BIOL537 - Biotechnology and Synthetic Biology Fall, 2020

Recent advances in biotechnology and synthetic biology, and their potential relevance to medicine, agriculture, and engineering. The course will include lectures, reading and discussions of papers from the primary literature, and student projects and presentations.
Prerequisite: Biology 202 (Genetics and Molecular Biology)

Course meetings: T/Th, 11:30-12:45, 200 Genome Sciences Building (2.5 contact hours/week)
Instructor: Jason W. Reed, 305 Coker Hall, jreed@email.unc.edu
Office Hours: by appointment, likely by videoconference

Intended audience. This course is intended for advanced undergraduates interested in how scientific advances in biology lead to new technologies. Just as understanding physics leads to new mechanical or electronic devices, or understanding melody and harmony allows a composer to write new music, understanding biology leads to new inventions that can be used in agriculture, medicine, or other fields. Such engineering is a creative and practical outcome of science. Students should have previous knowledge of genetics and molecular biology, through having taken Biology 202 (Genetics and Molecular Biology) or the equivalent.

Goals. The course will explore various advances in biotechnology, and the science that underlies these inventions. Students will:
i) learn about current methodologies and questions of scientific interest in biotechnology;
ii) practice reading and evaluating papers from the scientific literature;
iii) consider how discoveries in biology may be used to develop useful new technologies; and
iv) think up and present ideas for new technologies.
v) We will also discuss any legal or ethical issues that arise.

Readings. Articles from the scientific literature will be assigned to introduce and provide an overview of a particular topic (review articles), or to provide a detailed example (papers from the primary literature). We will analyze these carefully in class, in order to understand the logic of the experiments, the methodologies used, and the conclusions reached. It is important to read these in advance, and to think about any questions or comments you have about them, in order to be prepared to participate in (and benefit from) the discussions. A detailed schedule and reading list will be handed out separately. The syllabus and readings will also be available on the course Sakai site (**https://sakai.unc.edu/portal/site/biol537**) under "Resources." Some articles are open-access and others are not - as the university has subscriptions to all of the relevant journals, you are entitled to download them for your personal use.

Requirements and grading. Course grades will be determined as follows:
i) Two in-class exams (20% each) will cover material from the preceding classes.
ii) occasional small assignments online (5%)
iii) Preparation for and participation in class and group discussions (5%)
iv) Student paper presentations (15%)
v) Group project to propose a new biotechnological invention (15%)
vi) Final exam (20%)

Course grades will likely be curved to compensate for any skew in mean exam scores.

Course design. The course will include lectures, class discussions, and student presentations. Lectures will serve to introduce each topic, and in many cases will last for only a portion of the class period. Lecture slides will be available on the course Sakai site. We will spend a good portion of most classes discussing a paper from the scientific literature. Typically we will break into groups to discuss aspects of the paper, and then review collectively what we have understood. This style of teaching will predominate for the first month, and will also recur later in the course. Students should hone their paper-reading and analytical thinking skills through these activities.

During the second month of the course, students will "teach" a portion of the class, by presenting a particular advance or application of biotechnology or synthetic biology (item iv in the list above). This will be done with a partner. Later, I will provide literature papers to choose among, as well as further guidance. This year, we may include in this part of the class several diagnostic and therapeutic technologies that may help to manage the covid-19 pandemic.

Later in the semester, groups of students will propose a new biotechnological product or approach to solve some problem, and present this to the class during the last month. This group project will also be written up in a submitted document that will be assessed for clarity of presentation, novelty, and feasibility. More details about this assignment will be provided later. We will start thinking about it early in order to have time to generate questions and ideas. This exercise will serve as a chance to think creatively about how biotechnology or synthetic biology may be useful.

Changes. The instructor may make changes to the syllabus, including the schedule of topics, project due dates and test dates (excluding the officially scheduled final exam), as needed to accommodate unforeseen circumstances.

It is possible that we will switch the class format to partially or entirely online, if external events dictate or we decide we prefer that. In that case, we may adjust the schedule or design of class activities to accommodate the online mode. Any changes will be announced as early as possible so that students can adjust their schedules.

Classroom culture. For the safety of yourselves and everyone else, please wear your facemasks over mouth and nose, and maintain distance from others. Failure to abide by these new community standards can result in expulsion from the course. Please eat your lunch before or after, but not during class (impossible anyway with a mask on).

We strive to nurture a classroom environment that values the perspectives and opinions of all participants, and is free of bias based on race, gender or other factors. Therefore please always behave and discuss with genuine courtesy and respect. Please communicate to me any concerns that may arise about the class environment or dynamic.

During class, laptops and other electronic devices may be used for viewing scientific content relevant to the class discussions that day, but not to engage in social media conversations or other extraneous activity.

Some other useful resources.

Nature Biotechnology – a journal covering biotechnology advances and their economic and legal aspects http://www.nature.com/nbt/index.html

Current Opinion in Biotechnology – review articles about biotechnology
http://www.sciencedirect.com/science/journal/09581669

iGEM – an organization for synthetic biology ideas, with an annual competition
http://igem.org/About

Preliminary schedule, Fall 2020 (subject to modification)

T, August 11	Course introduction, biotechnology and synthetic biology
Th, August 13	Recombinant DNA – insulin production
T, August 18	Transgenic plants in agriculture
Th, August 20	Engineering biosynthetic pathways
T, August 25	Cell therapy
Th, August 27	Stem cell therapy
T, September 1	Gene therapy in humans
Th, September 3	Cancer Immunotherapy
T, September 8	Animal cloning (resuscitating extinct species)
Th, September 10	Genome engineering by CRISPR/Cas9
T, September 15	Exam I
Th, September 17	student paper presentations – case studies / covid biotechnology solutions
T, September 22	student paper presentations – case studies / covid biotechnology solutions
Th, September 24	student paper presentations – case studies / covid biotechnology solutions
T, September 29	student paper presentations – case studies / covid biotechnology solutions
Th, October 1	student paper presentations – case studies / covid biotechnology solutions
T, October 6	student paper presentations – case studies / covid biotechnology solutions
Th, October 8	Gene drives to alter populations
T, October 13	Optogenetics
Th, October 15	Engineering electromagnetic sensors or therapies
T, October 20	Directed evolution of proteins
Th, October 22	New gene circuits
T, October 27	Exam II
Th, October 29	Novel organisms, changing the genetic code
T, November 3	Presentations of student project ideas
Th, November 5	Presentations of student project ideas
T, November 10	Presentations of student project ideas
Th, November 12	Presentations of student project ideas
T, November 17	Presentations of student project ideas
T, November 24, 12:00	Final Exam

Biology 537, Biotechnology and Synthetic Biology – Reading list 1

All readings are available on the course Sakai site under "Resources," or follow the links.

T, August 11 – Introduction

Berg, P., D. Baltimore, H.W. Boyer, S.N. Cohen, R.W. Davis, D.S. Hogness, D. Nathans, R. Roblin, J.D. Watson, S. Weissman, and N.D. Zinder, *Letter: Potential biohazards of recombinant DNA molecules.* Science, 1974. **185**(4148): p. 303. http://www.ncbi.nlm.nih.gov/pubmed/4600381

Th, August 13 – Expressing and producing a protein

Please read one of these (your choice), and skim the other one:

Goeddel, D.V., D.G. Kleid, F. Bolivar, H.L. Heyneker, D.G. Yansura, R. Crea, T. Hirose, A. Kraszewski, K. Itakura, and A.D. Riggs, *Expression in Escherichia coli of chemically synthesized genes for human insulin.* Proc Natl Acad Sci U S A, 1979. **76**(1): p. 106-10. http://www.ncbi.nlm.nih.gov/pubmed/85300

Thim, L., M.T. Hansen, K. Norris, I. Hoegh, E. Boel, J. Forstrom, G. Ammerer, and N.P. Fiil, *Secretion and processing of insulin precursors in yeast.* Proc Natl Acad Sci U S A, 1986. **83**(18): p. 6766-70. http://www.ncbi.nlm.nih.gov/pubmed/3529091

What is insulin, and what methods are available to obtain enough for use by patients?
What DNA sequence elements need to be included to make insulin in bacteria or yeast?
How did they recover the insulin from bacteria or yeast? How did they know it was intact?

T, August 18 – Transgenic plants in agriculture

Vaeck, M. et al. 1987. Transgenic plants protected from insect attack. Nature **328**: 33-37. http://www.nature.com/nature/journal/v328/n6125/pdf/328033a0.pdf

How do you put a gene into a plant? How do you test whether it works as intended?
What other genes might be useful to introduce?

Th, August 20 – Engineering a biosynthetic pathway

Fuentes, P., F. Zhou, A. Erban, D. Karcher, J. Kopka, and R. Bock, *A new synthetic biology approach allows transfer of an entire metabolic pathway from a medicinal plant to a biomass crop.* eLife, 2016. **5**:e13664. DOI: 10.7554/eLife.13664 https://elifesciences.org/articles/13664

What treatments are available for malaria? What problems do these have?
What technical approaches enabled the researchers to make a useful chemical?
How might the plants they generated be used to fight malaria?