

BISC 406L: Biotechnology

4 Units

Fall 2022

Lecture:

Tu and Th 9:00-9:50 a.m.

Lab:

Th 10:00-1:00 p.m. (sometimes 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: cbancroft@usc.edu (best choice). Subject line should state: "BISC 406"

Phone number: 213-740-5553

Ian Ehrenreich, Ph.D.

Office: RRI 319a

Office Hours: By appointment

Contact Info:

Email: ian.ehrenreich@usc.edu

Phone number: 213-821-5349

We will typically reply to emails within 24 hours during the workweek and 48 hours over the weekend.

Laboratory Director: Celeste Chong-Cerrillo, Ph.D.

Office: ZHS 450

Office Hours: By appointment

Contact Info: chongcer@usc.edu (best choice). Subject line should state: "BISC 406"

Teaching Assistant: Daniel Lusk

Office:

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 Biotechnology 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 Blackboard internet site as .ppt and .pdf files (<https://blackboard.usc.edu>). All course materials, information, announcements and grades will be posted on Blackboard 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 Blackboard. 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 or Ehrenreich 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 Blackboard, with the exam should be returned to Dr. Ehrenreich 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 Blackboard 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.

Final project report: Students will be expected to provide a single-spaced, 10-page paper describing the problem, methods to address the problem, and the potential range of outcomes for the proposed experiments. The paper should be written in Arial font with a font size of 12 and 1-inch margins on each side of the page. Primary literature should be used to reference salient points, and at least 25 papers should be referenced.

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 Blackboard 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	120	17.8

Final Exam	120	17.8
Classroom Discussion	60	8.9
Final Project Report & Presentation	120	17.8
Laboratory	255	37.8
TOTAL	675	100

Course letter grades:

Course final grades will be determined using the following scale:

A	90-100
A-	87-89.9
B+	84-86.9
B	80-83.9
B-	76-79.9
C+	72-75.9
C	68-71.9
C-	64-67.9
D+	60-63.9
D	56-59.9
D-	52-55.9
F	below 52

Student Presentation Guidelines and Rubric

Will be posted to Blackboard 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: green

Ehrenreich lecture/discussion: blue

Both: black

Wk	Type	Date	Lecture Topic	Reading
1	Lect.	Aug 23	Intro to Biotechnology (CREATE program)	1 and 1a
	Lect.	Aug 25	Cloning and synthesizing DNA molecules	2
2	Lect.	Aug 30	Assembling DNA molecules into chromosomes and genomes	3
	Disc.	Sept 1	Bacterial genome synthesis and transplantation	4 and 5
3	Disc.	Sept 6	Eukaryotic chromosome synthesis and transplantation	6 and 7
	Lect.	Sept 8	CRISPR/Cas technology and applications	8
4	Disc.	Sept 13	CRISPR-based diagnostics	9
	Lect.	Sept 15	CRISPR therapies in humans	10 and 11

5	Disc.	Sept 20	CRISPR therapy clinical trials	12
	Lect.	Sept 22	DNA sequencing technologies	13
6	Disc.	Sept 27	Telomere-to-telomere genome sequences	14
	Disc.	Sept 29	Single cell sequencing	15
7	Lect.	Oct 4	Plant Biotechnology	16
	Disc.	Oct 6	Plant Biotechnology	17
8		Oct 11	Midterm Exam	
		Oct 13	Fall Break, no classes	
9	Lect.	Oct 18	Immunology	18
	Disc.	Oct 20	Vaccine Development	19 and 20
10	Disc.	Oct 25	Cancer Vaccines	21
	Disc.	Oct 27	Techniques in Diagnostics	22
11	Lect.	Nov 1	Drug Development	23
	Disc.	Nov 3	Monoclonal Antibodies as Drugs	24
12	Disc.	Nov 8	Tissue Engineering	25
	Disc.	Nov 10	Animal Engineering	26 and 27
13	Disc.	Nov 15	Microbial Engineering	28
		Nov 17	Student Presentations	
14		Nov 22	Student Presentations	
		Nov 24	Thanksgiving Break, no classes	
15		Nov 29	Student Presentations	
		Dec 1	Student Presentations	
17		Dec. 8	FINAL EXAM: 11 a.m. to 12 p.m. (60 min.)	

Readings:

- 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.
- Lu, Y. 2021. The gene synthesis revolution. New York Times November 24, 2021.
- Coradini, A. L. V., C. B. Hull, I. M. Ehrenreich. 2020. Building genomes to understand biology. Nature Communications 11, 6177.
- Hutchison, 3rd, C. A. et al. 2016. Design and synthesis of a minimal bacterial genome. Science 351, aad6253.
- Fredens, J. et al. 2019. Total synthesis of Escherichia coli with a recoded genome. Nature 569, 514-518.
- Dymond, J. S. et al. 2011. Synthetic chromosome arms function in yeast and generate phenotypic diversity by design. Nature 477, 471-476.
- Richardson, S. M. et al. 2017. Design of a synthetic yeast genome. Science 355, 1040-1044.
- Komor, A.C. et al. 2017. CRISPR-Based Technologies for the Manipulation of Eukaryotic Genomes. Cell 168(1-2): 20-36.

9. Kaminski, M.M. et al. 2021. CRISPR-based diagnostics. *Nature Biomedical Engineering* 5: 643-656.
10. Cong, L. et al. 2013. Multiplex Genome Engineering Using CRISPR/Cas Systems. *Science* 339(6121): 819-823.
11. Mali, P. et al. 2013. RNA-Guided Human Genome Engineering via Cas9. *Science* 339(6121): 823-826.
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. Hwang, B. et al. 2018. Single-cell RNA sequencing technologies and bioinformatics pipelines. *Experimental and Molecular Medicine* 50: 1-14.
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. Graham, B. 2020. Rapid COVID-19 Vaccine Development. *Science*. **368 (6494)**: 945-946.
20. Jackson, L. A. et al. 2020. An mRNA Vaccine against SARS-CoV-2 – Preliminary Report. *N Engl J Med*. **383**: 1920-1931.
21. Hu, Z., et al. 2021. **Personal neoantigen vaccines induce persistent memory T cell responses and epitope spreading in patients with melanoma.** *Nature Medicine* **27**: 515-525.
22. Gootenberg, J., et al. 2017. Nucleic acid detection with CRISPR-Cas13a/C2c2. *Science* **359 (6336)**:438-442.
23. 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.
24. Gasparo, R. D. et al. 2021. Bispecific IgG neutralizes SARS-CoV-2 variants and prevents escape in mice. *Nature*.
<https://doi-org.libproxy1.usc.edu/10.1038/s41586-021-03461-y>
25. Hofer, M. and Lutolf, M. 2021. Engineering Organoids. *Nat. Rev. Mater*
<https://doi.org/10.1038/s41578-021-00279-y>
26. Scudellari, M. 2019. Self-destructing mosquitoes and sterilized rodents: the promise of gene drives. *Nature* **571(7764)**: 160-162.
27. Faber, N. R. et al. 2021. Novel combination of CRISPR-based gene drives eliminates resistance and localises spread. *Sci. Rep.* **11**: 3179.
<https://doi.org/10.1038/s41598-021-83239-4>.

28. **Taketani, M.** 2020. Genetic circuit design automation for the gut resident species *Bacteroides thetaiotaomicron*. *Nat Biotechnol* **38**: 962-969.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism - presenting someone else's ideas as your own, either verbatim or recast in your own words - is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 - 24/7 on call
engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 - 24/7 on call
suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call
engemannshc.usc.edu/rsvp

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421

studentaffairs.usc.edu/bias-assessment-response-support

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

studentaffairs.usc.edu/sssa

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

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

dps.usc.edu, emergency.usc.edu

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) 442-120 - 24/7 on call

dps.usc.edu

Non-emergency assistance or information.