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young people's trust for the environment

The problem with plastic

No matter where you look these days, there's plastic. It's a big part of our lives. In fact, many of us make our first contact with plastic on the day we're born when the midwife puts the plastic identity bracelet on the newborn's ankle. From that moment on, we grow up in a world that's full of plastic and worryingly, it's getting fuller every day.

Above: From the moment a baby is born in the UK, they come into contact with plastic, from the plastic identity ankle bracelet to the plastic cot!

You see, every piece of plastic that has ever been made is still out there somewhere. Some of it gradually breaks up when it's thrown away, getting smaller and smaller, but never quite going away. Some plastics are thought to be able to break down in the environment after about 500 years, but many will last FOREVER - and that's a long time!

When did it all begin?

Believe it or not, plastic hasn't been around for all that long. Alexander Parks, an English inventor created the first plastic-like substance, Parkesine, in 1850. He wasn't able to find any takers for the industrialised manufacture of products made from Parkesine. In 1869, American inventor John W. Hyatt developed celluloid, which was initially used to make billiard balls, until its highly flammable nature was discovered. As a result of its habit of bursting into flame, it ended up being used mostly in the film industry. Despite further attempts by a few other inventors, it wasn't until the early 1900s that plastic production really took off.

Above: Leo Hendrick Baekeland (1863-1944)
Photo by courtesy of The Edgar Fahs Smith Memorial Collection, The University of Pennsylvania Libraries.

In 1907, a Belgian-born American inventor called Leo Baekeland created 'Bakelite'. It was light, durable, easy to mould and kept its shape when hot. He patented it in 1909 and very soon his revolutionary new material was being used to make a huge number of different items, including telephones, toys, building materials and car and aeroplane parts. By 1944, the year Leo Baekeland died, Bakelite had been used to create over 15,000 different articles.

Meanwhile in 1908, Jacques E Brandenburger created cellophane, a light, clear plastic that could be used to package products in a way that kept them protected from contact with water and dirt until they were unwrapped.

Other forms of plastic soon followed, like polyvinyl chloride (PVC) in 1920, still the most commonly-used type of plastic today, nylon in 1939 and acrylonitrile butadiene styrene (ABS) in 1948. The plastics have become lighter, stronger and more durable as they have developed. For example in 1965, Stephanie Kwolek developed Kevlar, a plastic that is so strong and light that it is used in bulletproof clothing!

Plastics use different compounds found in oil, a natural resource that we humans use huge amounts of each year. Only 4% of the world's annual oil production is used to manufacture all the plastics made each year.

What is so fantastic about plastic?

The fact that you can mould plastic into all kinds of different shapes, its strength and lightness and its ability to retain its shape even when heated have made it such an important material in our lives. You might well have taken a plastic lunch box to school today, drunk from a plastic water bottle or plastic cup at lunch time, sat on a plastic chair, spoken to your friends on a plastic telephone, worn a plastic cycle helmet when riding to the park, watched your plastic encased TV or played games while gripping the moulded plastic casing on your tablet computer.

Plastic's lightness is in some ways beneficial to the environment. For example, you use 40% less fuel by transporting drinks in plastic bottles than you would to to transport the same amount of liquid in glass bottles. Packaging in general could be over four times heavier if we didn't use plastics. A plastic carrier bag weighs six times less than alternative materials like cotton - maybe not that important when you're carrying one or two, but it's a really important difference if you have a truck loaded with 500,000 of them!

Above: Use of plastics in modern cars makes them lighter and saves significant amounts of fuel over the vehicle's lifetime.

Modern cars use about 105kg of plastics, which replace heavier traditional materials like wood and metal. This saves around 750 litres of fuel in a car driven for 90,000 miles and reduces carbon dioxide emissions across the European Union by 30 million tonnes each year. In London, 772 miles of cracked and broken Victorian water mains are being replaced by durable, flexible and non-leaking plastic pipes, preventing massive volumes of drinking water from leaking out of the system and going to waste.

Synthetic fibres in the water

Firstly, there's a big problem with plastic, although it might seem like a tiny one! Research has shown that every time a synthetic garment is washed, microfibres - tiny strands of plastics like nylon and acrylic - are washed out of the garment and into the waste water from the washing machine. Ultimately, the wastewater and its microfibres end up in the oceans. Up to 1,900 microfibres can be released by a single garment. Think how many clothes you have that are made out of synthetic fibres. Now think about how many people there are in the world and how many garments they own that are made of synthetic materials. Multiply that number by 1,900. Now you can see how big a problem this is!

We still don't know potentially how much of an impact these tiny plastic fibres are having on the environment and more research needs to be done before we know how serious an issue microfibre pollution might be. But we know the microfibres are there and research has already shown that they are becoming lodged in the intestines of fish. These microfibres are ending up in the intestines of the birds that eat the fish. The microfibres are too small to be filtered by water treatment plants, so they could well be in drinking water too. Think about that every time your fleece is washed.

An even bigger problem with plastic

In the introductory paragragh, brief mention was made about the main problem with plastic. It takes a VERY long time to biodegrade (to be broken down in the environment by bacteria and other living organisms) and some types of plastic will never biodegrade, because bacteria simply won't touch it. That means that as the years go by, our planet's surface is getting covered with more and more plastic that we have thrown away, but will never disappear. Some plastics photodegrade instead, meaning that prolonged exposure to light will break them down. But they only break down into smaller and smaller bits of plastic. They never actually disappear.

Above: only 37% of the UK's plastic is recycled each year. Photo by Ian Britton.

Much of the plastic we throw away ends up in landfill sites - huge holes in the ground that we fill up with rubbish, then cover over with soil . Increasing amounts of plastic are being recycled now as recycling methods improve and people's awareness of the problem is growing. But even with increased recycling, only about 37% of the UK's plastic is recycled. That's a staggering 440,401 tonnes of plastic from UK households according to the 2013 UK Household Plastics Collection Survey, but it still means that 749,872 tonnes of plastic ended up in landfill, or even in the sea and that's just from the UK.

Above: Each fleece can release thousands of microfibres every time it is washed. Photo by Andrew Gustar

A sea of plastic

You might think that throwing a single piece of plastic into the sea - a plastic drinks cup say - would not do much harm on its own. And you'd be right. But the trouble is that there are over 7 billion of us human beings on planet earth. And according to the UN's Atlas of the Oceans, 44% of us live within 150 kilometres of the sea. That's over three billion (3,000,000,000) people! If each of them threw just one piece of plastic into the sea each year, that would be a lot of plastic!

In fact, in 2010 alone, an estimated 7,725,477 tonnes of plastic rubbish ended up in the world's oceans. To understand what almost eight million tonnes means, it's the equivalent of lining up five carrier bags full of rubbish for every foot of coastline across the globe. According to predictions made in the same study by scientists from the University of Georgia, the amount of plastic going into the world's oceans each year will have doubled by 2025.

There is already an estimated 150 million tonnes of plastic rubbish in the world's oceans. If plastic keeps flowing into our oceans at the predicted rates, then by 2025, the world's oceans will contain a kilo of plastic for every three kilos of fish.

Above: Plastic rubbish is washed up on many Pacific beaches. Photo by Marko

In the Pacific Ocean, there is a huge mass of floating plastic debris that has been collected together through the action of the North Pacific Subtropical Gyre, a slow moving, clockwise spiral of currents created by systems of high pressure air currents. The area is an oceanic desert, with lots of tiny phytoplankton (microscopic animals living in the sea) but few large fish or marine mammals.

But that doesn't mean the water is empty. In fact it's full of plastic, 80% of which is thrown into the sea by people living on coastlines around the Pacific. The remaining 20% is dropped in the ocean by sailors, offshore rigs and massive cargo vessels. It all gets collected up by the actions of the Gyre into two huge floating garbage patches - the Western and Eastern Pacific Garbage Patches. The Eastern patch floats between Hawaii and California and its estimated area is about twice that of Texas (which makes it almost 14,000 square kilometres). The Western Garbage Patch floats in the ocean between Hawaii and Japan.

In some places, the water is full of dense concentrations of accumulated plastic waste, sometimes up to 10 metres deep, but across much more of the garbage patches, the water is filled with small plastic fragments - pieces of plastic that have broken off because of photodegradation. These get progressively smaller and smaller over time.

All of the plastic throught to be in the world's ocean gyres only account for about 5% of the total amount of plastic floating around in our oceans. The garbage patches are the big, obvious

Above: huge amounts of plastic debris like this is floating in the world's oceans. In some places. it is up to 10 metres deep! Photo by Steven Guerrisi

eyesores we can observe easily - the tip of an iceberg of floating plastic if you like. But most of the plastic in our oceans is actually smaller than 5mm in size and there is a vast quantity of it drifting around our oceans. There are thought to be more than 5.25 trillion pieces of it in total. That's 5,250,000,000,000 pieces!

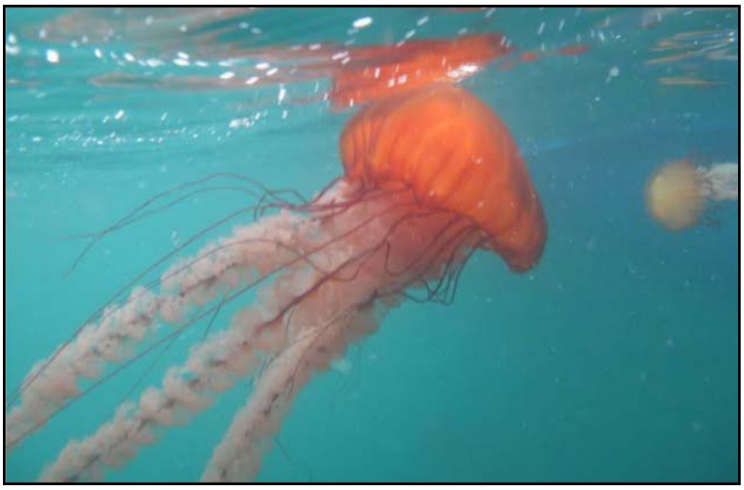
Plastic starts out as small grains or 'nurdles', which are then melted and moulded to form objects that we use every day - for instance a bottle, a chair, or the casing for a laptop computer. As it degrades and is broken down in the oceans, it gradually returns to the size of nurdles again.

The fact that the plastic is often so small meant that the Pacific Garbage Patches went largely unnoticed until the early 1990s, when Captain Charles Moore of the Algalita Marine Research Foundation sailed the rarely travelled route from Hawaii to the US mainland. For a week, he watched a continuous stream of plastic sail by, despite being hundreds of miles from land. The Great Pacific Garbage Patch is not the only such patch in the world's oceans - there are five big ocean gyres - but it is the best known.

Since then, we have learned much more about the scale of the problem that we already face and the alarming way that it is likely to get very much worse unless we make some big changes.

Damage to wildlife

Large plastic debris floating in the sea like nets and ropes can kill animals like seals and dolphins. Plastic bags drifting under the water are eaten by turtles, who mistake them for jellyfish (one of their favourite foods). The plastic bags block the turtles' digestive systems, eventually leading to starvation.



Marine turtles hunting for jellyfish (above) often eat plastic bags drifting underwater instead. Photo by Lindsey Hoshaw.

Research from the University of Queensland, published in 2012, showed that green turtles had a 50% chance of ingesting plastic in their lifetime, up from 30% in the 1980s.

Laysan Albatrosses are large seabirds living in the Pacific Ocean. They have a wingspan of over 6 feet. They are able to go years without touching land and can live for over 50 years. Sadly, increasing numbers of these amazing birds are eating plastic. They catch their food (fish, squid and other seafood) by skimming the surface of the water with their beaks. In the process, they pick up a lot of floating plastic that they then feed to their chicks. The adults are able to regurgitate the plastic they swallow, but the chicks can't, so it gradually fills their stomachs. The plastic either damages the chicks' stomach linings, or makes them feel full when in fact they are starving.

Above: This horrifying picture shows the amount of plastic that was removed from the stomach and intestines of a single dead albatross. Photo by Tim Zim.

Above: Even large mammals like seals can be trapped by the plastic debris floating in the ocean. Photo by Nels Israelson

So with fewer chicks surviving to adulthood, Laysan albatross numbers are falling.

The above examples show how large debris can damage marine life, but we know that the vast majority of the plastic in our seas is in much, much smaller pieces and a lot of it cannot be accounted for. There is growing concern about how much of the plastic is disappearing because it is being eaten by fish.

Plastic in the marine environment tends to attract any oily pollutants that may be in the water, so that the pollutants stick to it. The small fragments of polluted plastic often get eaten by small fish. They get a small dose of the pollutants from the fragments, but probably not enough to kill them. When bigger fish eat the smaller fish, they get a larger dose of the pollutants that the smaller fish have eaten, because they eat lots of smaller fish.

As you progress higher up the food chain, the pollutants become more and more concentrated. We don't yet know how the plastic being ingested by fish may be affecting humans when they in turn eat the fish.

Are there alternatives to plastic?

The reason there is so much plastic in the world already and that it shows no sign of slowing down any time soon is that as we have already seen, it's so useful! Whether it's as furniture, as a wrapper for keeping food and other goods clean and waterproof, as the casing for the latest tech, or simply as the bag to carry it all around in, there's no denying plastic can be a handy thing to have around. But the downside of having so much plastic in the world is becoming more and more apparent. Is there anything else we could be using instead? Here are some examples of the alternatives:-

Corn-based plastic

Polylactic acid (PLA) is a 'bioplastic', dervied from corn. It's made from lactic acid, produced when the starch contained in corn ferments. PLA can also be made from wheat or sugarcane. PLA has suffiicent strength and mouldability to replace polystyrene and polyethylene terephthalate (PET) but it has a significant advantage over either plastic, in that it can biodegrade within 47 days in an industrial composter. PLA does not emit toxic fumes when burned and making it uses up to 50% less fossil fuel than making petroleum based plastic.

However, there are downsides too. PLA won't degrade in the environment or in a landfill - it needs to go in an industrial composter. It is brittle and it doesn't stand up to heat well, but it is watertight, so it can be used to make cups, compost bags, food packaging and disposable cutlery. More complex polylactides like PDLLA are stronger and have greater heat resistance, meaning they can be used to make microwaveable food trays.

Left: Bearing the slogan, 'Made from corn', this is a disposable drink cup made from PLA. Photo by emily

PLA is often made using ingredients sourced from genetically modified corn, which in itself has potential negative impacts on the environment. But the biggest issue when we consider using PLA more widely to replace petroleum based plastics is that it uses up corn or other crops that could otherwise be used to feed people. With around one in nine of the world's population suffering from chronic undernourishment in 2012-2014 according to the UN's Food and Agriculture Organisation, we need to decide whether people or planet is more important. This highlights the difficulty we face when choosing biodegrabeable plastics.

PHA Polyesters

A quick look at their full name - polyhydroxyalkanoate polyesters - explains why PHAs are generally referred to as initials! They can be used for packaging, plastic films and even drinks bottles. PHAs are bioplastics produced by bacteria, which convert sugar into naturally-produced polyesters. The sugar the bacteria need can be provided using molasses and even activated sludge. PHAs biodegrade within 20 days when placed in an anaerobic digester. Currently, their main disadvantage over petroleum-based plastics is that they cost considerably more to produce.

Above: Chicken feathers can provide a commonly available biodegradable ingredient for some plastics. Photo by Aditya Mopur

Chicken feather plastic!

Every year, the world's demand for chicken meat means that millions of tonnes of chicken feathers are thrown away. Of course, they biodegrade, but they could perhaps be put to another use first, by mixing them with a polymer like polyethylene or polypropylene to make plastic. Feathers contain keratin, a substance that is also found in hair, fingernails and even horses' hooves. Research from the University of Nebraska suggests that chicken feathers could make up half of the weight of the resulting plastic.

They have already been used experimentally for thin plastic films to cover foods, which have proved to be more resistant to water than other plastics made from natural waste products (biowaste). Whilst chicken feather plastic isn't fully biodegradeable if it is being mixed with petroleum-based polymers, as only the part made of feathers biodegrades, it's a way of reducing our use of petroleum based plastic and of re-using an adundant natural product that would otherwise go to waste.

Above: Some bioplastics like PLA need to be broken down in a digester like the one in the background. Photo by American Biogas Council.

Starch as an additive

Believe it or not, you can make plastic at home using starch! It's fully biodegrabeable and can be used to form simple shapes. You can find instructions for making your own on page ??. Starch is now being used as an additive in petroleum-based plastics to make them biodegradable, but in reality, it's only the starch that biodegrades. The rest of the plastic remains.

Biodegradable plastics

Biodegradable plastics are made from petroleum-based plastic but contain special additives to make them degrade in certain conditions. Photodegradable plastics break down when exposed to sunlight, oxydegradable plastics break down in the air.

Downsides of biodegradable plastic and bioplastic

We have already discussed the way in which certain bioplastics use as their raw materials crops that could otherwise be used to feed people. However, that is not their only possible downside. Some bioplastics produce methane (a powerful greenhouse gas) when they break down in a landfill. Others like PLA can only be broken down in industrial digesters. Biodegradable plastics can leave behind toxic residues even after the plastic has disappeared. Neither bioplastic nor biodegradable plastic can be recycled easily. PLA looks very much like PET (polyethylene terephthalate), a petroleum-based plastic that can be recycled. If PLA gets mixed with a batch of PET in a recycling plant, the whole batch is useless.

How recyclable is plastic?

We know there are already huge amounts of plastic on the planet, so surely a sensible thing would be to recycle it all? Unfortunately, it's not quite that simple. Plastic drink bottles can be melted down and made into other items, like fleece jackets or plastic chairs for example, but they can't be made into other drink bottles, as this requires brand-new plastic. This means that plastic tends to be 'downcycled' rather than recycled. A real problem when it comes to recycling plastic is that all of the plastic you melt down has to be of the same type. If you melt down different kinds of plastic in one big pot, they will 'phase-separate' in a similar way to oil floating on water. This phase separation leads to layering and causes weaknesses in the resulting plastic.

The dyes and other additives used in plastics also mean that it's more difficult to recycle, because it's very difficult to remove the dyes and other additives. There tend to be less additives used in plastic carrier bags and drink bottles and it's because of this that they tend to be the most likely candidates for downcycling.

Above: Recycled plastic is broken down into flakes before being melted and moulded into a new shape. Photo by Wisconsin Department of Natural Resources.

What is the solution?

There is still no straightforward answer to this question. Developments in bioplastics and biodegradable plastics may provide a solution in the future to prevent newly-made plastic from building up in the environment. However, that will not solve the problem of all the plastic that is already there, gradually getting smaller, but never going away. Like the plastic itself, this will be a problem for years to come. There are ways that you can help every day. Here are a few ideas for some simple changes you can make:-

1. Try to avoid using single use drink bottles, disposable plastic cups, cutlery etc.

2. Don't use plastic carrier bags, use re-usable bags instead. In all parts of the UK except England, shops are now obliged to charge customers for plastic carrier bags. In Scotland, since the introduction of the 5 pence per bag charge 80% less carrier bags are being taken from shops. Meanwhile, plastic bag use has dropped by 71% in Wales since the 5p charge was introduced. A minimum charge of 5 pence per single use bag comes into force for large retail stores in England from 5 October 2015. Let's hope it has a similar impact on shoppers' bagging habits!

3. Recycle plastic whenever you can.

4. Cut down on foods wrapped in plastic packaging. Try to buy fruit, vegetables, meat etc. from the fresh food counter or local shops instead.

5. If you do have any plastic waste to get rid of, dispose of it responsibly. Never just drop it and walk away.

Clockwise from top left: Plastic carrier bags can be carried by the wind to the sea. Plastic bottles, although recyclable, do not degrade in the environment and will survive for thousands of years. This giant river otter is playing with a discarded plastic bottle in the Pantanal, a huge marshland in South America. This turtle got its shell stuck in the plastic rings of a six-pack when it was a baby. Its shell has become mis-shaped as it has grown. **Photo credits:** Ars Electronia, Steven Depolo, Paul Williams, Stefan Leijon.

Have a go at making your own bioplastic!

Here's a simple recipe for making your own bioplastic using a just a couple of simple ingredients. You will need:

- Corn flour
- Water
- Cooking oil
- A measuring spoon
- A microwave
- A microwavable container
- An adult (if required - to help with the microwaving!)

1. You can make as much as you like, but the proportions of ingredients to use are 1 tablespoon of cornflour to 1.5 tablespoons of water to 4 drops of cooking oil.

2. Mix the ingredients well in your microwaveable container until you have a milky liquid.

Above: This is what your conrnflour, water and oil mixture should look like before it goes in the microwave.

Above: Your bioplastic should look like this after microwaving.

3. Put the mixture in the microwave and give it about 30 seconds on high. It should start to bubble and become slightly transparent. If you have made a larger amount of mixture, you may have to heat it for longer to get it to bubble. Keep watching and don't let the mixture start to burn!

4. When the mixture is looking slightly transparent, ask your grown-up to take it out of the microwave very carefully. It will be hot! Make sure you let the plastic cool down until you are able to handle it safely. This will take 5 minutes or more.

5. Knead the plastic until it feels like play dough. You can now cut or mould it into the shape you want.

6. Leave it to cure for 24 - 48 hours. It should then be solid and maintain its shape.

If you'd like to make coloured bioplastic, try adding food colouring to your mixture before microwaving.

Above: you can mould your bioplastic into whatever shape you like!

Ideas for recycling plastic bags

If you have a collection of plastic bags at home (and let's face it, most of us do) don't just throw them away. Many supermarkets now run recycling schemes for carrier bags, so make sure you take them there.

Alternatively, you can find other uses for your plastic bags. Carrier bags make great bin liners for wastepaper baskets. Or, if you're feeling really crafty, you could always make something from them. By cutting carrier bags into long strips, you can weave them to make rugs, baskets and even sturdy re-usable shopping bags!

Above: you can make really spectacular rugs, bags and even bowls by weaving with torn up strips of plastic carrier bags. Photo by Sally.
Find out more here :
http://www.instructables.com/id/Woven-Plastic-Bag-Bag/

Ollaberry Primary School in Shetland made a brilliant animation and film to explain the problems caused by plastic bags in the world's oceans.

You can watch it here: https://youtu.be/keRWlwdrVHM

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