Supplemental Material 1: The following list was developed by members of the Biology department at Wofford College in response to the question “what do we want our students to know, do, and care about?” as they prepared to engage in reform of their first year curriculum.

Canonical Knowledge (Know)	**Skills (Do)**	**Dispositions (Care About)**
Core theories of natural world (e.g., evolution/natural selection)	Manage time effectively and practice effective study skills.	Increased confidence in ability to understand and use science.
Foundational content (e.g., DNA structure/function)	Effectively observe, hypothesize, predict, document, measure, collect data, analyze, interpret, and evaluate.	Greater appreciation & awareness of professional *scholarship.*
Functional numeracy (orders of magnitude, interpret graphs, statistics, concentrations, molarities, applied mathematics)	Design a good experiment or model and/or use computational methods to test hypotheses.	Motivation (take action, learn more than required, seek justice, etc.).
“Credentialing” of a scientist, the role of peer review process, primary research, etc.	Read and use primary literature appropriately. Paraphrase and cite others' ideas appropriately.	Honesty – Integrity
How new findings remodel accepted interpretations (e.g., *Hox* genes and phylogenetic relationships)	Think critically (use evidence, evaluate credibility, critique bias in self and others), practice open-minded skepticism.	Responsibility for others welfare/civic engagement.
The power and limitations of science (and scientists). Moral, ethical, economic, historical, & religious norms influence scientific practice. Learn beyond STEM.	Integrate and apply knowledge from other STEM and non-STEM disciplines. Transfer knowledge to novel situations, predict/create/innovate.	Self-reflection and improvement
Complexity and ambiguity are more the norm than fact and proof.	Communicate effectively in oral and written form.	Sense of belonging that is shared with other learners
	Work well in teams and individually.	Committed to institution & teachers
	Make meaning of complex issues in context; recognize role of underlying ethics, morals, and values.	Empathy for diversity of perspectives, backgrounds, etc.
	Utilize multidisciplinary knowledge and skills to investigate complex and ambiguous topics.	

Supplemental Material 2: The following short essays are a representative sample from students who were asked to reflect on "what they learned, how they learned, and how they felt about the experience" following the first three-hour laboratory session of Biological Inquiry, a course for first year students at Wofford College. During the lab, each team of four to five students read a primary research article and presented the research findings to their classmates, often in the form of a skit.

Student 1: *The lab time was extremely beneficial to reading and understanding some relatively complex primary literature. In some cases just reading the study is not thorough enough to gain a full understanding of the procedures and conclusion. The learning and teaching involved in our activities helped not only the class learn about our article but the group itself gained a higher understanding via having to break down the complex information and deliver it in a much simpler form to their peers. The skit was intimidating at first because I didn't understand how we would act out the lizard interactions. Also it required a certain outgoing personality to engage in a skit in front of the class that not all students have. The most important idea I learned from the lab time was the idea that it doesn't take a super genius like Einstein to be curious enough to come up with a question and then develop a study to find its answer. This is a fairly simple process that merely takes a little ingenuity and the means to set up a suitable control environment.*

Student 2: *Initially I was intimidated by the lab, but I was very curious as to what we would be doing, reading, and learning as well as how we would be doing all of these things in comparison to what I am used to. At the end of the lab I was comfortable with my groups material and I feel that I had a pretty good grasp on the other presentations. I was surprised with how well I could understand and engage with other peoples presentations due to how well they presented and how well I was able to pick I up and understand it. Overall, I felt comfortable and confident in this lab and I am excited to do more labs and learn from my classmates.*

Student 3: *Today I learned not only that piranhas travel in packs to avoid predators, but I also learned how to work in groups efficiently. Lab work at Wofford is totally different than lab work in high school. I am now working with people who graduated a the top of their class and are extremely bright kids. I was able to learn so much today because of the caliber of students I was working with and their willingness to put in a lot of effort. Initially, I was very intimidated, but at the end I felt very good about myself. It surprised me how intelligent everyone in our group was and how committed they were to work. I will never forget my feelings when I walked into my first college lab.*

Student 4: *I was initially intimidated by the lab because we were only given an hour to read the primary literature article and come up with a way to present the experiment with the rest of the class. By the time the hour had passed, I felt much more confident about the activity because my lab partners and I work well and efficiently together. We came up with a creative method for sharing our experiment while communicating its main aspects clearly. I was surprised at how well my group worked together and how willing each person was to do their part which was nice because it made the lab assignment easier. I did not encounter any frustrations during the lab because of our lab group's teamwork and support for each other. I learned about common misconceptions about* *shoaling of piranhas from primary literature and a first hand experiment that I won't forget because the lab format.*

Student 5: *In class I learned many things, a number of them being new scientific findings such as the finding of Mutualism and parasitism and how lizards physical appearance decide who will get laid. While these and other findings are important I think it is more important to understand the large role of all these experiments; which is how science changes constantly. For most of these experiments there was a commonly accepted idea that was soon overturned by these experiments. Also I learned that with each experiment tested that they open doors to more and more experiments. I learned this by trying to find similarities with these different experiments and then asking questions. I like this method of what we did because it helps and practices many essential skills like" creativity, cooperation's, analyzing, critical thinking, public speaking and it is very low key and not all serious about being right or wrong.*

Student 6: *Biology terrifies me. I have an ingrained fear of the field, deeply chivied from a year of poor grades, fruitless tutoring sessions, and muddled confusion. I was daunted, therefore to begin reading my group's primary source in lab. At the sight of innumerable complex biological terms, my head began to spin. Yet, after consulting Dr. Goldey as well as the other members of team Mack, the buzzing subsided. Biological terms are simply a collaboration of meaningful fragments, not to be feared, but appreciated for the clarity they bring. By explaining how to break long terms down into roots, Dr. Goldey and my teammates gave me tool for all other labs in the future. While it took me longer than my group to fully grasp the implications of our article, by understanding the nuances of the terms, for once I could comprehend a biological article. While the word biology may still increase my heart rate, group collaboration in lab gave me the courage to calm my nerves, using my understanding of words to learn science.*

Student 7: *Today in lab I learned that in science there is no one right answer. What some scientist may see as "exact" can be challenged by other scientists and proven wrong. In my article's case, scientists were proven wrong in concluding that the Carribean cleaning goby's relationship with the longfin damselfish is completely mutualistic. Their symbiosis can be mutualistic, parasitic, or neutral according to Cheney and Cote's experiment. I also learned that knowing what has happened in the past helps determine the future. When scientists read and study experiments from the past, they are able to build onto those conclusions, reject them, or formulate their own. I really enjoyed this lab because I like demonstrating for and teaching fellow students. I also find it easier to me to learn from different people rather than listening to the same teacher everyday.*

Title (should be descriptive of the work)

Your Names Here (typically in alphabetical order unless first author did most of the work)
Wofford College, South Carolina

Introduction

This section should provide background information from the *primary* literature about your topic. Your introduction should move from the general to specific and end with the purpose (or hypothesis) of your research. Narrow your literature review as much as possible to focus on your research topic (it takes time to find relevant articles!). Describe to the reader how your study is similar to prior work but also adds something new to what is already known.

Avoid plagiarizing the work of other authors by first summarizing their findings in your own words and citing the source. A citation of a paper with more than two authors would be Smith, et al. 2009, two authors would be Smith and Jones, 2009, etc. The citation should immediately precede or follow the sentence or portion of a sentence from which the information came. For example: Smith and Jones (2009) have shown that… Or: The genus Plasmodium is estimated to include at least 172 species (Telford et al., 1994), with four infecting humans (Cox, 1993).

Methods

This section includes information on how the experiment was performed. It should be brief but descriptive (a list of supplies and steps is not appropriate). Consider using photos or diagrams (each would have its own figure caption) *if* they would help the reader understand what was done. Remember that the reader should get the gist of the experimental protocols here. A research poster doesn't give as much detail as a full article, but it should provide an overview with enough detail for a peer (naive to the experiment) to understand what you did. Be sure to name/describe the statistical tests that you used to analyze your data.

Results

This section should be dominated by results that appear in graph or table form but will also typically have a descriptive paragraph. Each figure must have below it a descriptive <u>caption</u> that begins with Figure 1, Figure 2, etc. The figure caption should include information important for interpreting the figure (sample size, t-statistic, p value, etc). Each Table must be numbered (Table 1, Table 2, etc.) with a descriptive <u>header</u> across the top. Statistics should be displayed appropriately; mean values should be shown relative to sample variance (e.g., standard error values can be calculated using JMP). Your results SHOULD NOT include raw data and *you should not interpret* your results in this section.

<u>Other hints for preparing your poster</u>:

1. *Just type over the text in each section if you want to use the template as is and immediately save it as a new file with your section letter, team number, and assignment name (e.g., Bio150FTeam6Poster1).*
2. *If you want to change the background, logo, etc., then go to "slide master" under the view tab.*
3. *Consider adding relevant photos to your poster – they capture the eye and draw people to your poster.*
4. *The overall poster dimensions are 11" X 17"'. Stick with this, as it makes it easy for us to print on this larger paper.*
5. *Brevity is key – write out a draft of your text and then remove as many words as possible. Note: You are looking at too many words on this poster template!*
6. *Get many people to critique your poster to improve it. Remember that peer-review is a hallmark of good scholarship.*
7. *See example research posters on the walls of Milliken Science Center. Which ones are most effective and why?*
8. *Use past tense when describing your experiment. Use of first person (we) is acceptable..*

Discussion

In your discussion you should <u>interpret</u> your results rather than restate them. If needed, refer the reader back to a figure or table when you interpret it.

Reflect on your introduction -- do your results support your hypothesis and/or stated purpose? Do your findings support or refute the findings of other scientists? Your discussion should address these types of questions.

Remember, you must <u>interpret the results you get</u>, not the ones you wanted or expected. Getting unexpected results may mean that you're on to something interesting! Include what you consider to be the best explanation for your results, but include alternative explanation(s), too. Based on your findings, are there any changes in protocol that you would recommend to reduce ambiguity?

How might your work inform future studies? One common way to end this section is to describe a future study -- keep your focus here and design a "next step" experiment to address a question that emerges from your experiment. Provide enough detail to show that you've really thought about the proposed study's purpose and design.

At the end, you need to try to link the work you've done to the bigger picture. This is the "So What?" part of your poster.

Literature Cited

Any work that you have cited above must appear in this section. Format your citations like those in one of your primary articles or go for help to <u>http://nsm1.nsm.iup.edu/rgendron/citation.shtml</u>.

It is *not* OK to list a bunch of web sites. You must include at least four primary sources (published articles from refereed journals that you have read) related to your topic.

Acknowledgements

Use this space to thank those who helped you. It is optional, but nice.

Explanation of grading of performance	*Inadequate: Performance not acceptable (F)*	*Below average: Performance not up to minimum standards but shows marginal grasp of concepts (D)*	*Average to above average: Performance met all minimum standards (C)*	*Good to very good: Performance representative of good to noteworthy achievement (B).*	*Particularly strong to exemplary: Performance demonstrates that this team moved beyond expectations and came up with original ideas that provided unique insight (A).*
Introduction	Intro is not present, is incoherent, or is unrelated to experiment.	Intro disorganized, or lacks reference to relevant primary literature, or missing purpose/hypothesis.	Background info too broad or too narrow, or weak/missing purpose or hypothesis, or lacks sophistication and/or may contain fallacies of logic.	The intro smoothly pulls reader into topic. It is well organized, flows from general to specific, and makes clear the purpose of experiment.	Intro is uniquely well written and is crafted in such a way (e.g., relevant examples from 1° lit) as to educate the poster audience in a noteworthy and effective way.
Appropriate use of primary literature; including Literature Cited section	No 1° literature cited or it was plagiarized and/or citations missing or inadequate.	Attempts at paraphrasing border on plagiarism, or cited literature seems random and/or irrelevant to topic, and/or literature cited section inadequate and improperly formatted.	Use of reference literature perfunctory without clear context, and/or attribution inappropriate or misplaced, and/or literature cited section is inadequate.	Background information used in context (esp. in intro and discussion). Citations are appropriate and correctly located within text, with literature cited in appropriate format.	Creative and effective use of 1° literature, which is cited appropriately. Paraphrasing of other works represents noteworthy grasp of referenced articles applied to poster's context.
Methods	Methods absent or blatantly inaccurate.	Reader would have a tough time knowing what happened in the experiment and/or the methods was a list of materials and steps (style of H.S. lab report)	Methods gave general view of experiment but were incomplete or imprecise (e.g., only described single team's work rather than combined work across all sections)	Clearly states how experiment was conducted, and how data were collected and analyzed.	Methods are sophisticated, clear, and concise, giving particularly good insight (perhaps with visual aids) into how the study was performed and how the data were analyzed.
Results	No results, no figures, or what is present is grossly inaccurate.	Results are misleading or un-interpretable for reader due to mistakes or omissions (e.g., no figure captions).	Graphs/tables don't conform to minimum standards (e.g., contain raw data), or captions are incomplete, axes are misleading, or supporting text is inaccurate.	Figures & tables provide useful information for discussion. Captions are complete and accurate (include N, p-value, etc.), and supporting text is informative.	Results demonstrate effort beyond the norm, e.g., evidence that authors worked extra hard to create visually appealing, clear, and concise figures and supporting text.

This work was supported with funding from NSF (DUE grant 0836851). For additional information about the above document, please contact Ellen Goldey (goldeyes@wofford.edu).

Biological Inquiry Research Poster Grading Rubric.

Discussion	Discussion is not present, is incoherent, or is unrelated to experiment.	Discussion makes little attempt to address the purpose of the experiment or relate results to prior work and/or misuse of terms suggests ignorance of key concepts.	Discussion attempts to address the purpose of the experiment and relate results to other works, but misuse of scientific terms and/or *lack of coherence with other sections* confuses reader.	Authors do an adequate job of relating their findings to the hypothesis/purpose and situating their findings relative to background literature.	Communicates original synthesis of evidence in a way that is complex and free of logical fallacies. Future study recommendations are *specific* and reasonably follow from this study. Findings are discussed (i.e., so what?) in broader context.
Overall unity of poster across sections	Sections vary widely in quality and accuracy, resulting in a confusing hodgepodge.	Poster lacks unity and coherence (sections appear to have been developed separately then thrown together).	Acceptable coherence across some sections, but some sections (hint: often the intro and discussion) still lack any relationship to each other.	Demonstrates generally coherent and unified writing across sections providing a unified whole.	Sections are well integrated and interdependent (e.g., topics of intro are resolved in discussion) with smooth transitions. Discussion reflects back on other sections to provide novel, even exciting, insights.
Title, authors, & acknowledgements	Missing	Any part missing or misleading.	All present, but title is not descriptive of experiment.	All present, title is descriptive and accurate.	All present, title is descriptive yet brief (perhaps even creative).
Sentence structure, grammar, punctuation, spelling	Sentence structure seriously flawed, and/or numerous grammar and punctuation problems, and/or many spelling errors.	Several problems with sentence structure, spelling, grammar and punctuation make poster unprofessional.	Errors in grammar, punctuation, and/or spelling detract from quality. Vocabulary immature or misused. Text would benefit from additional editing!	A few errors in grammar, punctuation, or spelling do not detract too much from overall poster quality. Sentence structure is generally good, but may still contain waste words.	Poster is free of errors in grammar, punctuation, or spelling, and sentences are well structured. Poster demonstrates authors' careful editing. Vocabulary is notably sophisticated.
Creativity	Poster is visually unappealing; use of template not apparent, and/or extraneous clutter completely distracts from the poster's purpose.	Poster fails to meet minimal standards. Sections incomplete or obviously unbalanced in length and layout.	Poster meets minimal requirements (e.g., template used), but problems exist (e.g., overcrowding or reducing text size to squeeze in words) makes it less appealing.	Authors have followed guidelines and added visual interest while preserving white space.	Authors have added creative (e.g., images, humor) touches that enhance their poster's effectiveness <u>without distracting</u> from the poster's purpose. Be careful here!

This work was supported with funding from NSF (DUE grant 0836851). For additional information about the above document, please contact Ellen Goldey (goldeyes@wofford.edu).

Ovipositioning of *Callosobruchus maculatus* is Unaffected by Natal Experience and Antennal Ablation

Karl Cochran, Lauren Heaton, Kayla Johnson, and Nick Napier
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Introduction

Insects lay their eggs selectively in order to increase the survival rate of their offspring (Ward et al. 1999). Possible stimuli that serve as markers for this ovipositioning behavior include the natal host experience, attractant or deterrent odors, and the topography of the oviposition sites. For example, *Culex* mosquitoes will lay their eggs in skatole water (normally a deterrent) if they were reared in that odor (McCall et al. 2001). Sambaraju et al. (2008) found that when wheat extract (an attractive odor) is added to non-host sites Indianmeal moths, *Plodia interpunctella,* will lay their eggs on these sites. Additionally, deterrent odors have been linked to toxic seed coats and therefore reduce ovipositing frequency (Souza et al. 2011). Finally, yellow dung flies utilize topography by laying their eggs on hills rather than on points or in depressions to avoid desiccation or drowning, respectively (Ward et al. 1999). We tested to see which of these factors influenced the ovipositioning of *Callosobruchus maculatus*. We predicted that bean beetles would lay their eggs on their natal hosts and that they would use their antennae to detect attractive and deterrent odors innately present in each bean to determine which bean species to lay their eggs on.

Methods

We conducted two choice experiments to test ovipositioning of the bean beetle *C. maculatus* (See Figure 1). Both studies were analyzed through the use of Chi Squared Statistical Analysis.

Figure 1. Female bean beetle laying eggs on a bean
http://www.beanbeetles.org

In the first choice experiment thirty-six mung and thirty-six adzuki beans were placed into each petri dish. One female bean beetle was added to each dish. In 44 of the dishes, this was a beetle raised on adzuki beans and in 42 of the dishes this was a beetle raised on mung beans. Forty-eight hours later the beetles were removed and we counted the number of beans with at least one egg.

Figure 2. Three out of four bean types used (mung, adzuki, and black-eyed pea, respectively)
http://www.beanbeetles.org

For the second experiment, female bean beetles received one of three treatments. After exposing the beetles to Fly Nap for one minute, we used microsurgical scissors to cut off the whole antennae of 201 beetles, half of the each antennae of 224 beetles, and performed a sham operation on 196 beetles.

We filled the bottom of each petri dish with eleven of each type of bean (mung bean, adzuki bean, black bean, and black-eyed pea, see figure 2), and then added one female bean beetle from each treatment group. As in the first experiment, forty-eight hours later the beetles were removed and we counted the number of eggs on each bean type.

Results

Natal bean host had no effect on oviposition site (results not shown); therefore, we pooled the data from the two treatment groups (Figure 3).

In the second experiment, there was no effect of antennal treatment on oviposition (results not shown), so we used only the sham-operated group in order to test bean preference (Figure 4).

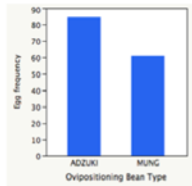

Figure 3. Frequency of eggs laid on bean types by female bean beetles. N=291 beetles. Beetles laid significantly more eggs on adzuki beans (P<0.01)

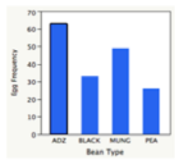

Figure 4. Frequency of eggs laid on beans by mung-reared bean beetles. N=196 beetles. Beetles laid significantly more eggs on adzuki beans (P<0.001).

Discussion

Contrary to our prediction, preference of natal oviposition sites was not shown by *C. maculatus. C. maculatus* preferred the adzuki bean for ovipositioning regardless of which bean it was reared on. Therefore, other explanations must be considered. One possibility is that the beetles prefer to lay their eggs on larger beans. The works of Samaraju et al. and Messina et al. support this possibility because moths chose larger-sized beads, and beetles chose larger beans, respectively (Sambaraju et al. 2008, Messina et al. 2003). However, host size alone cannot fully explain our results, as the larger black-eyed pea was not favored by the beetles. Souza et al. (2011) found that toxic compounds in the seed coat deterred beetles from laying their eggs. This suggests that the adzuki bean may have a less toxic seed coat or the coats of the black bean and black-eyed pea may be more toxic than the others. To test this we could apply the procedures of Souza et al. (2011) and test the toxicity of the coats of seeds used in our experiment. Further investigation into the effects of odors on ovipositioning also seem to be required. Magali et al. found that more odorous tomatoes elicited increased egg-laying from *Tuta absoluta*, which, when applied to our results, suggests that the adzuki bean had a more attractive odor (Magali et al. 2011). We could test the effects of such an attractive odor using the procedures of Sambaraju et al. (2008). Also, while antennae did not appear to have any effect on ovipositing in our experiment, Mbata (1994) and Parr (1998) suggest that both the antennae and the palps play roles in chemical signal recognition. Thus the roles of olfaction could be further tested by repeating our ablation experiment with both the antennae and the palps.

If we were able to discover why the beetles choose to lay their eggs on some hosts and not others, this information could be used along with genetic engineering to protect crops from this pest.

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