***Sustainable Invention: An Exploration of Bioplastics***

**Module 3**

***Table of Contents***

1. [Teacher Resources](#bookmark=id.gjdgxs)
2. [Overview of Lesson 1](#bookmark=id.30j0zll): Optimizing Your Formulation
3. [Overview of Lesson 2:](#bookmark=id.1fob9te) Material Testing, Analysis, and Conclusions
4. [Overview of Lesson 3:](#bookmark=id.3znysh7) Testing the Optimized Formula
5. [Overview of Lesson 4](#bookmark=id.2et92p0): CER Development
6. [Lesson 1](#bookmark=id.tyjcwt) Optimizing Your Formulation
	1. [Bell Ringer](#bookmark=id.3dy6vkm)
	2. [Lab: Optimizing Your Formulation](#bookmark=id.1t3h5sf)
	3. [Ticket-Out](#bookmark=id.4d34og8)
7. [Lesson 2](#bookmark=id.2s8eyo1) Material Testing, Analysis, and Conclusions
	1. [Bell Ringer](#bookmark=id.17dp8vu)
	2. [Lab: Material Testing, Analysis, and Conclusions](#bookmark=id.3rdcrjn)
	3. [Ticket-Out](#bookmark=id.26in1rg)
8. [Lesson 3](#bookmark=id.lnxbz9) Testing the Optimized Formula
	1. [Bell Ringer](#bookmark=id.35nkun2)
	2. [Lab: Testing the Optimized Formula](#bookmark=id.1ksv4uv)
	3. [Ticket-Out](#bookmark=id.44sinio)
9. [Lesson 4](#bookmark=id.kjntl3bus59u) CER Development
	1. [Bell Ringer](#bookmark=id.owiuqq5kcg6c)
	2. [Claims, Evidence, Reasoning](#bookmark=id.t2dyyvree1lo)
	3. [Let’s Try a CER Together!](#bookmark=id.a3xvo5cogywi)
	4. [Loop Formulation CER](#bookmark=id.2kh2fcy0ubqw)
	5. [Grading Rubric for a CER](#bookmark=id.xe4ea2sn2q16)
	6. [Ticket-Out](#bookmark=id.ud3x17w6okwj)

***Desired Results***

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| ***Enduring Understanding from Unit****:* * Inventing a new technology involves coming up with an idea, developing that idea with the use of peer feedback, and re-designing based on testing.
* Bioplastics can be used to create novel products and/or better versions of already existing products.

***Essential Question from Unit:**** How can we make a product that is good for people and the environment?
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| **Standards Addressed (Content and** [**ELP**](https://www.oregon.gov/ode/students-and-family/equity/EngLearners/Documents/ELPStandardsGlance.pdf)**)** |
| ***NGSS Science Standards:**** MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.
* MS-ETS1-2: Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem.
* MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
* MS-ETS2-2(MA): Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.

***Science and Engineering Practices:***1. Asking questions and defining problems3. Planning and carrying out investigations6. Constructing explanations and designing solutions 8. Obtaining, evaluating, and communicating information |

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| **Overview** |  |
| **Task overview:** Students will be introduced to the concepts of polymers, pH, acids, bases, pH scale, and crosslinking in a series of thought and reading activities. They will then apply those concepts to a lab activity where they will attempt to create an optimized version of their polymer loops after engaging in an evaluative session of material testing their loops as well as the loops of other members of their class. They will then evaluate their new loops as well as their classmates’ loops and use that to create a CER (claim-evidence-reasoning) about why their loop ended up being created with its specific set of properties. **Language focus** Communicating through verbal and written language by all participants. Small group discussions will also occur. * Written communication of what is pH, acids, and bases.
* Verbal and written evaluation of properties of loops created in a previous class
* Reading about polymers, pH and its associated language, and cross-linking.
* Verbal and written evaluation of properties of loops created during these lessons
* Written reflection of each day as well as hypothesizing what the next day may be like.
* Written evaluation of the lab process and the lab products
* Verbal communication to achieve team-work based tasks.
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| **Learning Targets** | **Formative Assessment** |
| * Content-focused:
	+ Polymers
	+ pH
	+ Acids
	+ Bases
	+ pH scale
	+ crosslinking
* Language-focused:
	+ Written communication
	+ Verbal / written evaluation
	+ Written reflections
	+ Verbal communication
	+ Associating readings with activity language
 | * See provided closures below
* Matching activity
* Compare/Contrast chart with feedback on what each group did to achieve their desired loop properties
* CER on why their loops did/did not have the properties they were seeking to achieve.
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| **Key Content Vocabulary** | **Cross-Disciplinary Vocabulary** |
| * Polymers
* pH
* Acids
* Bases
* pH scale
* Crosslinking
* optimized
 | * Material Testing
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| **Materials or Apps** |
| **Teachers:*** 250-mL beakers, 3 per student group
* Aluminum tray, 1 per student group
* Heat-resistant gloves, 1 pair per student group
* Hot plate, 1 per student group
* Stirring rod, 1 per student group
* Syringes, 1 per student group
* Graduated cylinders, 1 per student group
* Digital scale, 1 per student group
* Wax pencil, 1 per student group
* Protective gloves, 1 pair per student
* Protective goggles, 1 per student
* Wax paper
* Tape
* Additives: white vinegar, baking soda
* Coconut oil
* Sorbitol
* Tapioca starch
* Tracing Loops Sheet
 | **Students:*** pens/pencils
* Lab Safety Rules
* Cellphone Timer or Stopwatch
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| **Lesson Preparation**  |
| \*\*Teacher needs to hold onto results from testing in the previous Meeting in such a way as can be displayed for the class\*\*Options: Google Classroom, butcher paper chart, white board, display board, etc. Instructor needs to pre-print photocopies of worksheets if not a one-to-one school or for students who require hard copies as an accommodation to the curriculum. Instructor also needs to pre-print the loop outlines for each lab group.Instructors may want to have all the lab materials set-out in an organized manner to make it easier for the material manager of each group to both gather the materials and put them away at the end of the lab days. Alternatively, if there are enough materials, groups can keep their materials together in a box at their work station to lessen time spent collecting materials each day. Students should already know how to prepare a Claims-Evidence-Reasoning Statement. If not, the instructor may want to add a day to model and practice with the students using the provided extended learning activity.  |

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| **Estimated Time:** (5) 45-minute class periods with all resources used |
| **Lesson Sequence** |
| **Lesso****n 1: Optimizing Your Formulation** 1. Independent [Bell ringer](#bookmark=id.3dy6vkm) (10 minutes): Reading about the different starches (corn, tapioca. potato and rice) and their impact on various properties of the loops. Students hypothesize the impact of using different starting materials.
2. Whole Group (5 minutes): *We spent the last week testing several different variables for their impact on the flexibility of our loops. If you remember, we also thought that the starting materials might impact the qualities of the loops. Today, we are all going to go back to our original lab procedure so we can test and identify the impact the different starting materials (different starches) have on loop qualities.* Each lab group chooses a different starch to use. Ideally, there will be two groups testing each starch.
3. Small Group (20-25 minutes): The students work their way through the [lab](#bookmark=id.1t3h5sf) with the instructor functioning as the facilitator. Make sure students are following safety protocols (wearing goggles/glasses at all times and gloves as needed). During this time, the instructor functions as facilitator, engaging in frequent check-ins to ensure that everyone is progressing appropriately through the lab work. The instructor is also available to answer questions and assist groups that require more help than others.
	1. Possible check in questions:
		1. What are you noticing?
		2. What step is next? How can you prepare for that step?
		3. Are things going as expected? Can you pivot?
		4. Sometimes questions aren’t needed, you can just watch and collect ideas for group questions at the end.
		5. When students have questions, try to turn the question back to them, encouraging them to refer to their lab or their group mates.
4. Small Group (5-10 minutes): The students clean up the lab activity following the directions posted at the end of the lab, returning materials to designated locations, setting their loops in an out of the way location for setting overnight. Remind groups to label their loops so they know which ones are theirs. Have students complete the [ticket-out](#bookmark=id.4d34og8) when they are cleaned up.

**Lesson** **2: Material Testing, Analysis, and Conclusions**1. Individual or Small Group (5 minutes): answer the [bell ringer](#bookmark=id.17dp8vu) regarding loop disposal.
2. Small Group (10 minutes): Groups repeat their tests for flexibility using the [lab procedures](#bookmark=id.3rdcrjn) from earlier in the week. Have groups that tested the same starch work together and compare their results, discussing any inconsistencies between their findings.
3. Whole Group (5 minutes): Share out results of flexibility testing based on different starting starches.
	1. Have groups notice any other traits that were impacted--surface texture, color, etc.
4. Whole Group/Small Group (10 minutes): Groups will choose their optimized formula regarding each of the following variables (modified worksheet):
	1. Concentration of solution (how much water)
	2. Temperature
	3. Ingredients used (specifically which starch)
	4. pH
		1. For each variable, they will need to explain why they chose it and how they anticipate it impacting the final qualities of their loops.
5. Whole Group (5 minutes): Refer back to the lab from day 3 of Module 2 where the steps impacting each variable were highlighted so groups know which steps they will need to adapt or pay close attention to depending on what variables they will be testing.
6. Small Group (10 minutes): Groups plan and rewrite their lab procedure for testing their adjustments to each variable. \*\*Groups will turn in their lab procedure for the teacher to check over before the next day.\*\* Have students complete the [ticket-out](#bookmark=id.26in1rg) when they have turned in their lab procedures.

**Lesson** **3: Testing the Optimized Formula** 1. Small Group (5-10 minutes): Using the [bell ringer](#bookmark=id.35nkun2), students articulate final adjustments to their procedure and justify how the adjustment is consistent with their original design/client request.
2. Small Group (20-25 minutes): Students do [the lab](#bookmark=id.1ksv4uv) testing their chosen variable. During this time, the instructor functions as facilitator, engaging in frequent check-ins to ensure that everyone is progressing appropriately through the lab work. The instructor is also available to answer questions and assist groups that require help.
3. Small Group (10 minutes): The students clean up the lab activity following the directions posted at the end of the lab, and complete the [ticket-out](#bookmark=id.44sinio).

**Lesson** **4: CER Development (2 days)**1. Individual or Small Group (5 minutes): Complete the [bell ringer](#bookmark=id.owiuqq5kcg6c), a K-W-L-S brainstorm
2. Whole Group (10 minutes): Encourage and facilitate students sharing their individual K-W-L-S entries.
3. Whole Group (5 minutes): If needed, describe what a CER is as a whole class. Use the [provided CER text](#bookmark=id.t2dyyvree1lo) to illustrate.
4. Whole Group/Small Group (20-25 minutes): Complete a CER together. Watch the video *The Life Cycle of a Plastic Bottle*: <https://www.youtube.com/watch?v=_6xlNyWPpB8>. The handout [*Let’s Try a CER Together!*](#bookmark=id.a3xvo5cogywi) provides students example statements. Encourage students to add their own evidence and reasoning statements from the video or other sources. Students then individually or in pairs complete a paragraph using the statements from the group CER table. Use the [Put it All Together!](#bookmark=id.q1b2jncqnmty) template for this. You can prepare a slide for students to type in so that students can provide feedback on peer’s work.
5. Individual or Small Group (20 minutes): Once students are comfortable developing a CER paragraph, they will compose a [CER paragraph](#bookmark=id.2kh2fcy0ubqw) about their loop invention process. They should use all of the information and observations collected since the start of the unit, and should be encouraged to refer to the previous lab activity in which they made loops for the first time. The question is “What is the best formulation for the properties you have tried to produce?”As with the sample *Life Cycle of a Plastic* Bottle example, students will develop this CER in two parts: first using a note catcher or outline of what they will write (the graphic can be provided to students as a slide that they can type into), then to write their CER statement in a paragraph format (Putting it all together!). A [grading rubric for a CER](#bookmark=id.xe4ea2sn2q16) is provided which can also be reviewed with students prior to the completion of their paragraph.
6. Small Group (20 minutes): Students provide feedback on each other’s CERs.
7. [Ticket-Out](#bookmark=id.ud3x17w6okwj) (5 minutes): Students complete the 3-2-1 reflection.
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