

“What Happened to Alice Newfield?” An Investigative Case Study to Engage Non-science Majors’ Interest in Diversity of Life and the Nature of Science

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This exercise is designed to engage the interest of non-science majors in introductory level general biology lab. Student learning teams are presented with a crime scene scenario and evidence; the scenario and ‘evidence’ used should be locally relevant. Each team analyzes samples, identifies organisms present to the extent of their knowledge and keys available, proposes a hypothesis regarding the crime committed and presents their work to the class for review. Each team must support their hypothesis by presenting the data collected, indicating inferences made from it and why. The lab instructor then leads a discussion reinforcing “the nature of science.”

Keywords: crime scene, dichotomous key, evidence, hypothesis, inference, “nature of science”

Introduction

This laboratory exercise is designed to engage the interest of non-science majors in an introductory level general biology lab. Our freshman non-science major’s biology course is designed to increase students’ general biology literacy and their understanding of science as a way of knowing and understanding the natural world. Students in the laboratory course are divided into permanent groups of five or six to facilitate cooperative learning through collaborative work and discussion. The primary objective of this exercise is a creative approach to reviewing material the students have covered in the three previous laboratory sessions while showing the relevance and interconnectedness of the information. The secondary objective is to introduce students to general plant morphology and identification.

Students will have completed three previous lab exercises introducing them to “the nature of science” and the diversity of life on a microscopic level. Although, this is used as a review, it can be used to introduce the diversity of life and require three two hour lab periods for students to learn to identify the organisms. Lab opens with students taking a 10 minute pre-lab quiz over required reading material and previous lab exercises. This quiz is taken and scored as individuals.

Following the quiz, the lab instructor uses a brief, 10 minute, PowerPoint to set the “crime scene(s)” for the lab exercise and indicates where students can find their evidence specimens. I have prepared a PowerPoint presentation using locally *staged* crime scene photos and willingly share it. Alternatively, the “story” can be held back until after the stu-

dents have examined the evidence and are ready to propose and refine their hypothesis. The scenario should be adapted to the school’s location, using local flora and water specimens whenever possible. The intended outcome (where *was* Alice Newfield drowned) can be altered each semester by adjusting the contents of the evidence envelopes and sample jars. Additionally, lab instructors must remind students about proper aseptic technique and avoiding cross contamination of the evidence (see Appendix B).

The learning teams are given at least *one hour* to examine the evidence and prepare a *brief* report. They will most likely need to divide and conquer the work. The teams are asked to analyze the evidence samples, identify the organisms, or pieces of organisms, present to the extent of their knowledge and the keys made available in lab and online resources (see Appendix D), propose a hypothesis regarding how the crime was committed, and alter their hypothesis as new evidence is revealed. The 2011 ABL conference attendees suggested parceling out the evidence. With this approach, no group has all of the evidence; they must depend on collaborating with other groups to alter and refine their hypotheses. We tried this approach this semester in labs and it has worked very well.

When they have finished examining the evidence, some of our teams prepare “posters” with markers and brown paper that we provide while some of our teams prepare presentations using the board and yet others put together a quick PowerPoint and use the computer/data projector system. Each team is given roughly 5-10 minutes to present their

data and hypothesis to the class. This will be their team grade for the week (see Appendix C for grading rubric). During the presentation, the lab instructor looks for comprehensiveness (did they examine or consider all of the evidence, did they correctly identify domain and kingdom along with phylum and scientific and/or common name of the material in evidence, did everyone in the group participate, and did they correctly identify the location of death). Even though the lab instructors know where the 'death' occurred, according to the 'evidence,' they are encouraged to NOT reveal that bit of information

to the class. This is done to emphasize the tentative nature of science. How do we know we have the definitive answer in a scientific investigation? Don't we simply look for the best possible explanation of the data and information we have collected? The lab instructor concludes by leading a class discussion to reinforce the key concepts in "the nature of science" such as data vs. inference, what makes a "good" hypothesis, and the powerful yet tentative nature of science because it is self-correcting as new evidence is revealed.

Student Outline

Laboratory Objectives:

1. This lab exercise will give you the opportunity to apply your knowledge of the characteristics of Eubacteria, protozoans, fungi, plant cells and animal cells while evaluating unknown samples.
2. This lab exercise will give you the opportunity to practice formulating a hypothesis using the information and data that you have collected and to possibly amend that hypothesis as new information is revealed through your investigation.
3. This lab exercise will give you the opportunity to review the distinction between data and inferences.

What Happened to Alice Newfield?

At 10:00 the morning of Tuesday, 1 June 2010, Ted Newfield called the Huntsville Police Department to report that his wife, Alice, left for a run through Huntsville State Park the previous evening and had not yet returned. Police officers went to the Newfield home in rural Walker County (near the state park) to assess the situation. Upon arrival at the home, officers noted the grounds to be in need of repair and maintenance including the swimming pool full of stagnant water and algae. The disheveled and anxious Ted Newfield stated that his wife had left around 7:00 p.m. to go for her usual nightly run. Ted indicated that he had been out fishing since 4:00 a.m. the previous day and was very tired so he went to bed early and didn't notice until he awoke this morning that Alice had not returned home.

2:00 p.m., Tuesday, 1 June 2010: Huntsville P.D. receives word that a woman's body has been found in a low lying grassy clearing near the trail in Huntsville State Park. The body is collected by the Medical Examiner and taken to the morgue for identification. Crime Scene technicians collect samples from the low lying grassy area and the standing water that had been left there by a rainstorm a couple of days before the body was found.

The woman's body is identified to be that of Alice Newfield. Autopsy results show that Ms. Newfield died around 9:00 p.m. on 31 May 2010. Although there was evidence of blunt force trauma to the head, the official cause of death (C.O.D.) was drowning. Samples of the fluid in her lungs and foreign material in her head wound were taken. Because of the circumstances of her death, crime scene technicians were sent to the Newfield's home to collect samples from the pool and surrounding area.

Your group is an investigative laboratory team that has been assigned to evaluate some of the microscopic evidence in the case. Your team will receive samples from the scene where the body was found, the Newfield home site, and from the body itself. The team will attempt to identify any protozoa, fungi and plant matter in the samples and make comparisons. To accomplish your identification of the samples, you will need to observe the examples presented in lab and the course lab manual or any keys available in lab. Complete the following Forensic Lab Report for the case (#HPD-123). Your team will prepare an analysis of the evidence to present to the investigating officers (your classmates) for review and discussion. Please keep in mind the distinction(s) between data and inferences

Forensic Lab Report Case #HPD-123

Sample 1: Water

Collected by: Robert Knisely
 Collection Date & Time: 1 June 2010 at 2:30 p.m.
 Location: Low Lying Area near Trail, Huntsville State Park

Drawings and Identification of Microbes present in sample prepared as a wet mount stained with Methylene Blue and viewed with the CX-21 Microscope:

Drawings and Identification of Microbes present in sample stained with Crystal Violet and viewed with the CX-21 Microscope:

Sample 2: Grass

Collected by: Robert Knisely
 Collection Date & Time: 1 June 2010 at 2:30 p.m.
 Location: Low Lying Area near Trail, Huntsville State Park

Drawings and Identification of sample:

Sample 3: Water

Collected by: Robert Knisely
Collection Date & Time: 3 June 2010 at 8:00 a.m.
Location: Swimming Pool at Newfield Residence

Drawings and Identification of Microbes present in sample prepared as a wet mount stained with Methylene Blue and viewed with the CX-21 Microscope:

Drawings and Identification of Microbes present in sample stained with Crystal Violet and viewed with the CX-21 Microscope:

Sample 4: Grass

Collected by: Robert Knisely
Collection Date & Time: 3 June 2010 at 8:00 a.m.
Location: Lawn adjacent to swimming pool at Newfield residence

Drawings and Identification of sample:

Sample 5: Partially Submerged Splintered Tree Branch

Collected by: Robert Knisely
Collection Date & Time: 3 June 2010 at 8:00 a.m.
Location: Edge of swimming pool at Newfield residence

Drawings and Identification of sample prepared as a wet mount and viewed with the CX-21 Microscope:

Sample 6: Fluid from Alice Newfield

Collected by: Dr. Elwood Sorenson
Collection Date & Time: 2 June 2010 at 6:30 a.m.
Location: Lungs

Drawings and Identification of Microbes present in sample prepared as a wet mount stained with Methylene Blue and viewed with the CX-21 Microscope:

Drawings and Identification of Microbes present in sample stained with Crystal Violet and viewed with the CX-21 Microscope:

Sample 7: Grass from Alice Newfield

Collected by: Dr. Elwood Sorenson
Collection Date & Time: 2 June 2010 at 6:30 a.m.
Location: Wound on left temporal area of head.

Drawings and Identification of sample:

Sample 8: Splinters and Leaves from Alice Newfield

Collected by: Dr. Elwood Sorenson
Collection Date & Time: 2 June 2010 at 6:30 a.m.
Location: Wound on left temporal area of head.

Drawings and Identification of sample prepared as a wet mount and viewed with the CX-21 Microscope:

Reflection and Review

Inferences drawn from analysis of evidence in Case #HPD-123:

Use your notes to briefly define the following terms:

1. Fact
2. Hypothesis
3. Law
4. Theory

Additional Questions for Reflection and Review:

1. What is the difference between evidence (data) and inference?
2. What makes a "good" hypothesis?
3. Does the evidence/data examined today support your hypothesis 100%?
4. Is there any other possible hypothesis that can be explained by the evidence/data?
5. What additional evidence/data would either support, or not, your hypothesis?
6. How did collaboration with other research groups impact (or not) your hypothesis? Is collaboration valuable?
7. Did your personal biases and experiences influence the selection of a most likely hypothesis?
8. What is the effect of limited data?
9. How do collaboration, biases, and limited data (or knowledge) relate to the tentativeness of scientific explanations?

Team Report for "What Happened to Alice Newfield?"

Team Members Present: _____

1. What is your hypothesis regarding the location of Alice Newfield's drowning? (1 pt.)
2. What data exists to support your hypothesis? (7 pts.)
3. Was there any data that did not support your hypothesis? If so, what was it and how might it be explained? (1 pt.)

Sample drawings and identifications are worth 2 points each.

Materials

Equipment, supplies needed for a class of 25 students:

- 25 Compound, Bright-field Microscopes with 4-5X, 10X and 40-45X objectives,
- Lens paper,
- One box of clean microscope slides,
- One box of coverslips,
- Paper towels

Per group of 5 Students:

- Staining tray with a couple of clothespins
- Wash bottle of D.I. water
- Sterile swabs for transferring sample 6 to slides
- Disposal beaker with bleach water for swabs
- Disposable latex or non-latex exam gloves
- Four Plastic droppers (for use with samples 1 & 3)
- Permanent Marker
- Guides or Keys to *local* flora, protozoan and fungi
- Small Flip Top Dropper Bottles of crystal violet, methylene blue, Detain or Proto-slo, D.I. water
- Evidence Samples (*collect to reflect local flora, fauna*):

Evidence Envelopes:

- Sample 2, grass/leaves from body dump site
- Sample 4, grass/leaves from Newfield residence
- Sample 5, splinters from log
- Sample 7, grass from Alice Newfield's body
- Sample 8, splinters/leaves from Alice Newfield's head

Evidence Jars:

- Sample 1, water from low lying area where body was dumped. This can be collected from a natural site, or prepared in lab using Carolina's Pond Mystery Mix.
- Sample 3, water from swimming pool at Newfield residence. This can be prepared by using tap water mixed with a mixed algal culture.
- Sample 6, "fluid" from Alice Newfield's lungs (this can be prepared by using new toothbrush and sterile saline to obtain epithelial cells etc. from a HEALTHY individual – however it is still essential to remind students about aseptic technique when handling ANY body fluids – additional microorganisms may be added to reflect where the victim was drowned).

Notes for the Instructor

The estimated time required to prep this lab is roughly 2-4 hours depending upon the location of collection sites and the number of evidence sets to be constructed. Liquid evidence must be inspected/replaced between lab sections to insure quality. Staging the crime scene photos and preparing the PowerPoint can initially require an additional 2-4 hours. Choose a site familiar to most of your students and use a will-

ing victim/subject to help you stage the photos. Red cake decorator's frosting in the tube is a good stand in for dried and/or caked-on blood in photos.

It is important to monitor the quality (lack of cross contamination by students) of the evidence each morning and/or between lab sections throughout the day, replacing any contaminated specimens with fresh ones. We run approximately 27 lab periods of 25-30 students each four day lab week, Monday through Thursday; so, someone is bound to get careless and cross contaminate the samples.

The most important safety issue to consider is student handling of "Alice Newfield's lung fluid." This is prepared by using a new toothbrush and sterile saline to obtain buccal epithelial cells etc. from a HEALTHY individual. It is still essential to remind students about aseptic technique when handling ANY body fluids and to insist that students wear gloves and properly dispose of any droppers or slides used while examining the "lung fluid." If you do not have access to a biohazard/autoclave bag, a disposal container of water and bleach can be used.

Acknowledgements

I would like to acknowledge and thank the following: Victoria Ann Rose for posing as Alice Newfield's corpse while the minnows nibbled at her fingers and for helping me collect samples, Karen McMahon for sharing a murder mystery story with me at the 2008 ABLE conference and giving me the inspiration for this exercise, 2011 ABLE conference participants who provided valuable feedback, Sam Houston State University's Contemporary Biology Lab Instructors who continue to provide valuable feedback, Dr. Matthew Rowe who contributed portions of the PowerPoint presentation and moral support, and Rick and Thomas Rose for their moral support and patience.

About the Author

Lori Ann (Henderson) Rose received her Bachelor of Science degree from Fort Hays State University in 1985 and her Master of Science degree from Wichita State University (WSU) in 1988. Her thesis research involved genetic characterization of the pathogenic yeast, *Candida albicans*. After an additional two years at WSU as a research associate, she began work as the freshman biology laboratory coordinator at Sam Houston State University (SHSU). During her 21 years at SHSU, Ms. Rose has written four and contributed to or edited an additional five custom lab manuals for Sam Houston State University. She currently coordinates the labs for Introductory Botany, Introductory Zoology, Introductory Environmental Science, Contemporary Biology, and Foundations of Science. Ms. Rose's current research interest is pedagogical approaches to enhance critical thinking skills and fundamental science literacy.

Appendix A: Special Supplies

The following items can be ordered from Carolina Biological Supply Company (www.carolina.com):

1. #212122 Chain of Custody Evidence Envelopes
2. #212120 Crime Scene Evidence Markers
3. #212118 Crime Scene Tape
4. #212141 Evidence ID Labels
5. #212131 Crime Scene Template
6. #212132 Human Figure Template
7. #715740 Wheaton Redi Pak Clear, Straight-Sided Jars with caps, 60 ml
8. #132010A Pond Mystery Mix
9. #151216 Algae Survey

Appendix B: Procedure for Handling Human Body Fluids

Procedure for Examining Human Body Fluids:

1. The one team member handling the "lung fluid" should don a pair of gloves.
2. Label two microscope slides "LF" or "Lung Fluid."
3. Using a clean (unused) plastic dropper/pipette, transfer a drop of "lung fluid" to each of the two microscope slides.
4. Add a drop of methylene blue to one of the slide specimens and place a cover-slip over it. Observe it with the microscope and record your findings.
5. The remaining slide should be allowed to air dry while the wet mount is being examined.
6. Stain the air-dried slide by placing a drop of crystal violet on it and allowing it to sit for 1 minute before rinsing with water. Blot it dry and observe it with the microscope; record your findings.
7. Dispose of both slides, gloves, and the dropper in the red biohazard container.

Appendix C: Grading Rubric For Team Presentation

Grading Rubric for Team Presentation

Team Members Participating: _____

1. Team clearly stated their hypothesis? (2 pts. possible)
 - 0 pt. for no hypothesis
 - 1 pt. for stating a hypothesis
 - 2 pts. for stating a working hypothesis (a falsifiable, testable hypothesis)
2. Team clearly presented multiple lines of evidence (data) to support their hypothesis and this evidence was consistent with team's report. (4 pts. possible)
 - 0 pts. for no apparent evidence
 - 1 pt. for each line of accurate evidence presented, up to a total of 4 points.
3. Team was able to answer any questions posed by the instructor or classmates. (1 pt. possible)
4. ALL team members listened respectfully to other team presentations and at least occasionally asked valid questions. (3 pts. possible)

Appendix D: Online Resources For Plant Identification

Resources for identifying pond weeds:

- <http://aquaplant.tamu.edu/plant-identification/>
- <http://www.naturalenviro.com/Article.php?ArticleSKU=Aquatic-Weed-Identification>

For help identifying weeds and grasses, go to “Virginia Tech Weed Identification Guide”:

- <http://web2.ento.vt.edu/servlet/wid>

For help identifying trees and shrubs:

- <http://plants.usda.gov/java/profile?symbol=PITA>
- <http://texastreeid.tamu.edu/>
- <http://www.herbarium.unc.edu/seflora/firstviewer.htm>
- <http://129.252.87.104:8080/ClemsonHerbarium/advanced.jsp>
- <http://herbarium.duke.edu/>

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Citing This Article

Rose, L.A. 2012. “What Happened to Alice Newfield?”: An Investigative Case Study to Engage Non-science Majors’ Interest in the Diversity of Life and the Nature of Science. *Tested Studies for Laboratory Teaching*, Volume 33 (K. McMahon, Editor). Proceedings of the 33rd Conference of the Association for Biology Laboratory Education (ABLE), 389 pages. <http://www.ableweb.org/volumes/vol-33/?art=13>

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