Excerpt from "Gyre: The Plastic Ocean"
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PLASTICS UNWRAPPED

Ruth Pelz, Burke Museum of Natural History and Culture

WHEN BURKE MUSEUM STAFF GATHERED a few years ago to discuss potential exhibits, one subject leapt to the top of the list: plastics! Of all the suggestions discussed that day, nothing else expressed so vividly the relationships between people and the environment. Nothing else, we suspected, could better embody the museum's vision: inspiring people to value the interconnectedness of all life—and act accordingly.

Our suspicions were confirmed over the following months, as we undertook a journey of discovery with the generous assistance of experts from across the University of Washington, local industries, and the community. With their help, we explored questions we hadn't thought to ask before: What are plastics anyway? What did we do before we had them? What are the impacts of our choices to use them? Can our relationship with plastics be changed?

The answers turned out to be fascinating, nuanced, and often surprising.

Life before plastics

The most startling aspect of plastics' history, we quickly discovered, is that it's so short. Invented just over a century ago, plastics didn't became part of everyday life until the 1950s, after the end of World War II. Unless you're older than a baby boomer, you probably can't remember life without them.

So what did people use before that? How did they carry water, store food, or keep dry in the rain? All human cultures have faced and solved these challenges, often in beautiful and inventive ways. But until very recently, they were limited to materials derived from nature, such as wood, leather, shell, bone, plant fibers, metal, glass, and clay.

The Burke's anthropology collections include many captivating examples of pre-plastic materials. They are all functional and some are breathtaking, but they have clear limitations. Gathering, preparing, and shaping the materials took time and skill, and many objects were fragile, heavy, or rare. It should be remembered that pre-plastic materials had environmental impacts, too. In the 1800s, for example, elephants were hunted to near extinction to make billiard balls from their tusks!

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CONSIDER THESE EXAMPLES:

YUP'IK PARKA
Goodnews Bay, Alaska, early 1900s
Courtesy of the Burke Museum of Natural History and Culture
catalog 2-3516

HOW TO MAKE A
WATERPROOF GUT PARKA:

1. Kill seal or other large sea mammal
2. Remove and clean the intestines, inside and out
3. Set out to dry, then cut into strips
4. Stitch strips together with waterproof seams, using thread made from twisted sinew

TIME REQUIRED: About one month to make an adult parka

UTE WATER BOTTLE
American Southwest, early 1900s
Courtesy of the Burke Museum of Natural History and Culture
catalog 2-11585

HOW TO MAKE A
WOVEN WATER BOTTLE

1. Gather new willow branches in spring; strip bark and scrape into evenly sized rods
2. Soak strips for a day in water, then weave into a jar-shaped basket
3. Rub with a mash of pounded cactus or juniper leaves to fill spaces
4. Cover with pitch from the piñon tree *(melted to a thick syrup, poured into interior, and brushed onto the outside (add heated rocks to keep pitch warm while it flows into all openings)*

TIME REQUIRED: 1–2 weeks

The promise of "miracle materials"

Given the challenges of pre-plastic materials, people dreamed of better solutions, and countless inventors devoted their lives to the quest. Throughout the 1800s, determined researchers sought ways to improve on natural materials by applying heat, pressure, and a wide range of chemical additives. When successful, they created what we now think of as plastic precursors: materials that were modified from their naturally occurring chemical form but not yet fully synthetic. (Vulcanized rubber is an example. In its natural state, rubber melts in heat and stiffens in the cold. Charles Goodyear discovered a process to make rubber more usable in 1839.)

The first fully synthetic plastic material, Bakelite, was patented in 1909 by its namesake, Leo Baekeland. The plastic age had begun. Innovations continued and, as each new plastic was invented, it was greeted with great excitement. Imagine living without plastic food containers, synthetic fabrics, and other items on the timeline (to the right), and you can begin to understand why.

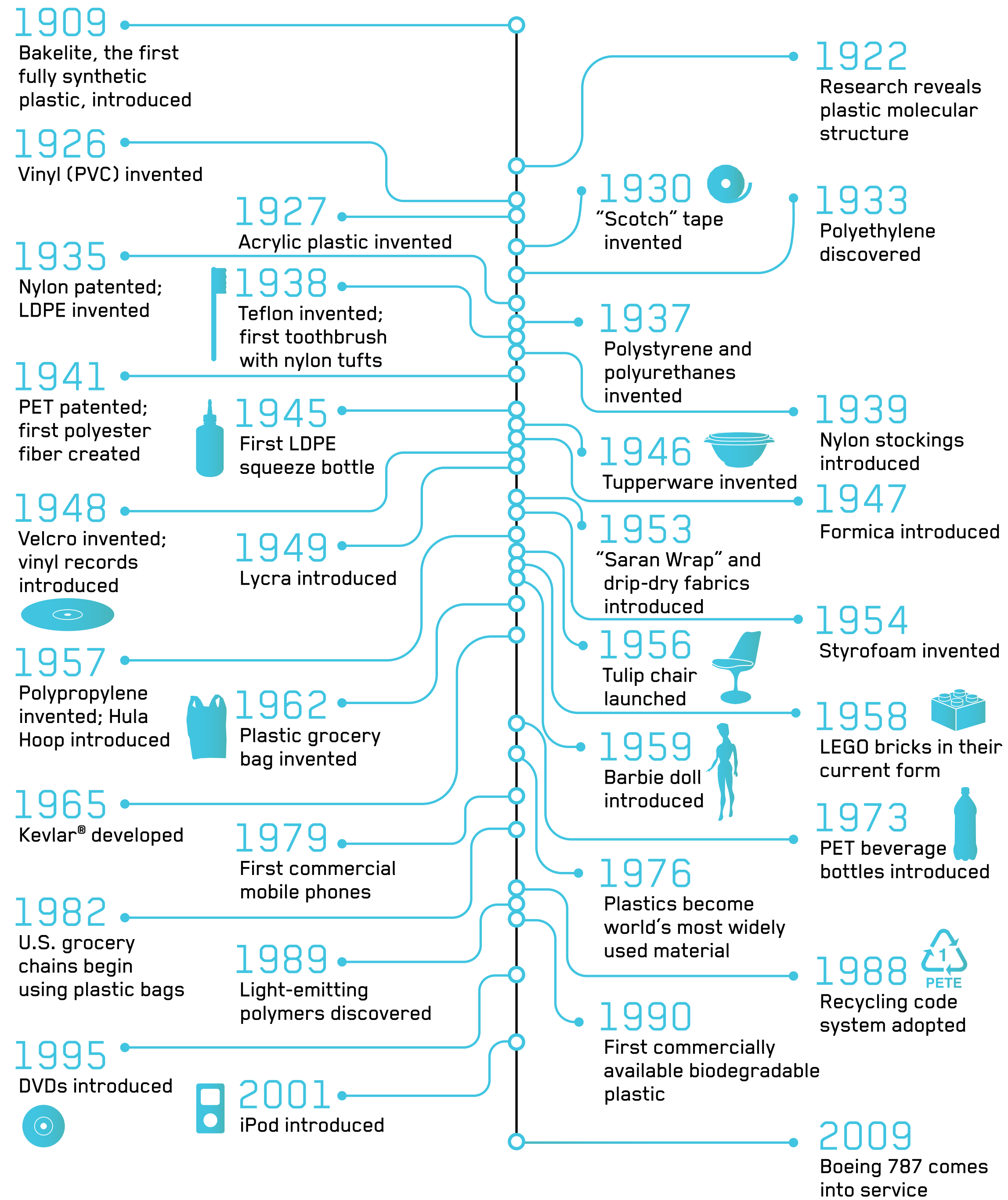
When World War II began, plastics were still new and rare. The industry shifted its focus to help meet military needs, from life rafts to radar development. Production boomed. At war's end, factories had huge capacity, and switched their production to consumer products.

Until this point, people generally used things until they wore out. The economics of plastic demanded a change, since production costs for 100 items or 10,000 were nearly the same. Advertisements began to promote the convenience of using things once and then throwing them away. By the 1970s, disposability was a way of life.

Plastic science: It's a matter of molecules

Our word "plastic" come from Greek: plastikos, meaning a thing that can be formed or molded. The almost infinite adaptability of plastics comes from their chemical structure: they're made up of polymers—long molecules with repeating units, like links in a chain. These molecular chains can be formed into a huge variety of shapes. There are many possible chemical units ("monomers") and ways they can combine, so thousands of different plastics can be made—each with different properties.

PLASTICS: THE FIRST 100 YEARS



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CRACKING THE CODE

Because all plastics are not chemically the same, you can't just melt them together and make a new bottle out of the mix. The plastics industry came up with a coding system to distinguish the plastics most often used in disposable containers. That's what the symbols on the bottom of the containers mean.

1 PET

CHEMICAL NAME Polyethylene Terephthalate
NICKNAMES PET, PETE, Polyester
PROPERTIES Clear, tough, impermeable
COMMON USES Beverage bottles, food jars, fabrics
ISSUES/FACTS About 50 billion PET bottles thrown away each year, even though demand for recycled PET is high

2 HDPE

CHEMICAL NAME High Density Polyethylene
NICKNAMES HDPE
PROPERTIES Relatively stiff, good chemical resistance, translucent
COMMON USES Bottles for milk, juice, household cleaners; cereal box liners,
ISSUES/FACTS One of the safer plastics

3 V

CHEMICAL NAME Polyvinyl Chloride
NICKNAMES PVC, Vinyl
PROPERTIES Stable, inexpensive, versatile; can be rigid or flexible
COMMON USES Plumbing, window frames, IV bags and tubing, meat wrap, shower curtains
ISSUES/FACTS Can release lead, phthalates, and other toxins

4 LDPE

CHEMICAL NAME Low Density Polyethylene
NICKNAME LDPE
PROPERTIES Transparent, touch, flexible
COMMON USES Clear wraps and bags, flexible lids and bottles, coatings for cartons and cups, toys
ISSUES/FACTS Like HDPE, a safer plastic.

5 PP

CHEMICAL NAME Polypropylene
NICKNAME PP
PROPERTIES Strong, resistant to acids and solvents, high melting point
COMMON USES Containers for medicine, condiments, yogurt; fabrics; molded parts for cars and appliances
ISSUES/FACTS One of the safer plastics

6 PS

CHEMICAL NAME Polystyrene
NICKNAMES PS, Styrofoam
PROPERTIES Versatile, can be rigid or foamed, significant stiffness, good insulation as foam
COMMON USES Cups, plates, cutlery, meat trays, protective packaging, CD cases, building insulation
ISSUES/FACTS Can leach toxins when heated (never use in microwave)

7 OTHER

NAME 7 is used for any plastic other than those labeled 1–6
PROPERTIES Variable, depending on type of plastic
ISSUES Plastics labeled 7 may be biodegradable polymers (PLA and others) that can be composted but not recycled; other plastics that are relatively safe but not typically recyclable (ABS, SAN), and polycarbonates (PC) that can leach BPA.

The fossil fuel connection

Traditional plastics are petroleum products; they're made from oil and natural gas. These fossil fuels are formed from plants and animals that lived hundreds of millions of years ago.

You've probably heard of hydrocarbons. These are the simple molecules, composed of carbon and hydrogen, that are the energy sources in fossil fuels and the main building blocks of plastics.[1] Living plants have hydrocarbons too, and new "bioplastics" are made from renewable sources, such as corn.

The chemical bonds in plastic are extremely strong; it takes a lot of energy to break them apart. That's good if you want an object to last a long time, but a serious problem if you don't. Plastic waste is everywhere because it takes a long time to degrade. How long? It depends on the kind of plastic and where it ends up.

In sunlight, most plastics break down into smaller bits over time, but those plastic bits never fully disappear. This process is very different from biodegradation, in which microorganisms digest organic waste, turning it back into water, carbon dioxide, and other basic compounds.

In the ocean, a plastic beverage bottle will likely take about 450 years to degrade[2] (In contrast, a paper towel takes 2–4 weeks; a tin can about 50 years). In a landfill, however, where there's no sunlight or air, the process is slower. Even natural materials break down slowly in landfills; plastics may take a thousand years.

With hundred of millions of tons of plastic produced each year, plastic waste is a global problem.

Engineering makes them better

Think plastics are cheap and simple materials? Think again! Researchers are developing highly-engineered plastics to do things that early inventors never dreamed of. These are some promising new directions:

- **Composite materials.** Composites combine two or more distinct materials to achieve new properties. The carbon composites used to create strong, lightweight parts for airplanes, cars, and sports equipment, are made by embedding thin carbon fibers in plastic resin. The Boeing 787 is the first commercial jetliner made mostly of composite materials. Lighter in weight than conventional planes, it uses less fuel and is quieter.
- **Bioplastics.** Engineers are creating new plastics from plant products such as sugar, starch, or cellulose, instead of fossil fuels. Relatively expensive now, they have promise as renewable and biodegradable replacements for the plastics we know.
- **New properties.** Most plastics are insulators. In fact, the need for electrical insulation was a powerful driver of early plastic discoveries and developments. But scientists have discovered that some plastics can conduct electricity. You might have an example of these new conductive materials in your pocket—plastics that glow in different colors when current is applied are now used in (OLED) cellphone displays.

Plastics and health

Nothing embodies the benefits and drawbacks—the yin and yang—of plastics as clearly as health issues. On the plus side, plastics have made modern medicine possible. From full-body scanners to the tiniest flexible tubing, pacemakers to prosthetics, plastics are essential components of medical devices. Plastics keep us healthier in other ways, too, from fresher foods to safer cars. Consider the following examples and imagine trying to make them with earlier materials, such as wood, metal, and glass.

- **Sterile disposables:** gloves, syringes, packaging
- **Medication delivery:** IV systems, tamper-proof medicine bottles
- **Prosthetics:** dentures, hearing aids, artificial joints and limbs
- **Auto safety:** airbags, child seats, impact-absorbing bumpers

On the other hand, there are many kinds of plastics—with thousands of chemical additives—and some raise real health concerns in the short and long term. Some additives of special concern are phthalates, used to make plastics soft and flexible, and bisphenol A (BPA), used in hard, clear plastics. Research is showing that even small amounts can disrupt hormones and damage health over time. Children, whose endocrine systems are still developing, and pregnant women face the greatest risk.

Additives can leach out when plastics are heated. To limit exposure, avoid heating plastic containers used with food. Unless the label says it's safe, don't microwave plastic food containers, use with hot liquids, or run through the dishwasher.

Medical waste is another problem, a huge one—an estimated 1,800,000 pounds annually. Efforts are under way to reduce it, but the task is complicated, because safe and sterile conditions are hospitals' first priority.

Toward solutions

Plastics are popular for good reasons, but we need to revise how we use (and misuse) them. Solutions depend on everyone: consumers, producers, governments, scientists, and engineers. Fortunately, there are plenty of people in each of these groups who are tackling the task. They're pointing out many ways to reduce our personal plastic footprint, make a difference in the community, and support organizations that are working for change. Here are a few opportunities.

Reduce/Reuse/Refuse: The best way to reduce plastic trash is not to acquire it. Think "Do I really need that?" before you bring more plastic home. Take it one step at a time. You could begin by:

- Saying NO to bottled water. It's hundreds of times more expensive than tap water and no safer. Rely on reusable containers instead. The options include water bottles with built-in filters if you don't like your tap water's taste.
- Reducing plastic packaging. Over 30 million tons of plastic are discarded in the U.S. each year, and much of this is packaging. You can help reduce plastic waste by choosing products with minimal, recyclable, and/or compostable packages and buying in bulk.
- Refusing disposable plastic bags. Bring your own reusable bags when you go shopping.

Recycle: The environmental benefits of recycling are clear—reductions in energy use, carbon emissions, pollution, and landfills. (Plastics take up about 25% of the space in landfills worldwide, and that space is disappearing fast.) A few things to consider:

- The resin codes included with this chapter can help you become an expert, but recycling agencies will tell you to start by paying attention to the shape of the container. If it looks like a beverage, milk, or detergent bottle or is shaped like a yogurt tub, it's probably recyclable. (Different places have different rules, so be sure to check out yours.)
- Compostable plastics are a good option if you live in a city like Seattle with a public compost program—these materials are designed to degrade in commercial compost facilities, not backyards or landfills. Just be sure to dispose of them in the yard-waste bin—NOT recycling or in the trash.
- Recycling has many benefits, but has to make business sense, too, in order to grow. There has to be a source and market for the product, and expenses have to pencil out. Individual actions help (the more recycled products we buy, the more industry will produce), but the real solutions depend on scale: public recycling programs, policies, and laws.

Shop smart: Look for products with minimal packaging, and safe, recycled/reusable materials. For example:

- Choose safer toys and baby products. Look for plastics without BPA and phthalates and non-plastic alternatives. Avoid vinyl (PVC).
- Buy recycled. Making products from recycled plastic requires less energy than producing with new materials, produces fewer greenhouse gases, and reduces landfill. Shoes and clothing made from recycled plastic can be just as high-performance as those made from new materials. Buying recycled goods from developing countries supports artisans and their families and helps reduce plastic waste in their communities.

John Dahlsen, THONGS
Digital print on canvas

Lobby for Change: Committed communities have shown that improvements are possible when people join together to change policies and laws. For example:

- Seattle has reduced landfill waste from homes by 70% through curbside recycling and compost programs
- New York—one of ten states that require a deposit on beverage containers—estimates that the "bottle bill" has saved two million barrels of oil and recycled almost four billion containers each year.
- Most developed countries have stronger laws on recycling than the U.S., including "extended producer responsibility" laws that require manufacturers to "take back" their used products in ways that are free, easy, and environmentally sound.[3]

Wrapping up

In just a few decades—a very short piece of human history—plastics have transformed the planet in ways we're just coming to understand. While they've made our lives safer, more convenient, and more colorful, they've also had unwanted side effects on people, wildlife, and environments around the globe.

As a natural history museum, it was the visible impact of plastic waste on world environments that drew us to this topic. When we began our investigation, we were prepared for a precipitous journey into despair. As we proceeded, though, we were inspired again and again by encounters with people committed to change. Researchers, retailers, activists, government workers, engineers, and entrepreneurs—each pushing the effort ahead in their varied areas of expertise, not dramatically, perhaps, but doggedly, one step at a time. These efforts haven't been around as long as plastic but already the incremental steps were adding up. It gave us confidence that we could do the same. At the end of our journey of discovery, we all agreed that it is time to rethink our relationship with plastics—and we can.

1 Ironically, because of the carbon, plastics are considered organic chemicals. When chemists use the word "organic" they are talking about substances that are carbon based.
2 Since plastics have only been around a few decades, researchers base their estimates on current, observed rates of decay.
3 Such as the Waste Electrical and Electronic Equipment Directive (WEEE) of the European Union