

# Chem 689. Nucleic Acids Chemistry: A Focus on Cutting-Edge Technologies for Research and Therapy.

T/Th @ 8:00 am, Room CHEM 2101

## Instructor

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## Office Hours

TBD

## Course Description

This course introduces students to the benefits and applications of technologies derived from nucleic acids (DNA and RNA) and related biopolymers. Although the physical and chemical properties of nucleic acids will be discussed, the course is designed to go well-beyond these basic principles by immersing students in the “real world” of nucleic acid-based technology (i.e. how are nucleic acids currently being exploited to advance research, biotechnology, and medicine). Importantly, students will also learn a variety of biochemical and biophysical approaches for conducting research on nucleic acids, which will be integrated into each lecture. Topics for each lecture are shown below (see Tentative Schedule).

**Prerequisites:** Students must hold an undergraduate degree in physical sciences, biological sciences, or engineering OR be a current upper-level undergraduate student in one of those areas. Although upper-level undergraduate students are encouraged to take this course, it is recommended they discuss enrolment with the instructor prior to registration.

## Texts

No specific text is assigned to this course. Numerous papers and review articles, both recent and classic, will be used. You will need a large 3 ring binder to hold class notes and handouts.

## Course Format

Lectures. Course content will be presented primarily using PowerPoint slides. To make time for class discussions, I will provide the slides and detailed lecture notes, including literature references, prior to each class period. Students will be required to read the associated literature references before class, which will also serve as the homework assignment.

Quizzes. Short (5–10 minute) quizzes will be given periodically. These quizzes will be devoted exclusively to the assigned readings for that lecture period.

Exams. Both a midterm and final exam will be given. The final exam will be given at the TAMU prescribed time.

Research Proposal. Students will be asked to prepare an original research proposal that, in some way, involves nucleic acids as a key component of the work. The goal of the research proposal is to challenge students to identify outstanding problems and/or questions and design experiments to address them. Furthermore, this project will expose students to the grant-writing process. **Proposals that integrate course topics with a student’s current graduate research are highly encouraged.** During the second half of the semester, every student will be responsible for preparing a 20-minute presentation regarding their research proposal topic, the purpose of which is to facilitate constructive criticism from the class and instructor. The format of the final document (6 pages) will be modeled after the National Institutes of Health (NIH) Research Strategy attachment, and therefore contain the following sections: Significance, Innovation, and Approach.

## Evaluation method

|   |            |
|---|------------|
| Quizzes                                     | 30 points  |
| Two in-class examinations (including Final) | 300 points |
| Research proposal presentation              | 50 points  |
| Research proposal document                  | 100 points |
| Total                                       | 480 points |

## Schedule of Lectures and Topics (tentative)

| <u>Lecture</u> | <u>Topic</u>   |
|----------------|--|
| 1              | Introduction and overview of nucleic acids research.   |
| 2,3            | DNA and RNA structure. Physical and spectroscopic properties of DNA and RNA; primary and secondary structures of DNA and RNA.  |
| 4              | Higher-order DNA structures: nucleosomes, chromatin, and genes/genomes.  |
| 5              | Enzymatic and chemical methods to manipulate nucleic acids and related laboratory techniques.  |
| 6              | Chemical synthesis of nucleosides.   |
| 7              | Chemical synthesis of oligonucleotides: the phosphoramidite method (history and scope). <b>A demonstration will be carried out on the Sczepanski Laboratory's solid-phase DNA/RNA synthesizer.</b> |
| 8,9            | Synthesis and applications of modified oligonucleotides.   |
| 10,11          | DNA sequence determination: the history of DNA sequencing technologies and current state-of-the-art from a chemical perspective. Case study: Human Genome Project vs. Celera.                      |
| 12             | Genome-wide approaches   |
| 13             | Xeno-nucleic acids (XNAs): base and sugar-modified nucleic acids.  |
| 14,15          | Antisense oligonucleotides and RNA interference (RNAi) technologies. Oligonucleotide reagents as therapeutics. Case study: Spinraza® (Nusinersen).   |
| 16             | Directed evolution of nucleic acids: aptamers, ribozymes, and DNAzymes.  |
| 17             | Aptamers, ribozymes, and DNAzymes in research and therapy. Case study: Macugen® (pegaptanib).  |
| 18             | <b>Midterm Exam</b>  |
| 19             | Synthetic evolution systems  |
| 20             | CRISPR/Cas-based technologies.   |
| 21,22          | <b>Research proposal preliminary presentations.</b>  |
| 23,24          | Nucleic acid technologies for imaging and diagnostic applications.   |
| 25             | DNA-templated synthesis and DNA-encoded combinatorial libraries.   |
| 26             | Nucleic acids nanotechnology (static constructions) and DNA origami.   |

- 27 DNA strand-displacement cascades, DNA logic gates, and DNA computing.
- 28 RNA structure and function. RNA post-transcriptional modifications and epitranscriptomics.

## Legal Material

### Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, currently located in the Disability Services building at the Student Services at White Creek complex on west campus or call 979-845-1637. For additional information visit <http://disability.tamu.edu/>

### Aggie Honor Code Policy

*"An Aggie does not lie, cheat or steal, or tolerate those who do."*

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the TAMU community from the requirements or the process of the Honor System. Additional information about the Aggie Honor Code can be found at: <http://www.tamu.edu/aggiehonor/>. The consequences for cheating and plagiarism on any assignment associated with CHEM227 will result in an unsatisfactory grade for the course.

### Make-Up Policies

If an absence is excused, the instructor will either provide the student an opportunity to make up any quiz, exam or other work that contributes to the final grade or provide a satisfactory alternative by a date agreed upon by the student and instructor. If the instructor has a regularly scheduled make up exam, students are expected to attend unless they have a university approved excuse. The make-up work must be completed in a timeframe not to exceed 30 calendar days from the last day of the initial absence.

The student is responsible for providing satisfactory evidence to the instructor to substantiate the reason for the absence. Among the reasons absences are considered excused by the university are the following (see Student Rule 7 for details <http://student-rules.tamu.edu/rule07> ). The fact that these are university-excused absences does not relieve the student of responsibility for prior notification and documentation. Failure to notify and/or document properly may result in an unexcused absence. Falsification of documentation is a violation of the Honor Code.

- 1) Participation in an activity that is required for a class and appears on the university authorized activity list at <https://stuactonline.tamu.edu/app/sponsauth/index>
- 2) Death or major illness in a student's immediate family.
- 3) Illness of a dependent family member.
- 4) Participation in legal proceedings or administrative procedures that require a student's presence.
- 5) Religious holy day. NOTE: Prior notification is NOT required.
- 6) Injury or illness that is too severe or contagious for the student to attend class.
  - a) Injury or illness of three or more class days:  
Student will provide a medical confirmation note from his or her medical provider within one week of the last date of the absence (see Student Rules 7.1.6.1)
  - b) Injury or illness of less than three class days:  
Student will provide one or both of these (at instructor's discretion), within one week of the last date of the absence:
    - (i.) Texas A&M University Explanatory Statement for Absence from Class form available at <http://attendance.tamu.edu>

(ii.) Confirmation of visit to a health care professional affirming date and time of visit.

c) An absence for a non-acute medical service does not constitute an excused absence.

- 7) Required participation in military duties.
- 8) Mandatory admission interviews for professional or graduate school that cannot be rescheduled.
- 9) Mandatory participation as a student-athlete in NCAA-sanctioned competition.
- 10) In accordance with Title IX of the Educational Amendments of 1972, Texas A&M University shall treat pregnancy (childbirth, false pregnancy, termination of pregnancy and recovery therefrom) and related conditions as a justification for an excused absence for so long a period of time as is deemed medically necessary by the student's physician. Requests for excused absence related to pregnancy should be directed to the instructor. Other absences may be excused at the discretion of the instructor with prior notification and proper documentation.

In cases where prior notification is not feasible (e.g., accident or emergency) the student must provide notification by the end of the second working day after the absence, including an explanation of why notice could not be sent prior to the class.

Accommodations sought for absences due to the observance of a religious holiday can be sought either prior or after the absence, but not later than two working days after the absence.