Advanced Technologies in Biosciences

Course Number: 11:126:444 (Undergraduate), 16:765:539 (Graduate)
Credits: 3
Time: Mondays and Thursdays 12:10 PM – 1:30 PM, Foran Hall, Room 138B

Prerequisites:
General Biochemistry (11:115:403) or Molecular Biology and Biochemistry (01:694:407)
Molecular Genetics (11:126:481)

Instructors:
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Course Materials:
Primary reading material will be scientific journal articles or other scientific literature.

Catalog Description:
This course will provide an overview of new technologies in molecular biosciences. It will cover the basic principles of these technologies and discuss various applications to biotechnology. It will consist of a lecture and demonstration format and cover the basic principles of each technology and their applications. The technologies covered include quantitative reverse transcription polymerase chain reaction (qRT-PCR) and its application to COVID testing, laser scanning confocal microscopy, genotyping, surface plasmon resonance label-free detection (Biacore), mass spectroscopy, flow cytometry and cell sorting (FACS), next generation sequencing, CRISPR-Cas9 technology, Fragment Based Drug Discovery (FBDD) and Computer Assisted Drug Design (CADD).

Course Description:
The course is designed for students with some understanding of molecular biology who wish to be familiar with the latest technologies. The course will consist of a lecture and demonstration format with two 80 minute lecture periods per week. The course is separated into nine modules covering quantitative reverse transcription polymerase chain reaction (qRT-PCR), flow cytometry and fluorescence-activated cell sorting (FACS), genotyping, surface plasmon

resonance label-free detection (Biacore), mass spectroscopy, CRISPR-Cas9 mediated genome editing, laser scanning confocal microscopy. Each module provides general introduction and explanation of the technical theory behind the technique. Unique features and limitations of each modality along with advantages and disadvantages of each are explored. The lecture periods include demonstration of each instrument, detailed description of how the analysis is done, what the results look like and how they are interpreted. Application of these techniques to relevant research is highlighted using current primary literature that will be used for class presentation and discussion.

In Class Hands-on Access to Instrumentation

For seven of the nine modules access to the instruments and/or demonstrations will be available to all students. In class demonstrations for qRT-PCR, flow cytometry and confocal microscopy will provide students the opportunity to experience working with these instruments during the class.

During the qRT-PCR session Dr. Pierce will set up a qPCR run at the beginning of class using the StepOnePlus instrument that will be brought to the lecture hall. When the run is complete students will learn how to set thresholds and baselines and be instructed how to evaluate data and identify quality data and outliers using the software.

During the flow cytometry session an Accuri C6 Flow Cytometer will be set up in the lecture hall. Students will break into two groups. One will discuss a case study with Dr. Bidle while the other group works with an expert technician at the instrument using samples provided by the Bidle laboratory. During this time the students will see firsthand how principles of flow cytometry are applied to real world samples. Properties such as cell size and relation to FSC, signal intensity and fluorescence will be covered.

The hands-on session for the confocal microscopy session will take place in the SEBS Core Facility's confocal suite. Using a triple labeled specimen, students will have the opportunity to work the microscope with the direction of Dr. Pierce. Students will learn the basics of capturing single confocal images as well as Z-stacking and 3D imaging.

For the remaining sessions (genotyping and Biacore) demonstration of experimental models are difficult since experiments using these techniques are either carried out over the period of several hours or are rely heavily on post experiment analysis. In these cases, the students will tour the labs that house these instruments where the instructor for each will cover the typical work flow for setting up the instruments and look at data generated from previous experiments providing the students with an idea of the experimental output generated by a particular instrument. During this time instructors will discuss the data differentiating between high and low quality data, features of the software that are important to the analysis and answer any questions about problems that can arise and how they are addressed.

Demonstrations will be conducted on the newly acquired high throughput Biacore 8K+ system which is used for screening fragments or small molecules for drug discovery.

Syllabus:

Month	Date	Module	Topics	Instructor
January	20		General Introduction	Tumer
	24	qRT-PCR	Introduction, key terms, detection chemistry, absolute quantification	Pierce
	27	qRT-PCR	Comparative quantification by ΔΔCt, Primer design, RT reactions, controls, and sample prep methods; **In class hands on demonstration with StepOnePlus qRT-PCR instrument**	Pierce
	31	qRT-PCR	qRT-PCR Presentations (Groups 1 and 2)	Pierce
February	3	Flow cytometry	Introduction; principles, parameters, and probes; measuring intrinsic versus extrinsic properties of cells	Bidle
	7	Flow cytometry	Application of functional probes and flow sorting; coupling with downstream molecular analyses; **In class hands on demonstration with Accuri C6 Flow Cytometer**	Bidle
	10	Flow cytometry	Flow Cytometry Presentations (Groups 3 and 4)	Bidle
	14	Quiz1		
	17	Genotyping	History and applications of molecular markers and genotyping	Honig
	21	Genotyping	Genotyping by Capillary Electrophoresis and Genotyping	Honig

			by Sequencing technologies; **Demonstration of AB 3500 XL Genetic Analyzer in the Honig lab**	
	24	Genotyping	Genotyping Presentations (Groups 5, 6and 7)	Honig
	28	Biacore	Surface plasmon resonance technology and overview describing what Biacore instruments can measure	Li
March	3	Biacore	Surface preparation, regeneration, and interaction measurement; **Demonstration of Biacore in the Tumer lab**	Li
	7	Biacore	Biacore Presentations (Groups 8 and 9)	Li
	10	Mass Spec.		Lobel
	14	Break		
	17	Break		
	21	Mass Spec.		Lobel
	24	Mass Spec.	Mass Spec. Presentations (Groups 10 and 11)	Lobel
	28	Quiz 2		
	31	CRISPR Genome Editing		Di
April	4	CRISPR Genome Editing	CRISPR Presentations (Groups 12 and 13)	Di
	7	Confocal	Introduction, fluorescence, confocal imaging and resolution, optical sectioning/Z-stack, linear un-mixing	Pierce
	11	Confocal	Confocal Presentations (Groups 14 and 15) **Hands on Demonstration on Zeiss LSM 710 in Core Facility**	Pierce
	14	Fragment Based Drug Discovery (FBDD)		Tumer
	18	Drug Discovery and Computer Assisted Drug Design (CADD)		Roberge

	21	Technique application to research projects	Graduate Student Presentations	
	25	Technique application to research projects	Graduate Student Presentations	
	28	Technique application to research projects	Graduate Student Presentations	
May	2	Quiz 3		

Learning Goals and Measures of Assessment:

1. After completing the course students will have a clear understanding of the underlying principles of each technology.

   Assessment: Student performance on quizzes and evaluation of performance in the classroom

2. After completing the course students will understand the unique role each technique has in basic and applied research and understand the limits of each.

   Assessment: Student performance on quizzes and performance on the group independent project and presentation

3. After completing the course students will have used current literature examples to understand how each technology is applied to address a biological question, why the particular technology is chosen and how the results are interpreted.

   Assessment: Student performance on the group independent project and group presentation

4. After completing the course students will understand the importance of attending events to which they have made a commitment.

   Assessment: Class attendance

Specific Measures of Assessment:

1. Three quizzes on lecture material and material covered in the student presentations. The two quizzes with the highest grades will be used for the final grade determination. The quizzes will comprise 60% of the grade for undergraduate students and 50% for graduate students. **Note: you may choose to skip a quiz for any reason such as illness, conflict with other exams, family issues, etc. Because we allow you to drop a quiz, we do not**

give make-up quizzes for any reason other than catastrophic circumstances such as prolonged illness, for which we will require documentation.

2. One student presentation. Students will select and read a paper chosen by the instructors on one of the technologies and present it in class. Presentations will focus on a current research paper assigned by the instructor covering that technology in class. Choice of papers is on a first come first served basis and the same paper cannot be presented twice. Presentations will be 15 minutes in length with 5 minutes for questions. The presentation will comprise 20% of the grade for both undergraduate and graduate students. The presentation will cover:

    a) Hypothesis, the objective of the research.
    b) Why is the particular technology chosen to address this hypothesis?
    c) How the particular technology addresses the hypothesis?
    d) What are the results obtained with the particular technology?
    e) How are these results interpreted?

3. Class attendance and participation will comprise 20% of the grade for under graduate students and 10% for graduate students.

Additional Requirements for Graduate Students:

Graduate students will write a brief description of their graduate research and discuss how **two** of the techniques described in class can be applied to experiments related to their own research (2 page maximum). In addition to the paper, graduate students will prepare a 10 minute in class presentation based on the paper regarding their own work. Grading will be based on the student's ability to succinctly frame the question, to select the right technique to answer that question, to select the proper controls for each technique and identify advantages and limitations for their experiments. This will comprise 20% of the final grade.

***A note about plagiarism:** Plagiarism is representing the words or ideas of someone else as if they were your own. Included in plagiarism, incidentally, is self-plagiarism: an example is representing something you wrote previously for another publication or assignment (for example, for another course) as if it were done as an original work for an unrelated publication or assignment (for example, this course). If you want to use part of a paper you wrote previously for another assignment, check with us first. You are all aware that one of the consequences of Google taking over the communications and publishing world and resources such as Turnitin being easily accessible is that it has become incredibly easy to detect even single sentences that were written by someone else. The possible dividend of incrementally supplementing your grade by a few points through plagiarism or other forms of cheating is not worth the risk of failing this course. If you have any question about what plagiarism is, please check with us.