Proteomics: Technologies and Applications Syllabus

BIOS 4710;4803 CHEM 4710;4823
BIOL 6710;8803 CHEM 6710;8823
3 credits

Location, day, time: TBD

Instructor Information

Instructor	Email	Office Hours & Location
Prof. Matthew Torres	mtorres35@gatech.edu	By appointment

General Information

Course Description/Modality:

This course is designed for graduate and undergraduate level students interested in understanding fundamental aspects underlying the study of proteins at the omics level (proteomics), including technologies and their application to biological problems. Several different aspects of modern proteomics will be discussed in the context of six major features: (1) Scientific problem; (2) Sampling; (3) Detection; (4) Data Processing; (5) Bioinformatics; (6) AI. Through a mixture of hands-on workshops inter-mixed with lectures, student presentations, and primary literature review, students will learn to recognize how these fundamental components are combined and exploited to study proteomes at multiple levels of complexity. The course will uncover commonalities in how different strategies inform the observer about biological process through quantitative measurement of protein abundance, molecular interactions, and post-translational modifications (PTMs). Once a foundation is reached, we will discuss alternative proteomics approaches – thinking about what other types of protein information is needed in cell and molecular biology and how this may define the future of the field. By the end of the course, students should have enough knowledge to propose novel strategies for proteomic analysis given a biological question of interest; and to discuss the inherent caveats and benefits of common proteomics strategies. Students emerging from this class will be on their way to designing, interpreting, and critically reviewing proteomics research.

Course Goals and Learning Outcomes:

Upon completion of this course, students will be able to: (1) Compare/contrast the advantages/ disadvantages of proteomics in comparison to genomics, transcriptomics; (2) Describe the fundamental components of any proteomics experiment; (3) Provide examples of each fundamental component including the caveats and benefits; (4) Interpret, critically evaluate, and discuss primary literature examples that include proteomics; (5) Carry out the analysis of raw mass spec proteomics data; and (6) Understand the growing list of alternative proteomics methods and applications emerging in the field today.

Prerequisites:

(BIOS 1107 or BIOS 1207) and (BIOS 1107L or BIOS 1207L) with minimum D grade.

Recommended background knowledge:

The class will be immersed in protein biochemistry concepts and it is advisable, though not required, to have experience (either from a biochemistry class and/or research) in this area before taking this class.

Course Requirements & Grading

Grading Components and Descriptions:

G = PhD graduate students
UG = Undergraduates students
G and UG students will be balanced across groups

***Workshops** (G: **25%** ; UG: **25%**):*

The workshops (typically 5 different workshops) are a guided "lab exercises" provided in digital excel spreadsheet or MS-word format (delivered and turned in for grading through Canvas). Each workshop consists of a series of questions that are meant to carry the student through a theoretical experiment. The students are allowed to work in class with their pre-organized groups and at various times during the workshop students may be asked to share their results/interpretation with the rest of the class. Students are intended to: 1) achieve the requested analysis successfully (well organized…proper plot axes…accurate data); and 2) properly interpret the results that they plot. After grading, the class will discuss key points about the workshop. The expectation is that the student provides well thought-out responses in a type-written and organized format. Short answer responses are graded on a "5-star amazon" scale where a 5-star response is something that everyone will buy without hesitation….a 4 star response is very good and acceptable though not quite perfect (maybe missing some nuance that is important)…a 3 star response is correct but missing some key element needed for a convincing argument….while 2 and 1 star responses are not going to be "purchased" as they lack key facts and are unconvincing attempts to provide an explanatory answer. I use this to try and avoid single sentence answers that don't tell me how they are thinking. The completed document serves as the deliverable product from the workshop and should be provided by each student.

***Exams** (G: **25%; UG: 45%**)*:

2 exams (Mid-Term = G: **10%** UG: **20%**; Final = G: **15%** UG: **25%**)
These will cover topics discussed and workshops completed. The exams will be take-home and involve the interpretation/explanation of data from primary literature as well as basic fundamental questions. Exams should be type-written and diagrams should be legible and clearly indicative or points will be taken off. Grad students will be asked additional questions to test depth of knowledge/understanding.

***Quizzes/Homework** (G: **5%** ; UG: **15%**):*

Intermittent quizzes and homework assignments will be given throughout the semester, which provide feedback on your understanding of founding principles. Quizzes may be in class or remote via canvas.

***Group Presentation** (G: **25%** ; UG: **10%**)*:

Each group of 3-4 will be responsible for teaching one of the class periods near then end of the semester. Each group will be given a paper(s) on a mass spec-alternative technology and the group will

then find a separate manuscript in which that alternative technology is applied to a biological problem. The group will lead the entire class through: 1) An introduction to the technology and 2) it's caveats and strengths; as well as 3) An introduction to the application paper and 4) it's application of the technology, interpretation, and conclusions. Presentations will be peer- and professor-evaluated.

Specific Aim Project (Grad Only) *(G: **15%**)*

Graduate students will design an NIH-style proteomics aim complete with: 1) *Hypothesis*; 2) *Rationale*; 3) *Data Acquisition Methods*; 4) *Analysis Methods*; 5) *Expected Outcomes*; and 6) *Potential Pitfalls and Alternative Approaches*. Aims will be chosen by the graduate student and approved by the professor at the beginning of the course. The project is due at the same time as the final.

***Active Participation (5%)*:**

Active participation is assessed by online polling and instructor-recorded student engagement. Students are expected to attend every class and assessed by digital question/response (live classroom polling). The class will not be streamed. Any absence due to sickness will require an official doctor's note. Each student is expected to be participate actively in class. Avoid falling into the background and be sure to be active in your presence (asking questions, facilitating dialogue, helping other students in workshops). Find ways to contribute and make the class better for everyone!

Grading Scale

90% and greater	A
80-89%	B
70-79%	C
60-69%	D
Less than 60%	F

The default will be to grade without a curve.

Course Schedule

This syllabus is subject to change as deemed necessary by Professor Torres

Mode: (L = Lecture; W = Workshop; ICD = In-class discussion; GP = Group presentation)

Reading is posted per number on canvas.

WEEK	DATE	TOPIC	MODE	READING
1	19-Aug	Lecture 1: Foundations of proteomics.	L	1
	21-Aug	Lecture 2: Protein biochemistry basics - parsable characteristics of proteins	L	2
2	26-Aug	Lect.2 (cont'), Workshop #1 - hands on with proteins and common web resource	L/W	2
	28-Aug	Workshop #1 - hands on with proteins and common web resource	W	
3	2-Aug	***NO CLASS LABOR DAY***		
	4-Sep	Lecture 3: Common protein separation and detection strats	L	3
4	9-Sep	Lecture 4: Mass spectrometry basics and MS for protein identification	L	4
	11-Sep	Lecture 4 con't plus CS breakout	L/W	4
5	16-Sep	Workshop #2 - (Peptide Mass Fingerprinting)	W	
	18-Sep	Lecture 5: Protein sequencing by MS	L/W	4
6	23-Sep	Workshop #3 - hands on with MS peptide ID (de novo sequencing)	W	
	25-Sep	Workshop #4 - MS sequencing of phosphopeptides	W	
7	30-Sep	Lecture 6: MS protein identification at Scale and Quantitative Proteomics	L	5
	2-Oct	Lecture 6 (continued) MS protein identification at Scale and Quantitative Protec	L/W	6,7
8	7-Oct	***REVIEW (TAKE HOME MIDTERM EXAM GIVEN (DUE BACK OCT 16 or earlier))***		
	9-Oct	Workshop #5- hands on with large scale proteomics data	W	7
9	14-Oct	***NO CLASS: FALL BREAK***		
	16-Oct	Workshop #5- hands on with large scale proteomics data	W	7
		TAKE HOME MIDTERM EXAM DUE BY MIDNIGHT		
10	21-Oct	Workshop #5- hands on with large scale proteomics data	W	7
	23-Oct	Lecture 7: Modern Enhancements to Traditional MS Proteomics	L	8
11	28-Oct	Lecture 8: Interactomics	L	
	30-Oct	*Primary Literature Case Study in Interactomics - Proximity Labeling*	ICD	9
12	4-Nov	Lecture 9: Chemical Proteomics	L	10
	6-Nov	*Primary Literature Case Study in Chemoproteomics*	ICD	11
13	11-Nov	Group-Taught Classroom: G1	GP	TBD
	13-Nov	Group-Taught Classroom: G2	GP	TBD
14	18-Nov	Group-Taught Classroom: G3	GP	TBD
	20-Nov	Group-Taught Classroom: G4	GP	TBD
15	25-Nov	Group-Taught Classroom: G5	GP	TBD
	27-Nov	***NO CLASS: THANKSGIVING BREAK***		
	2-Dec	***TURN IN PRESENTATION REPORTS *SLIDES + WORK DISTRIBUTIONS) BEFORE THIS DATE***		
16	11-Dec	***TAKE HOME FINAL DUE***		

***NOTE: Final exam will be turned in via Canvas on Dec. 11th WITHOUT EXCEPTION.**

Course Materials

Lecture Slides:

All slides used to facilitate discussion in class will be made available on Canvas *after* the class period in which they were presented. Students are encouraged to take notes.

Primary Literature:

The course will rely heavily on primary literature provided by Professor Torres via Canvas.

Workshop Sessions:

Workshops will require that each student has a laptop linked to the GT wifi so that they can perform analyses on data and run simulations. These tools are free and should be bookmarked to allow rapid access when necessary.

Course Website and Other Classroom Management Tools:

All class material that is not online will be uploaded to the Canvas website.

Course Expectations & Guidelines

Health-Related Considerations:

Please refer to http://health.gatech.edu/coronavirus/students for information regarding Covid-19 and up-to-date GT policies and FAQs. This course is completely remote/synchronous.

Digital Proctoring:

NA

Digital Etiquette:

Students will be respectful to one another and to the professor in their interactions in person and online. Strict professionalism is expected and required, and online bullying will be reported to the Office of Student Integrity (see Academic Integrity).

Academic Integrity:

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations. Please note that all quizzes must be taken in the classroom. Attempts to take the quizzes outside of the classroom, or facilitating other students taking the quizzes outside of the classroom, will be considered cheating.

Accommodations for Students with Disabilities:

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail the instructors as soon as possible in order to set up a time to discuss your learning needs.

Attendance and Active Participation:

You are expected to attend every class. Absence due to sickness requires a legitimate excuse such as an official doctor's note (note form STAMPS). Class time will be used for lectures/discussions, workshops, student presentations. If you miss class, *you* are responsible for obtaining all notes, announcements, and assignments. These will not be re-taught by the professor if a student misses class. The institute's excused absence policy will be enforced in this course (http://www.catalog.gatech.edu/rules/4/). *No exceptions!*

Extensions, Late Assignments, & Re-Scheduled/Missed Exams:

There will be no credit given for any assignments turned in after the deadline. Students that miss any assignments/exams for approved Institute activities and religious observances will be excused for any missed credit. See http://www.catalog.gatech.edu/rules/4/ for more information.

Student-Faculty Expectations Agreement:

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom:

Lecture is a time when we all work together, so be courteous to your fellow students and do not disrupt class by entering and leaving the room, reading, talking, allowing cell phones to ring, etc. In addition, non-class usage of electronic devices (laptops, tablets, smartphones, etc.) is prohibited during class.

Campus Resources for Students

Undergraduate Student Academic Success Resources:

For undergraduate courses, a sample statement that might be included in your syllabus for this section is "A list of resources for undergraduate students' academic success and information about advising can be found at Success at Tech.

- Academic Support: Academic Success and Advising (a unit in the Office of Undergraduate Education & Student Success) provides free support for your courses. Students can attend scheduled supplemental review (PLUS) sessions, stop by Drop-In Tutoring, or schedule a one-on-one appointment through Knack. To explore what options work best for you, please visit us online at success.gatech.edu/tutoring, email us at tutoring@gatech.edu, or come see us at Clough Undergraduate Learning Commons, Suite 283.

Graduate Student Academic and Professional Success Resources:

For graduate courses, a sample statement that might be included in your syllabus for this section is "A list of resources for graduate students is given on the Office of Graduate and Postdoctoral Education website. Specific information for current graduate students includes

- Academic Resources such as the Communications Center, Language Institute, Library, Catalog, Registrar, resources for conducting research, Advocacy and Conflict Resolution resources, and how to manage unexpected situations that may impact your academic performance;
- Student Resources such as Campus Services, Child Care/Family programs, Health & Wellness, Career Services, and the Student Resource Guide; and
- Professional Development such as the programming from the Career Center and other professional development resources and events"]

Student Well-Being: [Some faculty include resources that support students' mental and emotional well-being. Including these additional resources on your syllabus communicates to students that you care about them and that you are committed to facilitating their academic progress. For all courses, a sample statement that might be included in your syllabus is

"At Georgia Tech, we are concerned about your overall physical, social, and mental well-being. A comprehensive list of wellness related resources has been compiled and maintained by the Office of the Vice President for Student Engagement and Well-being (student-resource-guide (gatech.edu)

More resources on supporting student well-being on the syllabus and beyond are available through the Learning Well Initiative.