Traditional plastics are made from petroleum, or crude oil. But did you know that plastic can also be made out of natural materials like plant starch or animal protein? We call these bioplastics and they are made of renewable, biological materials. With this activity, you can try making your own moldable material from milk protein at home.

MATERIALS
- Whole milk
- Vinegar
- Hot plate & small pot (or microwave and microwave safe bowl)
- Measuring cups
- Measuring spoons
- Stir sticks (metal spoon or fork also work fine)
- Fine mesh strainer or cheese cloth
- Paper towels or cloth towel
- Wax paper or plate
- Science notebook
- Something to write with

PROCEDURE
- Heat up 1 cup of milk until it is hot, but not boiling. Get an adult to help with this part of the activity. Observe the milk before you add the vinegar. What do you notice about the milk?
- Add 4 teaspoons of vinegar to the milk. Stir for about a minute. What do you notice happen after you added the vinegar? How does the milk look different?
- Pour the milk through the strainer into the sink (careful, it may be hot!). Left behind in the strainer should be a mass of lumpy blobs.
- Dump the lumpy blobs left in the strainer onto several paper towels or a cloth towel and gently pat them dry. Fold over the edges of the towel and press down to absorb excess moisture.
- Once the blobs are cool enough to handle, hold some in your hands. What does it feel like? What does it remind you of?

Experiment continued on next page...
PROCEUDRE *continued...*

- Squeeze the blobs together. Knead together into a ball, like it is dough.
- Try molding the blobs into whatever shape you want. Place the molded shape on a piece of wax paper or a plate and allow it to dry out over a few days.

TRY THIS

- Look at some items that you use every day. Which ones are made from plastic? Which are made from other reusable materials such as glass or metal? Which are made from biodegradable or compostable materials such as paper, bioplastics, wood, or cloth made from natural fibers?
- Environmental engineers often need to compare properties of different materials and consider the advantages and disadvantages of using one material instead of another. Find two items that have a similar appearance and function, but which are made of different materials (e.g. a fork made out of plastic vs. compostable bioplastic, a fleece jacket vs. a cotton jacket). Make observations about the properties of both items (shape, color, texture, flexibility, durability, temperature/moisture resistance, etc.). Record these observations in your science notebook. Consider the following questions:
  - What are some similar properties between the two items?
  - What are some different properties between the two items?
  - What would the benefits be for using an item made of one material over the other?

WHAT’S HAPPENING?

Through this process, you made something called casein, which occurs when protein in milk interacts with the acid in the vinegar. The casein in milk does not mix with vinegar, so it clumps together to form blobs. True plastics or polymers are made up of different base materials, but they form in a similar fashion. Check out this video from the American Chemical Society to learn more about how chemical engineers are trying to design biodegradable food wraps made from casein! [https://www.acs.org/content/acs/en/pressroom/newsreleases/2016/august/edible-food-packaging-made-from-milk-proteins-video.html](https://www.acs.org/content/acs/en/pressroom/newsreleases/2016/august/edible-food-packaging-made-from-milk-proteins-video.html)

*Experiment continued on next page...*
DID YOU KNOW?

Plastic polymers can easily be molded into different shapes. Most petroleum-based plastics don’t degrade, or break apart, quickly. Some types take up to 1000 years to fully degrade. During the decomposition process, toxins can be released back into the soil making it unsuitable for future use. More than 18 billion pounds of plastic waste enter our oceans each year, harming marine wildlife and ecosystems.

Bioplastics are made from renewable resources of plant or animal origin. Bioplastics produce significantly fewer greenhouse gas emissions than traditional plastics over their lifetime. Some bioplastics are non-toxic and will decompose in a shorter amount of time. Bioplastics are not always biodegradable. The term biodegradable refers to the process by which microorganisms are able to break down a material completely into water, carbon dioxide, and compost.
6–8 GRADE EXPLORATION

Explore the following questions and write your observations in your science notebook.

- Not all chemical reactions are created equal. How does temperature affect the chemical reaction? How does the fat content of the milk (half and half, whole, 2%, skim) affect the yield of casein? Do milk alternatives (soy milk, almond milk, coconut milk) also contain casein? Does the amount of vinegar used make a difference?

- Repeat the experiment. Pick one variable to change. Possible variables include:
  - Changing the temperature
  - Using a different type of milk (or milk alternative)
  - Using more or less vinegar

- Record your observations in the table below, or in your science notebook.

<table>
<thead>
<tr>
<th>Control:</th>
<th>Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· 1 cup whole milk (heated)</td>
<td>· ____________________________</td>
</tr>
<tr>
<td>· 4 teaspoons vinegar</td>
<td>· ____________________________</td>
</tr>
</tbody>
</table>

   Results:                                           Results:

- Which of the two mixtures produced the greater yield, or amount, of casein? What else could you try to increase the yield?