THE NEW PLASTICS ECONOMY

September 2020

BAILLIE GIFFORD

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The undernoted table shows which examples from this paper were held by Baillie Gifford at June 30, 2020.

Baillie Gifford Positive Change Equities Fund Top Ten Holdings as of September 30, 2020

	Holdings	Fund %
1.	Tesla Inc	9.46
2.	M3	6.30
3.	TSMC	5.81
4.	ASML	5.02
5.	Dexcom	4.79
6.	Kingspan Group	4.70
7.	Illumina	4.12
8.	MercadoLibre	4.09
9.	Teladoc	3.94
10.	Moderna	3.52

It should not be assumed that recommendations/ transactions made in the future will be profitable or will equal performance of the securities mentioned. A full list of holdings is available on request. The composition of the fund's holdings is subject to change. Percentages are based on securities at market value.

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SEPTEMBER 2020

THE NEW PLASTICS ECONOMY

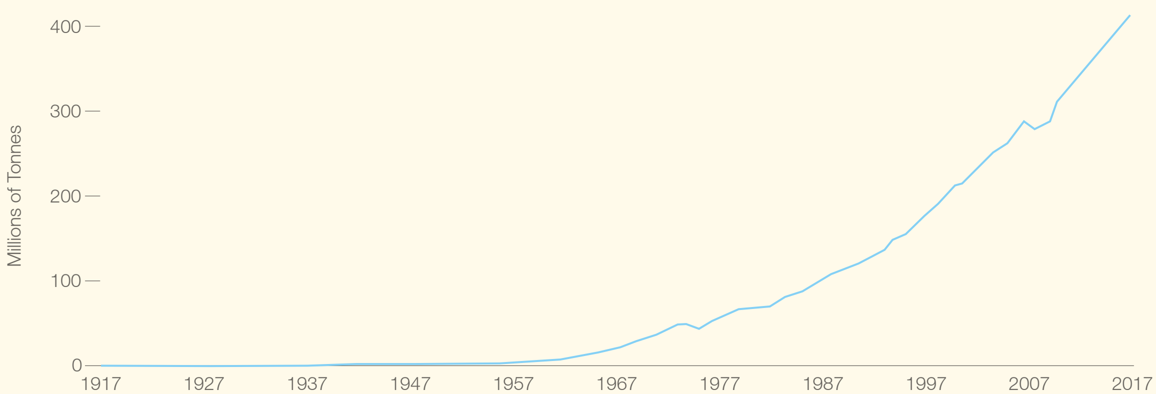
POSITIVE CHANGE TEAM

With plastics production set to double in the next 20 years and almost quadruple by 2050, the Positive Change Team considers whether a circular plastics economy could be the answer and what investment opportunities it might bring.

It would be hard to imagine modern life without plastics.

It would be hard to imagine modern life without plastics. Their low cost, versatility, durability and strength-to-weight ratio has made them a go-to material in packaging, construction, transportation, healthcare and electronics. Plastics are used in everything, even making up about 50 per cent of the weight of a Boeing Dreamliner plane and plastic's share in packaging increased from 17 per cent in 2000 to 25 per cent in 2015. Nor are we at peak plastic, global demand continues to grow, despite the 20-fold increase in plastic production between 1964 and 2018. In 2018, 360 million tonnes of plastic were produced, weighing more than the total mass of humans living on earth.

Global plastic production, 1917 to 2017



Source: https://www.darrinqualman.com/global-plastics-production/

WASTE NOT, WANT NOT

Plastics are not the problem, but plastic waste is. Plastics don't break down on their own, incinerating them is inefficient and harmful for the environment, we lack the infrastructure to recycle them effectively and we are consuming them in ever-increasing quantities.

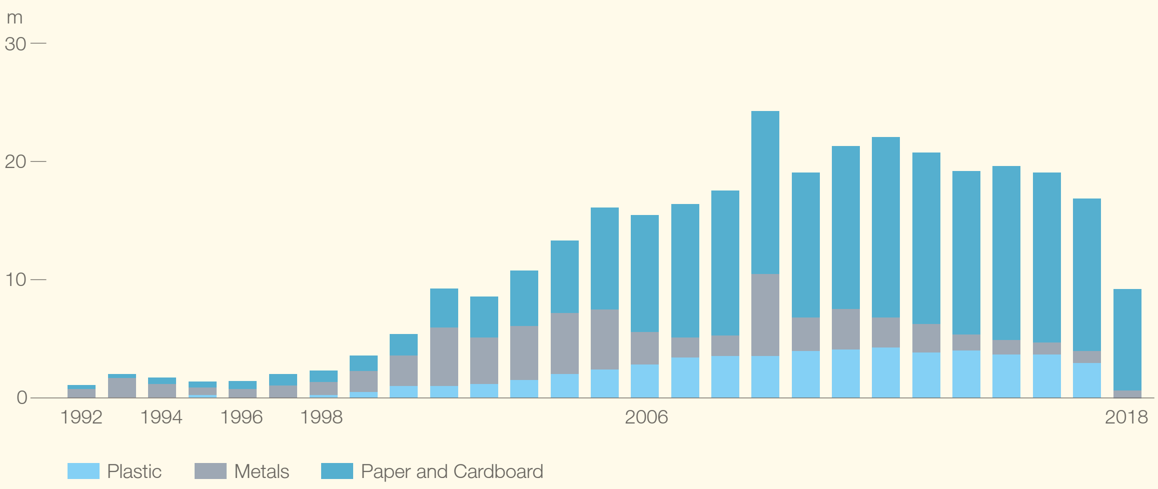
Where does all this plastic end up? Approximately 40 per cent accumulates in landfill and 32 per cent 'leaks' out of the collection system (meaning it is either not collected or is illegally dumped). Discarded plastics accumulate in our environment, as both bulk waste and omnipresent microplastic waste, causing harm to both human and animal health and the environment. The packaging recycling rate (14 per cent) is well below that for paper (58 per cent) and iron and steel (70-90 per cent). Ninety-five per cent of the material value of plastic packaging is lost to the economy, often after only one use. What is more, packaging plastics that do get recycled are mostly down-cycled into low-grade applications, such as toys and car-seat stuffing.

This is unsustainable. To prevent the ever-increasing accumulation of plastic waste, we need a 'closed loop' system or circular economy, where plastic remains within the economy, is re-usable in higher-grade applications infinitely and does not become waste.

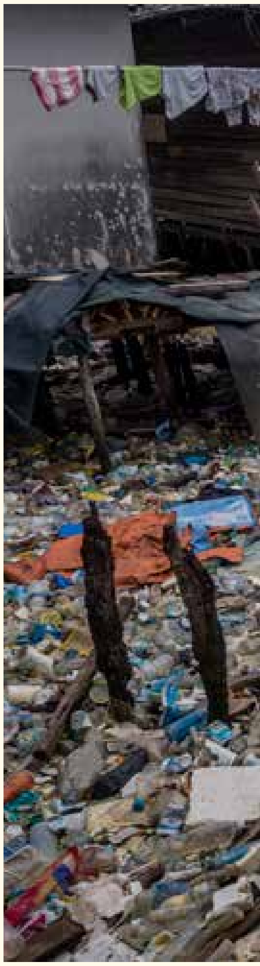
TURNING AROUND

The mismatch between the areas that get polluted by plastic waste – the big Asian rivers and the world's oceans – and where the waste is generated, is likely to force a change in habits. After importing nearly half of the planet's plastic recyclables for three decades, China barred the import of most residential recyclables in 2017 as part of its efforts to clean its environment and improve quality of life.

Total weight of scrap material imported by China, each year, in metric tonnes



Source: UN Statistical Division.

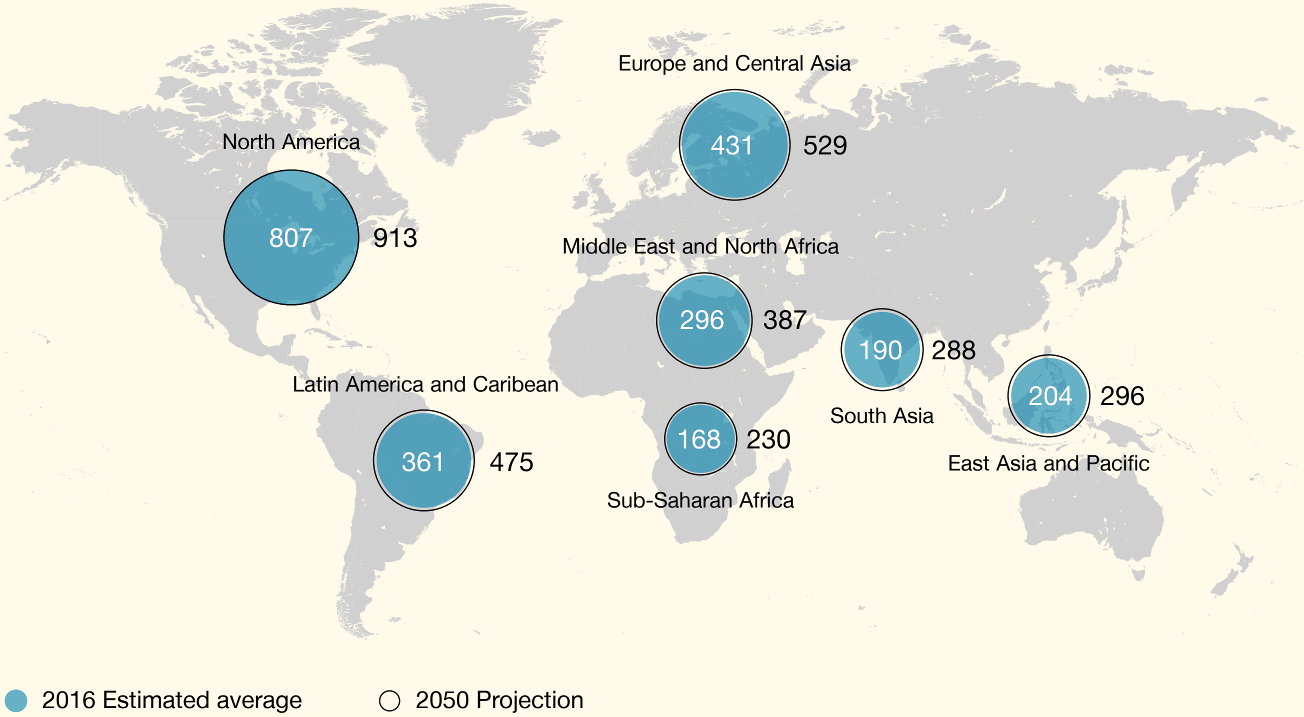


Initially, this led to a spike in waste flows being diverted to alternative export destinations, primarily in South East Asia. However, this can only be a temporary fix, given the aggressive recycling targets being set across the globe. Come 2025–2030, to meet these self-imposed targets, countries will be forced to recycle domestically. Here are some examples of the ambitious goals being set:

- China aims to reduce single-use plastic waste by 30 per cent by 2025
- Indonesia will reduce upstream waste by 30 per cent and targets a 70 per cent reduction of ocean plastic pollution by 2025
- The EU targets recycling at least 70 per cent of all packaged goods by 2030, and for household recycling rates to be 65 per cent by 2035. Single use plastics will be banned from 2021
- California has proposed a legislation to commit to a 75 per cent reduction in plastic waste by 2030
- The UK aims to eliminate avoidable plastic waste by 2024

Waste Generation is Rising Globally

Kilograms of solid waste each person creates a year



Source: Bloomberg and World Bank.

While the will to do better is certainly there, in the three years since China stopped importing waste, there has been much talk but little action. Lacking firm guidelines on how to practically meet these targets, the key stakeholders – waste management companies, the producers of low-cost consumer goods and chemical giants, recycling start-ups – have failed to find a unified solution.

Until recently, the informal nature of the market has made it difficult for individual stakeholders to establish what the supply and demand is for the newly created waste (plastics recycling) streams, and therefore establish a fair price for these services. This will change as the direction of travel becomes clearer, which it will, because in addition to the governments' commitments outlined above, the following developments since 2017 have coincided to provide the current inflection point:

— Packaging and apparel companies have made public commitments to greater recycling content, creating a market for the bulk raw material that wasn't there previously

— New recycling technologies are emerging from chemical and waste management plant operators, potentially offering a high return on investment

— Consumer awareness and willingness to pre-sort household waste is growing, and the introduction of deposit return schemes on bottles is increasing the flow of pre-sorted raw materials to the recycling process

— Scientific advances in producing bioplastics and enzymes at scale to decompose plastics will put further pressure on the production of virgin, petroleum-derived plastic.

From here, we can expect to see a circular plastics economy develop, where efforts will be concentrated on recycling a larger proportion of the plastics we use and extending their life cycle through re-use. We see three big growth areas emerging: the sorting of plastics, recycling them and developing sustainable materials to replace plastic use.

OUT OF SORTS

We anticipate increasing demand and supply of recycled raw material and improving recycling methodologies for the plastics already in circulation. Optical sorting, robotic waste sorters and reverse vending machines (RVMs) are the infrastructure that will make this possible and which we could invest in directly for Positive Change.

OPTICAL SORTING

Its relative low cost, high efficiency and the ability to retrofit existing waste and recycling plants means optical sorting is key to enabling many of the more complex processes that will be needed to establish a circular plastics economy. Optical sorting makes the plastic waste recycling process more efficient. Even if we were to move to bioplastics and alternative materials altogether, we would still use optical sorting to separate our waste.

According to a McKinsey report, the volume of global plastics waste will reach 460 million tonnes by 2030 (from 260 million tonnes today), with a 50 per cent reuse/recycle rate (a four-times increase on today's figure). This would result in a $60bn profit pool growth for the sector and will propel demand for optical sorters. Estimates suggest rapid increases in sorting and recycling plants will be required to keep up with this increase in volume.

WASTE-SORTING ROBOTS

Robotic arms accurately separate chosen types of waste from solid waste streams using a high-resolution camera, a laser scanner and a metal detector. In time, these robots will be cheaper and more reliable than hiring physical labour, however, they are much less efficient and costlier today. That said, efficient industrial automation of waste sorting cannot rely solely on sensor-based sorting equipment alone, it is likely that it will need to be complemented by robots at some stages of the process.

REVERSE VENDING MACHINES (RVMS)

RVMs are an imperfect but effective solution to part of the problem – the low polyethylene terephthalate (PET) bottle collection rate. Once introduced, collection rates of plastic bottles increase significantly and permanently. In Lithuania, the collection rate increased from 44 per cent to 92 per cent, Germany's result was similar. Nordic countries, the pioneers of this system, collect over 90 per cent compared to 30 per cent in the US and less than 20 per cent in Romania and Bulgaria where there are no deposit return schemes. With most of the developed world committing to collecting and recycling plastic bottles in a closed loop, the opportunity for the installed base of RVMs is substantial. Over time, the ability to collect other forms of packaging, including cosmetics bottles, may further expand the growth opportunity, providing the necessary infrastructure is in place. There are a number of investible companies operating in this area. Whilst growth prospects relative to valuations for companies in this market don't look appealing to us at the moment, this is an area we intend to monitor over time.

RECYCLING

In order to recycle plastics effectively though, it not only needs to be separated from other materials, but then into specific polymers.

Currently most plastic waste is recycled mechanically: it is sorted, shredded, washed, melted, mixed with virgin materials and made into new plastic. Sorting must be meticulous by grade and by type (colours). A good analogy, borrowed from Ilhan Savout, is mixed colour playdough. If we imagine that different colours of playdough are different types of plastics, a recycler receives a giant ball of playdough with all the plastics squashed and mixed together, and the recycler must separate the playdough by different types of colours to turn this valueless waste stream into valuable feedstock.

The end goal of plastic recycling is to have high-grade plastic of one colour, i.e. high purity content. This is where new technologies such as chemical recycling come in.

CHEMICAL RECYCLING

A key principle of the circular economy is that products and materials are always circulated at their highest value. In the technical cycle, this implies that plastic packaging is reused when possible (circulating the packaging product), then recycled (circulating the packaging materials).

Within recycling, this principle results in a general order of preference:

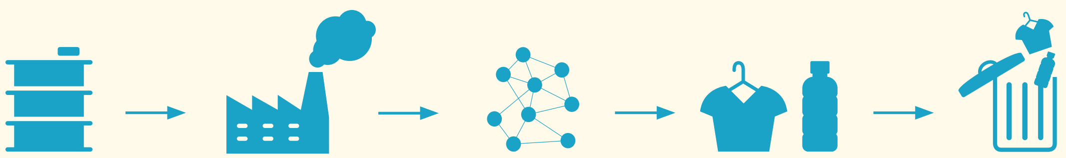
1. Mechanical recycling in closed loop (enabling technology: RVM)
2. Mechanical recycling in open loops ('cascading', enabling technology: optical sorting equipment)
3. Chemical recycling (enabling technology: depolymerisation and pyrolysis)

Mechanical Recycling	**Chemical Recycling**
Fairly mature and well-established process	Immature new process
Cheap	Expensive
Done at scale globally	Not proven in large scale commercial application
Preserves molecular structure	Splits polymer chains
Relatively environmentally-friendly process	For now, requires heat (energy) and emits CO2
Result in loss of mechanical properties over time	Requires high purity inputs but preserves quality
If part of a closed loop, it is the more 'value-preserving' option	Less value preserving due to need to de-polymerise

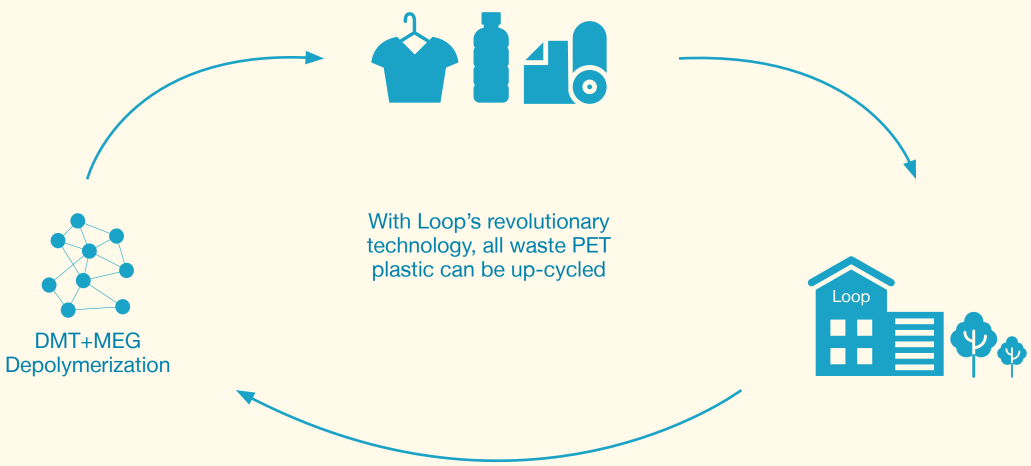
The holy grail of chemical recycling is to be able to turn degraded plastic back into high-quality plastics in an infinite loop. Moving away from our current wasteful linear economy to a circular one.

The status quo is the traditional linear economy where only ~2% plastic is recycled:

Traditional Linear Economy

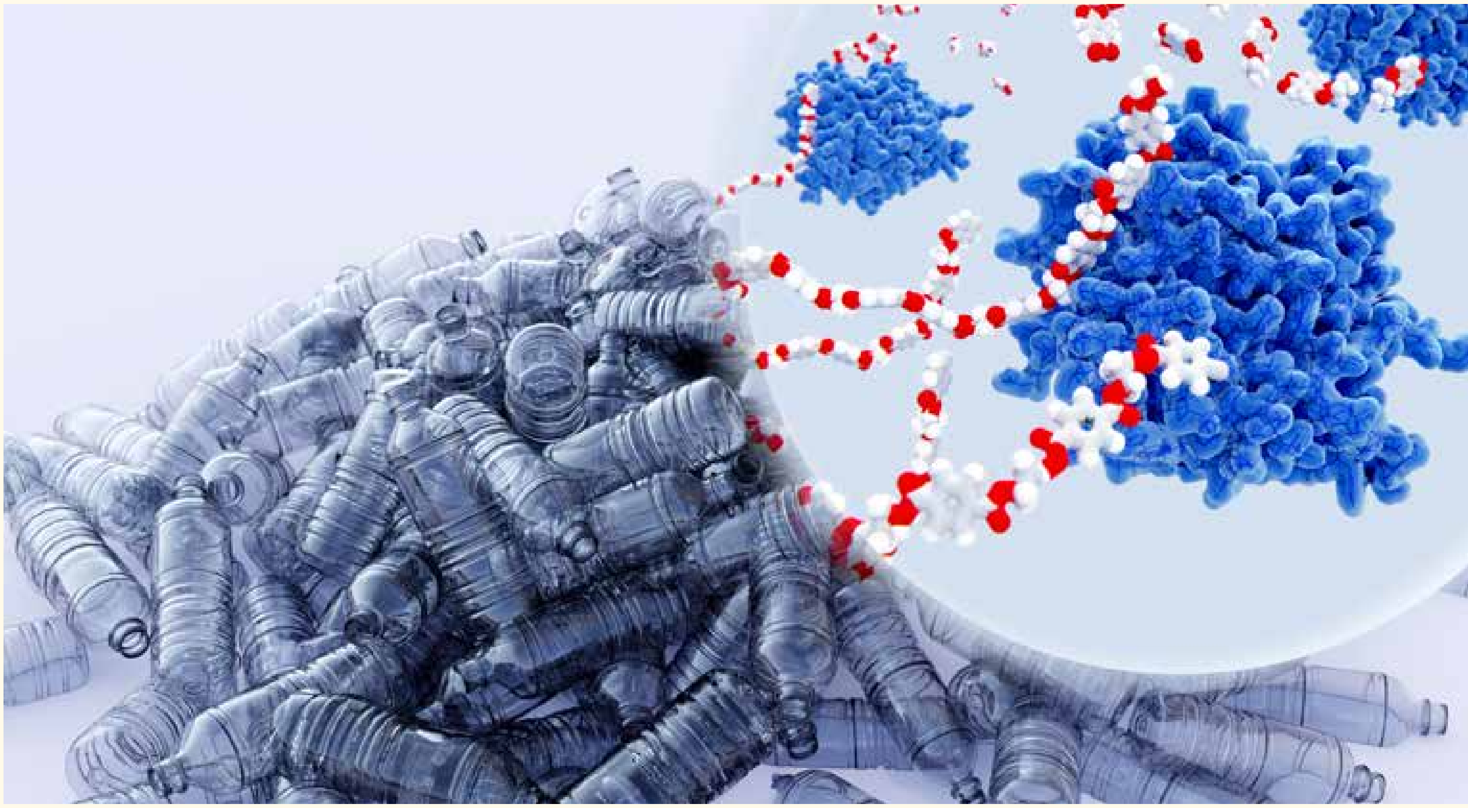


Circular Economy



Broadly speaking, there are two types of chemical recycling:

Monomer Recycling - Depolymerisation	**Feedstock Recycling – Pyrolysis**
While monomer recycling still requires pre-sorting by plastic type (sorting the playdough by colour), the 'glue and glitter' can be left in.	This involves heating up the plastic at high temperature in the absence of oxygen. It is used for lower-value plastics and the products are useful as raw materials (feedstock) for a variety of downstream industrial processes or as transportation fuels. Following the playdough analogy, feedstock recycling allows a recycler to have all the colours of the playdough still mixed and the result is a playdough that has no specific colour.



Monomer recycling is not yet commercially viable, but it is an exciting area from both a circular economy and financial perspective. First, the feedstock is of low quality which would normally be incinerated or landfilled and therefore is very cheap and, second, producing virgin-quality materials allows for higher-end applications, thereby increasing the value of the recycled output. This is why the chemical giant, Indorama Ventures, has committed to investing $1.5bn into its PET recycling capacity, investing in chemical recycling start-ups Loop Industries and Dutch ioniqa. Others are experimenting in scaling up chemical recycling plants alongside waste and chemical plants.

One exemption here is nylon, which is one of the very few polymers for which a closed-loop chemical recycling process already exists at industrial scale – but for low-end applications, including carpet scrap being depolymerised into virgin-quality material.

PLASTIC-EATING ENZYMES

Over time, microbes have evolved ways of breaking down natural materials by digesting them to create energy or useful chemicals. Recently, engineers at the French start-up Carbios developed a mutated bacterial enzyme that it claims can 'almost completely digest old plastic bottles in just a few hours', helping turn PET into chemical binding blocks to make new plastics. While this only happens very slowly in nature, Carbios introduced mutations that speed up the process, shredding 90 per cent of the plastic within 10 hours. The promise of the process is that it can turn a black plastic bottle into a white polyester t-shirt, or old shoelaces into shampoo packaging. A recent study published in Nature validates the process, and the company has early-stage commercial partnerships with L'Oréal, Nestlé, Pepsico and Suntory Beverage. Once Carbios moves to industrial production, Novozymes (already an investment in Positive Change) will produce this enzyme at scale.

SUSTAINABLE MATERIALS

This is an incredibly exciting area, populated with lots of new companies and technologies.

COMPOSTABLE PACKAGING

There are several types of compostable packaging (also known as biodegradable packaging):

- industrially compostable – biodegrades by 90 per cent within six months under controlled composting conditions
- home compostable – less stringent parameters
- water-soluble
- and even edible!

These materials improve what becomes of them when they are disposed of (they still need to be sorted, but not recycled in the traditional sense), with often similar performance as plastics during use. The two challenges faced by companies in this space has been scaling production to close the price gap with virgin plastics and feedstock availably. The status quo in bioplastics is the use of renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips and sawdust. Unfortunately, these use the same agricultural land that could be used for growing food, keeping costs – both in absolute and environmentally terms – high.

The development and biofabrication of novel materials mimicking the properties of plastics but with superior recyclability, chemical marking technologies and recycling would overcome some of the environmental and economic issues facing the current technologies. Being able to manufacture at scale would clearly help accelerate adoption of more sustainable alternatives to plastics, providing the ultimate step in reaching circular economy. With a long enough time-horizon, the question becomes when, rather than if this will be possible and we should continue to monitor scientific breakthrough in this area.

CREATING AN INFINITE LOOP

To date, the largest obstacle to creating a circular plastics economy has been the informal nature of the market, which has made it difficult for newly-created waste solutions to establish a fair price for their services. This is rapidly changing for the better. While mechanical recycling is the more circular option, there will always exist contaminated plastics that can no longer be mechanically recycled into valuable material once they've cascaded down the value chain. This is where chemical recycling's opportunity lies. It can help enable 'infinite' loops, decreasing the need for virgin plastic production. We can be hopeful that we are coming ever closer to solving the problem of plastic waste through the biofabrication of novel materials that mimic plastics' properties with superior recyclability, chemical marking technologies, and recycling that overcomes some of the environmental and economic issues facing current technologies.

CURIOUS ABOUT THE WORLD

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