REDESIGNING PLASTICS

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This lesson plan was piloted with the support of players of People's Postcode Lottery.

REDESIGNING PLASTICS

The Ellen MacArthur Foundation works with business, governments and academia to accelerate the transition to an economy that is restorative and regenerative by design: a circular economy. Our education resources are designed to actively engage students in thinking about the economy and exploring alternative models for the future.

Subjects: Design and Technology, Biology, Chemistry, Environmental Sciences, Business

Age range: 12+

Total time: 2x 45 minutes (90 minutes total)

Skills: Communication & teamwork, problem solving, creativity & imagination, presenting, scientific inquiry

Learning intentions: To deepen awareness of the systemic challenges around plastics packaging and how these might be overcome through redesign.

Preparation: Read additional teacher information, **print design sheet**[1], test **powerpoint presentation**[2], load videos and sound check.

Prototyping materials: It's useful to have some items that students can explore their ideas with. E.g. paper, tape, newspaper, blu tack, old card boxes, scissors, colour pens, etc.

Please note that embedded links to articles written by other authors are provided as stimulus for discussion but not necessarily endorsed by the Ellen MacArthur Foundation.

TEACHER'S INTRODUCTION:

Plastics have become an integral part of modern life, providing many benefits for consumers and producers. But what happens to our waste plastic? Where does it all end up? Is recycling plastics really that effective?

In this lesson, students will explore how we use plastics in everyday packaging and how these might be redesigned in such a way as to not become a 'waste' problem. Moving beyond methods to 'reduce, reuse and recycle' at end of life, students will explore ways of designing waste out of the system from the outset.

1 https://www.ellenmacarthurfoundation.org/assets/galleries/Design-sheet_WLL_Redesigning-plastics_V1.pdf
2 https://www.ellenmacarthurfoundation.org/assets/downloads/Redesigning-plastics-powerpoint.pptx

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SUGGESTED LESSON STRUCTURE:

Part 1

Part 1 of this lesson aims to build knowledge about plastics and introduce the concept of the circular economy. Part 2 is a hands-on design activity.

Use the Powerpoint provided to guide you.

1. Start by showing students the animation on slide 3, which provides an introduction to the topic of plastics.
2. Ask your students to think of everything that consists of plastics, and then feedback.
3. Explore some applications of plastics in the students' everyday lives.
4. Now discuss benefits and shortcomings of the current plastics system.
5. Introduce concept of 'learning from nature' by 'keeping materials in the loop' or go into introducing the circular economy, looking at the biological and technical cycle of the circular economy.
   (Here, differentiated slides are provided for different age groups and ability in Powerpoint.)
6. Show slide on three strategies to improve the global plastic packaging market and introduce the Splosh case study as an example of business and design innovation.
7. In pairs, ask students to discuss what problems Splosh are solving and what the potential benefits might be. Then have students think about where the splosh example fits on the 'Butterfly Diagram' (slide 14).

Part 2

1. Ask students to think about the processes involved in the production of crisps using slides 18-20.
2. Choose an item of plastics packaging that needs re-designing, e.g. crisp packets, plastics sachets or plastic packaging with tear-offs.
3. Guide the students through the design and prototyping process using printouts of design sheet and/or the slide deck.
4. Let students present their design questions and prototypes to each other.
5. Open discussion on what role students can play in helping the transition to a circular plastics system.

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TEACHER'S NOTES

Feel free to use any of this information, pictures or resources to build your own lessons.

AN OVERVIEW

WHY PLASTICS?

These days plastics are everywhere. They are an integral part of the modern economy and add in various ways to our quality of life.

Electronic devices, cars, chairs, food, hygienic products, containers, construction materials and packaging - they all contain plastics. Their use has increased twenty-fold in the past half-century and is expected to double again in the next 20 years. Today, nearly everyone, everywhere, every day comes into contact with plastics — especially plastic packaging.

Plastics In Your Face

"In addition to the obvious packaging role, plastic serves as a film-former in hair gel, hairspray, barrier products, and liquid bandages. Used as polyvinyl alcohol and various other forms, plastics are easily incorporated into many skin and hair care products. Plastic keeps your coif in that perfect Flock of Seagulls swoop, makes your waterproof mascara waterproof, and suspends those little beads in your eye gel. Speaking of beads, tiny polyethylene spheres are frequently used in exfoliating scrubs. The products are generally marketed as 'extra gentle', since they are perfectly round and do not damage the skin's surface when used in moderation."[3]

Q: Why do companies use plastics in all these products?

While delivering many benefits, the current plastics economy has drawbacks that are becoming more and more obvious.

- Many plastics are only used for a short time or a short first-use cycle.
- 95% of plastic packaging material value, or USD 80–120 billion annually, is lost from the economy.
- Approximately 32% of plastic packaging leaks into the environment.
- Only 14% is recycled, and only 2% is recycled back into plastics packaging production.

Need a better picture to illustrate these numbers? If we carry on as we are, research suggests that by 2050 there will be more plastic than fish in the sea.

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3 http://mentalfloss.com/article/18876/9-weird-ingredients-hiding-your-makeup-bag

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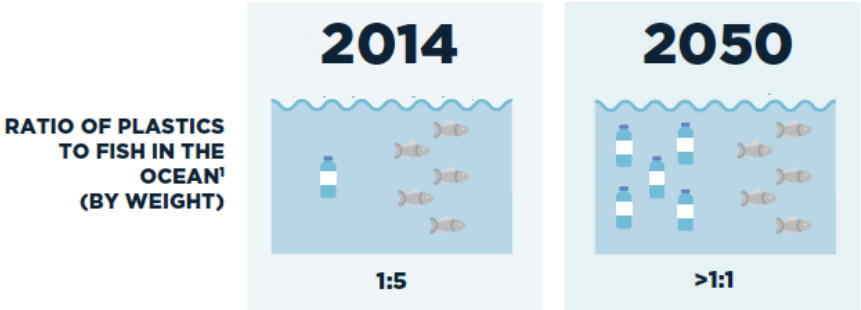

Plastics in the environment can lead to reduced productivity of vital natural systems such as oceans. Plastics can clog urban infrastructure, thus creating huge economic costs (i.e. negative externalities) for everyone.

Is anyone doing anything about this? Yes. Governments, cities and communities have activated various investments, schemes and collaborations.

People doing large scale clean-ups | **Re-use bottle banks and return schemes** | **Collection and recycling schemes** | **Renewable resources, design for degradability** | **Intelligent sorting machines**

However, many questions remain unresolved.

- Can we collect all the plastics?
- What about all the plastic in the oceans?
- What happens if we mix different plastics?
- Do we get the same properties from recycled plastics?
- What effects can the chemicals in plastics have on the body?
- Why are there no global regulations in place to govern plastics production world-wide?
- Can we create an effective plastics system, with more value captured, and better environmental outcomes?

A much more concerted, global, systemic and collaborative approach is required with fundamental redesign, new reuse models, and radically improved recycling.

One of the Ellen MacArthur Foundation's initiatives is the New Plastics Economy, set up to build momentum towards a plastic system that works. For more detailed information, find the New Plastics Economy Publications **here**[4] or watch our TEDx on plastics **here**[5].

4 https://newplasticseconomy.org/
5 https://www.youtube.com/watch?v=1E_irYHyrGU

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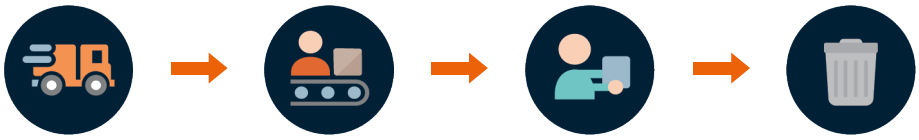
REDESIGN

Our current economy employs a linear, take-make-dispose, model (resources are **taken** from the ground, **made** into products and then **thrown away**). This model has contributed to both the positive but also negative effects of plastic being everywhere.



Take **Make** **Use** **Throw Away**

But what if we had an economic model that was more 'circular', and kept products and materials cycling within the system for longer? This vision for a 'circular economy' aims to optimise value by increasing the lifecycle of materials and designing out waste, thereby decoupling growth from the consumption of finite resources.

Cradle to Cradle and *Biomimicry* are two powerful design frameworks that offer ways of rethinking the materials we use in our product design.

Cradle to Cradle suggests that if we manage to separate biological and technical nutrients within products, the biological material can be returned safely to the biosphere (given that no toxins have been applied to them previously) and the technical components could be returned into the production system. As in the natural world, 'waste' becomes 'food', helping to nourish further cycling of materials.

Biomimicry, says **Janine Benyus**, author of **Biomimicry: Innovation Inspired by Nature**, is 'a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems'. Studying a leaf to invent a better solar cell is an example. She thinks of it as 'innovation inspired by nature'. Biomimicry relies on three key principles:

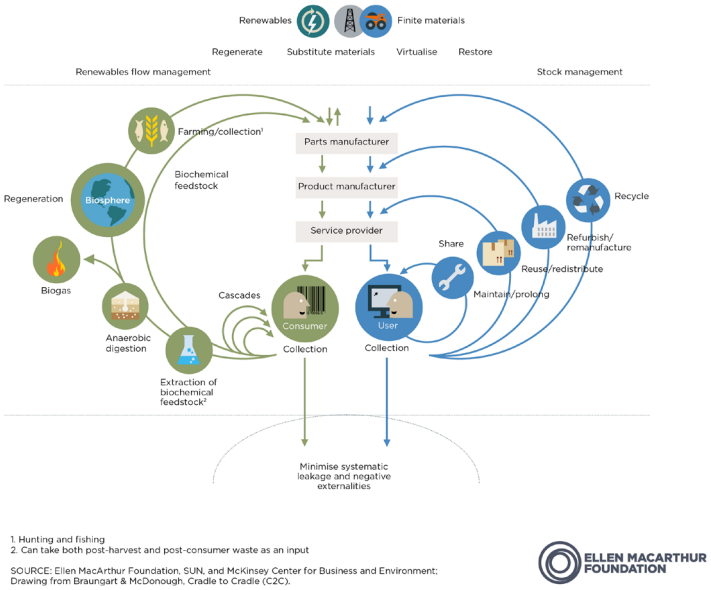
- **Nature as model:** Study nature's models and emulate these forms, processes, systems, and strategies to solve human problems.
- **Nature as measure:** Use an ecological standard to judge the sustainability of our innovations.
- **Nature as mentor:** View and value nature not based on what we can extract from the natural world, but what we can learn from it.

The biggest challenges of today's plastics economy are its non-renewable feedstock (fossil fuels), short use periods of packaging, and leakage into the environment.

Would making plastics from renewable (e.g. plant) feedstocks and making them biodegradable be the solution? Redesigning products is one aspect of a

circular economy, but there are other 'system conditions' to be addressed e.g. business models, policy, the logistics of cycling materials, and incentives to drive change.

Cradle to Cradle and *Biomimicry* are two examples from a number of schools of thought that have shaped the circular economy framework. To find out more click **here**.



The above 'Butterfly Diagram' illustrates the regenerative cycle of biological materials (green), and the restorative cycle of technical materials (blue). By cycling materials for longer, their value is 'optimised', leading to a reduction in negative externalities such as water pollution.

NEW RE-USE MODELS: THE CIRCULAR ECONOMY CONTEXT

A circular economy aims to be restorative and regenerative by design. It picks up on the *Cradle to Cradle* idea of biological nutrients (regenerative) and technological nutrients (restorative).

It suggests that by keeping materials at their highest utility and value at all times, the system can be optimised. For example, cleaning product containers that are long-lasting can be refilled and hence reused (as illustrated by the inner loop in above diagram marked 'share'), rather than being thrown away or recycled (as illustrated by the outer loop in above diagram marked 'recycle').

Football Shirts Made From Ocean Plastic Waste

"We have not only managed to make footwear from recycled ocean plastic, but have also created the first jersey coming 100% out of the ocean. But we won't stop there. We will make one million pairs of shoes using Parley Ocean Plastic in 2017 – and our ultimate ambition is to eliminate virgin plastic from our supply chain." - **Eric Liedtke**[6]

6 **http://www.thedrum.com/news/2016/11/04/adidas-creates-new-real-madrid-and-fc-bayern-munich-kits-recycled-ocean-plastic-part**

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Case Study: Splosh

Instead of buying new bottles filled with washing up liquid on a weekly basis, Splosh customers purchase a one-off 'starter box', containing a range of simply designed bottles. **If the bottle is reused 20 times it means 95% less packaging waste. Read the case study online**.

Q: What other products would lend themselves to this kind of model? How does this differ from people having large glass jars at home and refilling them in bulk stores?

The circular economy framework is a great tool for inquiry, generating questions, developing systems thinking skills and applying to challenges. If you want to dive deeper, this **information** allows you to do so.

Here are eight key terms to help communicate the concept:

Linear Economy

An economic system, characterised as 'take-make-dispose', in which companies make money through selling things, most of which end up as waste or in landfill.

Circular Economy

An industrial economy in which materials and objects are continuously reused or remade with no loss of quality, or else returned safely to the biosphere.

Technical Nutrients

Are metals, polymers, etc.; materials that are designed so that they continually flow in closed industrial cycles in good quality. They should not just be seen as raw materials but as embedded, e.g. in quality machinery which can be remanufactured, or as useful components and sub assemblies which can be reused or refurbished. If recovered for recycling, the material is not contaminated and it is easy to process.

Biological Nutrients

are made from things that grow and which ultimately can go back into the soil (see composting) and improve the soil by doing so (no toxins). They are the basic materials that organisms use to maintain life and are usually based on carbon compounds.

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System

A system is a set of interacting components forming an intricate whole. The circular economy is particularly concerned with complex adaptive systems (such as the global economy and the biosphere), which are characterised by emergent behaviour and self-organisation.

Biosphere

The regions of the surface and atmosphere of earth or another planet occupied by living organisms. It is the sum of all ecosystems.

Regenerative

A system is regenerative if its processes are able to renew or regenerate the sources of materials and energy that they consume. Regenerative design is associated with the **Lyle Center for Regenerative Studies in California**.

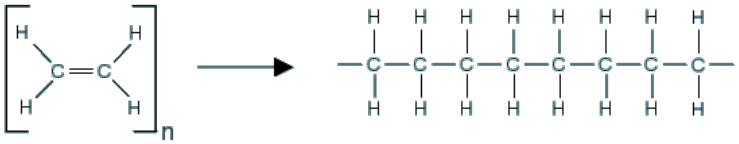
Restorative

In the technical cycle surplus energy is used to create order in matter so as to be able to build infrastructure, tools, and products. Processes such as remanufacturing restore this order, using less energy than would be needed when starting from scratch.

DIFFERENT TYPES OF PLASTICS

Polymer Basics

Plastics are polymers. It means they are **molecules made of chains of a certain building block.** In other words, **the monomer**[7] is a molecule that forms chemical bonds with other monomers to form a **polymer. Polymerisation**[8] can happen through several different mechanisms, and is often driven by applying pressure, heat, and a catalyst.



This lesson can be linked or extended in collaboration with chemistry, or science teachers around properties of materials, polymerisation and radical chemistry as well as environmental chemistry.

A leading question for such an interdisciplinary investigation could be: should plastics be biodegradable? This would be a larger project that could look into surfactants in cleaning products, food containers or heavy-duty plastics used in construction and infrastructure to understand the different properties,

applications and challenges of plastics better.

Guiding questions for students to explore plastics' material properties could be:

- Why are (some) plastics waterproof?
- Why are (some) plastics airtight?
- Why are (some) plastics hard and stiff?
- Why are (some) plastics bendable?
- Why are (some) plastics melting easily?
- Why are (some) plastics not biodegradable?
- Why are (some) plastics waterproof?
- Why are (some) plastics floating?
- Why are (some) plastics not conducting electricity?

Q: What experiments could allow you to test for these questions? And what can they tell you about the molecular structure of plastics?

7 https://en.wikipedia.org/wiki/Monomer
8 http://www.gcsescience.com/polymerisation.gif

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The Seven Types

The symbol on plastics packaging does not give a guarantee that it is recycled or recyclable, but identifies the type of plastic it is made of. The numbers indicate which polymer the plastic is made of and can help identify and sort different plastics.[9]

Number 1, for example, stands for PET which means its monomer basic building blocks are polyethylene terephthalate. (PET is an example of a copolymer, as it is made by combining two different monomers). The same monomer can also lead to very different polymer properties, depending on how long or short, linear or branched, the polymer chain is made.

For example, low-density polyethene (LDPE) cling wrap and high-density polyethene (HDPE) milk bottles, are made from the same monomer but have a different feel and properties to them.

There can also be different extrusion or polymerisation methods that affect the final properties of plastics made from the same polymer. In addition, additives such as softeners or plasticisers are routinely added to plastics, which means that even within one number type, the actual chemical composition of the plastic can vary a lot.[10]

Here is a summary table of the different plastics and their uses.

Pesky Plastics

Plastics labelled with a number 7 ('others'), are a large group of very different materials, including uncommon plastic types as well as multi-layered packaging that is extremely hard to separate or recycle to a high value.

Multi-layered packaging such as most crisps or sweet wrappers leak easily into the environment or end up in landfill. Their material properties also mean that small tear-offs often get lost and end up in places where they create harm, such as the ocean.

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9 https://www.ryedale.gov.uk/attachments/article/690/Different_plastic_polymer_types.pdf

10 http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/materials/molecstructpropertiesrev3.shtml

COMMON PLASTICS

Candy wrappers

Multi-composite packaging

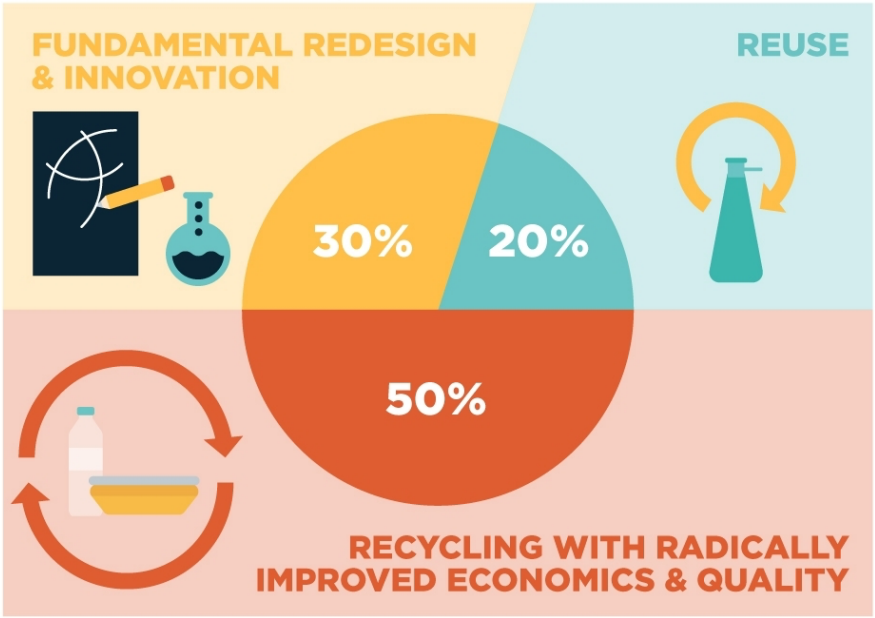
Different wrappers are made up of

- aluminium foil
- aluminium coated plastics
- natureflex (used for Quality street)
- plastic
- paper

Looking at these and other challenges, the 2017 New Plastics Economy report (titled Catalysing Action) suggests these approaches for improving on current processes:

- 30% of plastics packaging needs fundamental redesign and materials science innovation
- 20% of plastics packaging could be adapted or designed for reuse
- 50% of plastics packaging demands a better post-use recycling system with improved economics and quality

Three strategies to transform the global plastic packaging market



World Economic Forum and Ellen MacArthur Foundation
The New Plastics Economy – Catalysing action
(2017, www.newplasticseconomy.org).

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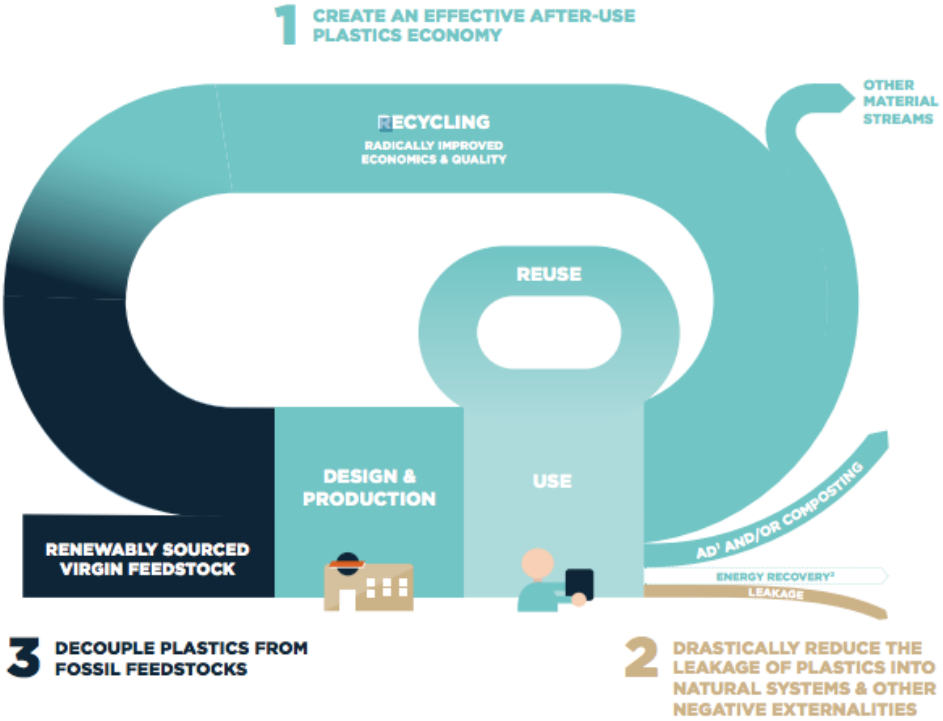
FIGURE 1: THE NEW PLASTICS ECONOMY AND ITS THREE AMBITIONS



Source: *The New Plastics Economy – Rethinking the future of plastics*

Design Frameworks

Part of this challenge is a system redesign which requires global collaboration much like the Ellen MacArthur Foundation's New Plastics Economy initiative is curating. There is great opportunity for young adults to get involved in the product and system redesign challenges.

Can you design better packaging or a better product system that allows easier return? Can you potentially create campaigns that change people's minds and show a better systemic way of tackling recycling challenges?

For 16-19 age range, the **Circular Design Guide**, a collaboration between the Ellen MacArthur Foundation and IDEO, can guide you through this process.

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WHAT NEXT?

TRY THIS LESSON

Designing for a circular economy, a useful resource for developing students' understanding of circular design principles. This interactive lesson looks at a variety of case studies, highlighting the latest in pioneering business and design innovation.

PROVIDE LESSON FEEDBACK

to help us improve our resources by completing this short **questionnaire**.

JOIN OUR COMMUNITY

and become part of a global network of educators who are engaging their students in learning for and about a circular economy. Sign up for the monthly updates **here** and join our **Google+** group.

LEARN MORE ABOUT CIRCULAR ECONOMY

by accessing **case studies** and information on the Ellen MacArthur Foundation website **www.ellenmacarthurfoundation.org**.

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at the **Disruptive Innovation Festival (DIF)**. Every November, we showcase the most exciting technologies and ideas that are reshaping our economy. The DIF is an open-access online experience in which you can watch, question and even contribute as a speaker.

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