PURDUE
UNIVERSITY

DEPARTMENT OF AGRICULTURAL & BIOLOGICAL ENGINEERING

TO: The Faculty of the College of Engineering

FROM: Bernard A. Engel, Department Head Agricultural & Biological Engineering

DATE: October 23, 2018

RE: New Graduate Course, ABE 54000 Principles of Systems & Synthetic Biology

The faculty of the School of Agricultural & Biological Engineering has approved the following new course. This submission is recommended to the Engineering Faculty for approval.

ABE 54000 Principles of Systems & Synthetic Biology
Sem.1, Lecture 3, Cr. 3
Prerequisites: BIOL 23000 or BCHM 56100, MA 16100 or higher

Course Description
Synthetic biology harnesses the power and adaptability of biology to engineer living systems that address grand societal challenges. This course introduces students to fundamental concepts and techniques in this interdisciplinary discipline, and studies state-of-the-art techniques from the primary literature. The course follows the standard Design-Build-Test-Learn (DBTL) cycle of contemporary practice and includes topics such as biological circuit design, advanced DNA assembly techniques, genome editing technologies, next generation sequencing, and directed evolution.

Justification

- Supports training of students in the applied life sciences by providing tools for how to apply biology to solve engineering problems (example majors: Biological Engineering, Biological Sciences, Chemical Engineering, Biochemistry, Biomedical Engineering, Food Science (Fermentation minor))
- This course fills a training gap for students interested in developing systems for biotechnology. Current offerings are at the extremes of the process: fundamental biology concepts (e.g. BIOL 230) and scale up of these systems (ABE 558/580, ChE 525) with little covering the actual development of real-world systems that are then fed to large scale production systems
- This course may serve as a substitute for ABE 440 required for Biological Engineering students who may follow alternative plans of study due to internship, etc.

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ABE 591 Principles of Systems & Synthetic Biology

Instructor: Dr. K. Solomon
Office: BND 216
Phone: 494-1134
Email: kvs@purdue.edu
Office Hours: by appt. at http://doodle.com/ksolomon
http://solomonlab.weebly.com

Course Information
Fall 2018
TR 12:00 – 1:15 pm
LILLY 3-120
https://mycourses.purdue.edu

Course Description

Synthetic biology harnesses the power and adaptability of biology to engineer living systems that address grand societal challenges. Driving our ability to engineer these systems are advances in molecular biology, quantitative understanding derived from systems biology, and engineering design principles. This course introduces students to fundamental concepts and techniques in this interdisciplinary discipline, and studies state-of-the-art techniques from the primary literature. The course follows the standard Design-Build-Test-Learn (DBTL) cycle of contemporary practice and includes topics such as biological circuit design, advanced DNA assembly techniques, genome editing technologies, next generation sequencing, and directed evolution. This course fosters interdisciplinary thinking in the creation of biological solutions culminating in a group design project tackling real-world problems and its ethical implications.

Prerequisites

Anyone with high school biology will have the minimum prerequisites to get through the class, but I highly recommend taking college-level molecular and/or cell biology prior to this course. Some knowledge of differential equations and integral calculus is preferred. This course is appropriate for graduate students and advanced undergraduates within the colleges of Engineering, Science, and Agriculture.

Course Goals

To develop fundamental understanding of synthetic biology principles and provide a broad overview of the field and its future direction.

Learning Objectives

At the end of the course, students will be able to:

- Identify and select biological parts needed for a specific engineering objective
- Use modern DNA assembly techniques to build biological circuits and designs
- Quantitatively describe the performance of biological circuits and their components
- Design biological circuits for specific applications
- Evaluate design performance with modern analytical techniques
- Discuss the ethical concerns of engineering biology

Course Requirements

There is **no final exam**. Students need to complete:

5 assignments	3% each – 15%
2 Tests	20% each – 40%
4 Journal Club Discussions + Peer Evaluation	2.5% each – 10%
Group Lit Review + Presentation – BioCAD tools	5%
Group Term Design Project (Report + Presentation)	30%
	100%

Class attendance and participation are critical for learning, especially for classes that discuss the current literature.

Group Lit Review – BioCAD tools

There has been rapid development of BioCAD (Computer Aided Design) tools for Synthetic Biology that aim to simplify the design process. To familiarize themselves with these tools and identify ones that may be beneficial for their own research, students will form groups of 4 to complete a literature review and in-class demonstration of the tool of their choice (e.g. Clotho, Cello). Students should discuss the power of these tools as well as any limitations in their current implementations by analyzing a model system in a brief technical report and 8 min presentation.

Group Term Design Project
Students will practice the course content in a single team design project due at the end of the semester similar to the iGEM competition (http://igem.org). The Design Project includes a technical report and a 25 min presentation that will be weighted equally. Final scores will be distributed according to contributions recorded on private peer evaluations (i.e. if you contributed less than the others, you will receive a score less than the graded total). The report should include:

- A problem description
- Solution design including specific parts
- Quantitative models justifying part selection (should include analysis of performance)
- Construction plan and pros/cons of techniques selected
- Proposed analytical pipeline
- Discussion of how results may refine solution design
- Discussion of ethics (e.g. biocontainment risks, public perception, ethics of solution)

There will be opportunities for teams to receive feedback at various stages of their project through their homework assignments.

Schedule of Topics (Tentative – see Blackboard for details and updated schedule)

Week 1	Engineering Biology Overview + Ethics
	DESIGN
Week 2	Programming Biology
Week 3	Properties of biological systems
Week 4	Network Motifs
Week 5	Nonlinear Systems and emergent phenomena
Week 6	***BioCAD***
	BUILD
Week 7	**Test 1**
Week 8	DNA Assembly
Week 9	DNA Assembly cont'd
Week 10	Genome Engineering
Week 11	Genome Scale Assembly
Week 12	Applications – Metabolic Engineering
Week 13	SynBio Frontiers – Microbial communities and directed evolution
	TEST/LEARN
Week 14	**Test 2**/*Thanksgiving*
Week 15	Learning from Nature + -omics
Week 16	***Design Projects***

Required Texts
Readings are assigned from the primary literature as indicated on the course schedule and posted on Blackboard weekly. **They should be read before class to maximize the value from the classroom discussion**. Students are encouraged to consult the following optional texts electronically via Purdue Library proxy or through on-campus PAL access for background information and further details.

1. **Biobuilder:** Synthetic Biology in the Lab. *Natalie Kuldell, Rachel Bernstein, Karen Ingram & Kathryn M. Hart*. ISBN: 978-1-4919-0429-9 (http://proquestcombo.safaribooksonline.com.ezproxy.lib.purdue.edu/9781491907504).
2. **Synthetic Biology**: Tools and Applications. *Edited by Huimin Zhao*. ISBN: 978-0-12-394430-6 (http://www.sciencedirect.com/science/book/9780123944306)
3. **Synthetic Biology.** *Editors: Anton Glieder, Christian P. Kubicek, Diethard Mattanovich, Birgit Wiltschi, Michael Sauer.* ISBN: 978-3-319-22707-8 (http://link.springer.com/book/10.1007%2F978-3-319-22708-5)

Policies

Grading

- Final scores will be calculated from the scores received on assigned homework, quizzes, term projects and literature reviews as indicated in the course requirements.
- Final scores may be curved at the discretion of the instruction.
- Any requests for reevaluation must be made in writing within 2 weeks of the return of the graded work indicating the grading discrepancy, justification for more points, and a proposed modified score. Requests made after this deadline will not be considered.

Grade	GPA	% range
A	4	93-100
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2	73.0-76.9
C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1	63.0-66.9
D-	0.7	60.0-62.9
F	0	<60.0

Academic Integrity

"As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue"

– Purdue Honor Pledge

https://www.purdue.edu/provost/teachinglearning/honor-pledge.html

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations].

The university does not tolerate any form of academic dishonesty and will investigate all reported and observed instances. Academic dishonesty may result in a failing grade for the assignment or course and will be referred to the Office of Students Rights and Responsibility. Further university penalties, including expulsion from the university, may result from any confirmed case of Academic Dishonesty. For guidance on university policy and to learn more about Academic Integrity, please visit: https://www.purdue.edu/odos/academic-integrity/

Note, students are encouraged to collaborate and work together. Indeed, this is how science moves forward. However, all work turned in for grading must be that of the student and not a copy of the 'group solution'.

Use of Copyrighted Materials

Students are not allowed to make course notes or materials available for others to purchase.

Attendance and Missed/Late Work

I will not accept course assignments missed due to unexcused absences and will assign them a failing grade. Excused absences for scheduled events such as interviews, doctor's appointments, etc. will typically be granted provided you inform me at least 2 days in advance and supply appropriate documentation. It is the responsibility of the student to make arrangements for any missed notes or assignments. In case of emergencies, please inform me as soon as possible upon return to class with appropriate documentation.

Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible…For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, or by contacting the main office that offers the course. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, the student or the student's representative should contact the Office of the Dean of Students,

The link to the complete policy and implications can be found at
http://www.purdue.edu/odos/services/classabsence.php

Grief Absence Policy for Students

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

For additional information, see: http://www.purdue.edu/policies/pages/facilities_lands/i_2_3.shtml

Students with Disabilities

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: ***drc@purdue.edu*** *or by phone: 765-494-1247." http://www.purdue.edu/drc/faculty/syllabus.html*

Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

If you have a disability that requires special academic accommodation, please make an appointment to speak with me within the first three (3) weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) *of an impairment/condition that may require accommodations and/or classroom modifications.*

Mental Health

CAPS Information: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Nondiscrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that

diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

EMERGENCY PREPAREDNESS SYLLABUS ATTACHMENT

EMERGENCY NOTIFICATION PROCEDURES are based on a simple concept – if you hear a fire alarm inside, proceed outside. If you hear a siren outside, proceed inside.

- **Indoor Fire Alarms** mean to stop class or research and immediately **evacuate** the building.
  - Proceed to your Emergency Assembly Area away from building doors. **Remain outside** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.
- **All Hazards Outdoor Emergency Warning Sirens** mean to immediately seek shelter (**Shelter in Place**) in a safe location within the closest building.
  - "Shelter in place" means seeking immediate shelter inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, find out more details about the emergency*. **Remain in place** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.

**In both cases, you should seek additional clarifying information by all means possible…Purdue Emergency Status page, text message, Twitter, Desktop Alert, Albertus Beacon, digital signs, email alert, TV, radio, etc.…review the Purdue Emergency Warning Notification System multi-communication layers at http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html*

EMERGENCY RESPONSE PROCEDURES:

- Review the **Emergency Procedures Guidelines** https://www.purdue.edu/emergency_preparedness/flipchart/index.html
- Review the **Building Emergency Plan** (available on the Emergency Preparedness website or from the building deputy) for:
  - evacuation routes, exit points, and emergency assembly area
  - when and how to evacuate the building.
  - shelter in place procedures and locations
  - additional building specific procedures and requirements.

EMERGENCY PREPAREDNESS AWARENESS VIDEOS

- **"The Coming Storm"** The Coming Storm is a movie that dramatizes the aftermath of a campus shooting, weaving within the story the best practices and lessons learned from active shooter incidents that have occurred throughout the United States. View FBI Short Movie [here].

- **"Run. Hide. Fight.®"** YouTube Video Produced by the City of Houston Mayor's Office of Public Safety and Homeland Security through a grant provided by a Department of Homeland Security Grant Funded Project of the Regional Catastrophic Planning Initiative, provides critical options for consideration to survive an active shooter event.
- **"Run. Hide. Fight.®"** Text Version.
- Department of Homeland Security Active Shooter web site…resources and tips on how to prepare for this type of horrific incident…learn more
- **Ready: Whenever, Wherever**—A public service campaign, from the Indiana Department of Homeland Security, which encourages Hoosiers to practice reasonable awareness and develop a plan for action in the event of an emergency

MORE INFORMATION
Reference the Emergency Preparedness web site for additional information:
https://www.purdue.edu/ehps/emergency_preparedness/

ABE 591 Principles of Systems & Synthetic Biology

Learning Objectives

a) Identify and select biological parts needed for a specific engineering objective
b) Use modern DNA assembly techniques to build biological circuits and designs
c) Quantitatively describe the performance of biological circuits and their components
d) Design biological circuits for specific applications
e) Evaluate design performance with modern analytical techniques
f) Discuss the ethical concerns of engineering biology

ABET Student Learning Outcomes

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Mapping of Learning Objectives to SLOs

A → 1, 2
B→ 1, 6
C → 1, 2
D → 1, 2
E → 6
F → 4