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Development of an Animal Models Systems Laboratory: for Undergraduate Students

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Abstract

Students will work in groups through learner-centered instruction to design and carry out experiments using one of four model systems listed: *Drosophila melanogaster (Fruit Fly)*, *Caenorhabditis elgans (Roundworm)*, *Dugesia tigrina (Planaria)*, or *Danio rerio (Zebrafish)*. Student groups will design a novel experiment and hypothesis, based on the current literature. The students will be responsible for the animal husbandry of the models; C. elegans, D. tigrina and D. melanogaster. Student groups will perform experiments in weeks 4-6 and analyze their initial findings for their model organism. Following initial data analysis, students will repeat the same experiments or refine their experimental design and then perform experimentation in weeks 9-11. Repeating experiments is a necessary component of scientific research, typically an experiment is repeated at least three times to show that the work is reliable and verifiable, a very important element of research. Students will then spend the next two weeks working in their groups, analyzing data and preparing their oral presentation. During the oral presentation students will present their findings to the class, which will strengthen their oral and written communication skills.

Keywords

Model Systems; Toxicology; Undergraduate; Inquiry-Based; Student-Centered

Introduction

The research experience is an essential component of an undergraduate curriculum. Undergraduate research has been shown to make a difference for the individual student performing the research experience, as well as the undergraduate curriculum, as a way for enhancing, completing or rounding out a science major's education [1-11]. Undergraduate research gives students the opportunity to develop an understanding for the complexity of science and put the concepts presented in traditional lecture into practice. Sometimes undergraduate research even allows students to contribute to the particular field of study in the form of a publication, research seminar or poster, or presentation at a scientific meeting. Each scientific discipline has its own set of concepts and vocabulary that needs to be learned, in addition to an equally complex set of techniques that are typically learned in a laboratory setting. The research experience is the final piece in the curriculum puzzle, as it gives students the opportunity to discover and apply their foundational material to new concepts, new areas of study or to answer an unknown question. The idea of the undergraduate research experience has been around for many years, and by itself is not a new idea. It has been established since the early 1990's that research is absolutely necessary in an undergraduate science education and an education without such opportunities is incomplete [12]. Following the National Resource Council Chemical Sciences roundtable report came restructuring of many science laboratory classes to include scripted labs completed by every student and designed to obtain the same result or outcome. This methodology however, still did not capture the component of discovery that many scientific researchers experience. Perhaps this could explain why amongst science majors, those not exposed to a research experience are less likely to go on to advanced study or obtain a job in their particular field [12]. Also students exposed to a research experience are more knowledgeable about graduate school and the expectations of research. There are additional benefits that are less quantifiable and more anecdotal around the personal growth and professional development of students participating in undergraduate research experiences. Research opportunities for students at Quinnipiac University have primarily been through faculty-mentored independent study, Quinnipiac Interdisciplinary program for research and scholarship (QUIP-RS) or through participation in research programs at other institutions. Through development of a learner-centered, research-oriented animal models systems elective we increase the undergraduate research experience opportunities for our students.

The Student Audience:

The Animal Model Systems Laboratory course is an organismal elective for biology majors and a recommended elective for biomedical sciences and behavioral neuroscience majors. The students enrolled in the course will be sophomores, juniors and seniors, who are simultaneously enrolled in the Animal Model Systems Lecture. All students enrolled in the course will have completed general biology.

Goals and Learning Outcomes:

The research-oriented Animal Model Systems Laboratory has three broad goals. The first goal is to challenge students to demonstrate mastery of foundational knowledge and apply concepts and skills obtained in previous courses to their novel research project. The second is to demonstrate skills in critical and creative thinking and utilize those skills to evaluate information and devise solutions to scientific problems. The third goal is for students to demonstrate an ability to work collaboratively to solve problems and effectively communicate results utilizing oral, written and visual mediums. Within the context of these broad goals, the laboratory has several more specific learning outcomes.

1. Students are expected to develop analytical and problem solving skills.
2. Students are expected to evaluate and interpret primary literature.
3. Students are expected to relate biological concepts to societal issues and consider implications of scientific research
4. Students are expected to develop and improve skills of observation and critical thinking.
5. Students are expected to demonstrate communication skills through scientific writing, presentations and discussions.

Course Organization and Requirements:

The official schedule for this 1-credit laboratory is one three-hour session of laboratory per week, for 15 weeks. Students will be responsible for the husbandry of all animals, which will require additional sessions. During the first two weeks, students will be introduced to the four animal models used in the lab through pre-lab lecture PowerPoints and observation of the animals' normal morphology and behavior. Thereafter, there will be no pre-lab lectures and students will work in groups designing and carrying out experiments. Students will be responsible for sharing the laboratory resources and maintaining the cleanliness of the lab.

On the first day of class, students will divide into groups of three-four and observe the normal morphology of *Caenorhabditis elgans* and *Drosophila melanogaster*. This will include a discussion of the normal animal husbandry, as well as current uses of the animal models in research. During the second laboratory, students will observe the normal behavior and morphology of *Dugesia tigrina* and *Danio rerio* and discuss normal animal husbandry and current uses of the model organisms in research. At the conclusion of the second class each group will randomly select their animal model. This model will be used for a semester long research project which culminates with an oral presentation and PowerPoint. During the third class students will work in groups and with the instructor to analyze primary literature and formulate a research objective, experimental design and assessable endpoints. For the next three weeks students will carry out experiments and begin analyzing the data they generated. They will continue to critique their experimental design and research question(s) as the semester progresses

and upon completion of their first set of experiments, groups will evaluate their progress and determine if their experimental design needs to be altered to better address their question. If the experimental design is accurately aligned with the research objective, the students will repeat their experiment over the next three weeks. Upon completion of experiments, students will analyze all data and work in groups to generate a 20-minute PowerPoint presentation. The presentation will include a defense of the application of their animal model, an explanation of the research question, the methods utilized, the results and conclusions. There will be no more than five groups of three working in each lab to allow for close interaction between the instructor and students. The laboratory schedule is outlined in Table 1.

Each group will keep an electronic research-type laboratory notebook where all activities are recorded as they are performed. The electronic notebook will allow each group member to annotate and review what has been completed during all stages of experimentation. The notebook will assist in the generation of the final presentation and will allow students to work both collaboratively and independently.

Table 1. Topics in the Animal Model Systems Laboratory

Week	Topic Area
1	Normal Morphology & Behavior of Drosophila & Roundworm
2	Normal Morphology & Behavior of Planarian & Zebrafish
3	Experimental Design & Endpoints to be Assessed-**Topic Selection**
4	Experimentation
5	Experimentation
6	Experimentation
7	Data Analysis & Experimental Design & Endpoints to be Assessed
8	Spring Break (no class)
9	Repeat Experimentation
10	Repeat Experimentation
11	Repeat Experimentation
12	Data Analysis
13	Group Work
14	Oral Presentations
15	Oral Presentations

Assessment Techniques:

Innovative course assessment is essential for the success of our 21st century students. Although the National Research Council (NRC) made a plea in 1996 to alter our assessment focus to support educational reform [13-25] this plea has yet to be fully addressed or implemented. The change in focus shifts the assessment techniques from learning outcomes, content knowledge and discrete, declarative facts to learning processes, understanding and reasoning, within and across content areas and rich, authentic knowledge and skills. In addition to instructor assessment, students will be asked to complete three self-assessments, through guided reflections, which they will post in eportfolio. These prompts will allow the student the opportunity to reflect on the process of formulating a research objective, carrying out experiments and working collaboratively. The guided reflections are going to be used as check-in points throughout the semester. The students will reflect on the experience of working in a group to develop hypothesis-driven research (this will include the process, the struggles and the strengths of the group), they will be asked to reflect on the experimental design, following the completion of Week 7's data analysis and they will be asked towards the end of the semester if computer modeling can replace animal models in research and if the research they performed could have be reduced, refined or replaced. Each reflection should be a page and a half to two pages. Self-assessment is a valuable skill aimed at producing self-directed, productive life-long learners. Students working collaboratively with one-another will attempt to understand a scientific problem and explain it, through novel research. One of the many benefits associated with peer assessment is that students will have the opportunity to develop higher-order thinking skills, an essential strategy for 21st century learning [13-25]. The assessments used in the course are outlined in Table 2.

Table 2. Animal Models Laboratory assessments

Experimental Design/Hypothesis	10%
Animal Husbandry	14%
Draft	10%
Oral Presentation	40%
Contribution	15%
E-Portfolio	11%
Guided Reflection 1 (3%)	
Guided Reflection 2 (3%)	
Guided Reflection 3 (3%)	
Upload research project (2%)	

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