**Back in May twenty-twenty, our friends in the science world brought us news that nature had evolved an enzyme that could chomp through the strong polymer chains in plastics like polyethylene terephthalate or PET, which is what plastic bottles are made of. It was a very exciting discovery, and the video I made on the subject at the time has had more views than any other video on this channel. So, I guess you guys were pretty keen to hear about it too.**

**Ever since that first enzyme was stumbled upon at a Kyoto recycling plant in Japan back twenty sixteen, scientists have been working to enhance its capabilities with the goal of producing a set of super enzymes that could be even more helpful in our interminable fight against plastic waste.**

**And in March twenty-twenty two, researchers achieved another leap forward in that struggle with the development of a variant that can take one of the previously useless waste by-products of the original reaction and break it down even further into simple molecules that can then be utilized by bacteria to generate sustainable chemicals and materials, essentially maximising the number of valuable products that can be made out of the world’s waste plastic.**

**So, it sounds like it’s high time we had ourselves a little progress review.**

**Hello and welcome to Just Have a Think**

**The scientists who discovered bacteria feeding on plastic bottles in that Kyoto recycling dump, decided – for reasons best known only to them – to call it Ideonella Sakeiensis. But we’ll forgive them that, because it’s what they did with it after they discovered it that’s so much more important.**

**When they took a close look under a microscope they saw that the bacterium used specific enzymes to break down the two components of PET - ethylene glycol, which is the stuff in the anti-freeze in your car radiator, and dimethyl terephthalate which to be honest isn’t really used in anything at all, other than PET itself.**

**Crucially, the researchers were able to identify the gene in the bacteria’s DNA that was responsible for those enzymes.**

**Then they managed to reproduce the enzyme and demonstrate that it could do the plastic chomping job on its own without the rest of the bacterium.**

**And that meant they could really start playing with it in their laboratories to improve and strengthen it into a super enzyme that could digest far greater quantities of PET far more quickly than it’s naturally occurring cousin.**

**In 2019, The University of Portsmouth here in the UK established the Centre for Enzyme Innovation or CEI, and their Professor of Structural Biology, John McGeehan gave a presentation showing how evolution had solved the PET problem. You can see the full explanation in my original video, which is linked at the top of the screen, but essentially the new enzyme was a mutation of cutinase, which is what bacteria use to break down nature’s own polyester, called Cutin. Cutin is what gives the surface of plants a waxy protective coating, and by breaking through that, bacteria can get inside plants to plunder all their goodies.**

**Cutinase enzymes break those natural polyester bonds using chemical jaws with a gap of just less than three ten-billionths of a metre or 0.3 nanometres.**

**What the research team found was that with only a single amino acid change in its structure, this new PETase enzyme had changed the shape of its jaws to make the gap almost 3 times wider, and that allowed it to cope with a man-made aromatic polymer like PET.**

**After a fair amount of genetic manipulation and an awful lot of trial and error in the lab, the Portsmouth team managed to produce a turbo charged version of PETase with a much faster rate of digestion than the naturally occurring version.**

**So far so good. Now they had a way of liberating large quantities of ethylene glycol, which has very good commercial value, mainly for use as anti-freeze as I mentioned earlier, but the enzymatic digestion process also produced a similar quantity of the other PET component, which is the dimehtyl terephthalate part, also known as TPA. And the molecular configuration of TPA doesn’t really have any uses at all.**

**So, the experimentation continued, which brings us to this latest breakthrough paper, published last month in the Proceedings of the National Academy of Sciences.**

**The paper was co-published by McGeehan’s Portsmouth team and a second research team at Montana State University in the US, headed up by Professor Jen Dubois.**

**It is of course, packed full of the obligatory impenetrable scientific lingo that you and I have come to know and love over the years that I’ve been making these videos. Here’s a little sample**

**”Terephthalate dioxygenase (TPADO) and its cognate reductase make up a complex multimetalloenzyme system that dihydroxylates TPA, activating it for enzymatic decarboxylation to yield protocatechuic acid (PCA).”**

**Now if that all makes perfect sense to you then thanks for watching, your work here is done. But for the rest of us, essentially what happened was that during their research, the Portsmouth team were able to isolate and identify another enzyme in the original plastic chomping Ideonella Sakeiensis bacteria. That’s the ‘terephthalate dioxygenase or TPADO’ that I just mentioned in the quote. Using oxygen and a couple of other balancing reduction agents, the TPADO converts the terephthalate molecule into something called dihydroxy cyclohexadiene dicarboxylate, which we’ll just call DCD to save my sanity.**

**That DCD can then be further converted by a zinc based reductive agent to produce protocatechuic acid or PCA.**

**Now that all sounds like a whole bunch of complicated chemistry to produce a molecule that looks remarkably similar the one you started with, but here’s the thing – PCA is a naturally occurring acid found in several plant species. It’s a major component of the antioxidants found in green tea for example, and it’s been shown to have anti-inflammatory effects as well. So, unlike the TPA molecule, which is more or less useless, the PCA molecule has all sorts of extremely beneficial applications in medicine and nutrition. It’s even been shown to have the ability to attack certain types of cancer cell, so it may prove even more useful in the future.**

**Interviewed in this article at the online journal Phys dot Org, Professor Dubois explained "The Portsmouth team revealed that an enzyme from PET-consuming bacteria recognizes TPA like a hand in a glove. Our group at MSU then demonstrated that this enzyme, called TPADO, breaks down TPA and pretty much only TPA, with amazing efficiency."**

**Professor McGeehan said**

**"The last few years have seen incredible advances in the engineering of enzymes to break down PET plastic into its building blocks. This work goes a stage further and looks at the first enzyme in a cascade that can deconstruct those building blocks into simpler molecules. These can then be utilized by bacteria to generate sustainable chemicals and materials, essential for making valuable products out of plastic waste.”**

**The study was undertaken as part of the**[**BOTTLE Consortium**](https://www.bottle.org/)**, which is an**[**international collaboration**](https://phys.org/tags/international+collaboration/)**bringing together researchers from across a wide range of scientific areas to tackle**[**plastic**](https://phys.org/tags/plastic/)**recycling and upcycling.**

**We humans currently produce more than four hundred million tons of plastic waste every year, most of which eventually ends up in landfills and in our oceans and food chains. And very recent research carried out by a team from the University of Hull and Castle Hill Hospital here in the UK has even discovered microplastics in the lung tissue of live human beings for the first time. Thirteen patients who were due to undergo surgery for various unrelated lung ailments agreed to allow tiny samples of tissue to be removed from their lungs during surgery and microplastics were present in eleven of the thirteen samples. No-one really knows what the impact of plastics in our food and in our respiratory systems may be having, but it’s probably not unreasonable to assume the effects are not particularly beneficial, to say the least.**

**So, keeping plastics out of landfill and out of our waterways must surely be one of the top environmental priorities of our time. Technologies that can either upcycle plastic into higher quality products, like those we looked at in a video a couple of weeks ago, or enzymes that can break polymers down into simple molecules, like the ones we’ve looked at today, will be a vital part of that initiative.**

**Now, if you’re involved in these cutting edge research programmes and you can share even more insight, or if you’ve got some great plastic collection and recycling programmes going on in your local area and you can share some best practice with the rest of us, then why not jump down to the comments section below and leave your thought there.**

**That’s it for this week though.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.  
See you next week**