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

**Module 2**

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***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-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
* MS-ETS2-2(MA): Given a design task, select appropriate materials based on the specific properties needed in the construction of a solution.

***Science and Engineering Practices:**** 8. Obtaining, evaluating, and communicating information
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| **Overview** |  |
| **Task overview:** Students will engage in the work of green chemists who are tasked with creating a plastic that meets the needs of a specific client. In creating their plastic, they will test different variables to determine their impact on bioplastic characteristics. They will evaluate their plastic and their classmates’ plastics to determine if their client’s needs have been met and to assess whether the use of a bioplastic in this instance is better than the use of a petroleum-based plastic. **Language focus** Communicating through verbal and written language by all participants. Public speaking by some participants. Specific language focus is on:* Listening to and discussing passages that discuss what is an additive, a starch, a plasticizer, an alcohol, and a formulation.
* Written analysis of the use of plastics versus bioplastics.
* Verbal and written evaluation of properties of loops.
* 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 to demonstrate understanding of each lesson.
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| **Learning Targets** | **Formative Assessment** |
| * Content-focused:
	+ bioplastic
	+ Formulation
	+ Starch
	+ Plasticizer
	+ Additive
	+ Chemical change
	+ Physical change
	+ Flexible/Flexibility
	+ Elastic/Elasticity
	+ pH
	+ Acid
	+ Base
	+ Cross-Linking
	+ Polymer
* Language-focused:
	+ Listening to and discussion of passages
	+ Written analysis
	+ Verbal and written evaluations
	+ Content reading
	+ Written reflections
 | * See provided bell ringers and tickets out included
* Matching Activity of content-focused vocabulary
* Sequencing activity for steps of the lab utilizing the content-focused vocabulary
* Claim-Evidence-Reasoning statement about whether the lab will be evidence of a chemical or physical change
* Analysis questions of lab
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| **Key Content Vocabulary** | **Cross-Disciplinary Vocabulary** |
| * bioplastic
* Formulation
* Chemical change
* Physical change
* pH
* Acid
* Base
* Cross-Linking
* Polymer
 | * Starch
* Flexible/Flexibility
* Elastic/Elasticity
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| **Materials or Apps** |
| **Teachers:*** 250-mL beakers, 3 per student group
* Heat-resistant gloves, 1 pair per student group
* Aluminum tray, 1 per group
* Hot plate, 1 per student group
* Stirring rod, 1 per student group
* Syringes, 1 per student group
* Graduated cylinder, 1 per student group
* Wax pencil, 1 per student group
* Wax paper, 1 8x11 sheet per group
* Protective gloves, 1 pair per student
* Protective goggles, 1 per student
* Photocopies of Tracing Loops sheet, 1 per student
* Tapioca starch
* White vinegar
* Sorbitol
* Wax paper
* Tape
 | **Students:*** pens/pencils
* Lab Safety Rules
* Cellphone timer
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| **Lesson Preparation**  |
| Instructor to provide photocopies of worksheets if not a one-to-one school or for students who require hard copies as an accommodation. It is helpful for the instructor to run through the [pre-lab](#bookmark=id.2s8eyo1) and [lab](#bookmark=id.1ci93xb) beforehand so they know about how long the lab takes and where students should be after a given amount of time. This will help them guide students with pacing during class. [Videos of making bioplastics.](https://edpuzzle.com/media/62b9d90afcfe77414a3fd29e) \*\*\*As students collect data, it is important for the instructor to record the class data so it can be used to make adjustments in the next portion of the unit. This might look like a class table on the board or on a poster, snapping photos and uploading to a shared file, or on a shared google doc. \*\*\* Clean all beakers, teaspoons, and stirring rod in a warm, soapy water bath with 30mL of vinegar in it. Some storage considerations for the loops: → The loops will dry out if left out to sit exposed to the air and that may change some of their properties. Students may want to store them in an airtight container to see how that impacts the loop properties. Have students consider (in writing or in discussion) how else could they compensate for this shift if their client needed a longer lasting product. → Remind students they are in the prototyping stage. What would they do with more time? Would shelf-stability be a focus of their next stage of iteration? → It may also be worth exploring the downsides of and design flaws in “compostable” items that actually just are trash because we don’t have facilities to process them.  |

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| **Estimated Time:** (6) 45-minute class periods with all resources used |
| **Lesson Sequence**  |
| **Lesson** **1: Experimenting with Bioplastics**1. Independent/Small Group (5 minutes): Students read the pre-lab and use it to answer the [bell ringer](#bookmark=id.4d34og8) question.
2. Whole Class (5 minutes): Have students share their bell ringer answer with an elbow partner, then have a couple students share out.
3. Whole Class/Small Group: (5 minutes): At this point, students can either choose their own lab groups or the instructor can pre-assign groups.
	1. Have groups establish roles for the day (or the roles can stay the same over the course of the unit).
4. Whole Class (5 minutes): The instructor reviews the lab safety expectations, reviews lab procedure, and confirms understanding of terms.
	1. → *Our main goal for today is two-fold: First off, we want to become familiar with the procedure for making bioplastics that we will be using multiple times as we make our final bioplastic product. Secondly, we are going to focus on observing the characteristics of bioplastics.*
5. Small Group (20-25 minutes): Students do the lab. 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.
	2. \*\*Provide time checks so students can know about how far they should be.

The students clean up the lab activity following the directions posted at the end of the lab. 1. [Ticket-out](#bookmark=id.3rdcrjn) (5 minutes): *Your ticket-out today is a reflection on lab process--parts that require extra paying attention, skills that were challenging, etc. Note specific places you deviated from the directions. This is not shaming, its information gathering so you have all the variables that might be impacting your bioplastic results.*

**Lesson** **2: Testing Flexibility** 1. [Independent](#bookmark=id.lnxbz9) (10 minutes): The students should return to their lab groups and select job roles for the day if they are changing. Together, groups brainstorm how to test for flexibility. Students can use the internet.
	1. Video Resources:
		1. Test for Flexibility: <https://qualityinspection.org/flexibility-plastic-china/>
2. Whole Class (10 minutes): Establish a class method of testing flexibility. Have students add data collection tables to their [Evaluating Bioplastic Loops](#bookmark=id.35nkun2) Handout as applicable.
3. Small Group (15-20 minutes): *You are now going to test your loops, as well as the loops of two other groups. When you compare with another group, if there are differences EITHER between your loops OR in the results of how you each tested the loops, see if you can figure out what is causing the differences. Take notes in the space on your handout. This isn’t a “Our group is right, yours is wrong” scenario. We are exploring what causes the differences in certain characteristics and having all the information available will help us best understand those causes and impacts.*
	1. Test their loops for flexibility + elasticity, record results for their group + two other groups.
4. [Ticket-Out](#bookmark=id.1ksv4uv) (5 min) is a reflection on their data collection. Have students share with an elbow partner and discuss as a class if time allows.

**Lesson** **3: Variation: Causes and Analysis**1. [Whole Class](#bookmark=id.2jxsxqh) (10 minutes): Have all groups share their results and collect all the data for the class. Post the data for all the students to see and have them make two observations about the data on their own. Then have them share an observation with an elbow partner. Have a couple students share out what they notice about the data.
2. Whole Class (15 minutes): *As we look at the data and notice these differences and similarities, what do you think might have caused the variation? This is not “oh you made a mistake and we are going to shame you as a class”--we are human and this is the first time you’ve ever made a bioplastic! The goal of this is to see if there are any specific steps that have a significant impact on the elasticity or flexibility of the loops if not followed correctly. Look at how your group’s data is different from other data--could any of your inconsistencies with the procedure have been the culprit?*
	1. In their lab groups, have students [hypothesize what caused the variations](#bookmark=id.z337ya) based on their reflections from the end of class the day before. Have the documentation specialist from each group share out their hypothesis.
	2. As they share, make a list of variables that seem to impact the bioplastic results:
		1. Concentration of solution (how much water)
		2. Temperature
		3. Ingredients used
		4. pH
		5. Specific errors?
	3. For the above list, what seems to be the impact of each variable?
	4. Provide time for students to record these notes in their worksheet.
3. Whole Class (10 minutes): groups choose a variable to focus on (concentration of solution, temperature or pH). Ideally, there will be two groups testing each variable in each class. We will reserve testing the variable of ingredients further on in the unit.
	1. As a class, discuss how we can alter concentration, temperature and pH.
	2. Ideally, one group will test more/higher of the variable vs the original procedure and one group will test less/lower of the variable vs the original procedure (i.e. one group will add more heat, one will use less heat).
4. [Ticket-Out](#bookmark=id.3j2qqm3) (10 min): Students consider the impact of variables on each other and how to mitigate those impacts.

**Lesson** **4: Redesigning Your Procedure**1. Small Group (20 minutes): In small groups or partners, students [match vocabulary](#bookmark=id.4i7ojhp) using the Variation Between Loops reading.
2. Whole Group (5 minutes): Referring to the reading, the list of variables from the previous day and their impact on flexibility fill out the chart at the bottom of [the handout](#bookmark=id.2xcytpi) as a class.
3. Small Group (5 minutes): Have groups make a hypothesis about how altering their group’s chosen variable will impact the loops’ final characteristics.
4. Whole Group (5 minutes): As a class, go through the [lab procedure](#bookmark=id.1ci93xb). Identify each step where the three variables (temperature, concentration and pH) are involved. Have groups highlight/star the step(s) that apply to the variable they have chosen.
5. Small Group (5 minutes): Groups plan and rewrite their lab procedure for testing their chosen variable. \*\*Groups will turn in their lab procedure for the teacher to check over before the next day.\*\*
6. [Ticket-Out](#bookmark=id.3whwml4) (5 minutes): Students identify the key steps of the procedure they will be modifying and anything they might need to be extra careful with.

**Lesson** **5: Testing Chosen Variable**1. Small Group (5-10 minutes): Students answer the [bell ringer](#bookmark=id.qsh70q) question while the teacher checks in with each group about feedback on their procedures. Groups make final adjustments to their procedure based on teacher feedback.
2. Small Group (20-25 minutes): Students do the lab 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 more help than others. Make sure to check in with groups as the work on the step that specifically applies to the variable they are testing.
	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.
	2. \*\*Provide time checks so students can know about how far they should be.
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.3as4poj).

**Lesson** **6: Optimizing the Formula**1. Small Group/Whole Group (10 minutes): Students answer the [bell ringer](#bookmark=id.49x2ik5) question. They can share with an elbow partner, then share out as a class what their initial observations are of similarities and differences between their modified loops and their original ones.
2. Small Group (10 minutes): Groups repeat their tests for elasticity using the procedures from earlier in the week. Have groups that tested the same variable work together and [compare their results](#bookmark=id.2p2csry), discussing any inconsistencies between their findings.
3. Small Group (5 minutes): have the two same variable lab groups work together to make a recommendation to the class for an optimized formula based on their results.
4. Whole Group (15 minutes): Have each variable group share out their recommendation, including reasons why. Discuss how there might be layers of interactions between the variables and how optimization of one variable might impact the others.
5. [Ticket-Out](#bookmark=id.147n2zr) (5 minutes): Students complete an if/then statement.
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