Advances in Life Sciences, Bioengineering, & Biomanufacturing Enabled by Glycosciences

Course Number: *16:155:532 (Fall 2021)*

Course Title: Topics in Biochemical Engineering (*Advances in Life Sciences, Bioengineering, & Biomanufacturing Enabled by Glycosciences*)

Credits: 3

Instructor: Professor Shishir Chundawat (shishir.chundawat@rutgers.edu)

Lecture Time: Tuesdays (6-9 pm EST)

Location: Online (Using Zoom for Synchronous/Asynchronous Lecture Delivery).

Office Hours: Zoom based office hour timings to be announced

Course Synopsis: This course will provide an introductory survey of the fundamental principles of glycosciences (i.e., science and technology of carbohydrates or the '*glycome*'), followed by discussions of some the cutting-edge applications of the principles of glycosciences to several interdisciplinary problems relevant to the disciplines of biochemical engineering, biomedical engineering, biomanufacturing, life sciences, and biotechnology in general.

Carbohydrates, or glycans, are the most abundant class of biomolecules on the planet that are known to play critical metabolic, structural, and functional roles in most known biological systems ranging from simple single cells to the largest known living organisms. The emergence of glycosciences and glycoengineering (i.e., the engineering of the glycome) as mature disciplines over the last few decades has provided key insights into the inner workings of complex biological systems, while also elevating the field of glycomics (i.e., the study of the glycome and its function) to similar stature as the well-established fields of genomics (i.e., the study of the genome and its function) and proteomics (i.e., the study of the proteome and its function). Glycans have practical applications that range from producing a diverse range of bioproducts for everyday consumption as designer foods (e.g., prebiotics for healthier guts) or renewable transportation fuels (e.g., 1st and 2nd generation plant-based biofuels) or advanced biomaterials (e.g., paper-based electronics, conductive textiles) to the development of more efficacious glycan-based biotherapeutics for the healthcare sector (e.g., glycoengineered monoclonal antibodies, antibody-drug conjugates, small molecule glycan based drugs).

The objective of this course is to introduce students to advanced concepts in glycosciences, biochemical engineering, and associated biotechnology-based solutions to address several challenges being faced by our modern society in a myriad number of areas. Specific application areas to be explored in this course include Personalized Medicine, Pharmaceutical & Biological Drugs, Food & Nutrition Supplements, Advanced Biomaterials, Cellulosic Biofuels & Industrial Bioproducts.

Required Reference Textbook: *Essentials of Glycobiology*, by Editors: Ajit Varki, Executive Editor, Richard D Cummings, Jeffrey D Esko, Pamela Stanley, Gerald W Hart, Markus Aebi, Alan G Darvill, Taroh Kinoshita, Nicolle H Packer, James H Prestegard, Ronald L Schnaar, and Peter H Seeberger, 3rd edition, Cold Spring Harbor, 2017. An electronic version of the textbook is available freely online for students as a reference source.

Other References & Textbooks: (1) Introduction to Glycobiology by Taylor & Drickamer; (2) The Sugar Code: Fundamentals of Glycosciences by Gabius; (3) Glycoscience: Biology & Medicine by Taniguchi et

al; (4) Glycosylation Engineering of Biopharmaceuticals by Beck et al; (5) Comprehensive Glycoscience Reference Work by Barchi et al (2nd edition, 2021); (6) Synthetic Glycomes by Guan et al.

Other Online eLearning Resources: (1) Glycopedia; (2) Transforming Glycoscience: A Roadmap for the Future by National Academies Press; (3) NCBI-Glycans; (4) CAZy Database.

Additional journal articles and assigned supplementary reading materials will be shared with students on the Canvas course website for all lectures on a weekly basis.

Prerequisites: This course is intended to introduce upper-level undergraduates and graduate students with limited prior exposure to the interdisciplinary field of glycosciences (or glycoengineering) and its practical relevance to biotechnology. While there are no specific prerequisites required to enroll for this course, students are expected to have a basic background in organic chemistry and/or biochemistry and/or cell biology and/or microbiology. Interested students from both life sciences and engineering based backgrounds are welcome to contact the instructor for further information, if needed.

Syllabus: The instructor will refer to contents of some chapters of the textbook (*Essentials of Glycobiology* by Varki et al) to help orient the students to a single reference source. However, additional reading material specifically assigned from other textbooks or journal articles will be shared with students on a weekly basis. Required readings will be indicated in the course syllabus at the start of the semester. Partially complete lecture slides (as pdf notes) and live Zoom lecture video recordings by Prof. Chundawat will be available to the students on the Canvas website. **But students will be expected to also compile their own notes based on self-study to assist with completion of their final term project!** Additional material will be distributed as handouts during the lecture. A tentative week-by-week schedule of the course, lecture topics, and reading assignments is given below (subject to change). *Please follow announcements on the Canvas course webpage for any changes to the schedule!* ***Students are advised to complete reading all assignments prior to attending each lecture to keep up with the class discussions and to do well on quizzes/exams/projects!***

#	*Lecture Topics*	*Textbook/Assigned Readings*
	Fundamentals of Glycosciences	
1	Introduction to Glycosciences & its Relevance to Society	Ch 1, Assigned Readings
2	Structures, Chemistry, & Biosynthesis of Glycans	Ch 2-7, 9, 10-17, 20-27
3	Carbohydrate-Active Enzymes & Cellular Systems	Ch 8, 28-38, Assigned Readings
4	Chemical-Biology, Analytical, & Modeling Toolkit	Ch 50-52, Assigned Readings
	Case Studies and Applications of Glycosciences	
5	Enzyme Engineering & Chemoenzymatic Synthesis - I	Ch 53-54, Assigned Readings
6	Enzyme Engineering & Chemoenzymatic Synthesis - II	Ch 53-54, Assigned Readings
7	Cellular and Metabolic Glycoengineering - I	Ch 49/56, Assigned Readings
8	Cellular and Metabolic Glycoengineering – II	Ch 49/56, Assigned Readings
9	Prebiotics, Probiotics, & Microbiome Engineering	Assigned Readings
10	Biomanufacturing of Drugs & Biotherapeutics - I	Ch 57, Assigned Readings
11	Biomanufacturing of Drugs & Biotherapeutics - II	Ch 57, Assigned Readings
12	Biomedical Engineering & Medical Diagnostics	Assigned Readings
13	Biofuels, Bioproducts, & Biomaterials from Biomass - I	Ch 59, Assigned Readings
14	Biofuels, Bioproducts, & Biomaterials from Biomass - II	Ch 59, Assigned Readings
15	Project Presentations & Class Discussion	-
16	Project Presentations & Class Discussion (Extra Day)	-

Assessment: Lecture Attendance, Participation, & In-Class Discussions – 10%; Homework & Quizzes – 20%; Mid-Term Exam (Take-Home) –30%; Final Term Team Project Report & Presentation –40%.

A significant fraction of the final course grade is based on student participation in class discussions as well as a team-based project where diverse skillset-based student teams will be working together to address a current or unmet application in the area of biomanufacturing or biotechnology or medicine that is made possible via a glycosciences and/or glycoengineering based approaches. In-person session (along with a live Zoom session for students attending lectures remotely) will be likely held for the final team project presentations and students will be informed about this later during the semester. Course outline and assessment criteria will be discussed at the start of the course. Please note that the instructor reserves the right to amend course policies, including the grading rubric, due to changing circumstances at his discretion.

Course Material Copyright: All course material posted on the Canvas course website is copyrighted and may not be posted on any other web site at or outside of Rutgers without permission from the course instructor. Noncompliance with this policy will be treated as a violation of the Code of Student Conduct and will be referred to the Office of Student Conduct for action.

Academic Integrity: Students are expected to familiarize themselves with and adhere to the University policy on academic integrity at: http://academicintegrity.rutgers.edu/policy-on-academic-integrity. This course requires students to summarize the work of others and to create their own original work as part of their homework/project assignments. It is critical that work submitted is the student's own work and that due credit is given to others whose work is cited or otherwise utilized. Students agree that by taking this course all required student submissions may be subject to textual similarity review (using Turnitin on Canvas) for plagiarism detection. Furthermore, it is understood that a student's name on any individual homework assignment, quiz, or exam indicates that he/she neither gave nor received unauthorized aid. On individual homework assignments, authorized aid includes discussing: 1) interpretation of the problem statement, 2) concepts involved in the problem, 3) approaches for solving the problem. Anything beyond this constitutes unauthorized aid and violates the academic integrity policy. A student's name on a group assignment indicates that he/she contributed significantly to the assignment. Quizzes and exams are tests of individual performance. The student is not permitted to obtain assistance from any other person (or persons) during quizzes or exams.