

# Course Organization

## MCB 406 Gene Expression & Regulation (CRN: 62528)

### Course description:

MCB 406 is a lecture-discussion course that provides in-depth and up-to-date coverage of gene expression and regulation. Lectures are centered on the principles of regulating gene expression in eukaryotic cells. The course covers molecular mechanisms of the key gene expression events including transcription, RNA processing, mRNA localization, translation and degradation, as well as macromolecule structures and functions in gene expression and regulation. Applications of these principles in medicine and therapeutics such as aging, cancer biology and drug design are also discussed.

### Prerequisite: MCB 354

### Course Objectives:

- Understand molecular mechanisms of the key gene expression events in eukaryotic cells
- Use chemistry and biochemistry knowledge to explore interdisciplinary research on gene expression
- Understand the many roles of RNA in gene expression
- Gain awareness of gene expression in therapeutics including drug design
- Develop skills for understanding and analyzing the primary scientific literature
- Develop skills for communicating scientific information at an advanced level

**Duration:** Jan 17<sup>th</sup> – May 2nd, 2023

**Tuesday and Thursday:** 12:30 -1:50pm

**Location:** 1306 Everitt Laboratory

### Instructor Contact Information

Prof. Hong Jin

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Office Hour (H. Jin): Tuesday 2:15 – 3:15pm. Online via Zoom

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**Office Hour (TA)** Wednesday and Friday 5-6pm

**Locations:** TBA

## **Textbooks**

No specific textbook is required for this course.

## **Highly recommended books:**

### **Biochemistry (4<sup>th</sup> Edition)**

By Voet, Voet and Pratt, John Wiley & Sons, Inc, 2013 ISBN 978-0470-54784-7

### **Nucleic Acids: Structures, Properties, and Functions**

By Bloomfield, Crothers, and Tinoco, University Science Books, Sausalito, 2000. ISBN 0-935702-49-0

### **RNA Worlds: From Life's Origins to Diversity in Gene Regulation**

By John F. Atkins; Raymond F. Gesteland and Thomas R. Cech, 2011. ISBN 978-0-879699-46-8

### **RNA: A Laboratory Manual**

By Donald C. Rio; Manuel Ares, Jr; Gregory J. Hannon and Timothy W. Nilsen, 2011

ISBN 978-0-879698-91-1

The above textbooks will be on reserve in the Funk library. (1101 S. Goodwin, Urbana, Illinois 61821, <http://www.library.illinois.edu/funkaces/>)

Relevant chapters of the books will be scanned and posted online for references.

Class handouts, recent review articles and original research articles will be posted on the course website (<https://moodle.life.illinois.edu>). They can also be accessed through the UIUC online journals.

Students are responsible for the material assigned during lectures and from the handouts.

## **Exams:**

- There are three examinations: two midterm exams and one final exam.

## **Grading procedures**

Student grades in MCB 406 will be based on a total of 1000 points

- Lecture Participation (Discussions and Quizzes):
- Homework: 250 points
- Three Exams: 750 points

A more specific point breakdown for MCB 406 follows:

- Homework: 250 points
  - Five homework sets: 50 points each
- Two Lecture Exams/Midterms (*non-accumulative*): 500 points
  - Two exams: 250 points each
- Final Exam: 250 points

**Grading Scale:**

- A: 850-1000 Points (A+: 950-1000; A: 900-949; A-: 850-899)
- B: 700-849 Points. (B+: 800-849; B: 750-799; B-: 700-749)
- C: 550-699 Points. (C+: 650-699; C: 600-649; C-: 550-599)
- D: 450-550 Points and so on.

**Disability Accommodations**

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TTY), or e-mail a message to [disability@uiuc.edu](mailto:disability@uiuc.edu).

**Academic Integrity**

According to the Student Code, It is the responsibility of each student to refrain from infractions of academic integrity, from conduct that may lead to suspicion of such infractions, and from conduct that aids others in such infractions.' Please know that it is my responsibility as an instructor to uphold the academic integrity policy of the University, which can be found in the University Student Code, Article 1, part 4, §I-104.

## MCB 406: Gene Expression & Regulation

	Day	Date	Lecture Topics
1	Tu	Jan 17	<p><b>Introduction to MCB 406: An Overview of Gene Expression</b></p> <ul style="list-style-type: none"> <li>▪ The COVID-19 pandemic: through the lens of science</li> <li>▪ Gene expression profiles in healthy and cancer cells</li> <li>▪ The chemical structure and physical property of DNAs and RNAs</li> <li>▪ Course organization, Grading and Office Hours</li> </ul>
2	Thr	Jan 19	<p><b>Introduction to Scientific Investigations and Scientific Reasoning Skills</b></p> <p><b>Chromatin Structure and Remodeling</b></p> <ul style="list-style-type: none"> <li>▪ Nucleic acid structure</li> <li>▪ Physical and chemical properties of nucleic acids</li> <li>▪ Chromatin structure</li> <li>▪ Chromatin remodeling</li> </ul>
3	Tu	Jan 24	<p><b>Mechanisms of transcriptional regulation in gene expression</b></p> <ul style="list-style-type: none"> <li>▪ Eukaryotic transcriptional apparatus</li> <li>▪ RNA polymerase I, II, III</li> <li>▪ Atomic structure of RNA polymerase II</li> <li>▪ Actions of regulatory factors in transcription</li> <li>▪ Transcriptional regulation and human disease</li> </ul>
4	Thr	Jan 26	<p><b>Macromolecule structure, function and evolution I</b></p> <ul style="list-style-type: none"> <li>▪ Protein-DNA interactions in gene expression</li> <li>▪ The DNA-binding proteins and their recognition motifs</li> </ul> <p><b>Methods in studying gene expression I: Protein-nucleic acid interactions</b></p> <ul style="list-style-type: none"> <li>▪ General methods: <i>in vivo</i> and <i>in vitro</i> methods</li> <li>▪ Gene cloning and manipulation</li> <li>▪ Protein expression</li> <li>▪ Protein and nucleic acid purification</li> </ul>
5	Tu	Jan 31	<p><b>Mechanisms of post-transcriptional regulation in gene expression I</b></p> <p><b>An Overview</b></p> <p><b>The World of RNA</b></p> <ul style="list-style-type: none"> <li>▪ Why RNA is So Important?</li> <li>▪ Basic Physical and Chemical Properties of RNA</li> </ul> <p><b>RNA Anatomy:</b></p> <ul style="list-style-type: none"> <li>▪ Nucleotide <ul style="list-style-type: none"> <li>▪ Phosphate backbones</li> <li>▪ Sugar Puckers</li> <li>▪ Bases</li> </ul> </li> <li>▪ Primary, Secondary and Tertiary Structures</li> <li>▪ Helix Parameters</li> <li>▪ Hydrogen bonds in the Watson-Crick, Hoogsteen and Base-Sugar edges of RNAs</li> <li>▪ Common RNA structure motifs</li> <li>▪ RNA Structure Model Building</li> </ul>
6	Thr	Feb 02	<p><b>Methods in studying gene expression II Tools for RNA Science</b></p> <ul style="list-style-type: none"> <li>▪ Biochemical and biophysical methods in studying RNAs</li> </ul>

			<ul style="list-style-type: none"> <li>Probing gene expression in three dimensions: Structural Biology</li> <li>An introduction to X-ray crystallography</li> </ul>
7	Tu	Feb 07	Discussions on DNA and Transcription
8	Thr	Feb 09	Review on Part I
9	Tu	Feb 14	<b>Examination I</b>
10	Thr	Feb 16	<b>Non-coding RNAs in gene expression I Catalytic RNAs</b> <ul style="list-style-type: none"> <li>A story of serendipity: The Discovery of Catalytic RNAs; the Group I Intron and RNase P</li> <li>Catalytic Mechanisms</li> <li>The RNA World Hypothesis</li> <li>Group II Introns</li> <li>Other Small Ribozymes: Hammerhead and HDV Ribozymes</li> </ul>
11	Tu	Feb 21	<b>RNA Folding</b> <ul style="list-style-type: none"> <li>Roles of RNA folding in gene expression</li> <li>Riboswitches and their Functions</li> </ul> <b>Macromolecule structure, function and evolution II</b> <ul style="list-style-type: none"> <li>Protein-RNA interactions in gene expression</li> <li>RNA-binding Proteins and Their Recognition Motifs</li> </ul>
12	Thr	Feb 23	<b>Mechanisms of post-transcriptional regulation in gene expression II</b> <b>RNA Processing 1</b> <ul style="list-style-type: none"> <li>RNA processing in prokaryotes</li> <li>RNA processing in eukaryotes: Pre-mRNA splicing</li> </ul>
13	Tu	Feb 28	<b>Mechanisms of post-transcriptional regulation in gene expression III</b> <b>RNA Processing 2</b> <ul style="list-style-type: none"> <li>Spliceosome: Pre-mRNA Splicing Machinery</li> <li>Alternative Splicing and Organismal Complexity</li> </ul>
14	Thr	Mar 02	<b>Mechanisms of post-transcriptional regulation in gene expression IV</b> <b>Overview of RNA export and localization, translation and degradation</b> <ul style="list-style-type: none"> <li>RNA export</li> <li>RNA localization</li> </ul>
15	Tu	Mar 07	Discussions on Riboswitches, Ribozymes, Splicing and Human Disease
16	Thr	Mar 09	Review on Part II
Mar 11-19			<b>Spring Break</b>
17	Tu	Mar 21	<b>Examination II</b>
18	Thr	Mar 23	<b>Mechanisms of post-transcriptional regulation in gene expression V</b> <b>Translational regulation 1</b> <ul style="list-style-type: none"> <li>General features of prokaryotic and eukaryotic translation</li> <li>Ribosome: Protein Synthesis Machine</li> <li>Mechanisms on Peptide Bond Formation and Peptide Release</li> </ul>
19	Tu	Mar 28	<b>Mechanisms of post-transcriptional regulation in gene expression VI</b> <b>Translational regulation 2</b> <ul style="list-style-type: none"> <li>Translation initiation and control</li> <li>Eukaryotic ribosome</li> <li>Actions of regulatory factors in translation</li> </ul>
20	Thr	Mar 30	<b>Mechanisms of post-transcriptional regulation in gene expression VII</b> <b>Translational regulation 3</b>

			<ul style="list-style-type: none"> <li>▪ The translational apparatus: Assembly, Biogenesis and Diseases</li> <li>▪ Functionally specialized ribosome: The forefront of the translational control</li> <li>▪ Extending Genetic Code with Catalytic RNAs</li> </ul>
<b>21</b>	Tu	Apr 04	<b>Non-coding RNAs in gene expression II</b> snoRNAs, snRNAs and microRNAs in development and disease Short non-coding RNAs and gene silencing
<b>22</b>	Thr	Apr 06	<b>Quality Control in Protein Synthesis</b>
<b>23</b>	Tu	Apr 11	<b>RNA Degradation and Control</b>
<b>24</b>	Thr	Apr 13	<b>Non-coding RNAs in gene expression III</b> The long non-coding RNAs: Epigenetic regulation of gene expression
<b>25</b>	Tu	Apr 18	<b>Protein Trafficking and Degradation</b>
<b>26</b>	Thr	Apr 20	Discussions on translational and post-translational regulations
<b>27</b>	Tu	Apr 25	Review on Part III
<b>28</b>	Thr	Apr 27	Summary of gene expression and regulation in eukaryotes Applications in human health and disease RNA and RNPs in Disease and Therapeutics
<b>29</b>	Tu	May 02	<b>Current Topics</b>
			<b>Final Exam</b> (Time and location will be determined by the campus)