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DATA Nugget

Working to reduce the plastics problem

Featured scientist: Nick Robertson from Northland College
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Research Background:

Nick (right) and one of his students (left) stretching the raw, preformed polymers.

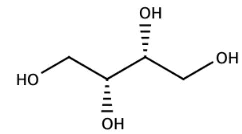
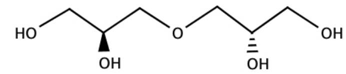
Plastics are materials that can be shaped easily and are used for many functions. This has made them extremely popular across the world. Thousands of products are made using plastic, including parts of cell phones, food wrappers from your lunch, and even the stitches you may need after an injury. In fact, if you look around right now, you can probably spot at least ten items made of plastic!

Once a plastic is made, it tends to stick around. **Synthetic plastics**, made by humans from petroleum, cannot be broken down by nature's decomposers – bacteria and fungi. This means they impact the environment for many, many years. Some types can take *thousands* of years or longer to break down!

Nick is a chemist concerned with the negative impacts caused by plastics. He knows that in order to reduce the amount of synthetic plastics in the environment, we need an alternative. And, this alternative needs to be just as good as the synthetic plastic it is replacing. Nick and his undergraduate students at Northland College are testing new ways to make plastics that are **biodegradable**, meaning they can be decomposed naturally and won't last as long in the environment. His research focuses on stretchy plastics, called **elastomers.** Elastomers are what make up rubber bands, tires, hoses, non-latex gloves, and many more items we use every day.

To try to solve the problem of making a biodegradable elastomer that has all the qualities of a synthetic one, Nick and his students got to work. First, they had to consider the chemical structure of plastics. Plastics are made of **polymers**. "Poly" means "many" and "mer" means "parts". This means that plastics are made of long chain molecules with many repeating parts. These repeating parts are called **monomers**. Different monomers can be used to make different types of plastic.

Nick chose to test two biodegradable monomers – diglycerol and meso-erythritol. Diglycerol is cheap and easy to buy. However, it might be too soft when used on its own. Meso-erythritol is more expensive, but more rigid. They wanted to use diglycerol and meso-erythritol because the chemical structures have the potential to create something that is not too rigid and not too flexible.

Substance	Chemical Structure
Meso-erythritol (ME)	
Diglycerol (D)	

Nick and his students designed an experiment in which they tested elastomers made from each of the monomers (diglycerol and meso-erythritol) alone, as well as elastomers made using both types of monomers. They made elastomers with the following percentage ratios of diglycerol over meso-erythritol: 100/0, 75/25, 50/50, 25/75, 0/100. The team was hoping to find the “sweet spot” between a product that is too stiff, and one that is not stiff enough to be useful in elastic materials. Once they finished making their elastomers, they prepared the stretch tests.

To start a stretch test, the team had to stamp out a piece of material from each elastomer, creating samples with the same size, shape, and thickness. They also cut pieces from rubber bands made of synthetic plastics to compare as a control. Next, they tested the elastomers using a machine that measures how much force is applied (**stress**) as a material is stretched (**strain**), both important measures of elasticity. The stress, or force per unit of area, is measured in megapascals (MPa) while the strain, or amount of stretch, is measured as a percent of the original length.

The sample on the right is made from 100% diglycerol and the left from 100% meso-erythritol.

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Scientific Question: What ratio of diglycerol and meso-erythritol results in a biodegradable elastomer that has similar properties to a rubber band?

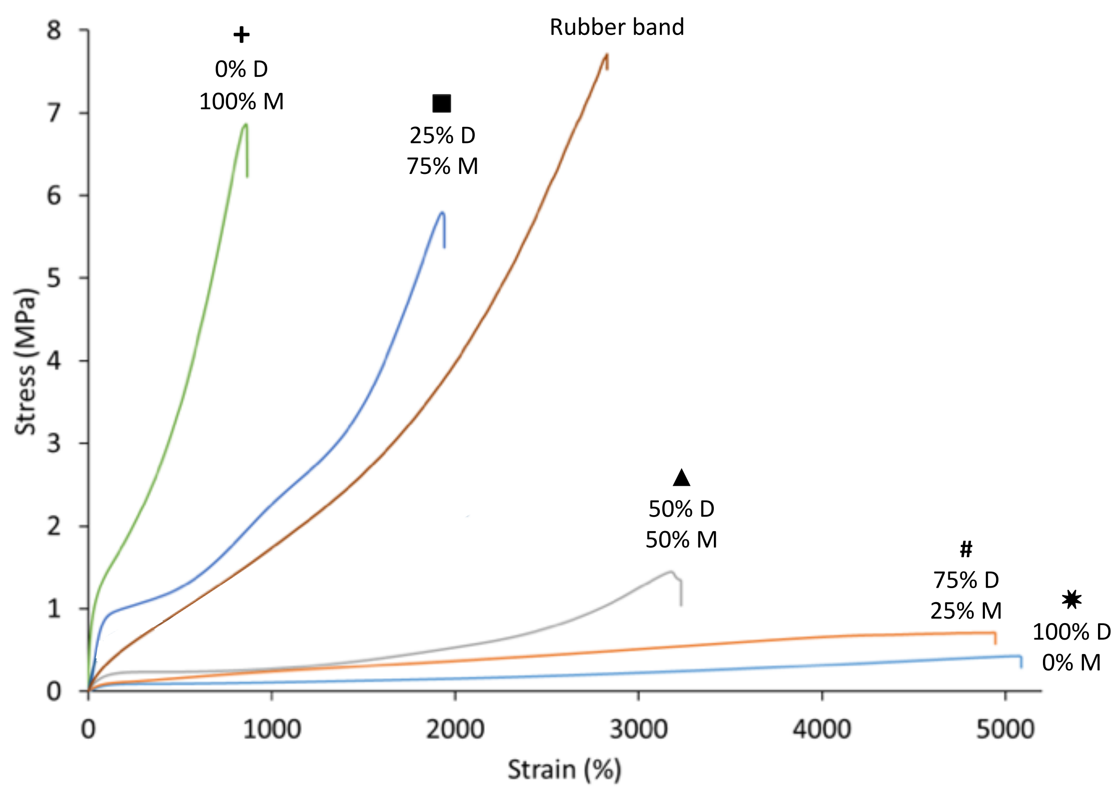
What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data and Graph:

Use the data and graph below to answer the scientific question:

The graph was produced by the Instron machine as it tested the various elastomers. The graph shows each elastomer's reaction to being stretched. The x-axis represents the percentage of stretch (strain), while the y-axis represents the force the elastomer exerts in resistance to stretching (stress). A strain of 1000% is equal to 10 times the original length of the material.

Each line represents an elastomer that Nick and his students were testing. They are labeled by what percent of diglycerol (D) and meso-erythritol (ME) are in the elastomer being tested. For example, the green line (labeled with +) has no diglycerol and is 100% meso-erythritol, so it represents a test of meso-erythritol alone. On the other hand, the orange line (labeled with #) is an elastomer with 75% diglycerol and 25% meso-erythritol.



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Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the graph, like the points at which each elastomer product snapped.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the two polymers and the process of engineering plastics.

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Did the data support Nick's hypothesis? Use evidence to explain why or why not. If you feel the data are inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?