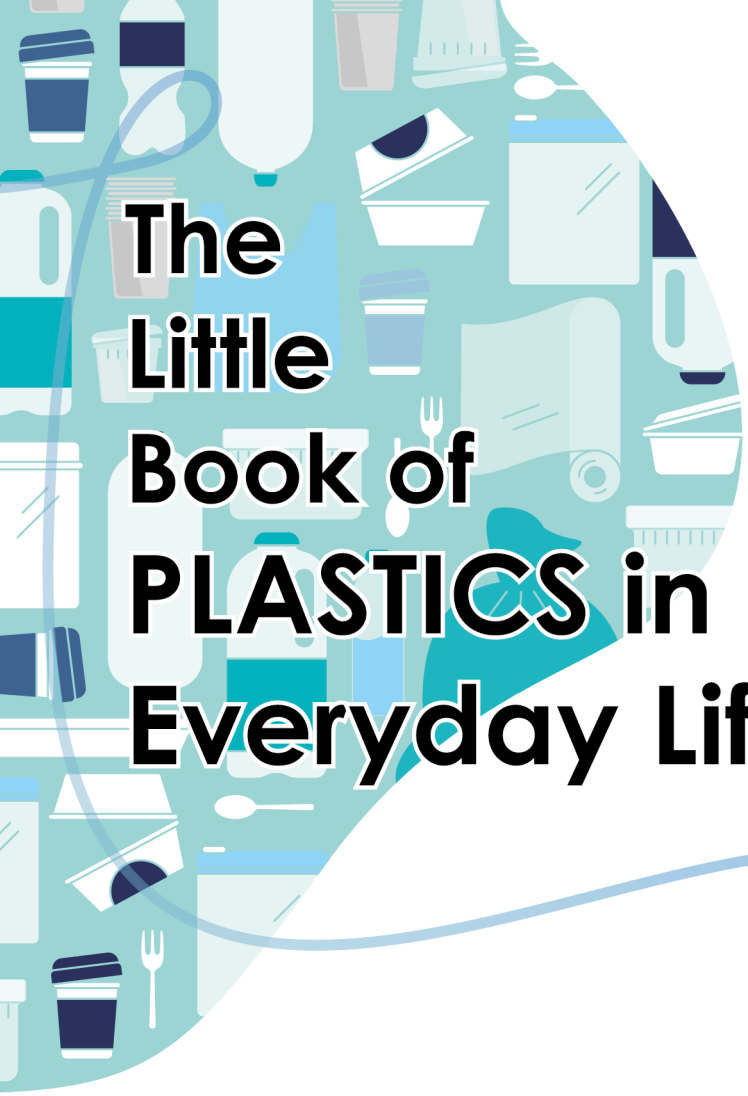

The Little Book of PLASTICS in Everyday Life

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What this Little Book tells you

The purpose of this Little Book is to provide a holistic but condensed overview of the key aspects of plastics as they are produced, consumed and disposed of in contemporary consumer culture. We centre attention not just on the materiality of plastics but also on their meanings and how they come to be experienced and lived with in daily life.

Amongst the grandest of challenges

Plastics are the material and symbolic handmaiden to almost all conceivable aspects of today's market economies, being used across the entirety of value chains from production, packaging, transportation, merchandising, storage, consumption and disposition. Polymer science and engineering are recognised as amongst the most essential research areas of the last century, providing us with endlessly ductile and versatile, light and durable plastic materials that allow for their easy, effective and widespread manufacture and application. Plastics are inexpensive, do not require extensive maintenance, and are cheaper to replace than to fix. Also, with their general resistance to corrosion and ability to serve as a water and oxygen barrier, plastics package and extend the shelf-life of our foods and medicines, improve the hygiene of our medical environments, make the textiles for our clothes weather-resistant or form-fitting, guarantee the affordability, compactness and performance of our electronics, appliances and gadgets, and generally improve the convenience of our everyday lives. Seemingly, the only limit to plastics' diversity of applications to daily life is our inability to control their 'stubborn materiality' (Hawkins 2009, p.43) or 'end-of-life fate' (Geyer *et al.*, 2017, p.1) after we have enjoyed their usage and consumption.

Plastics are synonymous with and endemic to the contemporary technological contributions of humanity, but have also spilled over to almost every corner of the Earth, with insoluble plastic waste, plastic fragments and tiny plastic particles (i.e. microplastics of <5 mm, and their smaller variants nanoplastics of <100 nm) being found at the deepest troughs and highest peaks of our blue planet. Observations of plastic's far-flung appearances include a plastic carrier bag and sweet wrappers at depths of nearly 11 kilometres in the Pacific Ocean's Mariana Trench (Morelle, 2019) and plastic particles amongst snow and water samples from Mount Everest (Napper *et al*., 2020). The lightweight and resilient properties of many plastics mean that they can endure for decades, if not longer, and can be carried significant distances by human haulage, drainage, currents and winds. Every year between 150,000 and 500,000 tonnes of plastic waste originating in the EU, finds its way into our oceans (Calleja, 2019). Accumulated mounds of waste plastic have even been found on the beaches of Henderson Island, an uninhabited coral atoll in the South Pacific and UNESCO World Heritage Centre, one of most remote places on the planet (Nichols *et al*., 2021). Besides the brazen colonisation of geography, plastics have also called claim to *anatomy*, having been discovered in the stomachs and tissues of multiple marine species including fish, dolphins, seals, turtles, mussels, whales and many types of seabirds. Autopsies also reveal plasticisers (additives that unstiffen and mollify plastics to make them bendable without breaking) in human liver and fat tissue samples (ACS, 2020). Plastics have even been found in humans' lungs (VishnuRadhan *et al*., 2021).

The aim of this Little Book is not to confront readers with a compendium of unsettling observations, statistics and verities on the ubiquity of plastics on land, in the sea, and in the flesh. Although that might be a worthwhile activity, the materials prepared for this contribution to the Little Books series by our interdisciplinary team are much more ambitious, and perhaps even naively quixotic, in their aims: to provide for readers across disciplines and sectors

a holistic and nuanced overview of what plastics are, where they came from, how we as humans interact with them in the messiness of everyday life, and how we come to think about their material and affective impacts on our personal and collective consumer interests. The authorial intention is to make good on those aims *while* remaining suitably accessible in language and style. *While* also upholding academic standards of rigour. *While* also evidencing the value that various positions and approaches on plastics can bring. Beneath the idealism of our aims, the scholarly direction and overall tone of this book can be summarised as a simple but principled attempt at approaching a single and particularly nebulous class of materials, plastics, from a position of critical curiosity. This book is more about how we might begin a conversation about asking the 'right' questions, than about definitive answers or solutions. Rather than co-opt this platform for pedagogic posturing by presenting the empirical results of our primary research or offering firm recommendations to stakeholders, we lean playfully and curiously into the plasticity of plastic itself.

Our critical practice of curiosity is exercised not just through deconstructing what plastics are, but also through representing the various contextualising, affective and historical conditions of plastics' ordinariness, pervasiveness and strangely invisible iconicity in everyday debates. By reflecting on the unconscious appeal of plastics, we do not discount the significance of their catastrophic environmental impacts, rather we aim to foster inquiry around the types of questions that we, as a society, could and should ask about our reliance on plastics and their seemingly irreplaceable, infinite value in modern living.

In this introduction, we outline what we mean when we talk about a Plastic Age. First, we will use and explain a technical term, 'synecdoche'. Second, we give a brief background to the Lancaster University Plastic Packaging in People's Lives project. Third, we provide an overview of the content that follows.

The Plastic Age

The term 'Plastic Age' is sometimes used in the media and in academia to mark out humanity's current state of global material culture, having superseded more commonly recognisable historical epochs such as the Stone Age, Bronze Age, Iron Age or Steel Age. These kinds of epochal labels infer that the materials widely used for producing artefacts at a particular moment in time do not just factor in – but are crucial to – the shaping and functioning of civilisations and, therefore, come to intimately characterise humans' collective ways of living, organising and developing. Popular materials function for analysts as a 'synecdoche', a symbolic part of the whole that stands for or is seen as the whole. When regarded as synecdochical, and standing for an entire epoch, materials are recognised as inseparable from the systems of social and commercial relations they are embedded in.

At the heart of their synecdochical quality to represent how manifestations of civilisation are constituted, sustained or transformed is the recognition that materials are more than raw commodity inputs for the production and consumption of 'finished' artefacts, whether they are tools like smartphones or computers, or status-signalling ornaments like jewellery or home décor. Materials are, more importantly, basic currencies for measuring relative notions of 'progress' and offer coordinates for making collective sense of environments and standards of living. Materials are:

- semantically rich *tokens* of a civilisation's priorities at a given point in time
- the catalysts for humanity's technological and mechanical advances
- the vectors for its artistic expressions
- the substructures for its commerce and
- the framework for its ability to expand and sustain itself.

Just as the synecdochical materials of previous epochs – whether iron spearheads, bronze crotals, or steel-wrapped telegraph cables – remain behind to assist in the archaeological reconstruction of earlier civilisations' systems of images, tools and objects, plastics will be observable in the fossil record to identify our current collective market-based commitments and compulsions (Corcoran *et al*., 2014).

Today's global capitalist market-economies are largely underpinned by the ethos of consumption, with household consumption alone making up typically around 60% of gross domestic product (OECD, 2021). To meet the steep demands of mass consumption, approximately 8,300 million metric tons of plastics have been produced since the industrial-scale development of synthetic-polymers thrived in the immediate post-World War II 'Great Acceleration' period (Geyer *et al*., 2017). In terms of sheer volumes of production, plastics have, since the 1980s, surpassed steel as the most widely-used material of today's societies. As summarised nicely by Gay Hawkins:

> *"Plastic is the definitive material of the 20th century and the rise of synthetic modernity. Deeply connected to the growth of carbon economies post WWII, it is now, in the 21st century, considered an anthropocenic marker, part of the living archive of human impact on earth systems."*
>
> *(Hawkins, 2017, p.15)*

Hawkins' recognition of plastics as an 'anthropocenic' marker is important because our consumption and discarding of plastics leave behind evidence of humans' ways of living and being in the world, and even beyond it. The nylon flag that Neil Armstrong and Buzz Aldrin planted on the moon in 1969 eternises human civilisation's interests as channelled through plastics.

What make plastics so interesting, not just as a synecdoche for civilisation's current commitments but as an anthropocenic marker more generally, is how *recent* plastics are to human history. The mass consumption of synthetic petro-based polymer materials, that we consider emblematic of the Plastic Age, has only been going

on for less than one hundred years. The first truly synthetic polymers including Bakelite, cellophane, viscose, nylon, polystyrene and polyvinyl chloride (PVC) appeared between the 1920s and the 1940s, followed by the commercialisation of artificial elastomers, acetal resins, polyester fibres, polyethylene bags, acrylic paints and polypropylene applications in the immediate post-war decades. These were tailed by the rapid marketisation of the now ubiquitous polyethylene terephthalate (PET) bottle in the 1970s and 1980s.

Plastics, while iconic in their own right as materials, are unrivalled in their ability to assist in the iconisation of many other artefacts (Cronin *et al.*, 2022). Most of the iconic products, brands and commercial markers of our contemporary consumer culture – whether smartphones, toys, Swatch watches, flatscreen TVs, sports trainers, Blu-ray discs, imitation leather handbags, BIC pens, stilettos, lipstick, PlayStations, or automobiles – feature plastic, are packaged in plastic, and/or were brought to market using plastic. Cronin and colleagues (2022) suggest plastics' indispensability to the marketplace iconicity of so many desirous consumer objects hinge upon a complex intersection of 'absent presence' and 'versatility'. First, by being materially present but largely absent from consumers' conscious awareness, plastics lend themselves to being unobtrusive, ordinary and thus increasingly integrated into our daily lives. Second, the versatility of plastics ensures that, not only are many types of plastic remarkably materially diverse and advantageous for the manufacture, packaging or merchandising of any number of commodities, they are also capable of being integrated into a plethora of objects, experiences and services, which means they constantly stimulate new market amenities and access to them. With the coordinates of the Plastic Age mapped out, and the appeal and importance of plastics identified, we now turn to our own interest in them.

Who we are: a background to our project

The Plastic Packaging in People's Lives (PPiPL) project, established at Lancaster University in 2020, was formed from funding by the UK Research and Innovation programme's Natural Environment Research Council. The aim of the PPiPL project is to critically explore consumer culture at multiple levels, with a view to unlocking existing barriers to informing and achieving systemic change in the UK to meet Plastic Pact targets.

The UK Plastics Pact, led by WRAP (Waste and Resources Action Programme), is an agreement of sorts between UK-based organisations across the entirety of the plastics value chain with the UK government and NGOs on the urgent matter of bringing plastics consumption and plastics wastage under control. The UK Plastics Pact members are responsible for 85% of plastic packaging sold through UK supermarkets and have pledged to take actions to deliver cleaner growth, with significant reduction in plastic waste entering the environment by 2025. PPiPL's role in informing the UK's plastic-reduction targets is to increase understanding of consumer behaviour as it relates to plastic packaging and plastics more broadly, and to develop a critical understanding of how consumption, in its various forms impacts, and is impacted by, decisions across supply chains and throughout society. We are working with partners along supply chains, combining various tools, concepts and empirical methods to provide valuable insights to increase collaboration and shared understanding of the state of food plastic packaging in the UK. PPiPL aims to support the UK Plastic Pact Targets by delivering the outputs shown overleaf in Table 1.

The PPiPL team understand that successful interdisciplinary working requires approaching challenges from differing perspectives using varied methods and techniques, but also needs a willingness to communicate theory and ideas in ways that go beyond traditional boundaries. In the next section, we outline how we attempt to do this.

Table 1. **UK Plastic Pact and PPiPL targets**

UK Plastics Pact 2025 Targets	Key Outputs of PPiPL
Eliminate problematic or unnecessary single-use packaging	Development of a detailed understanding of consumer behaviour to better inform initiatives towards the elimination of problematic or unnecessary single-use plastic packaging and overcome likely conscious and unconscious rejection.
100% of plastic packaging to be reusable, recyclable or compostable	Detailed guidance for industry and policymakers to bridge consumers' attitude-behaviour gap, to drive acceptable reusable, recyclable and/or compostable plastic packaging solutions.
70% of plastic packaging effectively recycled or composted	Creation of actionable strategies for authentic consumer and industry behaviour change to increase the amount of plastics being effectively recycled or composted.
30% average recycled content across all plastic packaging	Development of a roadmap co-designed with businesses highlighting a route to improved food packaging design to increase recycled content across any plastic packaging forms.

The plasticity of communication: alternative forms of representing plastic

Although academic writing is the main format for research communities to communicate their findings, that format comes with certain rules and expectations concerning the authorial voice, representation of meaning and delivery of conclusions and segmented knowledge that may make it inaccessible to those outside of the discipline. Knowledge sharing is therefore restricted if we rely solely on conventional forms of representation, particularly when that knowledge relates to objects, experiences and affects that people face in many pre-cognitive, habitual or largely 'invisible' ways in the messiness of everyday life (Hill *et al*., 2014).

In recognising the limits of relying on conventional academic

writing alone, we made a conscious effort to include alternative forms of representation in the *Little Book of Plastics in Everyday Life*. Our interdisciplinary team includes voices across the entire gamut of research philosophies, from the empiricism of polymers chemistry, through the critical realism of supply chain management, to the non-representational and interpretivist accounts of socio-cultural consumer and post-consumption research. To reach common ground, we needed modes of communication that jettison at least some elements of disciplinary-specific language and style. Accordingly, we invoke several modes of communication, each encouraging reflection on the key issues relating to plastics. These include poetry, a photo-essay and a 'playlist of plastic' – a musical breakdown of how plastic has been represented in popular culture.

First, we include our poem, *Hidden*, which reflects the sheer inescapability of plastics in packaging. Beyond the transparent and inconspicuous plastic packaging that we might consider to be obviously 'hidden' through self-concealment (for allowing visibility of core products such as soft drinks, fresh meats, salads etc.), plastics also lurk in plain sight in bottle and jar tops, wine corks and the painted graphics on cardboard boxes. By placing stylistic attention on the furtive omnipresence of plastics, *Hidden* ventures to move past the stilted descriptions that literal language – academic language especially – frustrates us with. "Poetry thrives on the margins of knowledge," Sherry and Schouten (2002, p.223) argue, "where literal meaning must be stretched; poetry draws its power from our need to live 'beyond our intellectual means'". *Hidden*, we hope, will allow readers to *feel* and *get to know* plastics before we move onto a more conventional narrative of plastics.

In 'A (very) brief history of plastics', we offer a short whistle-stop tour of plastics' storied history over human civilisation, highlighting the important role that plastics played in 20th century technology, style, convenience and the political flexing of innovation.

In 'What's in a name?', we provide a breakdown of some of the key

terminology in polymer science and sustainability efforts. Language of all kinds has the power to influence and shape ideas and inspire change but, when it comes to plastics, language becomes a key sticking point. Plastics have a wider meaning than is usually understood in everyday life, and we discuss the importance of specificity when dealing with the intersection of plastics and sustainability, relying on key definitions and terms.

Next, we provide the 'Plastic in Music' playlist which gives readers the opportunity to consider how plastics have come to be spoken and heard about in popular culture, being a dominant theme for commentary and critique in music over several decades.

What follows is 'Supply Chains at the ready?', which comments on the urgent need for cooperation and commitments across the full breadth of supply chains and beyond. We show the problems of taking a short-sighted view and placing sole responsibility on the shoulders of consumers and we discuss the opportunities for policy, manufacturers and retailers to legitimise new forms of 'circular' economic behaviours.

In 'Getting to know what's what', we give the reader an opportunity to take stock of some of the common plastics they encounter in their everyday lives and provide a visual breakdown of what certain symbols on packaging mean.

Finally, we present a photo-essay of plastic that offers readers a visual glimpse of plastic waste and littering in contemporary consumer culture. Then, we present the poem 'What we take from the earth.' Both the photo-essay and poem invite readers to develop their own interpretations by drawing upon their personal experiences and engagements with plastics in everyday life. We end with a short conclusion.

Altogether, we hope you will find these materials useful for contending with the multi-faceted character of plastics – invoking their objective material benefits that have made them so normalised but also the uniqueness of their political and environmental effects.

Hidden

Take care,

in those neon palaces.

They hide it so well, so cleverly

In jars and bottles, and cardboard boxes.

Fools me!

Maybe it's easier than I think,

although I found it hard, this austerity in affluence.

I tried, I really did,

to crack the code, find the key.

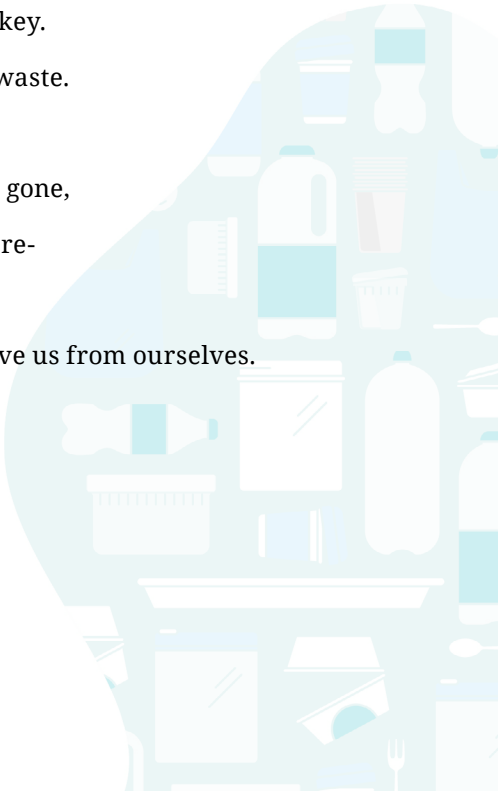
Ditch the plastic, stop the waste.

But the greengrocers have gone,

and that stuff is everywhere-

it's a convenience world.

And we have no time to save us from ourselves.



A (very) brief history of plastics

Today's Plastic Age is defined by contemporary synthetic 'petro-based' polymers, but the category of plastics has a much longer history. Ancient civilisations had long made use of what might be considered *natural* plastics; materials that are malleable during manufacture or use and do not require extensive chemistry knowledge or industrial processing. Mayans, Olmecs, Aztecs and other Mesoamerican cultures were known to fashion rubber balls, bands and sandal soles from the raw latex and resources sourced from local trees (Tarkanian and Hosler, 2011). Ancient Egyptians used resins extracted from plants as a lacquer for sarcophagi, and Ancient Greeks crafted jewellery from amber, a fossilised tree resin (Bijker, 1987). Horn, bone and antler are all 'natural' forms of plastic that were used in the manufacture of various wares and utensils for the medieval household across the British Isles and Europe. Being non-flammable and more durable than glass, thin transparent panes (or 'leaves') of horn were used for metal-framed 'lanthorns' (lanterns) (MacGregor, 1991).

Although semi-synthetic celluloid-based plastics were introduced in the 19th century as substitutes for finite luxury materials like ebony, ivory, pearl and agate, and found application in the manufacture of film for photography and the burgeoning moving-pictures industries, it was not until the early 20th century that chemical

research became committed to the synthetic polymers that are so widespread today. Fully synthetic petro-based polymers came about between the 1920s and 1940s. In the textiles industry, nylon, admired for its ability to emulate natural fibres, became "the next best thing to silk" (Suggitt, 1997, p.127) and was enthusiastically taken up as a popular and affordable alternative to traditional fabrics. With the early 20th century arrival of Art Deco design sensibilities and the aerodynamic aesthetics of a machine-age, the stage was set to take full advantage of synthetic plastic moulding technologies to produce a range of consumer goods including, kitchenware, bases and sockets for light bulbs, telephones, jewellery, furniture and domestic appliances.

The mass production of synthetic polymers for wartime economies (1939–1945) found continued and expanded application in the post-war decades. Consumer appliances, streamlined automobiles, electronics and mass-merchandised packaged goods all exploded in production numbers. The mid-century technological boom saw rivalry play out between the USA and the USSR in arenas where synthetic plastics research and innovation featured prominently. In terms of industry, the intensive East German plastics programme drove forward plastics' practicality while, on the consumption side, promotional photographs such as Soviet model Mila Romanovskaya posing in a futuristic nylon one-piece suit next to a Vostok space capsule show one side of the historic competition dubbed the 'Nylon War' (Pavitt, 2008, p.29). In the USA and the UK, plastics became the ideal symbol for hedonism and pop culture, synonymous with throwaway lifestyles and celebrated for their convenience and disposability (Cronin *et al.*, 2022).

Plastics today continue to play an important role in the electronics and automotive industries, in fashion, food, pharmaceuticals and medicine, art, fast moving consumer goods, transport, aeronautical advances and many domains of contemporary consumer culture. Next, we look at the nomenclature that underpins the ubiquity of plastics.

What's in a name?

In a classic line of dialogue from Shakespeare's *Romeo and Juliet*, Juliet asks of Romeo "What's in a name? That which we call a rose / By any other word would smell as sweet" (Act 2, Scene 2). If, however, Juliet was to ask the same of a botanist, that expert might enquire as to which rose she speaks of, as there are hundreds of *species* (a type/kind of thing) and thousands of *cultivars* (a cultivated variety of a plant species or hybrid of two species) that can and will vary in scent, appearance, colour, size, etc. The important issue for the botanist in terms of replying to Juliet's query centres on scientific nomenclature (a system of names/terms and/or rules for composing assumptions, questions and answers in a particular field of interest). By navigating the boundaries of the query using the appropriate nomenclature, the botanist might caution Juliet that the Persian yellow rose (*Rosa foetida*), in fact, smells quite bad and might advise that she reframe her initial assumption.

As outlined in the opening of this book, plastics present solutions to the world's problems yet simultaneously create problems. One source of problems is the nomenclature of the chemicals used to produce plastics and/or products and packaging composed of plastics. Colloquially, 'plastic' or 'plastics' are often used as catch-all terms to describe all 'polymer'-based materials, which – while commonly understood – can reduce the specificity of queries, complicate answers, demonise unproblematic materials and ultimately slow down the introduction of solutions. However, the more specific we try to get, the more we are left with specific questions like what are polymers? And how are polymers related to plastics?

The International Union of Pure and Applied Chemistry (IUPAC) is the world authority on chemical nomenclature and defines plastic as a "[g]eneric term used in the case of polymeric material that may contain other substances to improve performance and/or reduce costs" (Vert *et al.*, 2012, p.394), noting that using the term 'plastic' instead of 'polymer' is a source of confusion in technical circles, and is therefore not recommended for use in expert analyses. The IUPAC defines a polymer as a "[s]ubstance composed of macromolecules" (p.394) and define a macromolecule as a "[m]olecule of high relative molar mass, the structure of which essentially comprises the multiple repetitions of units derived, actually or conceptually, from molecules of low relative molar mass" (p.392). As you can see, with the emergence of follow-on terms like 'molar mass', 'units' being derived, the split between 'actually' and 'conceptually' etc., things begin to get very technical very fast. Defining one term inevitably seems to introduce another. To try and simplify this, in the next section, we provide a practical overview of how polymers are made.

Where do polymers/plastics come from?

Most of the polymers that people refer to as 'plastics' are, in fact, synthetic 'petro-based polymers'. The class of petro-based polymers are derived from fossil fuels that form underground over millions of years by the decomposition of the dead remains of organic matter such as animals and vegetation. As described by the author John K. Mumford nearly one hundred years ago in his book about the first petro-based polymer, Bakelite: "[i]t is a wonder-stuff, the elements of which were prepared in the morning of the world, then laid away till civilization wanted it badly enough to hunt out its parts, find a way to put them together and set them to work" (Mumford, 1924, p.7). In extracting and refining fossil fuels like crude oil and natural gas, the basic ingredients (monomers) – or 'feedstocks' – for petro-based polymers are accessed, which are subsequently treated through chemical processes known as polymerisation. Like all applications of fossil fuels however, the processes are reliant on finite resources

and are not the cleanest or most sustainable source of growth for civilisation.

Other sources of chemical feedstocks exist, including chemicals derived from non-fossilised contemporary biomass, whether animal-, forestry-, marine-, or plant-based sources. These are used to produce 'bio-based polymers'. It is also possible to extract what are known as 'biopolymers' directly from biomass (e.g., cellulose, lignins, leather, silk, starch, gutta-percha). In relation to these, IUPAC identifies the catch-all term 'bioplastic' used in everyday life but notes that this term has the potential to mislead because it is often used with the inferred meaning that any polymer derived from biomass is more environmentally friendly, which contradicts the fact that fossil resources are also a product of biomass. That is why the use of the term 'bioplastic' is discouraged by the IUPAC who suggest that the term 'biobased polymer' should be used instead, similar to petro-based polymers.

Polymers from the various sources are processed into resins which can be mixed with additives (e.g., fillers, plasticisers) to impart specific properties (colour, flexibility/strength, opacity/transparency, etc.) and are melted, cooled and fashioned into very small industry-ready pre-production pellets. These tiny pellets, called 'nurdles', serve as the raw resource needed by manufacturers who use heat and moulds to shape the output into the different parts, components or housing needed to produce their products. These products may be food packaging materials, toothbrushes, trimming for motor vehicles, keyboards for computers and so on and so forth.

Polymers/plastics and the environment

There are a variety of initiatives to help with the reduction of plastic in the environment, such as encouraging and enabling the reuse, recycling or composting of our plastic waste. However, the nomenclature related to some of the specifics of refuse management, recycling and recyclability can be as complicated as the chemistry of

polymers. It is therefore useful to provide a brief overview of some key terms about plastic waste, litter and how long they 'last' in the environment.

Waste is defined as the material which is left over after production or consumption that has no value in normal, ordinary use and is undesirable, or something we want to dispose of. A key marker of how long waste lasts is its 'degradability', or its capability to degrade (i.e., break down or deteriorate) via physical and/or chemical changes of some of its properties by being in the environment. Various types of degradative processes exist (a list of definitions of some of these from IUPAC is summarised in Table 2). Importantly, while 'biodegradable' polymers are degradable (i.e., broken down either biologically or chemically), not all degradable polymers are biodegradable (i.e., broken down by bacteria or other organisms), and polymers made from biomass-based feedstocks (i.e., non-fossil-fuel-based feedstocks) are not necessarily degradable. The continual evolution of the English language means that new terms are coming into use that may not yet be IUPAC-approved. Haram *et al.* (2020) in their journal article A Plasticene Lexicon provide us with a useful breakdown of the specialist terminology and new words associated with the study of environmental impacts of plastic (examples of which are summarised in Table 3).

Table 2. **Examples of IUPAC terminology for waste and degradation processes**[1]

Term	Definition
Litter	"Solid *waste* carelessly discarded outside the regular garbage and trash collection" (p.405).
Sustainability	"Developments that meet the needs of the present without compromising the ability of future generations to meet their needs" (p.406).
Environmentally degradable polymer	"*Polymer* that can be degraded by the action of the environment, through, for example, air, light, heat, or microorganisms" (p.404).
Biocompatibility	"Ability to be in contact with a living system without producing an adverse effect" (p.382).
Biodegradability	"Capability of being degraded by biological activity" (p.382). i.e., by the activity of cells, organisms, and/or microorganisms.
Thermal degradation	Degradation by "the action of heat or by the combined effect of chemical agents and heat" (p.387).
Photodegradation	Degradation "by visible or ultraviolet light" (p.387).
Oxidative degradation	Degradation "by the action of oxygen or by the combined action of light and oxygen" (p.387).
Hydrodegradation	Degradation "by the action of water" (p.387).

[1] All definitions sourced from Vert *et al.*, 2012.

Table 3. **Examples of non-IUPAC terminology for waste and the environment[2]**

Term	Definition
Plastitrash	"[G]arbage, litter, debris or other waste material made of any type of plastic material" (p.2).
Plastic confetti	"[S]mall, 'multi-colored fragments' of plastic … formed by the degradation of larger plastic pollution" (p.2).
Plasticene	"[A]n era in Earth's history, within the Anthropocene, commencing in the 1950s, marked stratigraphically in the depositional record by a new and increasing layer of plastic" (p.2).
Plasticized	"[M]ade abstractly plastic by the proliferation of plastic pollution in the environment" which "points to human behavior having plasticized animals, through their ingestion of or entanglement in plastic litter" (p.2).
Plastivore	"Any organism that ingests, processes, and regurgitates or defecates plastic materials" (p.2).
Epiplastic	"Living on floating plastic" (p.2).
Plastisphere	"The living microbiotic … and macrobiotic community colonizing plastic" (p.2).

Closing thoughts

It is important to recognise the language used to describe materials and its impact on our ability to address the 'grand challenge' of waste management in society. Just like roses, there are many varieties of polymers/plastics and, consequently, rigorous life cycle assessments undertaken by impartial regulatory bodies may be necessary to understand the environmental impacts of each individual polymer/plastic product and the most effective methods to reduce/recycle/compost them.

[2] All definitions sourced from Haram *et al.*, 2020.

Plastic in music: A playlist

> *"A Pop person is like a vacuum that eats up everything, he's made up from what he's seen. [...] And that's why people are really becoming plastic; they are just fed things and are formed."*
> *(Warhol, 1966 as cited in Suggitt, 2020 pp.166–167)*

Besides the material meanings of the word and its complex systems of nomenclature, 'plastic' has, since at least the 1960s, been used colloquially to signify cheapness, artificiality, a lack of authenticity or some general connotation of a consumerist society. As the opening quote by the pop artist and filmmaker Andy Warhol suggests, plastic lends itself particularly well as a metaphor for the insatiable, manipulable desires of people to be 'fed' things and to be 'formed' within the popular mainstream. Warhol channelled his commentary on what he considered to be an increasingly plasticised material culture through his unapologetically visual "Exploding Plastic Inevitable" (EPI), a series of shifting, concert-cum-intermedia art performances which toured across the United States in 1966 and 1967. The EPI spectacle intersected psychedelic light shows with screenings of Warhol's films, sporadic dancing, and live music by *The Velvet Underground* for the aim of subverting conventional forms of artistic expression (Joseph, 2002).

In the specific context of music, around the time of the EPI, plastic was increasingly becoming drawn upon lyrically to suggest ambiguity, fluidity and creativity, but also the dehumanising effects of consumer culture's artifice and lack of roots. The 'Plastic in Music' playlist that follows is a collection of fourteen tracks from various

artists and bands which invoke the word plastic in their title and lyrics. The playlist highlights the ambiguous use of plastic in music and popular culture. It moves chronologically through *Captain Beefheart*'s "Plastic Factory" and *Jefferson Airplane*'s "Plastic Fantastic Lover" of the countercultural 1960s to *Radiohead*'s "Fake Plastic Trees" and beyond. With this playlist we invite readers to step away from the academic writing of this book and engage with plastic in a *non-representational* manner (Hill *et al.*, 2014). By immersing yourself in the sound journey of an increasingly plastic-driven consumer culture, it becomes possible to fully internalise the impact of plastics on daily life. Please start that journey by navigating the playlist's titles below and listening to the mixtape here: https://www.mixcloud.com/ppiplproject/plastic-in-music/

SIDE A

1. Captain Beefheart & His Magic Band **/Plastic Factory** (1967)
   © Buddha Records
2. Jefferson Airplane **/Plastic Fantastic Lover** (1967)
   © BMG Heritage
3. The Kinks **/Plastic Man** (1969)
   © Sanctuary Records Group Ltd., a BMG company
4. The Cure **/Plastic Passion** (1980)
   © Fiction Records Ltd.
5. Galaxie 500 **/Plastic Bird** (1989)
   © 20/20/20
6. Radiohead **/Fake Plastic Trees** (1995)
   © XL Recordings Ltd.
7. Sonic Youth **/Plastic Sun** (2002)
   © Geffen Records

SIDE B

1. Miike Snow **/Plastic Jungle** (2009)
   © Miike Snow under exclusive license to Sony Music Entertainment UK Ltd.
2. Gorillaz **/Plastic Beach** (2010)
   © Parlophone Records Ltd.
3. Low **/Plastic Cup** (2013)
   © Sub Pop Records
4. New Order **/Plastic** (2015)
   © New Order under exclusive license to Mute Artists Ltd.
5. The Charlatans **/Plastic Machinery** (2017)
   © BMG Rights Management (UK) Ltd.
6. U.S. Girls **/Rage of Plastics** (2018)
   © 4AD Records Ltd.
7. King Gizzard & The Lizard Wizard **/Plastic Boogie** (2019)
   © Flightless Records

Supply chains at the ready?

Although plastic packaging waste is created at every stage in supply chains, it mostly becomes visible to society at the point that it reaches the consumer, who then becomes responsible for disposing of their post-consumption waste. Images of littering, fly tipping and discarded single-use plastics (such as those in our photo essay that follows) are certainly capable of inciting outrage toward the personal irresponsibility of consumers. However, the issue is much more complex than that. The grand challenge of achieving a sustainable waste management infrastructure is only possible if organisations and participants at all points of the supply chain shoulder some of the burden. The onus cannot remain with consumers but must be met with systems-wide efforts that facilitate the 'reverse logistics' of plastic. Bing *et al.*, (2014, p.121) define reverse logistics as "the process of planning, implementation and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal". Reverse logistics, when upheld across the entire breadth of supply chains, provides the basic operating conditions for a 'circular economy', which advocates for production and consumption systems that are intended to be restorative and regenerative. A circular economy is only conceivable when the logic of supply chain management moves from extractive or 'linear' (take → build → consume → dispose) to regenerative or 'circular' (take → build → consume → recover) designs.

In recent decades, supply chain participants' focus has been on reducing the amount of packaging material by transitioning to light-weighting, using less material, and removing packaging at the source. In line with the circular economy though, there has been a more contemporary emphasis on reverse logistics via 'refill and reuse' solutions as an alternative to one-way plastics (i.e., single use plastic packaging intended to be discarded after use) (Mahmoudi and Parviziomran, 2020). Nevertheless, industry norms can be disjointed, and fail to transfer across some product categories or to inspire a wider behavioural change amongst consumers. In alcohol distribution, for instance, reusable glass bottles have long been an accepted norm across the on- and off- trade in most countries while, for the soft drinks industry, single-use PET plastic bottles are the dominant packaging. Coelho *et al.*, (2020, p.8) highlights this conflict as an "interplay of the assessment of economics (e.g., breweries & distilleries find reusable bottles cheaper, while the soft drinks industry asserts the opposite), cost distribution, organizational barriers, marketing, retailer relations, industry and national cultures, as well as regulation and policy". Care should be given especially to "regulation and policy" because, without government intervention, research suggests it would be challenging to transition from recycling to the more sustainable ethos of reuse (Kunamaneni *et al.*, 2019).

Who's steering the ship?

The responsibility for normalising supply chains that are fully integrated with circular economy principles is not down to the leadership of any single 'captain' of sustainability but is intrinsically linked to the joint efforts of multiple stakeholders. Policy has a key role in identifying, regulating and incentivising industry to conform to reusable and recoverable packaging formats via deposit and return systems, while building public norms with regards to consumer reuse behaviour. Responsibilities lie with manufacturers too, who must commit to providing reusable and recoverable pack-

aging and impart strong and persuasive messaging to consumers via informative brand claims concerning sustainability and green values. Retailers are in a unique position to communicate to consumers the message to reuse and return packaging at key contact-points with manufacturer-branded packaged goods. National supermarket chains have the potential to assist and expedite a mass behaviour shift as, collectively, they have the scope and marketplace footprint to make reuse, refill and return facilities accessible and convenient to consumers, and they have the influence to undo ingrained shopping habits which might stop people using those facilities.

For those in the supply chain, there are many questions. Does it matter who creates plastic waste? What are the risks and costs we face for discontinuing single-use plastic? What happens if the end-user is not 'on board' with reuse? If we make the change, will our competition do the same? Who are we doing this for? Shouldn't this just be a problem for consumers?

Whatever the answers are, the fundamental question is: if the need is put upon us, as a society, to go single-use plastic free, are the many and complex supply chain structures at the ready? The finite world is an ever-evolving ecosystem in which all of us play a part – an imperative for all of us is to ask, what part do we wish to play?

Getting to know what's what

As readers must appreciate by this point, plastics are varied, diverse and complex. Once we break past basic categories like natural and synthetic, and petro-based versus bio-based polymers, and we side-step all the attached meanings, baggage and caveats, we are still only scratching the surface. The consumer marketplace is awash in tongue twisting types and variants of plastics including, but not limited to, polyethylene, polypropylene, polyvinyl chloride, polystyrene and bio-polyethylene. The language of polymers and its alternatives can be overwhelming. As a useful guide, we have prepared the following tables of some common types of plastics to make the meanings of plastic accessible in everyday lives. The first column shows a triangular icon of arrows which indicate that the substance is recyclable, and its number serves as an identifier.

Table 4. **Plastic polymers and materials**

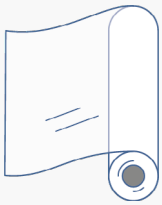
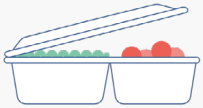
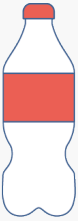
ASTM International Resin Identification Coding System (RIC) & name of polymer	Applications	
POLYETHYLENE TEREPHTHALATE (PET) 	PET is typically used in the manufacture of bottles for many carbonated soft drinks, fruit juices and water. It is popular for packaging salad dressings, cooking oils and honey in squeezable bottles etc.	
HIGH DENSITY POLYETHYLENE (HDPE) 	Thicker, more rigid and more durable than PET, HDPE is used for packaging milk bottles, bleach, detergents, some food storage containers and some shampoo bottles.	
POLYVINYL CHLORIDE (PVC) 	PVC is used for a range of food packaging applications, including bottles, clamshell punnets, trays for fresh fruit and some vegetables, blister packaging for medication, and cling film.	
LOW DENSITY POLYETHYLENE (LDPE) 	Given its flexible qualities, LDPE is commonly used in the manufacture of bin liners, carrier bags, frozen food packaging and squeezable bottles.	
POLYPROPYLENE (PP) 	PP is commonly used in packaging for margarine and butter tubs, yoghurt pots, ready-made microwavable meal trays and first-aid products.	
POLYSTYRENE (PS) 	PS is used for some food packaging such as egg cartons, yoghurts and disposable meat trays, hot drinks cups and takeaway meals.	

Table 5. **Bio- and bio-compostable plastic materials**

ASTM International Resin Identification Coding System (RIC) & name of polymer	Applications	
POLYLACTIC ACID (PLA) 7 OTHER	PLA can be used in the manufacture of disposable cups and flexible films to seal fresh food products, bottled water and juices, yoghurt containers, lunch boxes and teabags.	
POLY-HYDROXYAKANOATE (PHA) 7 OTHER	PHAs can be processed into various household and foodservice applications including films, trays and coatings on other bio-based materials (e.g. paperboard).	
POLYBUTYLENE SUCCINATE (PBS) 7 OTHER	PBS can potentially be used for the manufacture of food and cosmetic products packaging, including boxes and coffee cups, because of its good resilience.	
POLYSACCHARIDE DERIVATIVES 7 OTHER	With their impressive film-forming and gel-forming properties, polysaccharides can be used in the manufacture of thin membrane-films, including edible films and aerogels for packaging various foods.	
BIO-POLYETHYLENE (BIO-PE) 7 OTHER	Bio-PE has the same chemical composition as conventional petro-based PE and can find application in both rigid and flexible food and drinks packaging, such as bags, films and bottles.	
BIO-POLY ETHYLENE TEREPHTHALATE (BIO-PET) 7 OTHER	Bio-based polyethylene terephthalate can potentially be used in the packaging of food, cosmetic, and pharma products, and the bottling of a wide range of liquids including soft drinks, alcoholic beverages and cooking oils.	

A photo-essay of plastic

> *"To collect photographs is to collect the world [...] Photographed images do not seem to be statements about the world so much as pieces of it, miniatures of reality that anyone can make or acquire."*
> *(Sontag, 1977, pp.3–4)*

Photography is considered a well-established research method in the field of visual anthropology and, in recent years, has gained traction as a useful mode of presenting empirical phenomena in other academic fields and areas of study (Ozanne *et al.*, 2013). Visual methods are consistent with what are known as 'non-representational approaches' to research which discourage prescriptive authoritative analyses. Rather than try to impose one 'correct' interpretation on the reader, non-representational research leaves room for the reader's interpretation also.

Non-representational research is built on what Phillip Vannini calls "experimental originality" and aspires "to make us feel something powerful, to give us a sense of the ephemeral, the fleeting, and the not-quite-graspable" (Vannini, 2015, p.6). Photography works well as a form of non-representational research as it concentrates on the ephemerality of events: contexts caught in time and place, happenings and how they unfold, and requires some level of work to be made sense of. Any given event – including its location, temporality, objects, characters, politics and consequences – is much more nuanced, meaningful and complicated than we ever give it credit for. To commit to a single exclusive narrative around an event does an

irrevocable injustice to the many things that must have happened for it to take place. Even the most mundane of events – a plastic bag floating through the wind, an abandoned coffee cup lid on a park bench, a rubbish bag bursting out of a bin – is the confluence of conditions, conscious or unconscious choices, junctures, mishaps, proceedings, predicaments, habits, coincidences, chances, care or a lack of care. Some events might, at first glance, appear inherently dreary or asinine, but all have some consequence, however minute and, to draw a summative judgement of what is going on and attempt to explain the situation away inevitably omits the wicked complexity of the situation.

In sustainability-related research, the capacity for photography to enable us to pause and reflect on the complexity of a single event as frozen in time allows readers to truly understand and reach their own conclusions about the contingency of acts and circumstances that give rise to outcomes and what alternative futures might look like. Here we invite you to peruse a short photo-essay of plastics. We provide, with only basic contextualising information, seven photographs taken in various settings and contexts at different times which capture plastic waste in society today. Each is mundane and commonplace, but that is the point. Only by making sense of the ordinary can we ever hope to make sense of the systemic.

We urge you to consider each photo carefully and with patience, asking yourself questions such as: What do you see going on? Why do things look the way that they do? What must have happened for things to appear that way? Who is responsible? What could have been in place for things to appear differently? Have you seen these events before? Will you see these events again? Why or why not?

1. After a live music gig.
   Manchester, UK (2020).
   Photo by
   Alex Skandalis.
2. My festival is more 'wasteful' than yours.
   London, UK (2016)
   Photo by Alison
   Stowell.
3. The spatial 'politics' of the litter bin.
   Manchester City
   Centre, UK (2019).
   Photo by
   Alex Skandalis.
4. The aftermath of a summer day's picnic.
   Richmond, UK (2021).
   Photo by Marta Ferri.

5 Marine pollution on the beach.
Sandsend, UK (2021).
Photo by Marta Ferri.

6 (Un-)sustainable behaviour on a summer day.
Kythnos, Greece (2021).
Photo by Alex Skandalis.

7 Nature versus culture.
Kythnos, Greece (2021).
Photo by Alex Skandalis.

What we take from the earth

What we take from the earth,

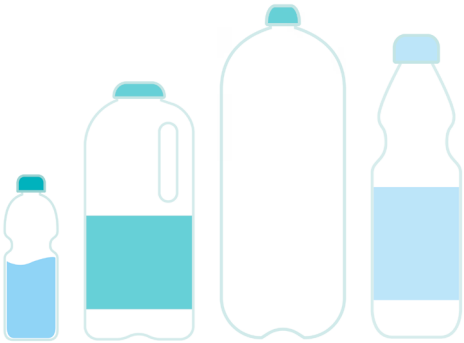
Maybe leaves no chance to save ourselves.

Our hunger tangles us in polymer chains,

we lie in grey despair.

But we must leave this mental bondage,

The stakes here are too high, there's no time.



Conclusion

This contribution to the Little Books series sought to offer a condensed and nuanced overview of society's most commonplace and versatile category of materials, plastics. Few materials are so widespread or in possession of such diversity of form and meaning that they feature in industrial chemists' debates about nomenclature as much as they do in the song lyrics of musical artists. We sought to capture that breadth of representation in the *Little Book of Plastics in Everyday Life* without attempting to arrive at definitive solutions or firm recommendations. As stated from the outset, this short book is about fostering critical curiosity and inviting novel and inspiring questions rather than trying to answer those that have already been asked and might continue to be asked. We know that plastic will continue to infiltrate and shape our daily lives. That inevitability requires a breadth of inventive perspectives which do not just respond to current knowledge gaps, but reveal the looming threats of future challenges, and will unlock opportunities to transform how plastics are made, seen and thought about. From the oceans to our lungs, plastic waste is found everywhere and represents a burden that must be dealt with urgently and creatively by a diversity of actors within and beyond supply chains. More information about the PPiPL project can be found at https://www.lancaster.ac.uk/ppipl/.

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