Plankton to Plastic Pollution

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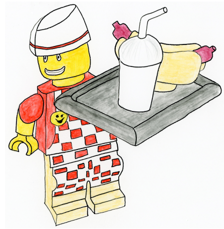
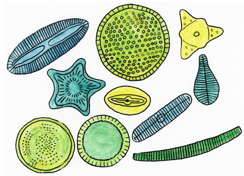


The Plastic Age

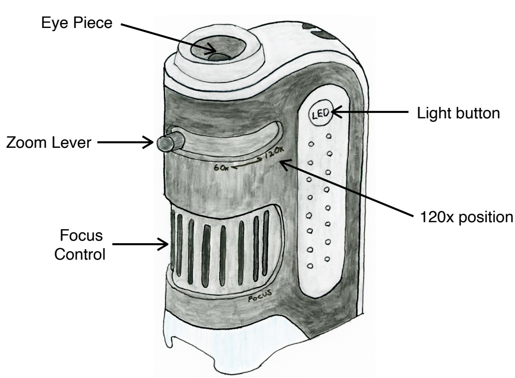
PLASTIC is everywhere! In our daily lives we rely on plastic more than we think. Plastic is used in almost everything we own, from toys, games, and bicycles to sporting equipment, cell phones, and medical devices. Where does all of this plastic come from? Plastic seems like such an unnatural material, but its raw ingredients actually have a biological origin! New materials have long defined the technology used throughout human history: Stone Age, Bronze Age, Iron Age, and now we are in the Plastic Age!

Make a list of plastics that you use. In one column, list some of the plastic that you use over and over again, in a second column, list the plastic items that you use only once before throwing them away.



Plankton to Petroleum

PLANKTON are microorganisms making up the base of the food chain in the ocean. They are split in two main groups: zooplankton and phytoplankton. Phytoplankton, such as diatoms, make their own food through photosynthesis and provide 50-75% of the Earth's oxygen that we need to breathe! Zooplankton, such as foraminifera, consume other microorganisms. Plankton (phytoplankton and zooplankton) provide food for larger organisms such as herring, cod, whales and even us! This kit contains a microscope and slides mounted with foraminifera and diatoms so that you can see what they actually look like.



STEPS

1 Draw two large (5 cm diameter) circles in your science notebook and label one “Phytoplankton: Diatoms” and the other “Zooplankton: Foraminifera.”

2 Take out the microscope and the mounted slides. Study each slide through the microscope.

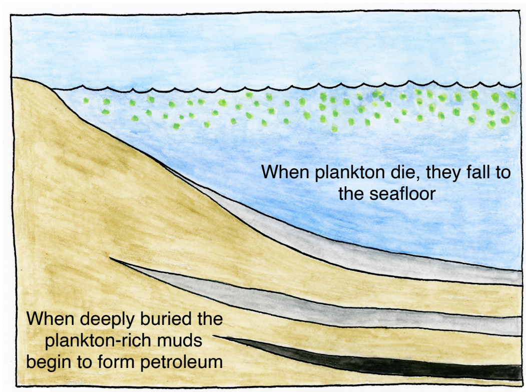
3 Set the zoom to 60x, then focus (see illustration on page 4).

4 In the correct circle, draw several examples of each of the different types of organisms you see through the microscope. It helps to use the zoom lever to get a closer look.

5 Add a scale bar to your drawing. The width of the field of view at 60x is 2 millimeters and at 120x it is 1 millimeter.

Describe the differences you see between the phytoplankton and zooplankton.

When plankton die, they fall to the seafloor and get trapped under many layers of sand and mud.



Over *millions* of years, as they get buried deeper and deeper, heat and pressure turns them into petroleum (oil). We extract the petroleum and use it to make fuels, asphalt, and plastics.

Let's take a look at how plankton settle in the ocean with a model.

STEPS

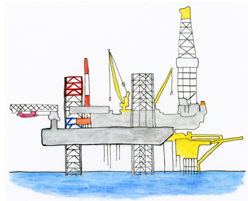
6 Take out the vial that is full of liquid and give it a good shake and place it on the table where it won't get bumped.

7 Using the provided vial template (not in this booklet), draw and write what you observe immediately after shaking the vile.

Time 1: ________ Time 2: ________ Time 3: ________

6 Check on the model two more times as you work through the kit and draw what you see. Tape the template into your science notebook.

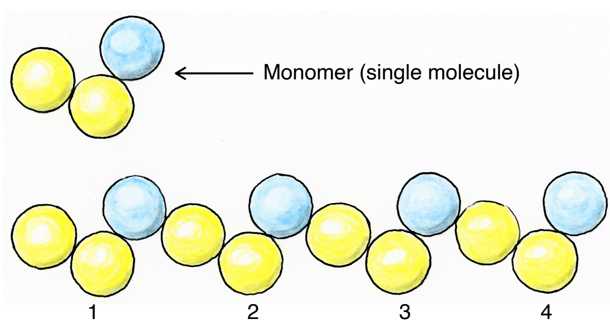
Since the petroleum forming process continues to this day, why are we worried about running out of petroleum (oil)?



Petroleum to Plastic

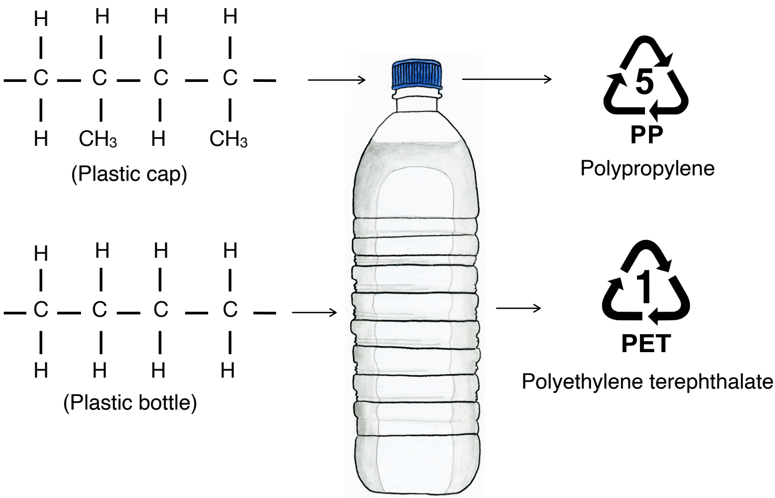
IN 1907, scientists discovered how to use petroleum to make plastic. Petroleum has lots of different chemical building blocks that can be hooked together to make a variety of plastics. Let's explore the structure of different plastics.

The key to making plastic is to select certain molecules called "monomers" and join them together to form long chains called "polymers."



Polymer (chain of many monomers)

The long polymer chains allow plastic to bend and be molded into any shape when heated. Chemists found that different monomers could be made that resulted in polymers with different physical properties.



These different physical properties have led to many creative ways to use plastic. Today, many items that had been traditionally made from plants or animals, some of which are now endangered, are being made from plastic. We can now make feathers, fur, and clothing out of plastic. And chances are, the "rubber" soles of your shoes are actually plastic.

Because of the diverse types and uses of plastic, the amount being produced is increasing. Here are some data that scientists have collected:

Year	Amount of Plastic Produced (Millions of Tons)
1950	2
1960	10
1970	47
1980	87
1990	153
2000	251
2010	367
2020	
2030	

STEPS

1 Use the graph template provided to plot these data and tape it into your science notebook.

2 Draw a smooth curve through the data points and extend your curve to the years 2020 and 2030.

Science Notebook

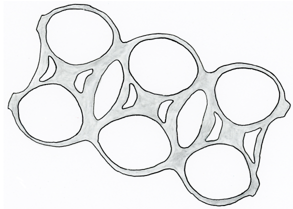
How many millions of tons of plastic do you predict we will be producing in the years 2020 and 2030 if we don't slow down?

We now have so much plastic that it is getting more and more difficult to keep it out of the environment. It is clear that plastic is a useful material, but we also use a lot of plastic only once before throwing it away.

These plastic polymers are non-biodegradable, meaning that the polymer molecules do not decompose to the atomic level; rather, they will just break down into smaller and smaller pieces of plastic. Therefore, when the plastic we throw away gets into our rivers and oceans, it stays there *forever*.

Science Notebook

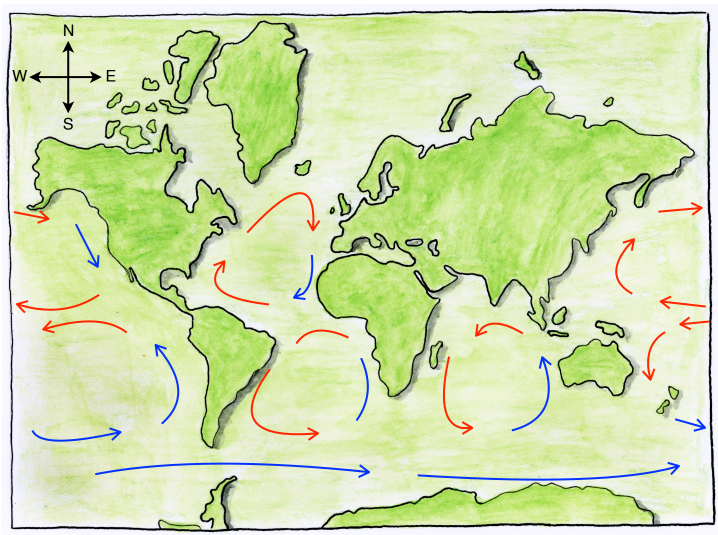
Check on your plankton settling model and draw your second observation.



Plastic to Pollution

WHERE does plastic go after we are done using it? Some of it goes to the landfill where it gets buried. Some of it gets recycled into new plastic. Some of it ends up in rivers where it gets carried out to sea. Some of it gets in the ocean directly from ships. What happens to plastic when it reaches the ocean?

When we think of the ocean, we think of **waves**. Waves are created by the wind dragging on the surface of the water. Ocean waves carry an enormous amount of energy but do not help transport things that float on the water. The energy of the waves sets water molecules into a forward, backward, up, and down motion. If you place a rubber ducky in the ocean, a wave would pass underneath it and return the ducky to its original location. **Currents** are larger in scale than waves and are like large rivers of water that can carry things very quickly from one place to another. In each of the major ocean basins, North and South Atlantic Ocean, North and South Pacific Ocean, and Indian Ocean, we have a set of five ocean currents, forming **gyres** *(pronounced "ji-er")*.



In each gyre, the western current carries warm water from the equator poleward and the eastern current returns cold water to the equator. Can you find the five gyres on the map above?

Science Notebook

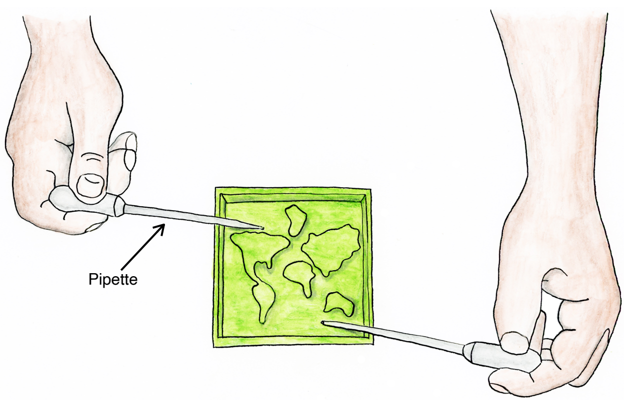
Sketch the map of the world's oceans from page 13. Add labels for the five gyres.

In this activity you will be creating your own currents and observing how they move plastic around the oceans.

STEPS

1 Using the beaker, add 60 mL of water to the ocean basin model. You will have to estimate since the beaker is only marked to 50 mL.

2 Place both pipettes in your model and fill them with water from your model.



3 Add two small plastic beads from the jar to an ocean. Two beads represents two million tons of plastic pollution in 1970.

4 Take turns with your partner squeezing the pipettes in the model paying close attention to how the plastic beads move in the ocean basins.

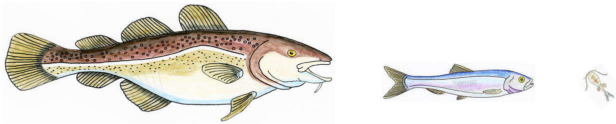
5 Add 28 plastic beads to the model. This represents the 30 million tons of plastic pollution in the year 2000.

6 Repeat step 4 and this time watch where and how the beads move.

7 Finally dump the remaining beads (~120) into the oceans. This represents the plastic pollution we might have in the year 2030!

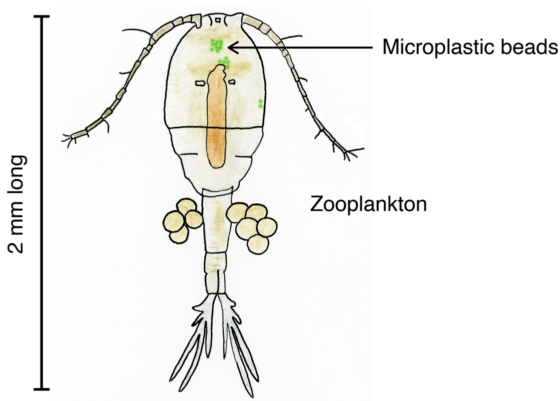
Science Notebook

How were the currents you created in your model similar to and different from the real ones shown on the map on page 13?



Problems with Pollution

BIOMAGNIFICATION happens when pollutants move through the food chain as predators eat their prey. Plastics carry and absorb many chemicals. Scientists are worried that potentially bad chemicals will end up in the food that we eat. Another problem with consuming plastic is that it can make an organism feel full but not provide any nutrients. When marine biologists have dissected zooplankton, they have found microplastics inside.



Your kit has a model cod fish to dissect using plastic beads to represent microplastics.

STEPS

1 Copy the following table into your science notebook.

Phytoplankton	Zooplankton	Herring	Cod

2 Find the food chain model in your kit. Each size of baggie represents a different organism.

3 Unpack the food chain model and make a line of organisms from largest to smallest.

4 Because phytoplankton make their own food through photosynthesis, they don't take in microplastics, so record a zero in the phytoplankton column.

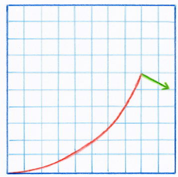
5 Have the zooplankton "eat" the phytoplankton. When they do this, they also take in some microplastics. Record how many plastic beads are now in the zooplankton.

6 Now the Herring will "eat" the zooplankton (along with everything it has in it) and some more microplastics. Record how many total plastic beads are in the Herring.

7 The Cod will "eat" the Herring (along with everything it has in it) and some more microplastics. Record how many total plastic beads are in the Cod.

Who eats the cod? We do, its in our fish sticks!

Make a bar graph of the number of plastic beads in each organism. Write a description of what is happening.



Solution to Pollution

YOU have learned the roles of plankton in the production of petroleum and how that petroleum is used to make plastic. You have observed how plastic moves around our ocean with the help of ocean currents and gyres and how microplastics can infiltrate our precious food webs. Now it is up to you to decide which plastics are most important for humanity in this world of diminishing petroleum. Let's make a plan for how we can solve these problems together. Here are the 4 R's to rethinking plastic:

Refuse: Plastic bags, straws, lids, free give-away trinkets, etc. Ask for non-plastic alternatives.

What will you refuse?

Reduce: Choose to buy durable items that will last you a long time instead of things that will break quickly.

What will you reduce?

Re-use: If you can't use an alternative to plastic, make sure you re-use it where possible and dispose of responsibly. Many things can be reused for a different purpose.

What will you re-use?

Recycle: If you must purchase plastic, opt for items that are easily recyclable. Recycling also reduces the amount of oil needed.

What will you recycle?

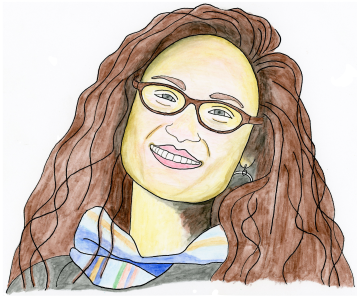
Check on your plankton settling model and draw your third observation.

Clean Up

1 Pour the water from your circulation model through the strainer into the beaker, thus *reusing* the plastic beads.

2 Dry the beads with a paper towel and put them back into the small jar.

3 Dry the model and rinse out the pipettes before packing everything back in the box.



Interview with Robin Cywar

WHAT grade were you when you first became interested in science?

My dad is a chemist so I was exposed to it my whole life, but it's one of those things you aren't crazy about because it's kind of forced on you. Hands-on lab experiments really got my attention in high school, like turning a penny from copper to "gold," bending a stream of water with a charged rod, and making a piece of metal disappear by reacting it with acid to form a pretty blue solution.

Was there a particular moment when you began thinking about becoming a scientist?

When I was picking a major, I wanted something that would have job security and I wouldn't hate doing every day. Chemistry offers a nice balance of routine work and intellectual challenge, and you can get paid well. Turns out I like it so much I want to become a Doctor of Chemistry!

Who was your favorite teacher in high school?
My chemistry teacher. He taught with so much enthusiasm and every class was fun, so I took AP Chem with him after the intro level class. I've noticed that people who say they hate chemistry didn't like their high school teacher, and vice-versa, so I am grateful to have had him. I was also influenced by my art and English teachers.

What classes did you take in high school that helped you get into college?
Chemistry/AP chemistry, and AP English/writing were very important – I got college credits for both of those too which prevented me from being overloaded with classes freshman year.

Advanced English/writing helped me learn how to write correctly and well, which is extremely important for scientists, believe it or not. Trigonometry was also crucial for college calculus, even though I hated it.

What are you working on in the lab?
We are developing completely recyclable polymers (plastics). Typical recycling, "mechanical recycling," involves melting down the long chains and crafting them into something new. However, they will degrade and lose their quality (strength, durability, color, etc.) quickly during this process, and then we cannot use them for every application. Instead, we can easily break the repeating units of the polymer with a catalyst and heat, and then put them back together – this is known as "chemical recycling." Chemically recycled plastic will be like-new, regardless of how many times it's been recycled. And we're making them from a biorenewable source instead of fossil fuels.

How do you think your research will affect the future of this planet?
If the technology can be cost and/or performance-competitive with mainstream plastics, chemically recyclable polymers could prevent a lot of plastic waste. However, successful integration also lies on improved recycling infrastructure, environmental policy, and more responsibility from both corporations and the general public.