Developing Investigative Labs for Biology 230

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Introduction

To implement the educational reforms called for in *Vision and Change in Undergraduate Biology Education* (AAAS 2010)[1], we designed lab modules for Biology 230: Physiological Systems in which students learn bioscience competencies by investigating physiological responses and homeostasis of plant and animal systems in response to environmental changes.

Scientific competencies emphasized in Biology 230 Lab:

- scientific process
- quantitative reasoning
- interdisciplinary nature of science
- relationship between science and society

Pedagogical strategies:

1. Employ project-based learning in which students gain knowledge and skills by investigating real-world challenges through extended research projects.
2. Make use of best practices in scientific teaching:
   - Experiential – Learn science by doing science
   - Integrative – Science as a liberal art
   - Evidence-based – Pedagogical choices informed by the literature; revisions informed by assessment data
   - Responsible – Informed by ethical and societal considerations

Key Outcomes: Competencies

Core Competencies	Module 1	Module 2
Relationship between science and society	Using science to explore society's role in creating and alleviating environmental stress	Using science to assess the importance of physical activity for public health
Scientific process	Controlled laboratory experiment: literature → research question and hypotheses → controlled experimentation → data collection and analysis	Cohort study: literature → research question and hypotheses → survey to differentiate subpopulations with different risks → data collection and analysis
Quantitative reasoning	Experimental design informed by statistical considerations; data manipulation; statistical analyses	Survey and database design informed by statistical considerations; data manipulation; statistical analyses
Interdisciplinary nature of science	Preparation of chemical solutions; chemical extractions and assays; statistical methods for data analysis	Epidemiological strategies (cohort study); chemical extractions and assays; statistical methods for data analysis

Module Descriptions

Module 1: Environmental Stress and Plant Physiology

Central Research Question: How do abiotic stresses and stress combinations affect plant physiological responses?

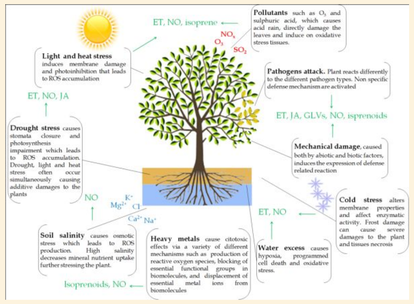
Learning from the Literature: Read and discuss review article concerning plant responses to abiotic stress combinations (Suzuki *et al.*, 2014)[2].

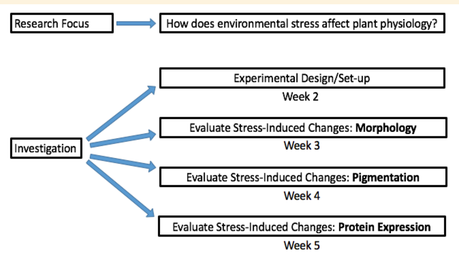
Class Experiment: Design and conduct a controlled, laboratory experiment evaluating stress-induced changes to three key indicators of physiological responses: morphology, pigmentation, protein expression.

Key Methodologies:

1. Pigment Analysis
   - Quantitative: spectrophotometry
   - Qualitative: thin layer chromatography (TLC)
2. Protein Analysis
   - Quantitative: bradford protein assay
   - Qualitative: SDS-PAGE

Data Analysis: Use statistical methods (ANOVA) to compare stress-induced changes between treatment groups.





Module 2: Exercise and Human Physiology

Central Research Question: Does acute, dynamic exercise elicit different physiological responses in physically active populations versus sedentary populations?

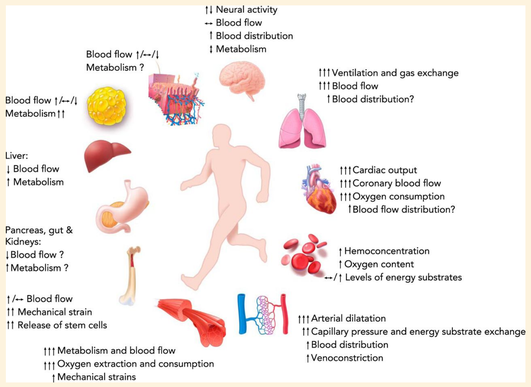
Learning from the Literature: Read and discuss recent research investigating immediate physiological responses to acute physical activity (Warburton *et al.,* 2006)[3].

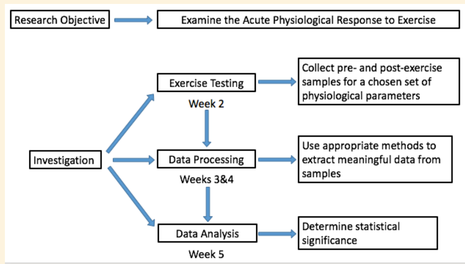
Class Experiment: Design a physical activity survey to define populations; conduct a cohort study to assess the acute exercise effect on the following physiological parameters: blood pressure, blood glucose, insulin, protein and potassium levels.

Key Methodologies:

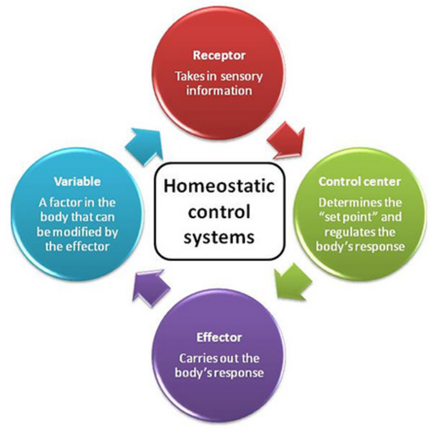
- Blood pressure monitoring
- Blood glucose tracking
- ELISA insulin assay
- Bradford protein assay
- Serum kalium microplate assay

Data Analysis: Use statistical methods (ANOVA) to compare exercise-induced physiological responses between cohorts.





Key Concept: Homeostasis



Assessment Plan

After the first iteration of the course is complete (in December 2016), we will assess:

1. Student learning gains, as measured by:
   - laboratory notebooks
   - final exam
2. Student perceptions and attitudes toward the course, as reflected in:
   - Student Assessment of Learning Gains (SALG) surveys
   - Course evaluations

These will drive subsequent modifications of learning materials and pedagogies.

References

[1] AAAS (2010) *Vision and Change in Undergraduate Biology Education,* Washington, DC: American Association for the Advancement of Science.

[2] Suzuki *et al* (2014). Abiotic and biotic stress combinations. *New Phytologist.*

[3] Warburton *et al* (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*.