According to Appendix H of the Next Generation Science Standards (NGSS), the nature of science relies upon the accumulation of science knowledge through the use of various practices, such as questioning, investigating, data collection, and data analysis (Appendix H, page 1). At the same time, the nature of science requires more than just engaging in activities and conducting investigation. It requires both the explanation of the natural world, but also an understanding of what "constitutes the formation of adequate, evidence-based scientific explanations" (Appendix H, page 2). In other words, it requires understanding of how and why we know something. Anchor phenomenons can provide students with a context for which they can engage in the nature of science.

The past few years, I've used a relatively simple anchor phenomenon to begin my first unit on motion: the constant velocity car. It's a common starting point in a lot of introductory physics courses, but it allows for kids to immediately engage in science and engineering practices, as well as the nature of science. Students are told that the car moves at a constant velocity (it says so on the box that the car comes in) and are asked "how do we know?" Students make initial observations and provide initial explanations, but many of these explanations lack adequate evidence to support their claims. As a result, students are prompted to design an investigation to gather data that they can use as evidence to support their claim. This directly aligns to the first two nature of science tenets: "Science Investigations Use a Variety of Methods," and "Science Knowledge is Based on Empirical Evidence." Specifically, students are not told what data to collect or how they should do it. Different students and different lab groups will inevitably use different means of data collection to state why or why not the car moves at a constant velocity. Once students have this opportunity to design their own investigation and collect their data of choosing, we can have a whole class discussion about what data we collected, how we can represent it (i.e. in a table, graph, with an equation, etc) and how these different representations can be used to "support the same explanation" (Appendix H, Page 5).

Upon reflection, I need to be more intentional about centering the third tenet of the nature of science: Scientific Knowledge is Open to Revision in Light of New Evidence. It would be easy to introduce this into the constant velocity unit. There might be students who claim that the car does not move at a constant velocity. This invites a follow up conversation, post data collection, about how we use data to revise our claims. In some ways, this allows students to confront misconceptions around the idea of a hypothesis and how they might think that their prediction is "wrong." This idea was spoken about in Week 3's reading, titled, "What's in a Word? How Word Choice Can Develop (Mis) Conceptions about the Nature of Science." Rather than state, "the purpose of the investigation was to prove that the car moves at a constant velocity," students can and should say. "The purpose of the investigation was to gather data to answer the question of 'how do we know if the car moves at a constant velocity'."

One area where I would like to build on this third tenet is in my unit on Forces and Newton's Laws. A few years ago, I rolled out a 5E lesson aimed at tackling a common misconception about force and velocity. Namely, a force is needed to keep an object moving at a constant velocity. The 5E lesson had students making initial predictions about what would happen to an object's velocity, and then having them gather data for different situations in the presence of and in the absence of multiple forces. By the end of the lesson sequence, students would have to make arguments from evidence to answer the question. "Under what conditions does an object move at a constant velocity? Under what conditions does an object's velocity change (speed up, slow down)?" As a result, they would need to use the new data they collected to revise their explanation to this question.

I decided to look at the "Standards for Mathematical Practice" to think about the connection between the nature of math and the nature of science. Three standards that connect directly are: reason abstractly and quantitatively (CCSS.MATH.PRACTICE.MP2), model with mathematics (CCSS.MATH.PRACTICE.MP4), and using appropriate tools strategically (CCSS.MATH.PRACTICE.MP5). One way in which kids need to reason abstractly during the constant velocity unit is where they need to consider the slope of a position vs time graph. Using the units from the y axis (meters) and x axis (time), students can identify that the slope (the velocity) must have units of meters per second. This is a math skill that's transferable to all problems/contexts where kids have to work with graphs. Furthermore, during our energy, students construct energy bar diagrams where they have to identify where energy is stored in a system, at different points in time. Students then use these bar diagrams to construct equations relating the initial energy to the final energy. This directly aligns with mathematical modeling since students are "able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas" (Standard CCSS.MATH.PRACTICE.MP4). Lastly, I want to better support students in how to use graphical tools to help them graph raw data. Students should be able to set up a data table on excel or desmos, for example. Likewise, students should have it in their arsenal to get a line of best fit and see what information this might provide them.