Advanced Technologies in Biosciences

Course Number: 11:126:444 (Undergraduate), 16:765:539 (Graduate)
Credits: 3
Time: Monday and Thursday 8:30AM – 9:50AM, 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 qRT-PCR/dPCR, confocal microscopy, surface plasmon resonance label-free detection (Biacore), flow cytometry and cell sorting (FACS), peptide synthesis/screening, CRISPR-Cas9 technology, Fragment Based Drug Discovery (FBDD), Computer Assisted Drug Design (CADD) and NMR and mass spectroscopy methods.

Course Description:
The course is designed for students with some understanding of molecular biology who wish to be familiar with the technologies routinely used in academic and industrial reasearch. The course will consist of a lecture and, when possible, demonstration format with two 80-minute lecture periods per week. The course is separated into 10 modules covering qRT-PCR/dPCR, confocal microscopy, surface plasmon resonance label-free detection (Biacore), flow cytometry and cell

sorting (FACS), peptide synthesis/screening, CRISPR-Cas9 technology, Fragment Based Drug Discovery (FBDD), Computer Assisted Drug Design (CADD) and NMR and mass spectroscopy methods. Each module provides general introduction and explanation of the theory behind each technique. Unique features and limitations of each modality along with advantages and disadvantages of each are explored. The lecture periods include demonstrations, if possible, 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 may be used for class presentation and discussion.

In Class Hands-on Access to Instrumentation

In class demonstrations for qRT-PCR, flow cytometry and confocal microscopy will provide students the opportunity to experience 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 class will be held the Marine and Coastal Sciences build, where Dr. Bidle's lab is located. Here, an Accuri C6 Flow Cytometer will be set up. Students will discuss a case study with Dr. Bidle while 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 demonstration of experimental models are difficult since experiments using these techniques are either carried out over the period of several hours or 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 workflow 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.

Syllabus:

Month	Date	Module	Topics	Instructor
January	22		General Introduction	Tumer/Pierce
	26	Flow cytometry	Introduction; principles, parameters, and probes; measuring intrinsic versus extrinsic properties of cells	Bidle
	29	Flow cytometry **Class will be held in Marine Sciences, Room 203**	Application of functional probes and flow sorting; coupling with downstream molecular analyses; **In class hands on demonstration with BD Influx Mariner**	Bidle
February	2	qRT-PCR	Introduction, key terms, detection chemistry, absolute quantification	Pierce
	5	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
	9	Digital PCR	Introduction to digital PCR, comparison of traditional qPCR and various digital PCR technologies, and a case study on turfgrass diseases.	Chou
	12	Quiz 1		
	16	Biacore	Surface plasmon resonance technology and overview describing what Biacore instruments can measure	Li
	19	Biacore	Surface preparation, regeneration, and interaction measurement; **Demonstration of Biacore in the Tumer lab**	Li
	23	Fragment Based Drug Discovery	Introduction, surface plasmon resonance-based fragment	Li

		(FBDD)	screening for drug discovery	
	26	Computer Assisted Drug Design (CADD)	Lead optimization using CADD and medicinal chemistry	Roberge
March	2	Quiz 2		
	5	Peptides & Small Molecules in Drug Discovery		Szekely
	9	FA & TR-FRET in Drug Discovery		Bryan
	12	Quiz 3		
	16	Break		
	19	Break		
	23	Mass Spectrometry (MS)		Zheng
	26	Mass Spectrometry (MS)	Antibody-Drug Conjugates	Szekely
	30	Mass Spectrometry (MS)	Antibody-Drug Conjugates (cont'd) **system demonstration**	Szekely
April	2	Nuclear Magnetic Resonance (NMR)		Andy Nieuwkoop
	6	Quiz 4		
	9	CRISPR Genome Editing		Di
	13	Confocal Microscopy	Introduction, fluorescence, confocal imaging and resolution, optical sectioning/Z-stack, linear un-mixing	Pierce
	16	Confocal Microscopy	Confocal Presentations **Hands on Demonstration on Zeiss LSM 710 in Core Facility**	Pierce
	20	Quiz 5		
	23	Technique application to research projects	Graduate Student Presentations 1	Kaitlin and Ethan
	27	Technique application to	Graduate Student Presentations 2	Carmaleen and Ross

		research projects		
	30	Technique application to research projects	Graduate Student Presentations 3	Chase and Christopher
May	4	Technique application to research projects	Graduate Student Presentations 4	Elizabeth and Jaspreet

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 evaluation of performance in the classroom

3. After completing the course graduate students will have used what they have learned and applied it to their current research project demonstrating an understanding of how these technologies can be 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. Five quizzes on lecture material and material covered during demonstrations. The four quizzes with the highest grades will be used for the final grade determination. The quizzes will comprise 80% of the grade for undergraduate students and 60% for graduate students. **Note: you may choose to skip a quiz for any reason such as illness, conflict with other exams, family issues, etc. We allow you to drop one quiz, therefore 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. Class attendance and participation will comprise 20% of the grade for undergraduate 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 **at least one** 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 20 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 30% 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 represents 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 questions about what plagiarism is, please check with us.