Advanced Technologies in Biosciences

Course Number: 11:126:444 (Undergraduate), 16:765:539 (Graduate)
Credits: 3
Time: Mondays and Thursdays 9:15-10:35 Room 138A

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 technologies in molecular biosciences. 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), laser scanning confocal microscopy, genotyping, surface plasmon resonance label-free detection (Biacore), mass spectroscopy, TIM system and applications, flow cytometry and cell sorting (FACS) and next generation sequencing.

Course Description:
This course will provide an overview of technologies in molecular biosciences. It will cover the basic principles of these technologies and discuss various applications to biotechnology. 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 eight modules covering quantitative reverse transcription polymerase chain reaction (qRT-PCR), laser scanning confocal microscopy, genotyping, surface plasmon resonance label-free detection (Biacore), mass spectroscopy, TIM system and applications, flow cytometry and fluorescence-activated cell sorting (FACS) and next generation sequencing. 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 eight modules access to the instruments and demonstrations will be available to all students. In class demonstrations for qRT-PCR, flow cytometry and confocal microscopy will give students the opportunity to actually work 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 Frank Natale 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, Biacore, TIM and next generation sequencing) 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.

Syllabus:

Month	Date	Module	Topics	Instructor
January	18		General Introduction	Tumer
	22	qRT-PCR	Introduction, key terms, detection chemistry, absolute quantification	Pierce
	25	qRT-PCR	Comparative quantification by ΔΔCt, Primer design, RT reactions, controls and sample prep methods; **In class hands on demonstration with StepOnePlus qRT-PCR insturment**	Pierce
	29	qRT-PCR	Presentations (Groups 1 and 2)	Pierce

February	1	Flow cytometry	Introduction; principles, parameters and probes; measuring intrinsic versus extrinsic properties of cells	Bidle
	5	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
	8	Flow cytometry	Presentations (Groups 3 and 4)	Bidle
	12	Quiz1		
	15	Genotyping	History and applications of molecular markers and genotyping	Honig
	19	Genotyping	Genotyping by Capillary Electrophoresis and Genotyping by Sequencing technologies; **Demonstration of AB 3500 XL Genetic Analyzer in the Honig lab**	Honig
	22	Genotyping	Presentations (Groups 5 and 6)	Honig
	26	Confocal	Introduction, fluorescence, confocal imaging and resolution, optical sectioning/Z-stack, linear un-mixing	Pierce
	1	Confocal	**Hands on Demonstration on Zeiss LSM 710 in Core Facility**	Pierce
	5	Confocal	Presentations (Groups 7 and 8)	Pierce
	8	Drug Discovery		Kimball
	12	Break		
	15	Break		
March	19	Mass Spec.		Lobel
	22	Mass Spec.		Lobel
	26	Mass Spec.	Presentations (Groups 9 and 10)	Lobel
	26	Quiz 2		
	29	Biacore	Surface plasmon resonance technology and overview describing what Biacore instruments can measure	Li
April	2	Biacore	Surface preparation, regeneration and interaction measurement; **Demonstration of Biacore T200 in the Tumer lab**	Li
	5	Biacore	Presentations (Groups 11 and 12) on academic and industrial applications of Biacore technology	Li

	9	Next Gen. Seq.	Evolution, description, and capacities of the main platforms used to generate NGS data; e.g., Illumina, Ion Torrent, PacBio.	Bhattacharya
	12	Next Gen. Seq.	Use of NGS data for genome assembly, gene prediction, functional genomics, metagenomics, and single cell genomics; **Demonstration of Illumina MiSeq in the Bhattacharya lab**	Bhattacharya
	16	Next Gen. Seq.	Presentations (Groups 13 and 14) on applications of NGS.	Bhattacharya
	19	**T**NO **I**ntestinal **M**odel (TIM)		Ribnicky
	23	**T**NO **I**ntestinal **M**odel (TIM)	Introduction, Applications of TIM in Pharmacy Food and Safety; **Tour of the TIM lab and intestinal model**	Ribnicky
	26	**T**NO **I**ntestinal **M**odel (TIM)	Presentations (Groups 15 and 16)	Ribnicky
	30	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 group 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.

2. One group presentation. Students will read an assigned paper covering the particular technology discussed in the lecture and present it in class. Group presentations will be made in groups of 2-3 students each and will focus on a current research paper assigned by the instructor covering that technology in class. 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 the particular technology is 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:

1. 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 15-20 minute in class presentation with time for questions based on the paper. 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 10% of the final grade.
2. In addition to the material covered in each of the quizzes graduate students will be responsible for a take home quiz related to the primary literature assigned for student presentations. These questions will be more in depth and assess the student's ability to critically analyze the results and interpretations found in the assigned reading. This will comprise 10% of the final grade.