| Sagebrush Seed Weight | Instructor Guide  Preparation  [**Learning Goals**](#vzri94yw6acg)  [**Investigation Overview & Materials**](#kix.vsqhfw7q0ofr)  [**Student Thinking & Assessment**](#kix.13q1ai7ktbaa)  Instruction  [**Variation in Sagebrush Seed Weights**](#kix.lvd76icyx6vb)  [**Variation in Sagebrush Seed Weights within Populations**](#kix.34n8av4y5kfx)  References |
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| **Learning Goals**  **Social Practice & Argumentation Focus**   * Making and critiquing claims about seed weights of Big Sagebrush subspecies and the relationship that sampling location has on seed weight * Propose claims to answer a research question * Describe and justify students’ data analysis and data interpretation * Compare, contrast, critique, and revise arguments * Formulating claims about within Sagebrush population variation and its importance * Working within groups initially, but formulating a written/drawn response to make your claim, support it with evidence and a justification individually. * Represent ideas/claims/thinking in multiple ways (through writing, drawing, plotting data)   **Biology Focus**   * Exploring seed weight in sagebrush plants and the effect that sampling location has on seed weight * Explore the ecological importance of Sagebrush in students’ local ecosystem * Investigate what environmental factors may be important in determining seed weight AND investigate what genetic factors (subspecies information) is important in determining seed weight * Introduce the idea of variation within populations and how variation within populations can affect survival * Make inferences about future populations and how variation may affect these populations |

| **Investigation Overview & Materials**  This investigation focuses on students exploring the relationship between Sagebrush seed weight and sampling location. During these two lessons, introductory biology students will learn how to take the data they are presented with about these sampling locations and develop an argument for how different attributes of a sampling location affects the seed weights of Sagebrush populations. This investigation will not only allow students to explore the concept of local adaptation in a locally relevant species, but this module will also give them opportunities to generate an argument. After generating arguments within a group, students can share that argument with their peers, and have the opportunity to critique others’ arguments as well as revise their claim in response to peers’ critique. (Keep in mind that this investigation can be done with smaller and larger lecture courses.)  **Lesson 1: Variation in Sagebrush Seed Weights**  Students are introduced to Big Sagebrush subspecies and the ecosystems they live in. Students learn about three different subspecies and identifying characteristics along with the importance of understanding threats that sagebrush populations face. Students are then introduced to the idea that sagebrush seed weight can influence the plant’s survival for subsequent generations and can be further influenced by environmental factors. This lesson engages students with genetic and environmental data from a variety of sampling locations to try and determine the relationship between the two. Once students have worked with the data, they will develop an argument to answer the guiding question: ***How does sampling location affect variation in seed weights of Big Sagebrush subspecies?***  This then can be shared with the whole class and provide an opportunity to discuss differing answers to a question.  Materials   * Lesson 1 Slide Deck * Student Handout 1: Generate an Argument (Variation in Sagebrush Seed Weights) * Program to collect initial student ideas ([Padlet,](https://padlet.com) [Socrative](https://www.socrative.com), [Google Forms](https://www.google.com/forms/about/), etc.) * Google JamBoard or Poster Boards   **Lesson 2: Variation in Sagebrush Seed Weights within Populations**  Students have now been introduced to Sagebrush and its subspecies, what is happening to Sagebrush locally, and have had the opportunity to explore how sampling location affects seed weight among sagebrush populations. This next lesson will focus students’ attention to how variation occurs within a population. The concept of evolution acting on the variation within populations is the goal for students to grasp. In this lesson, students will be given a scenario and some data, from which they will need to decide which population will survive best and why. They will need to explore variation within these different populations to make sense of which population will survive. Students will initially work in groups again, but will respond to the guiding question/scenario individually (as a homework assignment). They are encouraged to respond by giving their claim, evidence and justification both through words and drawings.  Materials   * Lesson 2 Slide Deck * Student Handout 2: Individual Assignment * Program to collect initial student ideas ([Padlet](https://padlet.com), [Socrative](https://www.socrative.com), [Google Forms](https://www.google.com/forms/about/), etc.) |
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| **Student Thinking & Assessment**  These lessons provide a variety of opportunities for assessment, and make use of diverse types of information. Assessment is an ongoing activity in these lessons, and can be utilized in both a formative and summative assessment format. As defined in *Ambitious Science Teaching*, formative assessments are utilized to “allow students to show what they know” (Windschitl, Thompson, and Braaten, 2018, p.12). Formative assessments can update instructors about student understanding or misconceptions of topics and help them make decisions about future instruction (Beatty and Schweingruber, 2017, p. 28). According to *Ambitious Science Teaching* summative assessments are utilized by instructors to assign grades, whether it be test grades or overall course grades (Windschitl, Thompson, and Braaten, 2018, p. 231). See the below sections for how this module can be utilized for both types of assessments.  **Formative Assessments**  Along with formative assessments being utilized to update instructors about students’ current understanding of topics, it has been shown that engaging in activities such as the ones outlined in this module allow students the opportunity to participate in scientific practices even in large lecture courses (Bierema, Schwarz, and Stoltzfus, 2017). For instance, considering the complexities involved with gene and environmental interactions can be a difficult topic for students, providing fruitful opportunities for class discussions. Additionally, considering this module is intended for introductory biology students, providing them with opportunities to discuss a locally relevant and essential species to the ecosystem they are surrounded by may prove to be beneficial in them appreciating Biology and becoming scientifically literate citizens. Through discussions, you can gain insight into student thinking and determine if aspects of instruction were effective or ineffective and adapt as necessary (Windschitl, Thompson, and Braaten, 2018, p. 231). A crucial part of this activity is a class discussion, which can effectively serve as a formative assessment. While this portion of the class and activity will not be graded (unless for participation points) it still provides the instructor with useful feedback of where students' understanding is at a given point in time. See below for potential discussion questions that can be utilized during a class discussion.  Student Handout 1: Generate an Argument  The purpose of this handout is to guide students through working with data regarding sagebrush seed weights from different sampling locations. Working in groups, students will develop an argument to answer the research question and can be the basis for a class discussion.  **Summative Assessments**  Throughout the duration of the module, students will gain an understanding of important biological concepts. As such, an examination or assignment of some nature may be needed to assign grades to students. One approach is to create an assignment based on the activities the students have already completed, allowing students to be familiar with what they are doing and allowing the instructor to gain insightful evidence regarding the individual understanding of each student. This method is crucial to the teaching approaches described in *Ambitious Science Teaching* and *Seeing Students Learn Science* (Beatty and Schweingruber, 2017, p. 73; Windschitl, Thompson, and Braaten, 2018, p. 231). These approaches inspire instructors to utilize “authentic assessment tasks” or tasks that students could see in the real world as scientists. They require students to work with problems, data, results, and communicate those findings – all critical aspects of working in the scientific field (Windschitl, Thompson, and Braaten, 2018, p. 231). The summative assessment designed for this module is composed of open response questions that allow the instructor to obtain a more accurate description of the student’s foundational understanding (Windschitl, Thompson, and Braaten, 2018, p. 231).  Student Handout 2: Individual Assignment  Throughout the duration of the sagebrush module, you will have opportunities to make student thinking visible. However, in a large lecture course you will likely be unable to converse with each individual student. This assignment provides you with the opportunity to understand individual student thinking through the writing/drawing and development of an argument. See this [link](https://docs.google.com/document/d/1efgptHC1WMEDmW8QoX7YtVz2pK-6AWIqqYIp0zDw7so/edit?usp=sharing) for a rubric to grade this individual assignment. |
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| **Instruction**  Lesson 1: Generate an Argument: Variation in Sagebrush Seed Weights  **Propose ideas** about how seed weight is influenced by environmental and genetic factors in different sampling locations.  PREVIOUS LESSON - This is the first lesson in the module with a new phenomenon to explore: Big Sagebrush seed weight variation. However, previous lessons have focused on the theory of Evolution and Plant Diversity so students should be somewhat familiar with concepts such as evolution, natural selection, and variation.  WHAT WE FIGURE OUT - One particular research area of interest is the seed weight of sagebrush plants and how weight can affect the survival of the seedling and subsequent generations. Research has shown that an increase in seed weight can have a positive influence on the emergence and survival of the plant and subsequent generations (Busso & Perryman, 2005). However, it is unclear how seed weight varies across different subspecies and sampling locations. In this lesson, students explore how different ecological niches can influence the survival and reproduction of different subspecies to answer the guiding question: *How does sampling location affect variation in seed weights of Big Sagebrush subspecies?* Students will explore this phenomenon in their groups and develop an argument that can be displayed on poster boards or Google Jamboards.  NEXT LESSON - Arguments developed in Lesson 1 will be shared in a round robin format. Then we look at just 3 populations of Sagebrush to help understand how variation within populations is important.  Potential Class Discussion Questions(also see Slide Deck 1 for Potential Class Discussion Questions)   * What is the claim that you and your group developed? * How did your group analyze the data and why?   + Is that method free from errors? Why or why not? * Does the evidence support your claim?   + Why did your group decide to use that particular evidence? * Were there other claims your group explored before deciding on your current one? If so, why was that previous claim rejected? * Are there other factors that could be influencing the sagebrush seed weights?   + How do you think weather patterns (both in terms of temperature and precipitation quantity) could influence the sagebrush seed weights?   + Are the coldest places where sagebrush has the heaviest seeds?   + What could be the effect of fires and invasive species play?   + Could there be variation as a result of differing parental plants? * What do you anticipate would be the benefit of heavier seeds? Lighter seeds?   LEARNING OBJECTIVES:   * Propose claims to answer a research question (Social Practice & Argumentation Focus) * Exploring seed weight in sagebrush plants and the effect that sampling location has on seed weight (Biology Focus) * Compare, contrast, critique, and revise arguments; within groups and as a whole class (Social Practice & Argumentation Focus) * Investigate what environmental factors may be important in determining seed weight AND investigate what genetic factors (subspecies information) is important in determining seed weight. (Biology Focus)   TIMELINE: 1 hr 15 minutes |
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| LEARNING PLAN:   1. (20 min) Introduce the current ecological circumstances Sagebrush are being faced with, identifying characteristics of Sagebrush subspecies, refresh students on ideas about Evolution. This will lead into the guiding question (Slide Deck 1: Slides 1-10 ) 2. [(10 min)](#kix.a9vll1j7b9vz) Introduce activity/guiding question: ***How does sampling location affect variation in seed weights of Big Sagebrush subspecies?***  (Slide Deck 1: Slides (11-13) 3. [(40 min](#kix.r0mdiuvjzen3)) Students break into groups and formulate their claim, evidence & reasoning posters (Using Google Jamboard). (During this time, the instructor should try and circulate around the room to listen in on discussions, answer questions, etc.) 4. (5 min) Wrap-Up; Collect answers on a platform that makes ideas visible: (e.g., [Padlet](https://padlet.com), [Socrative](https://www.socrative.com), [Google Forms](https://www.google.com/forms/about/). [Google Jamboard](https://jamboard.google.com)) |
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| **Instruction**  Lesson 2: Variation in Sagebrush Seed Weights within Populations  Using **data and prior knowledge**, reason through why one population will survive over two other Sagebrush populations.  PREVIOUS LESSON - Proposed ideas about how seed weight is influenced by environmental and genetic factors in different sampling locations. Groups developed a claim along with supporting evidence and reasoning.  WHAT WE FIGURE OUT - So far we have explored variation in seed weights among different populations of Big Sagebrush and different subspecies. However, individuals within a population can be quite variable as well. Students are given a scenario where a bird that inhabits the sagebrush steppe ecosystem prefers to eat larger seeds (the sum of 10 seeds is larger than 1.5 mg) as opposed to smaller seeds. When provided with seed weight information for individuals in three different populations, students determine which of these populations would be the most successful at surviving based on the birds’ feeding preferences to answer the guiding question: *What is it about the seed weights in a certain population that will allow them to be more successful in survival?* Students initially explore this phenomenon in groups, but complete an individual write up on their argument as a homework assignment.  LEARNING OBJECTIVES:   * Formulating claims about within Sagebrush population variation and its importance (Social Practice & Argumentation Focus) * Working within groups initially, but formulating a written/drawn response to make your claim, support it with evidence and a justification individually. (Social Practice & Argumentation Focus) * Introduce the idea of variation within populations and how variation within populations can affect survival (Biology Focus) * Represent ideas/claims/thinking in multiple ways (through writing, drawing, plotting data) (Social Practice & Argumentation Focus) * Make inferences about future populations and how variation may affect these populations (Biology Focus)   TIMELINE: 1 hr 15 minutes |
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| LEARNING PLAN:   1. (20 min) Round robin sharing of arguments from the previous guiding question: ***How does sampling location affect variation in seed weights of Big Sagebrush subspecies?*** (Slide Deck 2: Slide 1) 2. **(10 min) Whole class discussion: Finalize thoughts and gather information from students on how their claims may have evolved by talking and seeing what other groups did (Slide Deck 2: Slide 2)** 3. (5 min) Transition from looking at average data for populations to individuals within a population and introduce the individual assignment/guiding question: ***What is it about the seed weights in a certain population that will allow them to be more successful in survival?*** (Slide Deck 2: Slides 3-10) 4. [(30 min](#kix.r0mdiuvjzen3)) Students break into groups to explore the data and begin to formulate their arguments (During this time, the instructor should try and circulate around the room to listen in on discussions, answer questions, etc.) 5. (5 min) Introduce the Vertically Integrated Project course at ISU where students can continue this and related work (Slide Deck 2: Slides 11-12) 6. (5 min) Exit ticket for students to individually think about where they are at in the development of their argument for the individual assignment |
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| POTENTIAL ADAPTATIONS FOR NON-MAJORS, INTRODUCTORY BIOLOGY COURSES:   1. The non-majors introductory biology course this module was enacted in does not have a math prerequisite. In similar courses it might be beneficial to include a little background on math/statistics skills that might benefit students in this module (graphing, averages, standard deviation, distributions, etc). 2. Depending on the content covered before enacting this module, it might be necessary or beneficial for students to cover more detail regarding evolution, particularly descent with modification (for Lesson 1). It may also be necessary or beneficial for students to cover more detail regarding the concept of biological variation and why variation within populations may be a benefit (for Lesson 2). 3. If students are unfamiliar with the claim, evidence, reasoning framework additional instruction/support for students might be beneficial. For instance, reasoning seems to be the most difficult thing for students, so a potential support could be to have an example claim and work on developing the reasoning together as a class and then having groups work on determining the reasoning for their specific claim. 4. Students in the course this module was implemented in tended to spend the majority of their time exploring the data and ran out of time when it came to developing claims and reasoning. Therefore, it might be beneficial to have time reminders for students as they are working with the claim, evidence, reasoning framework. For instance, reminding students that “in 5 minutes your group should have developed a claim and then should start to work on reasoning.” If your schedule allows and your class needs more time with Lesson 1, you could also consider spreading these lessons across 3 days of instruction.   \*\* These are just suggestions, as the instructor you know your students best and feel free to adapt this module as you see fit for your students. |
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| POTENTIAL ADAPTATIONS FOR ADVANCED BIOLOGY COURSES:   1. Could include additional background information on Big Sagebrush subspecies identification. 2. If students are unfamiliar with the claim, evidence, reasoning framework additional instruction/support for students might be useful. For instance, reasoning seems to be the most difficult thing for students, so a potential support could be to have an example claim and work on developing the reasoning together as a class and then having groups work on determining the reasoning for their specific claim. 3. Students in the course this module was enacted in tended to spend the majority of their time exploring the data and ran out of time when it came to developing claims and reasoning. Therefore, it might be beneficial to have time reminders for students as they are working with the claim, evidence, reasoning framework. For instance, reminding students that “in 5 minutes your group should have developed a claim and then should start to work on reasoning.” If your schedule allows and your class needs more time with Lesson 1, you could also consider spreading these lessons across 3 days of instruction. 4. Could include requirements for students that they analyze the evidence using some type of mathematical or statistical analysis. 5. Could include more discussion on how the data was collected and potential sources of error throughout the data collection and data analysis processes. 6. The homework assignment following Lesson 2, could include a component where students have to conduct a brief literature search and cite sources to support their claim, evidence, and reasoning.   \*\* These are just suggestions, as the instructor you know your students best and feel free to adapt this module as you see fit for your students. |
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| **Suggestions for Absent Students**   1. If there are students who were absent for the first lesson but intend to make it to the next class session, it may be necessary to reach out to them with the materials they missed (Slide decks and Student Handout 1) and ask them to come to class with their Claim, Evidence & Reasoning for the first guiding question. This way they can still have time to revise and keep working on their CER within a group, they may even bring a new perspective to this group that they hadn’t previously thought of. This will also allow them to participate in the round robin discussion and not be completely lost. 2. If students are absent for the second lesson, they still should be able to complete the individual assignment. 3. Depending on your course format and community, you could also consider a makeup “Reflection Paper” assignment, where you would ask the student to respond to the Round Robin discussion and/or the whole lesson 1 group assignment– similar to the individual assignment for Lesson 2. (This is really dependent on what you hope students that were absent still gain from this module). |
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| **References**  Beatty, A., Schweingruber, H. (2017). *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom.* Washington , DC: The National Academies Press. doi:10.17226/23548.  Bierema, A., Schwarz, C., & Stoltzfus, J. (2017). Engaging Undergraduate Biology Students in Scientific Modeling: Analysis of Group Interactions, Sense-Making, and Justification. *CBE - Life Sciences Education, 16*(68), 1-16.  Busso, C. A., & Perryman, B. L. (2005). Seed weight variation of Wyoming sagebrush in Northern Nevada. *Biocell,* 29(3), 279-285.  Crispo, E. (2008). Modifying effects of phenotypic plasticity on interactions among natural selection, adaptation and gene flow. *Journal of evolutionary biology*, *21*(6), 1460-1469.  Richardson, B. A., H. G. Ortiz, S. L. Carlson, D. M. Jaeger, and N. L. Shaw. 2015. Genetic and environmental effects on seed weight in subspecies of big sagebrush: applications for restoration. Ecosphere 6(10):201. http://dx.doi.org/ 10.1890/ES15-00249.1  Dailey, Rocky. “What to Do about Those Absent Students.” *Faculty Focus | Higher Ed Teaching & Learning*, 9 Oct. 2015, https://www.facultyfocus.com/articles/teaching-and-learning/what-to-do-about-those-absent-students/.  Schlaepfer, D. R., Lauenroth, W. K., & Bradford, J. B. (2014). Natural regeneration processes in big sagebrush (Artemisia tridentata). *Rangeland Ecology & Management*, *67*(4), 344-357.  Windschitl, M., Thompson, J., & Braaten, M. (2018). *Ambitious Science Teaching.* Cambridge, MA: Harvard Education Press. |
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