

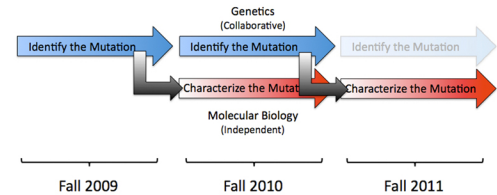
An Inquiry-Based Approach to Teaching Undergraduate Students Advanced Molecular Genetics

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Abstract

Research experiences are not only central in training undergraduate students in discipline-specific techniques, but also in fostering the development of science process skills including hypothesis formulation, experimental design, data interpretation, problem solving and scientific writing. I have designed a research-methods course, Biol350 Molecular Genetics that engages students in faculty-mentored research through the identification and characterization of mutant alleles of *Drosophila* genes required for axonal transport, previously identified in a large-scale mutagenic EMS screen. Employing a unique nested approach that addresses the severe time-restrictions of a short 15-week semester, students simultaneously participated in both a collaborative gene mapping group project and an independent molecular and phenotypic analysis of identified mutations.



In the span of a single semester, seven students were able to map, identify the lesion, and carry out a phenotypic analysis associated with mutant alleles of seven genes including the peroxisome biogenesis factor 1 gene (*Pex1^{WU1}*), the ubiquitin specific protease genes fat facets (*faf^{WU2}*) and non-stop (*not^{WU3}*), the transcription factor single-minded (*sim^{WU4}*), the co-lin phosphatase gene slingshot (*ssh^{WU6}*), the protein O-mannosyltransferase gene rotated abdomen (*rt^{WU5}*), and a gene that encodes a pericentrin-like protein, cp309 (*cp309^{WU7}*). A summary of the results of the work performed on these mutant alleles will be presented, as will a detailed description of the course and an assessment of the impact it has on the development of science process skills and student attitudes towards research.

Results

Table 1. A summary of the seven mutant alleles identified by Biol350 Molecular Genetics class of 2010.

Mutant Allele	Gene	Cytology	Function	Lesion
<i>Pex1^{WU1}</i>	peroxisome biogenesis factor 1	70D1-70D2	AAA ATPase	TTG → TAG Leu ²²² to STOP
<i>faf^{WU2}</i>	fat facets	100D2	ubiquitin-specific protease	CAG → TAG Gln ¹⁹² to STOP
<i>not^{WU3}</i>	non-stop	75D4	ubiquitin-specific protease	CGA → TGA Arg ⁶⁸ to STOP
<i>sim^{WU4}</i>	single minded	87D11	transcription factor	n/a
<i>rt^{WU5}</i>	rotated abdomen	68C13	protein O-linked mannosylation	TGG → TGA Trp ⁵⁰⁵ to STOP
<i>ssh^{WU6}</i>	slingshot	96B10-96B11	protein phosphatase	GGA → GAA Gly ²³³ to Glu ²³³
<i>cp309^{WU7}</i>	cp309	71B2-71B4	centrosome protein	n/a

A Biol350 Molecular Genetic students typical characterization of an identified mutation: A Molecular and Phenotypic Characterization of *ssh^{WU6}*

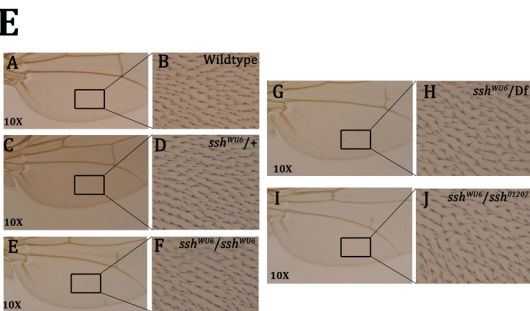
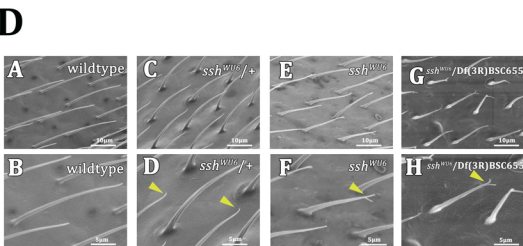
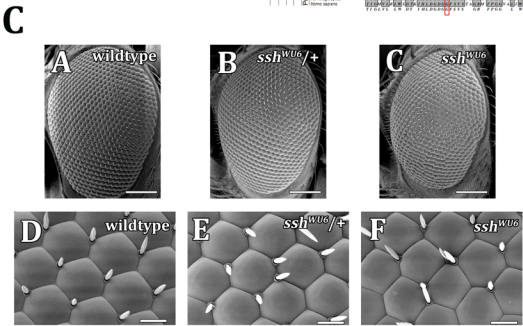
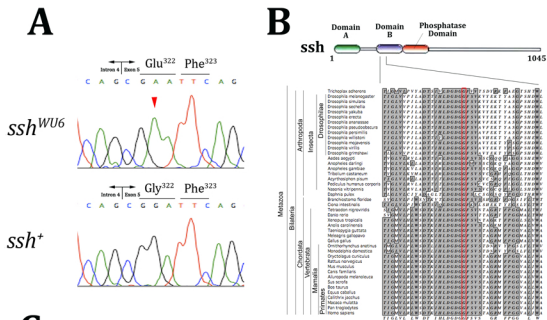


Figure 1. A Molecular and Phenotypic Characterization of *ssh^{WU6}*
The *slingshot* (*ssh*) gene encodes a family of phosphatases that dephosphorylate ADF/cofilin, a regulator of actin dynamics. **A)** The mutant allele, *ssh^{WU6}* arises as a consequence of a transition mutation that converts Guanine⁶⁹⁸ to Adenine⁶⁹⁸ in exon 5 of the *ssh* gene, an exon conserved in all four *ssh* isoforms, ultimately causing a missense mutation that converts the amino acid Glycine²³³ (CGA) to Glutamic Acid²³³ (GAA). **B)** Glycine²³³ is an amino acid found in a region of the ssh protein called Domain B and is highly conserved across the eumetazoa. Domain B represents the ADF/cofilin binding domain, whereas Domain A represents the F-actin mediated activation domain (Kurita et al., 2008). **C)** A small percentage of *ssh^{WU6}* adults are homozygous viable, and exhibit mild disorganization of the ommatidia of the eye. **D)** *ssh* mutant adults also exhibit defects in the formation of the wing hairs. Heterozygous *ssh^{WU6}* adults have wing hairs that begin to bend slightly at their distal tips (Figure D-C and D-D). In viable homozygous *ssh^{WU6}* adults, the wing hairs are split at their distal tips (Figure D-E, and D-F). **E)** The *ssh* gene is required for the maintenance of planar polarity of wing hairs. Planar polarity of wing hairs is mildly disrupted in *ssh^{WU6}* homozygotes (Figure E-F), and more severely disrupted in *ssh^{WU6}/Df* (Figure E-H) and *ssh^{WU6}/ssh⁰¹²⁰⁷* (Figure E-I) wing blades.

Conclusions

The Classroom Undergraduate Research Experience (CURE) survey, developed by David Lopatto at Grinnell College, was employed as an assessment tool allowing comparison of the perceived gains of students in *Biol350 Molecular Genetics* to a cohort of students from across the nation who completed similar research courses in the same academic year. Table 2 highlights the perceived gains *Biol350* students reported concerning *Attitudes About Science*, which were all greater than that reported by the national cohort. This measure has been reported to reflect student engagement in the course, and correlate with higher reported learning gains and a greater likelihood of students to declare a science major.

Table 2. CURE Assessment of Biol350 Molecular Genetics - Attitudes About Science

Attitudes About Science - Engagement	Biol350 Students Fall 2010	National Cohort (1107 students)
Even if I forget the facts, I'll still be able to use thinking skills learned in science	4.83	4.71
The process of writing in science is helpful for understanding scientific ideas	4.14	3.93
I get personal satisfaction when I solve a scientific problem by figuring it out myself	4.86	4.18
I can do well in science courses	4.29	3.96
Explaining science ideas to others has helped me understand the ideas better	4.71	4.03

1 = strongly disagree
5 = strongly agree

In summary, students reported large gains in overall assessment of their experience in *Biol350 Molecular Genetics* compared with other undergraduate research experiences offered nationally (Table 3).

Table 3. Summary of CURE Assessment of Biol350 Molecular Genetics

Overall Assessment of Biol350 Molecular Genetics	Biol350 Students Fall 2010	National Cohort (1107 students)
This course was a good way of learning about the subject	4.86	4.17
This course was a good way of learning about the process of scientific research	4.71	4.12
This course had a positive effect on my interest in science	4.86	3.99
I was able to ask questions in this class and get helpful responses	4.86	4.21

1 = strongly disagree
5 = strongly agree

Acknowledgements

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Biol350 Molecular Genetics - Fall 2010



Biol350 Molecular Genetics - Spring 2012