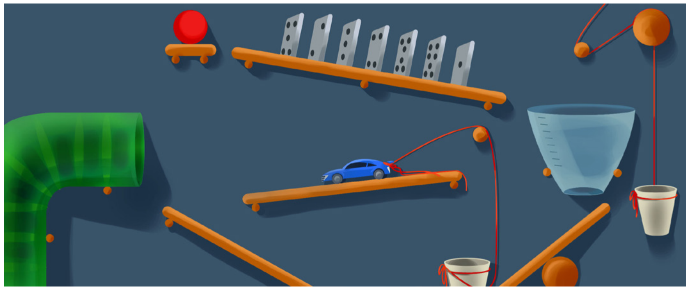

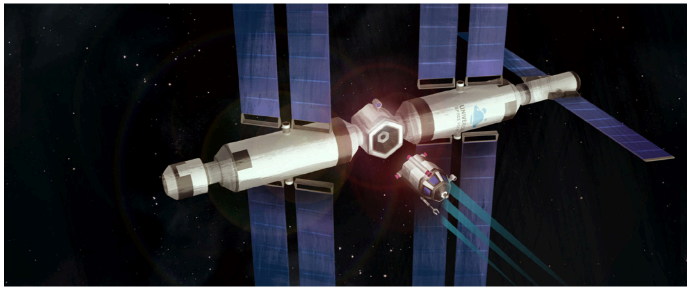

What’s so phenomenal about phenomena?

An introduction to phenomenon-based learning

Amplify Science

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Table of contents

Introduction

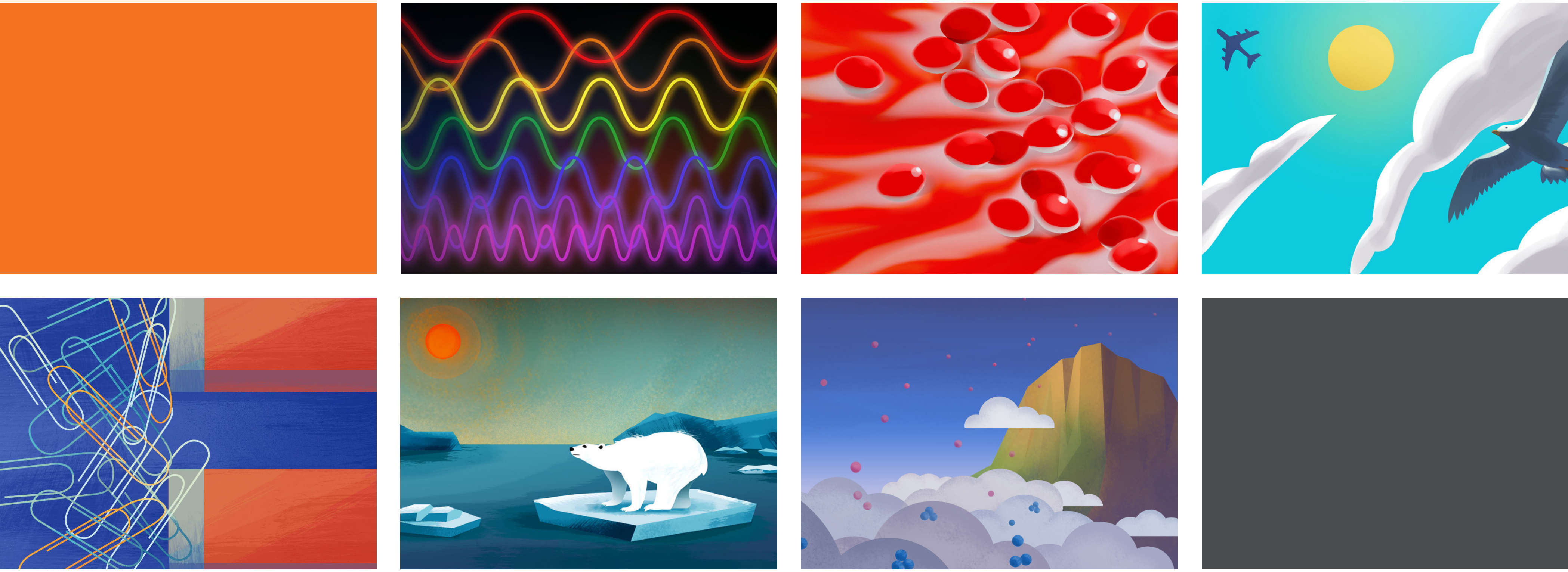
The Next Generation Science Standards (NGSS) turn science learning on its head — in a good way. One hallmark of the NGSS is their firm grounding in phenomenon-based teaching and learning, which serves to shift the approach to science instruction from *learning about* to *figuring out*.

According to the STEM Teaching Tools: "Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education, which too often has focused on teaching general knowledge that students can have difficulty applying to real world contexts." (Bell & Bang, 2015).

With the NGSS, that has all changed. "Phenomena are key in the NGSS," says Brian J. Reiser, Ph.D., an NGSS expert, professor of learning sciences in the School of Education and Social Policy at Northwestern University, and member of the National Research Council committee that developed the 2012 Framework for K–12 Science Education. "What we really are after is helping kids connect what they're learning about in science to what goes on in the world — not just learning in the abstract."

In the field of science, an event does not have to be exceptional or unexplained — that is, "phenomenal" — for it to be a phenomenon. To qualify as a scientific phenomenon, an event simply has to be observable: a rainbow, a tornado, erosion of dunes or soil, even the everyday formation of bubbles or ice. The power of the phenomena lie in their capacity to bring real life into the classroom. When it comes to teaching and learning, those everyday occurrences play a role in inspiring deep engagement. Rather than learning something general or abstract in class and then seeking to apply it in the real world, the phenomenon itself — and the challenge of explaining or predicting it, which itself is the goal of building science knowledge — becomes the motivating factor in instruction.

Here, we will take a closer look at the powerful role phenomenon-based teaching and learning can play — and how you can bring it into your classroom.



“The power of the phenomena lie in their capacity to bring real life into the classroom.”

What is phenomenon-based teaching and learning?

A **scientific phenomenon** is an observable event that occurs in the universe — one that we can use our science knowledge to explain or predict. **Phenomenon-based learning**, then, is a holistic, interdisciplinary approach in which the starting point for inquiry is that specific, observable, real-world event: *Why is brown water coming out of the pipes built for drinking water? Where did all the monarch butterflies go?*

This contrasts with learning that is centered on exploring a *topic*, such as *chemical reactions*[1] or, simply, *butterflies.* With a phenomenon-based approach, students — and, indeed, actual scientists — become well-versed in *topics* by figuring out *phenomena*. STEM Teaching Tools puts it this way: "The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena." And that gets at what is arguably the very essence of science: figuring things out. If science were only a static body of knowledge and not a process of observation and investigation, we would still be, both metaphorically and historically, in the Dark Ages.

Phenomenon-based learning is not new. The approach has been used in Finland and Scandinavia for decades, and it's now at the core of the main pedagogical model embodied by the NGSS: the shift from *learning about* to *figuring out.*

In Needs of Plants and Animals (kindergarten) students take on the role of scientists in order to figure out why there are no monarch caterpillars in the fictional Mariposa Grove community garden since vegetables were planted. They investigate how plants and animals get what they need to live and grow, and make a new plan for the community garden that provides for the needs of the monarch caterpillars and also produces vegetables for humans.

[1] Why isn't a chemical reaction a phenomenon? It is, insofar as the definition of a chemical reaction fits the definition of a scientific phenomenon. The distinction in terms of teaching and learning is between *learning about* what a chemical reaction is in general (a process involving rearrangement of the molecular or ionic structure of a substance) and *figuring out* what's going on in a particular real-world chemical reaction presented to a class, e.g., *What's going on in the pipes that's making the water turn brown?*

Anchoring and investigative phenomena in the NGSS

The NGSS include two types of phenomena: **anchoring** and **investigative**.

Anchoring phenomena

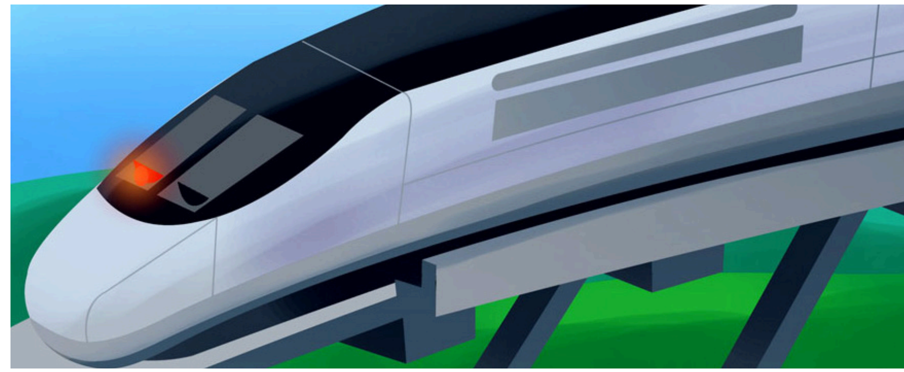
An anchoring phenomenon is the main phenomenon that drives a particular unit (or instructional sequence). That is, the entire unit is dedicated to developing students' ability to explain the "how" and "why" of the phenomenon. An anchoring phenomenon needs to be rich and complex enough to motivate learning for an entire instructional unit.

Examples of anchoring phenomena might include:

- *What is the brown substance coming out of the city water pipes?*
- *Why are there no more monarch caterpillars in Mariposa Grove?*

Investigative phenomena

Investigative phenomena are smaller sub- or component phenomena related to an anchoring phenomenon. For the investigative phenomenon, students gather evidence from different sources. That leads to the construction of new science ideas. Those new science ideas, in turn, help students start to make sense of the anchor phenomenon.



In Balancing Forces (grade 3) students are challenged to figure out how a floating train works in order to explain it to the citizens of Faraday. People in Faraday are excited to hear that a new train service will be built for their city, but concerned when they hear that it will be a floating train. Students develop models of how the train rises, floats, and then falls back to the track; then, they write an explanation of how the train works. In one of the lessons students are challenged to make their own chain reactions and identify and record information about the forces involved.

Why use a phenomenon-based approach?

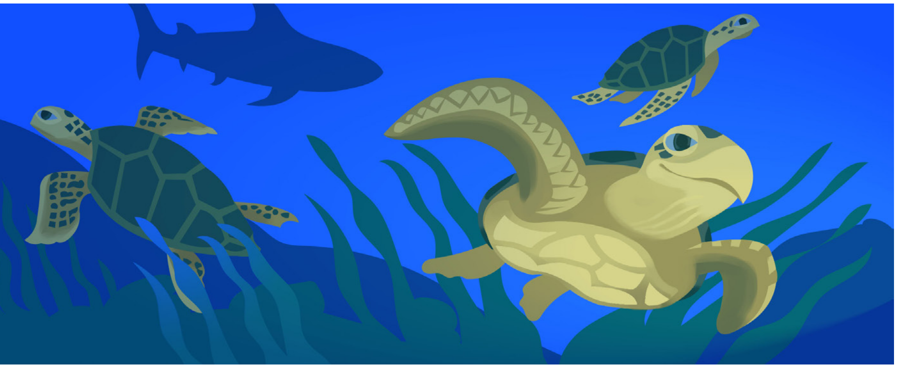
If we want students to engage in learning about the natural world as scientists do, then we must give them opportunities to construct their knowledge in ways that scientists do. By pairing interesting, relevant anchor phenomena with instruction that allows for multiple angles of investigation, this approach helps students craft arguments and explanations far deeper and more sophisticated than those drawn from isolated, abstract topics. **Phenomenon-based teaching and learning engage students deeply; position them as scientists by giving them questions, not answers; and deliver results in and beyond science class.**

The experts agree. According to Reiser, "One of the biggest shifts in the NGSS is using phenomena as the starting point, to raise questions so that we build science knowledge in the context of trying to understand or solve a problem. The whole idea of NGSS is to make learning more meaningful for kids by engaging them not just in the bare facts but in the big ideas, and not just in learning about facts or ideas that other people have figured out, but engaging in the process of figuring them out, with help from teachers, of course."

Here's why phenomenon-based learning is so powerful.

Phenomenon-based learning motivates students by providing them with a sense of purpose and agency, and by engaging their curiosity. According to STEM Teaching Tools,"Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to 'Why do I need to learn this?' before they even know what the 'this' is. In contrast, students might not understand the importance of learning science ideas that teachers and curriculum designers know are important but that are unconnected from phenomena." The impact of phenomenon-based learning is exemplified in the classroom in many ways, including the following:

- Phenomena inspire students to ask questions and motivate more in-depth investigation.
- Unlike a topic (say, ecosystems), a phenomenon *(Why has the moon jelly population in Glacier Sea dramatically increased?)* provokes immediate questions.
- Phenomena give students a purpose (by asking them to answer a question like *Why is Eliza experiencing certain symptoms and not others?*), as opposed to information *(Here is how metabolism works).*
- The problem-solving and project-based approach encourages students to take responsibility for and ownership of their own learning (Barron, et. al., 1998).



In Animal and Plant Defenses (grade 1) students play the role of marine scientists. In their role, students apply their understanding of plant and animal defense structures to explain to aquarium visitors how a sea turtle and her offspring can defend themselves from ocean predators when they are released into the wild.

Phenomenon-based learning leads to deep, transferable knowledge. In the phenomenon-based model, teachers are not there primarily to transmit facts or deliver knowledge; rather, students construct knowledge collaboratively, with teachers facilitating and providing scaffolding as needed (Symeonidis & Schwarz, 2016). The result: "Students develop strategies and construct knowledge through the experience of solving real-world problems. In this way, students become active learners who assume responsibility for their learning, developing a flexible understanding and lifelong learning skills" (Hmelo-Silver, 2004).

Phenomenon-based learning is relevant to students and the real world, which helps make science itself feel relevant to students. Phenomena allow students to explore an event in the real world, as opposed to receiving information in a classroom. Especially when it's not just the real world, but their world. "Choosing the right phenomena for our students helps empower those who don't normally identify as successful science students. When a phenomenon sparks enough student curiosity to carry a unit, it's because the phenomenon is relevant to them: it taps into their interest and their identity," says TJ McKenna, staff scientist for the Connecticut Science Center and Charles H. Barrows STEM Academy.

Weather is a complex system that affects our daily lives. Understanding how weather events, such as severe rainstorms, take place is important for students to conceptualize weather events in their own community. In Weather Patterns (grade 6 integrated model) students play the role of forensic meteorologists as they discover how water vapor, temperature, energy transfer, and wind influence local weather patterns in a fictional place called Galetown. They use what they have learned to explain what may have caused rainstorms in Galetown to be unusually severe in recent years.

"Students become active learners who assume responsibility for their learning, developing a flexible understanding and lifelong learning skills."

—Hmelo-Silver, 2004

How does phenomenon-based teaching and learning look in the classroom?

Here is a look at how an entire unit can be based on an anchoring phenomenon, with a kindergarten unit from Amplify Science as an example.

Students are told about a place in Mariposa Grove that used to be a field, and now is a community garden. They are then introduced to the **anchoring phenomenon:** There used to be monarch caterpillars in Mariposa Grove. Now there are not. Why?

Background: Last year, monarch caterpillars could live in the grove because the milkweed they eat was there. Now, the milkweed is gone; therefore, so are the caterpillars.

What ideas will kindergarten students need to understand in order to figure out why the monarch caterpillars are no longer present in Mariposa Grove?

1. Animals and plants get everything they need to survive in the place they live — and that place is called a habitat.
2. There are different kinds of habitats.

We know that the field was a habitat where the caterpillars could get what they need to survive. It must have had the food that the caterpillars eat. Through a series of activities, students first figure out that different animals eat different foods. Then students research what monarch caterpillars eat, and find that they eat a certain type of plant.

We know that animals get everything they need to live in their habitat, so there must have been milkweed plants in the field. Students engage in activities to figure out that when a habitat changes such that the animals and plants that live there no longer get what they need to survive, the animals may leave.

By identifying the plants in the photos, students figure out that the milkweed plant was removed when the field was turned into a garden. Maybe there are no more monarch caterpillars in Mariposa Grove because the food that the monarch caterpillars eat no longer grows in Mariposa Grove.

This anchoring phenomenon works to anchor students' learning. Though students engage in a series of smaller investigations, it is all in service of trying to figure out the *why* of the phenomenon: Why have the monarch caterpillars disappeared from Mariposa Grove?

Over the course of this unit:

- Students engage with multiple investigative phenomena.
- These investigative phenomena give rise to questions.
- Students' questions lead them to sources of evidence.
- Students use evidence to construct new science ideas.

Conclusion

A classroom investigating an interesting and meaningful phenomenon is an engaged classroom. Teachers can maximize this engagement by:

- Ensuring that students are asking their own questions — a crucial element of *figuring out*.
- Guiding students to focus on a grade-appropriate line of inquiry. Students should be able to figure out the workings of a phenomenon — but not without instruction, guidance, and thoughtful application of science and engineering practices.
- Identifying culturally relevant phenomena. (Details matter. For example, when studying how sunlight warms the earth, considering hot sand may be less relevant to certain cohorts than considering hot concrete.[2])
- Challenging students to take closer looks at even the most everyday phenomena by inviting them to consider that, even if they do know that sounds travels through air or that those beads of water are condensation, they may not know the how or why.
- Selecting phenomenon-based learning materials that support teachers' efforts to deliver all of the above.

[2] See STEM Teaching Tools.

Amplify.

A pioneer in K–12 education since 2000, Amplify is leading the way in next-generation curriculum and assessment. Our captivating core and supplemental programs in ELA, math, and science engage all students in rigorous learning and inspire them to think deeply, creatively, and for themselves. Our formative assessment products turn data into practical instructional support to help all students build a strong foundation in early reading and math. All of our programs provide teachers with powerful tools that help them understand and respond to the needs of all their students. Today, Amplify serves more than three million students in all 50 states.

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The mission of The Lawrence Hall of Science is to inspire and foster learning of science and mathematics for all, especially those who have limited access to science. The Hall investigates, creates, and evaluates educational materials and methods, professional development programs, and hands-on learning experiences for their science center, schools, communities, and homes. To address the challenges in science, technology, engineering and mathematics (STEM) education today, they have created a comprehensive set of programs to help increase the quality and quantity of science learning that children get both in and out of school. Their programs have been proven effective in informal after-school environments and in K–12 classrooms.

The Hall not only grounds its work in the best available research, but also conducts its own studies to inform curriculum design and development. Amplify partnered with the Hall as publisher and technology partner to create Amplify Science, our K–8 science curriculum designed for the NGSS. Amplify worked directly with the Hall's Learning Design Group, which focuses its research and development on the interface of science and literacy. The group's aim is to do more than help students learn about science. It is "to enable all students to inhabit the role of a scientist and successfully use science to solve real-world problems."

The Hall has developed a robust approach to phenomenon-based learning in Amplify Science.

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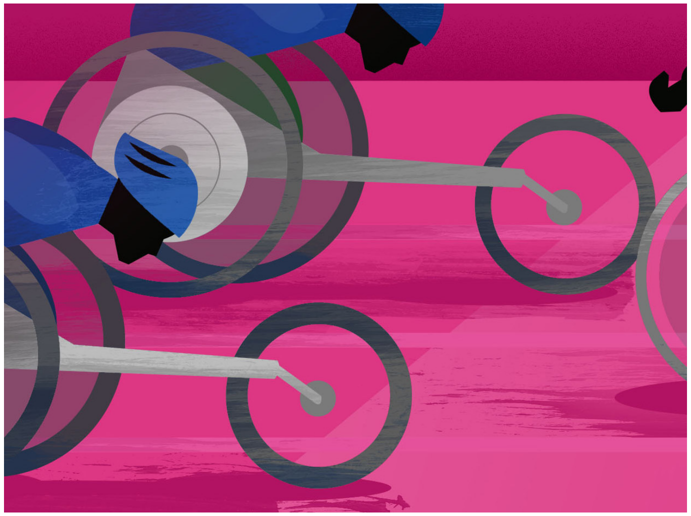

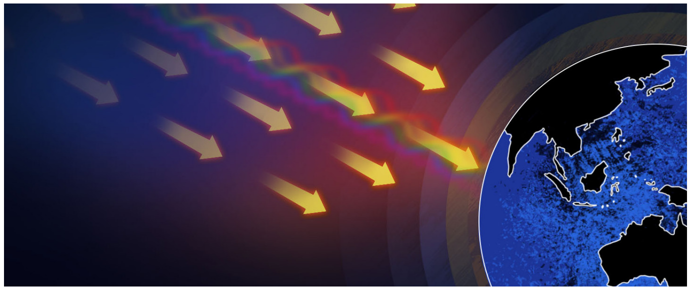

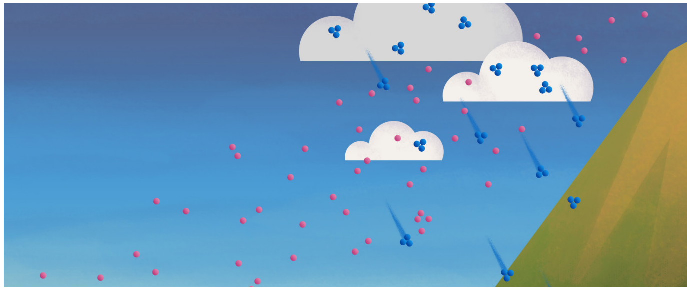

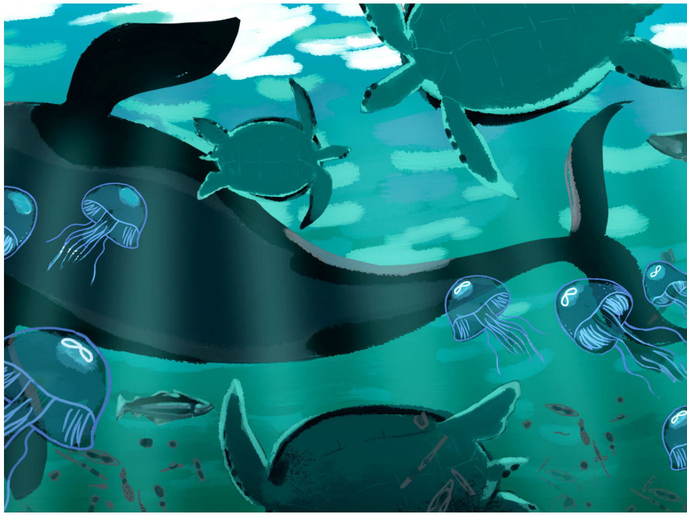

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