USC Dornsife
Dana and David Dornsife
College of Letters, Arts and Sciences

BISC 406L: Biotechnology

4 Units
Fall 2025
Lecture:
Tu and Th 9:00-9:50 a.m.
Lab:
Th 10:00-1:00 p.m. (usually we will begin lab at 9:00 a.m. and start lecture after)
Room: ZHS 472

Instructors:
Christa Bancroft, Ph.D.
Office: ZHS 470
Office Hours: By appointment
Contact Info:
Email: cbancrof@usc.edu (best choice). Subject line should state: **"BISC 406"**
Phone number: 213-740-5553

Laboratory Director: Celeste Chong-Cerrillo, Ph.D.
Office: ZHS 450
Office Hours: By appointment or open door policy
Contact Info: chongcer@usc.edu. Subject line should state: **"BISC 406"**

Laboratory Instructor:
Office Hours:
Contact Info:

Course Description

BISC406L is the capstone course for the BS in Biological Sciences with Emphasis in Biotechnology. It is also the capstone course and the Minor in Biology and Business offered by the Dornsife College of Letters, Arts and Sciences and the Marshall School of Business. The course will focus on the impact of the biotechnology revolution on health care in this age of molecular medicine. Topics to be covered include: (1) Recombinant DNA technology from plasmids to genomes; (2) CRISPR applications including genome editing; (3) Modern DNA sequencing technologies; (4) Genomics and Proteomics; (5) Manipulating Prokaryotic and Eukaryotic gene expression; (6) Molecular Diagnostics and Therapeutics; (7) Vaccines and Gene Therapy; (8) Genetic Engineering of Plants and Animals and; (9) Biotechnology regulation. We will address the ethical, legal and social implications of advances in biotechnology and will discuss governmental regulation of food, drugs and biotechnology itself. The laboratory exercises will focus on synthetic biology and other techniques, which have played a fundamental role in the "new" biotechnology revolution.

Learning Objectives

Explain the difference between historical biotechnology and modern biotechnology.
Know how to synthesize genes and to build plasmids, chromosomes, and genomes.

Have an understanding of how CRISPR/Cas systems work and can be utilized in diverse ways for human benefit, including as therapies.
Develop knowledge of the history of DNA sequencing technologies, especially modern short and long read approaches and their applications.
Provide examples on how to use microbes and mammalian cells for the production of pharmaceutical products.
Explain the concept and application of monoclonal antibody technology and the development of vaccines.
Explain the general principles of using DNA technology to generate transgenic plants, animals and microbes.
Provide examples of current applications of biotechnology and advances in different areas: medical, microbial, environmental, bioremediation, agricultural, plant, animal, and forensic science.
Discuss ethical implications of biotechnology research and development.
Design an experiment with step-by-step instructions to address a research problem.
Demonstrate proficiency of technical skills in a variety of biotechnology methods.
Explain relevant background content, interpret data and critically evaluate conclusions of a scientific research paper. Effectively communicate the information to peers in a classroom setting during discussions and presentations.

Prerequisite: BISC 320L
Recommended Preparation: BISC 313 or BISC 325

Course Notes

Lectures: The lecture slides will be posted on the course Brightspace website as .ppt and .pdf files. All course materials, information, announcements and grades will be posted on Brightspace until the end of the semester.
Class lecture periods will either be lectures given by the instructor (labeled Lect. on syllabus calendar) or discussions of reading assignments by students (labeled Disc. in bold red on syllabus calendar). Participation in these discussions is an important part of the course. A TENTATIVE reading list is given in the course syllabus below the topic calendar. If we deviate from this version of the reading list, a new, dated version of this syllabus will be posted on Brightspace. You should be prepared to discuss reading assignments on the days specified as discussions. Questions will be assigned ahead of time that each student will answer and discuss during the discussion period.

It is important to attend all of the lectures during the course and to take good notes for study. Prior to attending each lecture, it is important to have read the appropriate papers. However, many of the lectures will contain new and additional information that is not in those readings. Examinations will be based on information in lecture slides, communicated during lecture, discussed during class discussions and presented in assigned readings. In studying for examinations, complete and accurate lecture and discussion notes are of prime importance.

Lecture and Discussion Absences:
Attendance at all lecture and discussion sections is expected. If you must miss a discussion due to illness or valid USC travel, please present Dr. Bancroft with evidence of the reason for absence and you will be allowed to make-up the discussion assignment within 1 week of the missed lecture period.

Exams:
In case the midterm exam must be missed for legitimate reasons, discuss the situation with the course instructor **prior** to the exam, if possible. If the midterm is missed for an emergency or for a valid health reason (with written documentation), the score of the final exam will be used to comprise your total point score for course exams.

Regrades:
In the event an error is made in the grading of your exam, written submittal a description of the error, using the regrade form posted on Brightspace, with the exam should be returned to Dr. Bancroft within a week after receiving your graded exam. After this time period, exams will not be regraded.

Email Communication:
To ensure privacy, only student's USC email accounts may be used for email communications. Students are responsible for understanding the content of email messages that the instructor sends to their USC accounts. Therefore, each student must check their USC email regularly and make sure their account is not over quota, so new messages can be received.

Required Readings and Supplementary Materials

There is no textbook for the course. All reading assignments will be posted on Brightspace in .pdf format for you to access.

Description and Assessment of Assignments

Midterm and Final Exams will include multiple choice, short answer and mathematical problems that can be done without a calculator.
Classroom discussion questions will be assigned to each lab partner group during the class meeting prior to the class discussion. Pairs will present relevant data and figures to answer the questions during class discussion time. Points will be awarded based on participation of each member and correctness of answer.
Student presentations will occur during the last four weeks of class. Presentation dates will be assigned at least 3 weeks ahead of the first scheduled presentation. Detailed information about this assignment is posted on Brightspace under Course Documents. During student presentations attendance is mandatory and all students are expected to listen attentively and ask questions of other groups. Missing another group's presentation without a valid excuse will result in a 5 pt. deduction from your own presentation score.
Laboratory work assignments are discussed in more detail in the laboratory manual.

Grading Breakdown

The course grade will be based upon 675 possible points:

Assignment	**Points**	**% of Grade**
Midterm Exam	150	22.2
Final Exam	150	22.2
Classroom Discussions	100	14.8
Student Presentations	75	11.1
Laboratory	200	29.6
TOTAL	675	100

Course letter grades:

Course final grades will be determined using the following scale. If necessary, course grades will be adjusted at the end of the semester such that the average will be the lowest "B" for the class.

Letter grade	Corresponding numerical point range
A	93-100

A-	90-92.9
B+	86-89.9
B	83-85.9
B-	80-82.9
C+	76-79.9
C	73-75.9
C-	70-72.9
D+	67-69.9
D	63-66.9
D-	60-62.9
F	59.9 and below

Student Presentation Guidelines and Rubric

Will be posted to Brightspace website under Content and "Student Presentations".

Grading Timeline

Grades for Midterm Exams will be posted within one calendar week following the exam date.

Course Schedule:

Bancroft lecture/discussion: Black
Student presentations: **Green**

Wk	Type	Date	Lecture Topic	Reading
1	Lect.	Aug 26	Intro to Biotechnology	1 and 1a
	Disc.	Aug 28	Molecular Biology Fundamentals	2 and 3
2	**Disc.**	Sept 2	Genetic Engineering	4
	Disc.	Sept 4	Synthetic Biology & Nanobiotechnology I	5
3	**Disc.**	Sept 9	Synthetic Biology & Nanobiotechnology II	6 and 7
	Disc.	Sept 11	Synthetic Biology & Nanobiotechnology III	8 and 9
4	**Disc.**	Sept 16	CRISPR and Genome Editing I	10
	Disc.	Sept 18	CRISPR and Genome Editing II	11
5	**Disc.**	Sept 23	CRISPR and Genome Editing III	12
	Disc.	Sept 25	Biotechnology in Medicine I	13
6	**Disc.**	Sept 30	Biotechnology in Medicine II	14
	Disc.	Oct 2	Biotechnology in Medicine III	15
7	Lect.	Oct 7	Bioinformatics & Computational Biology I	16
		Oct 9	Fall Break, no classes	
8		Oct 14	**Midterm Exam**	
	Disc.	Oct 16	Bioinformatics & Computational Biology II	17
9	Lect.	Oct 21	Agricultural Biotechnology I	18
	Disc.	Oct 23	Agricultural Biotechnology II	19 and 20

10	**Disc.**	Oct 28	Industrial & Environmental Biotechnology I	21
	Disc.	Oct 30	Industrial & Environmental Biotechnology II	22
11	**Disc.**	Nov 4	Future Trends & Innovations I	23
	Disc.	Nov 6	Future Trends & Innovations II	24
12	**Disc.**	Nov 11	Ethics & Regulation in Biotechnology I	25
	Disc.	Nov 13	Ethics & Regulation in Biotechnology II	26
13		Nov 18	**Student Presentations**	
		Nov 20	**Student Presentations**	
14	Lect.	Nov 25	Case Studies or Guest Lecture	27
		Nov 27	Thanksgiving Break, no classes	
15		Dec 2	**Student Presentations**	
		Dec 4	**Student Presentations**	
17		**Dec. 11**	**FINAL EXAM: 11 a.m. to 12 p.m. (60 min.)**	

Readings:

1. **Clark, D. P., and N. J. Pazdernik**. 2015. Basics of Biotechnology. In Clark, D. P., and N. J. Pazdernik. (Authors), Biotechnology: Applying the genetic revolution, p. 1-32. Elsevier Academic Press, San Diego, CA.
1a. https://www.labiotech.eu/in-depth/history-biotechnology-genentech/
2. **Lu, Y.** 2021. The gene synthesis revolution. New York Times November 24, 2021.
3. **Coradini, A. L. V., C. B. Hull, I. M. Ehrenreich.** 2020. Building genomes to understand biology. Nature Communications 11, 6177.
4. **Hutchison, 3rd, C. A. et al.** 2016. Design and synthesis of a minimal bacterial genome. Science 351, aad6253.
5. **Fredens, J. et al.** 2019. Total synthesis of Escherichia coli with a recoded genome. Nature 569, 514-518.
6. **Dymond, J. S. et al.** 2011. Synthetic chromosome arms function in yeast and generate phenotypic diversity by design. Nature 477, 471-476.
7. **Richardson, S. M. et al.** 2017. Design of a synthetic yeast genome. Science 355, 1040-1044.
8. **Cong, L. et al.** 2013. Multiplex Genome Engineering Using CRISPR/Cas Systems. Science 339(6121): 819-823.
9. **Mali, P. et al.** 2013. RNA-Guided Human Genome Engineering via Cas9. Science 339(6121): 823–826.
10. **Komor, A.C. et al.** 2017. CRISPR-Based Technologies for the Manipulation of Eukaryotic Genomes. Cell 168(1-2): 20-36.
11. **Kaminski, M.M. et al.** 2021. CRISPR-based diagnostics. Nature Biomedical Engineering 5: 643-656.
12. **Frangoul, H. et al.** 2021. CRISPR-Cas9 Gene Editing for Sickle Cell Disease and β-Thalassemia. New England Journal of Medicine 384: 252-260.
13. **Slatko, B.E. et al.** 2018. Overview of Next Generation Sequencing Technologies. Current Protocols in Molecular Biology 122: e59.
14. **Nurk, S. et al.** 2022. The complete sequence of a human genome. Science 376(6588): 44-53.

15. **McNulty, R., Sritharan, D., Pahng, S.H. *et al***. 2023. Probe-based bacterial single-cell RNA sequencing predicts toxin regulation. *Nat Microbiol* 8, 934–945. https://doi.org/10.1038/s41564-023-01348-4
16. **Clark, D. P., and N. J. Pazdernik**. 2015. Transgenic plants and plant biotechnology. In Clark, D. P., and N. J. Pazdernik. (Authors), Biotechnology: Applying the genetic revolution, p. 397-424. Elsevier Academic Press, San Diego, CA.
17. **Chen, JH. et al.** 2020. Nuclear-encoded synthesis of the D1 subunit of photosystem II increases photosynthetic efficiency and crop yield. Nature Plants **6:** 570-580.
18. **Clark, D. P., and N. J. Pazdernik**. 2015. Immune Technology. In Clark, D. P., and N. J. Pazdernik. (Authors), Biotechnology: Applying the genetic revolution, p. 181-217. Elsevier Academic Press, San Diego, CA.
19. **Mason, G.** 2022. Protecting with PROTAC. *Nat Chem Biol* **18**, 915. https://doi.org/10.1038/s41589-022-01124-1
20. **Si, L., Shen, Q., Li, J. et al.** 2022. Generation of a live attenuated influenza A vaccine by proteolysis targeting. *Nat Biotechnol* **40**, 1370–1377. https://doi.org/10.1038/s41587-022-01381-4
21. **Hamilton, J.R., Chen, E., Perez, B.S. *et al***. 2024. *In vivo human T cell engineering with enveloped delivery vehicles. Nature Biotechnology* https://doi.org/10.1038/s41587-023-02085-z.
22. **Aubert, M., Strongin, D.E., Roychoudhury, P. *et al***. 2020. Gene editing and elimination of latent herpes simplex virus in vivo. *Nat Commun* **11**, 4148. https://doi.org/10.1038/s41467-020-17936-5.
23. **Ordóñez-Reyes et al.** 2022. Bispecific Antibodies in Cancer Immunotherapy: A Novel Response to an Old Question. *Pharmaceutics* 14, no. 6: 1243. https://doi.org/10.3390/pharmaceutics14061243
24. **Zhao, Z., Chen, X., Dowbaj, A.M. et al**. Organoids. *Nat Rev Methods Primers* 2, 94 (2022). https://doi.org/10.1038/s43586-022-00174-y
25. **Bier, E.** 2022. Gene drives gaining speed. *Nat Rev Genet* **23**, 5–22. https://doi.org/10.1038/s41576-021-00386-0
26. **Isabella, V., Ha, B., Castillo, M. *et al***. 2018. Development of a synthetic live bacterial therapeutic for the human metabolic disease phenylketonuria. *Nat Biotechnol* **36**, 857–864. https://doi-org.libproxy2.usc.edu/10.1038/nbt.4222
27. **Berg, J. M., J. L. Tymoczko, and L. Stryer.** 2015. Drug development. In Berg, J. M., J. L. Tymoczko, and L. Stryer (Authors), Biochemistry, 8th ed., p. 1033-1056. W. H. Freeman and Company, New York.

Statement on University Academic and Support Systems

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.

Student Financial Aid and Satisfactory Academic Progress:
To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the Financial Aid Office webpage for undergraduate- and graduate-level SAP eligibility requirements and the appeals process.

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 consists 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) 740-2500
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.

Course Topic Schedule (28 Class Meetings)

Class #	**Topic**	**Key Concepts & Activities**
1	**Introduction to Biotechnology**	Course overview, history of biotech, major applications
2	**Molecular Biology Fundamentals I**	DNA & RNA structure, gene expression, central dogma
3	**Molecular Biology Fundamentals II**	Protein synthesis, transcription & translation mechanisms
4	**Genetic Engineering I**	Recombinant DNA, cloning vectors, restriction enzymes
5	**Genetic Engineering II**	PCR, gel electrophoresis, transformation methods
6	**CRISPR and Genome Editing I**	Mechanism of CRISPR, gene knockouts, repair pathways
7	**CRISPR and Genome Editing II**	Applications in medicine, agriculture, ethics of gene editing
8	**Biotechnology in Medicine I**	Biopharmaceuticals, monoclonal antibodies, biologics
9	**Biotechnology in Medicine II**	Gene therapy, regenerative medicine, stem cells
10	**Bioinformatics & Computational Biology I**	DNA sequencing, genomics, big data in biotech
11	**Bioinformatics & Computational Biology II**	AI & machine learning in drug discovery, protein modeling
12	**Agricultural Biotechnology I**	GMO crops, plant tissue culture, CRISPR in agriculture
13	**Agricultural Biotechnology II**	Biofortification, sustainable agriculture, controversies
14	**Midterm Exam & Review**	Covers Classes 1-13
15	**Industrial & Environmental Biotechnology I**	Bioprocessing, fermentation, enzyme technology
16	**Industrial & Environmental Biotechnology II**	Biofuels, bioplastics, bioremediation
17	**Synthetic Biology & Nanobiotechnology I**	DNA assembly, biomaterials, synthetic life
18	**Synthetic Biology & Nanobiotechnology II**	Drug delivery systems, biosensors, bioelectronics
19	**Ethics & Regulation in Biotechnology I**	FDA regulations, intellectual property, biosafety
20	**Ethics & Regulation in Biotechnology II**	Bioethics, controversies in biotech, public perception
21	**Future Trends & Innovations I**	AI in biotech, regenerative medicine, biofabrication
22	**Future Trends & Innovations II**	Startups, biotech entrepreneurship, industry case studies
23	**Student Presentations I**	Research & innovation proposals
24	**Student Presentations II**	Research & innovation proposals

25	**Student Presentations III**	Research & innovation proposals
26	**Student Presentations IV**	Research & innovation proposals
27	**Final Exam Review & Course Wrap-Up**	Discussion, Q&A, reflections on biotech's future
28	**Final Exam**	Comprehensive assessment

This schedule ensures **deep coverage of core biotechnology concepts** while integrating **student presentations** and a **midterm exam** at a logical point. Let me know if you'd like to adjust any topics! 🚀