Tested Studies for Laboratory Teaching
Proceedings of the Association for Biology Laboratory Education
Volume 40, Article 53, 2019

A Hard Day's Write: Teaching Writing in the Lab with a Minimum of Pain and Suffering

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Washington College, a small liberal arts college of approximately 1400 students, has designated introductory biology as a course that can fulfill part of our undergraduate writing requirement. To fulfill this responsibility, we have incorporated changes in assignments, grading, and small lab activities that have resulted in better quality writing. This article reviews the facets of our current program to support students in their writing before, during, and after the writing process. These approaches can be used separately or together to improve student writing quality.

Keywords: writing, peer review, revision

Introduction

Teaching writing to undergraduate lab students is a perennial challenge and takes time and effort. Nevertheless, there are ways to maximize the time and effort that students spend on writing, and to use instructor time and effort efficiently.

In 2016, the BIO112 second semester course for majors was designated a writing intensive course by Washington College. This designation means that students may take either English composition or BIO112 and satisfy the W2 writing requirement for graduation. To support this designation, I redesigned portions of both BIO112 and its prerequisite, the first semester introductory course, BIO111. This paper details the changes in our curriculum that have resulted in stronger student writers.

Before Writing: Prepare Students to Write Well

Giving students strong support before the writing process begins is important, not only because it sets expectations, but also because it demonstrates to the students that the instructor and the discipline value the writing process.

Provide a Detailed Rubric

Students enter introductory biology courses with a wide range of previous experience in scientific reading and writing. At my institution, as at many others, this experience is often minimal. Therefore, students need a detailed summary of what is expected in a scientific paper. Our students are provided with a rubric for each assignment; the specific assignment rubrics are built from a generic rubric used in the entire introductory course sequence (Appendix A). We use this generic rubric to build a common vocabulary and so that students understand that the expectations for different writing assignments are similar to one another.

If writing is what you value, then writing must be part of the student's grade. In the rubric, we include a section that specifically evaluates writing. This inclusion conveys to the students that writing is important to us and should be important to them.

Provide Model(s)

Some students will struggle with applying a rubric to their own writing; a model is a helpful tool to add to their toolbox. Both good and bad models are provided in our required writing handbook for the course (Knisely 2017). In addition, we provide a model report in the student lab manual. This model was modified from a student lab report for a lab exercise that is no longer conducted at our school; the model also features annotations that supply metacommentary on the function of each part of the model (Appendix B). The first semester that I used this model, I found that several student papers echoed the model very closely. As imitation of models is the first step in learning how to write, I view students' imitation as evidence that the model is helpful.

Teach Mini-Lessons on Writing Principles

If students are not coming into our courses with knowledge of scientific or general writing principles, it is our responsibility to teach them. There are several helpful videos on YouTube that provide short, targeted lessons on writing—the Grammar Squirrel videos from the University of British Columbia are my personal favorites. Often, lab instructors will show one of these short videos before conducting a peer review session, and ask students to focus on that particular principle in their peer review. Another way to use mini-lessons is after an assignment has been turned in; if the instructor notices a weakness in student submissions, it can be addressed with a short 5-10 minute lesson during lab.

Provide Time for Drafting

Drafting is an essential part of the writing process. If students are not required to write and turn in drafts, the draft that is turned in is often the first one. Therefore, if you want students to draft their work, you need to provide more time for them to complete multiple drafts of assignments. One way of doing this is to do more inquiry-based labs, where students are introduced to a system in one week, design their own experiment with that system, and then perform their experiment the following week. A sample calendar for our schedule is as follows:

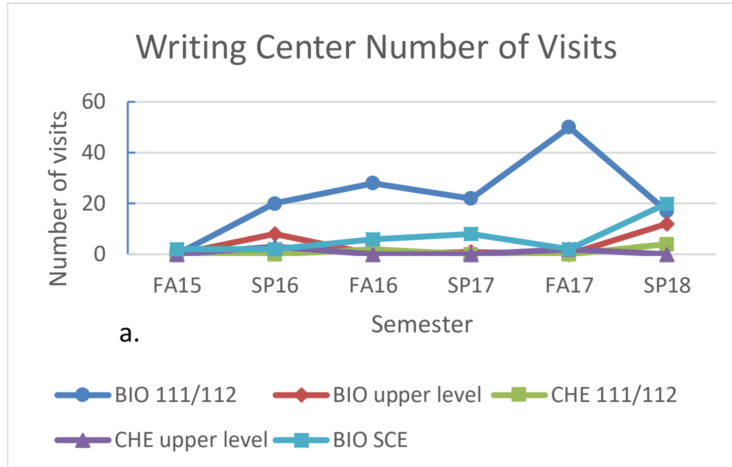
Week 1: Learn System A, design an experiment.
Week 2: Perform the experiment on System A.
Week 3: Rough draft due about System A; Learn System B.
Week 4: Final draft due about System A; Perform the experiment on System B.
Week 5: Rough draft due about System B; Learn System C.
Week 6: Final draft due about System B; Perform the experiment on System C.

This every-other-week schedule gives us time for drafting and feedback on the assignments. To save further time, we do not have students write full lab reports on every experiment. See the section titled "Build up skills and sections of a report slowly" for more details on this approach.

Partner with the Writing Center

Ideally, there are already tutors in your campus Writing Center who are biology majors or who have taken the course. If this is the case, simply having these students visit the lab sections to introduce themselves can have a powerful impact. The tutors can also share their availability and show students how to book appointments, which is especially helpful for first-year students who may not have used the Writing Center. We try to schedule these visits about a week before the first major writing assignment is due.

Beginning in Spring 2016, we had writing tutors who had taken the course visit our lab section. The numbers of students and visits to the Writing Center by biology students increased, both compared to previous years and compared to chemistry students and upper level biology courses during the same years (Figure 1). The introductory chemistry courses did not have writing tutors visiting their lab sections.



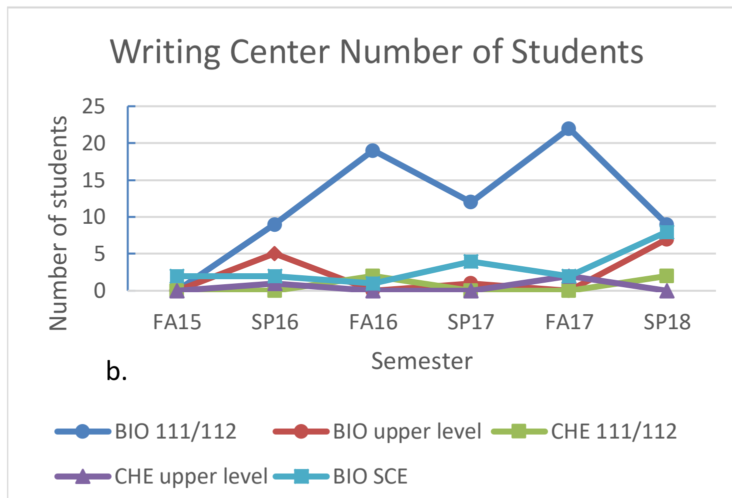


Figure 1. a. Total number of visits to the Writing Center after tutors began visiting introductory biology lab sections (BIO111/112).
b. Total number of students visiting the Writing Center in the same time period.
Writing Center tutor visits to BIO lab sections began in Spring 2016; CHE = Chemistry; SCE = Senior Capstone Experience

If there are no tutors who have taken the course in the Writing Center, find out how to get some! At the end of each year, when our Writing Center asks for recommendations for students, our lab instructors submit names of strong student writers in their sections. This practice ensures that we always have a few tutors in the pipeline to help with future lab sections.

Another simple way to partner with your Writing Center is to make sure that the tutors know the expectations for writing in your course. We provide our Writing Center with copies of the rubric(s), lab manual, and writing handbook. These resources are kept in the Writing Center, available for reference when students come for their appointments.

During Writing: Provide Effective Feedback

Teaching writing requires practice with feedback. Our goal with the feedback we provide is to be efficient and effective, both with our time and the students' time.

Perform Structured Peer Review

Peer review is a time-honored technique for improving writing. However, if students simply trade papers and review them with no structure or guidance, neither party gains much. Our peer reviews are conducted during lab and usually take 15-30 minutes depending on the length of the assignment. We have the students peer review each other's work before it is seen by the instructor, and then students have a few days to fix up their draft. In our experience, the peer review step improves even the first drafts that the instructors see. In addition, peer review can catch low-level issues such as missing sections, so that the instructor can focus on higher-order concerns.

We provide our students with a peer review handout that includes the rubric for the assignment and space for comments. The students are reassured that the score they give their partner will not be part of their partner's grade. The handout also includes questions that guide the student reviewer to compliment what is good about the paper, what else could be added, and what should be prioritized for the next revision. Sometimes, the students are also directed to review their partner's paper with reference to a specific mini lesson on writing that has just been conducted in lab.

The peer review handout is collected and graded for completion; the instructor makes a copy or has students take a picture of the peer review handout so that the writer also has a copy of the feedback given.

The instructor should support the peer review by walking around the room and encouraging conversations between partners, especially after the review sheet is finished. In my experience, questions often come up about the rubric at this stage, and I can then address common issues with groups or with the entire class.

Provide Feedback Almost Exclusively on Rough Drafts

Feedback is most effective when it is given at a time when students are receptive. Students rarely view or incorporate feedback from final drafts of papers; they are often only concerned with the grade. Therefore, we spend most of our efforts to provide personalized feedback during the rough draft stage of a paper.

We encourage our students to view us as a coach during this stage—our job is to identify and help them to correct the biggest problems in their papers, not to pre-grade or to fix every problem. The instructors are encouraged to set a time limit and spend approximately the same amount of time on each paper. Our responsibility here is not to make every paper an "A" paper, but to help each student improve his or her paper to the next level. If a weak student sees red over his entire paper, he may be overwhelmed and quit. Instead, we focus on identifying the most pressing issues, and then when those are solved, focus on the next most pressing. Sports coaching is an apt analogy here: a pro tennis coach does not spend an hour with her weakest player listing all of the ways he is not a pro. She identifies his biggest weaknesses and works with him on improving them, and repeats the process.

When the final draft is turned in, instructors simply complete the rubric and publish the final grade. Very little additional commentary is added. Of course, if students would like additional feedback on a final draft, they can request an appointment with the instructor. This rarely happens, so the overall result is that we spend more time making targeted feedback when students are receptive, and less time grading final drafts of papers.

Refer to Resources for Reteaching in Your Comments

If the comments on students' papers consist of correcting their errors or rewriting for them, students will simply copy and paste the fixed text and learn very little from the exercise. Instead, we can point out the problem and point them to resources that can help them fix the problem themselves. Sample comments that I have given on student reports include:

- Check the rubric—you are missing several elements in this section.
- Explain trophic levels (See chapter 54 in your text).
- This is not correct APA format. See https://owl.english/purdue.edu/owl/resource/560/01
- You have lots of minor grammar errors like this throughout. Read aloud or have a friend who is good with this type of thing go over your paper.

These comments have the double benefit of fixing current problems and pointing students to resources that may help them resolve similar problems in the future.

Respond from a Reader's Point of View

Ideally, students would be asking as they write, "How would a reader see this? Is what I'm trying to say clear?" To get this voice into our students' heads, responding as if we are readers may help. Using "I" and "you" statements can also help personalize comments. Sample comments that I have given include:

- I'm not sure what this bracket means. Can you explain it in the figure legend?
- Can you make the arrows larger? They are hard to see.
- Can you condense this paragraph and summarize more? There's too much detail for your intended audience.

Phrasing comments in the form of a question also helps comments sound less dictatorial. Notice also that comments don't always have to tell students exactly how to accomplish a goal—just identify the goal and leave the mechanics to the student.

A Spoonful of Sugar Helps the Medicine Go Down

People are more receptive to feedback when it is delivered with a positive tone. We try to compliment students on parts of their paper that are well written. Not only does positivity make students more receptive to feedback, but also specific comments such as "Nice informative title!" pinpoint *why* the work is good.

However, simply praising without being specific is counterproductive. A vague "good job" gives students no information as to what they did well or how they can replicate their performance for the next time.

Save Time on Comments

If your feedback is given electronically, you can save a lot of time by keeping a list of comments as you make them and pasting them into documents. With careful phrasing, you can make comments that will be useable on many papers. An example is: "See lab manual pp. 22-23 and Knisely pp. 55-56 on what level of detail is appropriate in the Materials and Methods." These lists can even be shared between instructors as a Google Doc or other shared document.

After Writing: Follow Through and Build Skills Slowly

Building strong writers takes time and effort. Remember that students will not be perfect writers when they come in, and will not be perfect writers when they leave your course. Your course is one step in the students' journey to becoming an adult writer.

Follow Through on Feedback

Ensuring that your students actually view and respond to feedback can be challenging. One way to do this is to incorporate a category into your rubric that gives students credit for using and incorporating revision suggestions.

In addition to the rubric, I use a temporary zero to incentivize responding to feedback. When students first turn in their final draft, I pull up the rough draft alongside it. By quickly scanning, I can pinpoint students who made no changes from their rough draft. Those students receive a temporary zero on the final draft and a note that explains, "This 0 is temporary—you need to go back to your draft and revise based on my comments. You have a 5% penalty which will increase each day until resubmission." The zero commands the students' attention—on early assignments, some students don't even realize that they have received electronic feedback! The zero stays in the gradebook until I grade the resubmitted draft. If the draft is never resubmitted, then the assignment stays as a zero. This is a powerful incentive for students to respond to feedback.

Build Skills and Sections of a Report Slowly

We spend the entire first semester focusing on each section of a lab report and spending part of our lab time discussing what should be in each section. Then students write a draft of that section (plus the Results section, which they write every time). Then, they revise and polish their draft. The students have practiced every section at least once before they are asked to write a full lab report toward the end of the first semester. The shorter, more focused assignments have the additional benefit that they can be graded more quickly.

During the second semester, we have students writing three full lab reports, but adding skills of literature use and research. We build these skills by first paraphrasing sentences from research that is provided, then finding and citing their own articles. Students also work on specific stylistic and structural writing skills, to improve the style of their writing.

Conclusion

We must not be too hard on ourselves when teaching writing—it is a time-consuming, difficult process for both us and our students, even if we use these techniques effectively. We must keep in mind that our courses are just a part of teaching our students how to write, and they will not leave our courses as perfect writers. However, if they leave our courses as stronger writers than they started, we will have done our part in their education.

Cited References

Knisely K. 2017. A student handbook for writing in biology. Fifth edition. Sinauer Associates, Inc., Sunderland, Massachusetts.

Acknowledgments

Thank you to Dr. John Boyd for the Writing Center use data. Thanks to all my BIO111 and 112 instructors and students, who have tested these approaches and provided me with valuable and honest feedback, and thanks to the participants in ABLE 2018 in Columbus, OH who did the same.

About the Author

Suzanne Thuecks received her B.A. in Interdisciplinary Science: Biology/Chemistry and French from Lawrence University and her Master of Arts in Teaching from the University of Iowa. After 11 years teaching science in grades 8-12, she became an Instructor and Lab Coordinator for the introductory sequence for majors at Washington College in 2015. She was the recipient of an ABLE Charlie Drewes grant in 2015. Her interests include the teaching of science writing and college-level teacher training and mentoring.

Appendix A
Scientific Paper Rubric- BIO 111/112

Note: This rubric is meant to be used as separate parts, depending on which sections are the focus of the particular lab. Not all categories would be used with all labs. Some categories could be duplicated (for example, if there are multiple figures or tables).

Title					
Title uses the format "The effect of (independent variable) on (dependent variable) in (scientific name of organism including strain or subspecies or other identifying info)"	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Abstract					
Hypothesis, prediction, and reasoning are clearly stated and separate from each other	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Methods are 2-3 sentences, but detailed enough to get a strong sense of the experiment	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Results are briefly summarized including ratios or percentages to back up statements	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Conclusion states a plausible and factually correct biological explanation for the results	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Abstract is 200-250 words and word count is included			2-Completely	1-Partially	0- Not at all
Introduction					
Includes brief overview of biology concepts from Campbell textbook and/or lab manual to provide context for experiment; Campbell textbook and/or lab manual is cited.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Explains why the organism(s) used in the experiment were chosen and appropriate for the context	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Information from primary sources is paraphrased, not plagiarized, and shows student understanding of the Results/Discussion section of the source material	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all

Required number of primary literature sources was used	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Hypothesis stated (general relationship that is being explored)	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Experiment-specific prediction and reasoning stated; reasoning makes sense and is biologically correct	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
1 sentence summary of techniques or methods used including mention of specialized equipment	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Intro is structured like an upside-down triangle; information flows from general to specific	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Materials and Methods					
Completely written in past tense and in the student's own words; lab manual is cited appropriately	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Describes procedures in sufficient detail that they could be replicated, including statistical methods and any specialized tools used	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Results					
Contains a paragraph of text that compares results using percentages, includes standard deviation, but does not explain why the results happened. Figures are referred to in the text like this (Figure 1).	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Table title is "The effect of (independent variable) on (dependent variable) in (organism)"; includes a table number and number of replicates; title above the table	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Data analysis table properly formatted, units identified, columns labeled, data matches collection table	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Figure properly formatted, no gridlines, axes present and labeled, appropriate data, standard deviation(s) and p-value(s) indicated	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all

Figure legend-Title "The effect of (independent variable) on (dependent variable) in (organism)"; has number of replicates and figure number; legend below figure	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Figure legend-methods are 1-2 sentences and descriptive of how data were obtained	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Figure legend- Important trends are identified			2-Completely	1-partially	0-Not at all
Discussion					
Each result is explained fully and separately in comparison to control(s) and each other. Figures are referred to in the text like this (Figure 1).			2-Completely	1-partially	0-Not at all
Explanation of results is based on correct biological principles and reasoning	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Research is compared to the required number of published articles; results from the article(s) are compared and contrasted with the current experiment	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Experimental weaknesses are discussed in 1-2 sentences and solutions are suggested.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Author concludes by suggesting applications or implications of this research (why should we care?)	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Discussion structured like a triangle; information flows from specific to general	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Literature Cited					
The required number of references are used and they use proper APA format.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
In-text citations used in the correct context and properly formatted (APA name-year)	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Writing					
Style is appropriate to a scientific paper-formal tone, careful and correct use of terminology	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Typos, misspellings, grammar and usage errors minimized	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all

Sentences and paragraphs flow well and help the reader to follow the paper.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Effectively used and incorporated revision suggestions in the final draft.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Overall, this work is at a sufficiently high level for an introductory biology class.	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all
Appendix					
Data collection table easy to read and interpret, units identified, averages present	4-Completely	3-Mostly	2-Somewhat	1-Very little	0-Not at all

Appendix B
Annotated Sample Lab Report

Title is the same format as table/figure titles, but note capitalization. Note italicized genus/species names and capitalized genus name.

The Effect of Increased Humidity on the Transpiration Rate in *Pelargonium hortorum* Leaves

Abstract

Introduce the general topic with 1-2 sentences.

State hypothesis and prediction clearly.

Briefly summarize the methods.

Briefly summarize the results.

Explain why the reader should be interested.

Transpiration is an essential process in plants that allows for the uptake and distribution of water throughout xylem tissues, and is highly dependent on humidity. In this experiment, the hypothesis tested was that as humidity increases, the transpiration rate should decrease. We predicted that a 40% increase in humidity would result in a 40% (that is, linear) decrease in transpiration. We made this prediction because evaporation is a linear process and slows down as humidity increases. In this experiment, we increased the environmental humidity around geranium (*Pelargonium hortorum*) leaves from 45% to 85% by enclosing the leaf. We measured the transpiration rate for 13 minutes with an air pressure sensor. The average pressure change per minute was calculated and the measurements were adjusted for leaf surface area. We found that the transpiration rate per square centimeter at the higher humidity was 38.68% lower than that of the control. Therefore, our experiment demonstrates that the rate of transpiration decreases as humidity increases, a result which was expected due to the difficulty of evaporation at higher humidity levels. This result is important because transpiration rate can affect plant growth rate; farmers and gardeners would do well to consider average relative humidity levels when planting crops.

Word count: 203 words

Word count included. 200-250 words is recommended.

Introduction

First paragraph provides background information

Introduces general topic

Explains how the general mechanism works, cites the textbook

Explains why the process is important, cites the lab manual

Explains why the organism was used

Transpiration is an essential process in plants that allows for the uptake and distribution of water throughout the plant's tissues. Transpiration occurs when water evaporates through stomata, or small openings in the leaf (Reece et al., 2014). When water is lost, the pressure inside the xylem becomes negative; this negative pressure is then balanced by the flow of water up the plant. Because of water's ability to stick to itself, known as cohesion, and water's ability to stick to its surroundings, or adhesion, water is able to move from the roots, through the xylem, and up to the stomata to replace any water loss (Reece et al., 2014). Transpiration is a process that continues throughout a plant's lifetime in order to maintain the distribution of water and balance any negative pressure created through evaporation (Ford et al., 2016). *Pelargonium hortorum* was chosen for this experiment due to its low cost and because its petiole was the proper size to fit in the tubing apparatus.

Second paragraph describes the experiment at hand

Narrows the focus to the specific variable tested

Reasoning for prediction

States the hypothesis and specific prediction

Briefly summarize methods and special equipment

The purpose for performing this experiment is to determine the effect of increased humidity on the transpiration rate in Pelargonium hortorum leaves. An increase in humidity will result in a smaller pressure gradient, therefore decreasing the transpiration rate. We predicted that the rate of transpiration would be 20% lower than the baseline if the humidity was raised by 20% in the surrounding environment. This prediction was tested by using a pressure sensor to measure the change in pressure of a leaf over a period of 13 minutes.

Materials and Methods

Describe the organism used and how the experiment was set up (you can use a picture here)

Explain why certain steps are necessary

First, a leaf was removed from a *Pelargonium hortorum* plant, including the petiole. Next, a gas pressure sensor was mounted on a ring stand and set up by filling a ¼" diameter plastic tube with distilled water so that there were no air bubbles present. After the tube was placed in a clamp on the stand and connected to the sensor with one end, the geranium leaf's petiole was cut underwater at a 45-degree angle with a razor blade and gently placed directly into the open end of the tube while not crushing the cells (Verville et al., 2017). Cutting the stem underwater is necessary to ensure a constant flow of water through the tube to the leaf and out of the stomata. If the leaf was not cut underwater, the ends of the xylem would have been filled with air and the pressure collected by the sensor would have been incorrect (Verville et al., 2017).

Explain what materials were used and any measurements of experimental conditions

The pressure in the leaf was recorded over time for approximately 13 minutes. When the time had passed, we then took a plastic bag and sprayed the inside with water to simulate a humid environment and placed the bag over the top of the leaf and sealed it. The humidity level was recorded inside and outside of the bag using a Kestrel humidity sensor. The humidity level was 85.4% inside the bag, and 45% outside the bag. The pressure was once again recorded over 13 minutes.

Describe any calculations done with the data (including statistics if you did them)

In order to be able to compare the two trials, the mass of the leaf was used to determine surface area. First the leaf was weighed. Next, the leaf was cut into a 4 cm by 4 cm square and that piece was then weighed. The mass of the square section was divided by 16 to determine the mass of 1 cm^2. The total mass was the divided by the mass of 1 cm^2 and multiplied by 2 to get the surface area. The adjusted transpiration rate was calculated by dividing the slope by the surface area (Verville et al., 2017).

Cite the lab manual for any procedures you did not invent yourself.

Results

Paragraph summarizing the results goes before any tables or figures.

Describe the general trend(s) visible in the figure and refer to the figure in parentheses.

There was less pressure inside the xylem in the humid conditions than there was under normal conditions (Figure 1). Overall, the transpiration rate per square centimeter with increased humidity was 38.68% lower than the transpiration rate per square centimeter in normal humidity.

Use percentages to compare experimental and control.

Note: To calculate percent change, use the following formula:

$$\frac{\text{Experimental} - \text{Control}}{\text{Control}} \times 100$$

If the result is negative, it means that the experimental condition decreased compared to the control.

Title above the table. The table has a number and a title in the format: "The effect of (independent variable) on (dependent variable) in (species name or system)."

(N=1 per condition) tells the reader that only 1 trial was conducted for control and experimental conditions.

Table 1. The effect of increased humidity on the transpiration rate in *Pelargonium hortorum* leaves (N=1 per condition).

Test	Slope (kPa/min)	Surface Area (cm^2)	Rate/area (kPa/min/cm^2)
Increased Humidity	-0.01539	220.16	-0.0000699
Control	-0.0251	220.16	-0.000114
Difference			0.0000441
% Difference			38.68421053

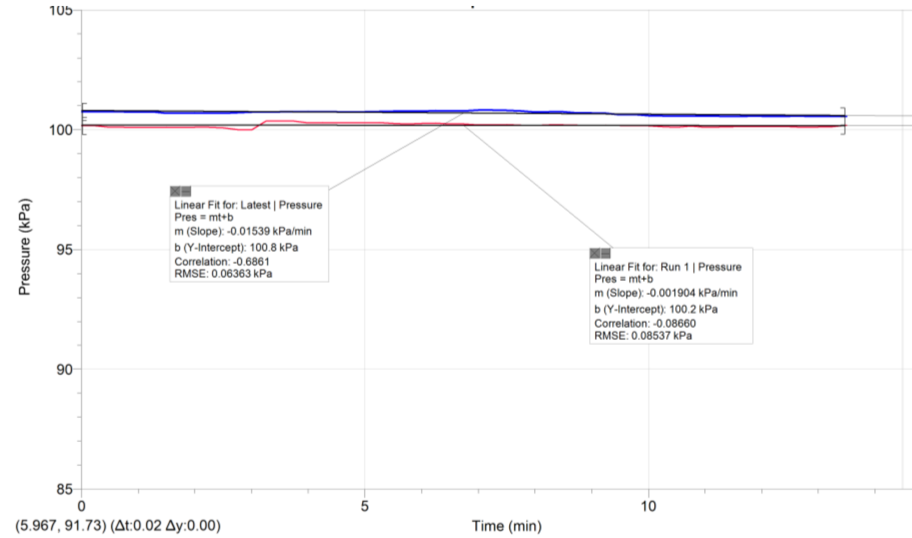
Independent variables in the first column, dependent variables in the columns following

3 horizontal lines: top, under titles, bottom

Titles and information are centered in each column

No vertical lines

Note: This graph was not generated by Excel.



Axes labeled with units

Title in same format as a table: number, “The effect of…”, N=?

Figure 1. The effect of increased humidity on the transpiration rate in *Pelargonium hortorum* leaves (N=1 per condition). The transpiration rate in *Pelargonium hortorum* was recorded using a gas pressor sensor for 13 minutes. Then the leaf was covered in a plastic bag sprayed with water on the inside to simulate increased humidity and the pressure was measured for an equal amount of time. Compared to the control, the leaf in the more humid environment showed a less negative slope, which translates to a slower rate of transpiration.

1-2 sentences describing the methods

Final sentence describes the trend, but does not explain why

Discussion

Compare results to predictions

Quick summary of results and refer to figure

Explain results with known scientific principles.

We observed that as the humidity around the leaf increased, the rate of transpiration decreased exponentially compared to the control condition (Figure 1). Stomata typically close when there is a danger of losing too much water. When there is an increase in humidity, the water concentration in the air is increased. As a result, the plant would not lose as much water to the surrounding environment. The stomata would remain open because less water is being lost. Our results confirm existing hypotheses about humidity and transpiration, and our prediction of a 40% decrease in transpiration for a 40% increase in humidity was relatively close to the result.

Briefly describe experimental weaknesses and describe how to fix them and/or how they could have changed your results

Some equipment difficulties could have contributed to the reliability of our data. The gas pressure sensors occasionally gave erratic readings. Using a different sensor or multiple gas sensors would help to reduce this source of error. Additionally, when I weighed the leaf to determine the mass and surface area, I did not cut off the petiole. As a result, the calculated surface area was too high since the stomata are only found on the leaf.

End by widening the scope—where should research go from here, why do we care about this research?

The effects of humidity on transpiration should be further studied, including larger sample sizes, different plants, and different environments. This research topic is important because the plant's reaction to the humidity of its environment can have a direct effect on how well the plant keeps it water balance and thus on its growth rate. Farmers and gardeners alike must understand the effects of humidity on the plants they are trying to grow so that they can choose the appropriate plants for the growing environment and adapt to changes in climate.

APA format

Literature Cited

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Citing This Article

Thuecks SE. 2019. A Hard Day's Write: Teaching writing in the lab with a minimum of pain and suffering. Article 53 In: McMahon K, editor. Tested studies for laboratory teaching. Volume 40. Proceedings of the 40th Conference of the Association for Biology Laboratory Education (ABLE). **http://www.ableweb.org/volumes/vol-40/?art=53**