

**Lesson 3: How Can Lady Beetles’ Response to Temperature Change Be Tested?**

| **Unit: Adaptation and Evolution: Response to Climate Change in Ladybugs** | **Essential Question: How do different populations of lady beetles vary in response to temperature change?** | **Duration: Wet lab requires two 1-hour class periods; Data Nugget only requires one 1-hour class period** |
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| **Foundational Concept for this Lesson:**A useful, quantifiable trait in lady beetles (also known as ladybugs or ladybird beetles) and their relatives is their natural ability to enter Chill Coma. (Students learned about this trait in Lesson 2.) Chill coma is a reversible total paralysis; emergence from chill coma can be timed. This measurable parameter is known as **Chill Coma Recovery Time (CCRT).** The effect of different variables on CCRT can be tested. |
| **Performance Expectation(s):** HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.  |
| **Learning Targets (Students will be able to…):** * Plan & carry out investigations
* Use mathematics and computational thinking
* Analyze and interpret data
* Engage in argument from evidence
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| **Student Evidence:** * Completed lab reports (wet labs), *and/or*
* Completed Data Nuggets (dry lab)
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| **Materials:** See each scaffolding option for activity-specific materials. |
| **Scaffolding Options:**1. **Medium scaffolding (Wet lab: guided inquiry option):** Students place beetles in chill coma and measure their recovery time; population data is compared to data provided from other populations.
2. **Low scaffolding (Wet lab: stand-alone, open inquiry option, or this may be used as an extension to medium scaffolding):** Students use the background knowledge developed in Lessons 1 and 2 to conduct the experiments they designed at the end of Lesson 2.
3. **High scaffolding (Dry lab: data analysis option; may be used if wet lab is not feasible, or as an extension to low or medium scaffolding):** Students complete the “Beetle, It’s Cold Outside!” Data Nuggets, Parts 1 and 2.
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| **MEDIUM SCAFFOLDING OPTION: Guided inquiry - Measuring CCRT variation in beetles kept on ice for 24 hours** |
| Engage: In Lesson 2, students suggested possible experiments to test lady beetles’ responses to temperature change. Honor all ideas, but explain to students that they will be participating in the research done by Dr. Caroline Williams’ lab, which explores the variation in beetles’ responses to cold.*Necessary resources:*1. [*TEACHER GUIDE, DAY 1: Preparation and Day 1, Beetle Lab*](https://docs.google.com/document/d/1lXI29XmgfBY6OaTfNSudHz9uAZJgUkau/edit?usp=sharing&ouid=111015151090405190057&rtpof=true&sd=true)
2. [*TEACHER GUIDE, DAY 2: Procedures for Measuring CCRT*](https://docs.google.com/document/d/15HSI33IrXIg8cVcGlHPhe7QIUnK1-Q8D0eAe_Hnf1dQ/edit?usp=sharing)
3. [*Student Handout 1: Determining CCRT Variability in Different Lady Beetle Populations*](https://docs.google.com/document/d/1hVRuYpWlp34eWzLyvVqXeg7LgF8ny_24KNhBZHmEOUo/edit?usp=sharing)
4. [*Supplemental Lesson/Student Handout: Mean, Standard Deviation, and Standard Error*](https://docs.google.com/document/d/1cj5R8OLap0qLak8-vcLb4o1K-o2BEjaGf8zc34GrZJA/edit?usp=sharing)
5. [*Sample Lab Report Template*](https://docs.google.com/document/d/1am-gFC2U6W7A4kgq29vS9O7gKsqp9GCB/edit?usp=sharing&ouid=111015151090405190057&rtpof=true&sd=true)

Explain: Pass out the “Determining CCRT Variability in Different Lady Beetle Populations” student handout*.* Have students read the Background Research, make predictions, and record the geographic source of their beetles. Field questions and discuss.Explore: * **Day 1**: students, working in pairs, follow the “Procedure for placing beetles in chill coma” to sequester beetles in tubes and place the tubes in ice for 24 hours.
* **Day 2**: students, working in pairs, follow the “Procedure for timing beetle chill coma recovery” to record CCRT for their beetles.
* Students determine the mean CCRT and SEM for their population of beetles. *The Supplemental Lesson/Student Handout on Mean, Standard Deviation, and Standard Error may be used first, if desired.*

Explain/Evaluate:* Students compare their findings to the CCRT data for different geographic populations provided in the Sample Lab Report Template. *This may be done informally, via class discussion, or more formally as part of a written lab report, which can be summatively evaluated.*
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| **LOW SCAFFOLDING OPTION: Open-ended inquiry/student-designed experiments** |
| *In Lesson 2, students planned experiments to test lady beetles’ responses to temperature change. As a low scaffolding, open-ended inquiry option, the teacher may choose to facilitate students performing some/all of their proposed experiments. Although there are many possible experimental designs, Chill Coma Recovery Time (CCRT) is a useful, quantifiable parameter when conducting these tests. Several useful resources are provided below, if CCRT will be investigated. The following teacher guides explain how to place lady beetles into chill coma, and how to observe and record their chill coma recovery time. Student Handout #1 is useful if students decide to design experiments to test CCRT. A supplemental lesson/handout on basic statistics is provided, for use as appropriate.*Useful resources:1. [*TEACHER GUIDE, DAY 1: Preparation and Day 1, Beetle Lab*](https://docs.google.com/document/d/1lXI29XmgfBY6OaTfNSudHz9uAZJgUkau/edit?usp=sharing&ouid=111015151090405190057&rtpof=true&sd=true)
2. [*TEACHER GUIDE, DAY 2: Procedures for Measuring CCRT*](https://docs.google.com/document/d/15HSI33IrXIg8cVcGlHPhe7QIUnK1-Q8D0eAe_Hnf1dQ/edit?usp=sharing)
3. [*Student Handout 1: Determining CCRT Variability in Different Lady Beetle Populations*](https://docs.google.com/document/d/1hVRuYpWlp34eWzLyvVqXeg7LgF8ny_24KNhBZHmEOUo/edit?usp=sharing)
4. [*Supplemental Lesson/Student Handout: Mean, Standard Deviation, and Standard Error*](https://docs.google.com/document/d/1cj5R8OLap0qLak8-vcLb4o1K-o2BEjaGf8zc34GrZJA/edit?usp=sharing)

Variables that could be tested include (but are not limited to):* Comparison of CCRT in nourished vs. starved lady beetles
* Comparison of CCRT in populations of beetles from different sources
* Mass comparison of “fast” vs. “slow” recovering beetles
* Sex comparison of “fast” vs. “slow” recovering beetles
* Comparison of CCRT in a population that experiences chill coma once, vs. multiple times
* Comparison of climbing speed in beetles that have/have not experienced chill coma
* Comparison of CCRT in beetles who have previously experienced heat shock (CAUTION: beetles die when exposed to temperatures above 45℃!)
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| **HIGH SCAFFOLDING OPTION: Data analysis of CCRT experiments** |
| Engage: In Lesson 2, students suggested possible experiments to test lady beetles’ responses to temperature change. Honor all ideas, but explain to students that they will be analyzing the research done by Dr. Caroline Williams’ lab, which explores the variation in beetles’ responses to cold.Explore/Explain: Students complete [“Beetle, It’s Cold Outside!” Data Nugget](http://datanuggets.org/?s=beetle), http://datanuggets.org/2018/11/beetle-its-cold-outside/Evaluate: Completed Data Nugget is evaluated, using the Grading Rubric provided on the Data Nugget website. |