Press, ISBN: 978-0-19-967139-7.

Ch. = Chapter

Inclusivity statement: It is our intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. We will be having open discussion regarding some puzzling topics together - a collaborative environment where everyone is equally heard will enhance our experience and allow for richer discussion. Some topics we are discussing will include human diseases and may be sensitive for some students. **Therefore, there will be no tolerance for any offensive language or dismissive talk regarding human diseases or disabilities. Such language will result in immediate removal of the student from the discussion and class for that day.** It is our intent to present materials and activities that are respectful of diversity: gender, sexuality, ability status, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let us know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let us know so that we can make arrangements for you.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluations

Course evaluation occurs at the end of the semester university-wide. It is an important review of students' experience in the class. The process and intent of the end-of-semester evaluation should be provided. In addition, a [mid-semester evaluation](#) is recommended practice for early course correction.

Statement on Academic Conduct and Support Systems

Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.