Biodegradation Of Plastics By Specialized Bacteria

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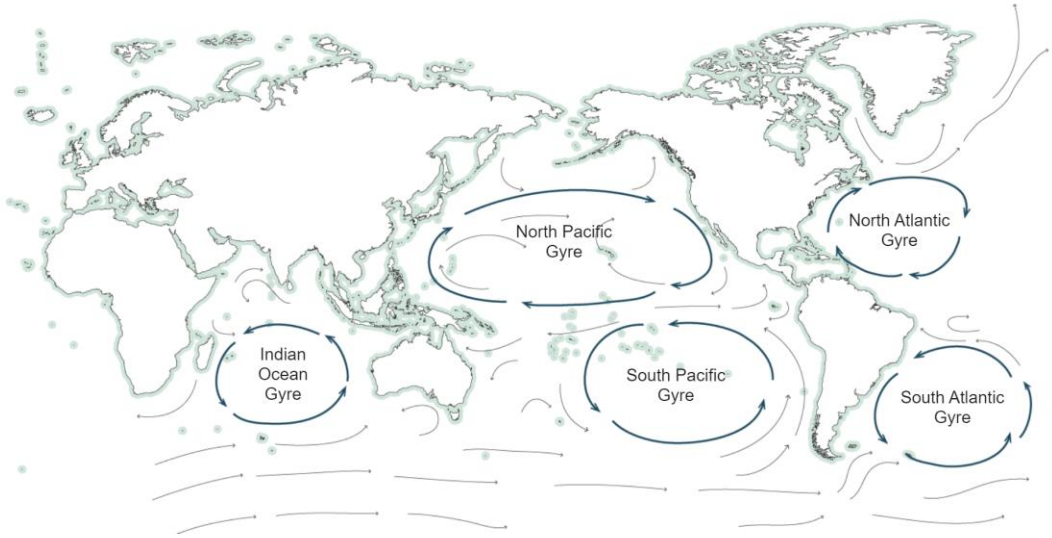
Background and Significance

Our planet Earth is drowning in plastic pollution. Since 1950, we have produced about 8.8 billion tons of plastic worldwide. Commercialized plastics are commonly made from fossil fuels with crude oil and natural gas as cheap sources [1].

Our world as we know it would not be the same without the invention of plastic. With its characteristics of light weight, durability and flexibility, plastic has contributed to some of mankind's great inventions enabling transportation with materials used in building cars, airplanes and education toys for kids.

The ubiquitous of plastic gives us convenience with the explosion of single-use products such as grocery bags, water bottles and straws. There products do not degrade well. With additives in the manufacturing process to make the plastics more durable, they can take hundreds years to breakdown. Most under-developed countries do not have adequate recycling centers to handle massive plastic waste. Those countries with recycling centers often have low recycling rates to due to the difficulty in collecting the waste.

With all the plastic produced each year, only about 9% of it is recycled. It is estimated that between 1.1 and 8.8 metric tons of plastic enter our oceans from coastal communities each year [1]. Often these plastic materials are carried to the oceans by major rivers in the world.



Plastic Garbage Islands

The impact on wildlife is enormous. Plastic pollution affects at least 700 marine species, while some estimates suggest that at least 100 million marine mammals are killed each year from plastic pollution. With the current trend, our oceans will have more plastic than fish by year 2050. We, humans, are not immuned from the impact. The fish that we eat can contain plastic residues.

Plastic impact on wildlife

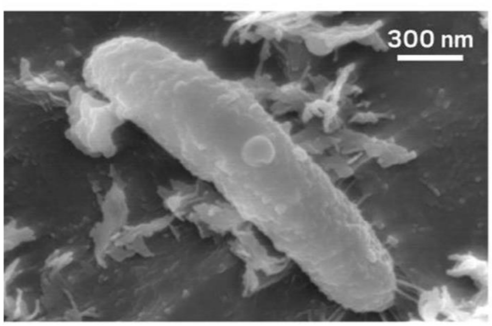
Solutions

We can revert the pollution problem. It's a problem created by humans, so we should be able resolve it.

- Improve waste management systems and recycling, better product design that takes into account the short life of disposable packaging, and reduction in manufacturing of unnecessary single-use plastics
- Some states in the US have made unnecessary plastic use illegal
- In Africa, most countries have adopted a total ban on the production and use of plastic bags.
- Use alternative biodegradable plastics made from crops such as corn starch.
- ***Advance biodegradable solutions through the use of plastic-eating agents***

Ideonella sakaiensis 201-F6, Plastic Eating Bacteria

In 2016, a team of Japanese scientists first discovered and studied *Ideonella sakaiensis* strain 201-F6 bacteria found from sludge samples collected close to a Japanese PET bottle recycling site.



Ideonella sakaiensis

Figure 1: Ideonella sakaiensis bacterium[10]

Polyethylene Terephthalate (PET) is a widely used type of plastic for making a variety of products from water bottles to polyester clothing. PET in natural environment can take many years to breakdown. With the enzyme, PETase, secreted by Ideonella sakaiensis, PET can be broken down in days. How can scientists genetically engineer PETase mutants that can thrive in different environment and breakdown PET in seconds?

PETases are an esterase class of enzymes that catalyze the hydrolysis of polyethylene terephthalate (PET) plastic to monomeric mono-2-hydroxyethyl terephthalate (MHET).

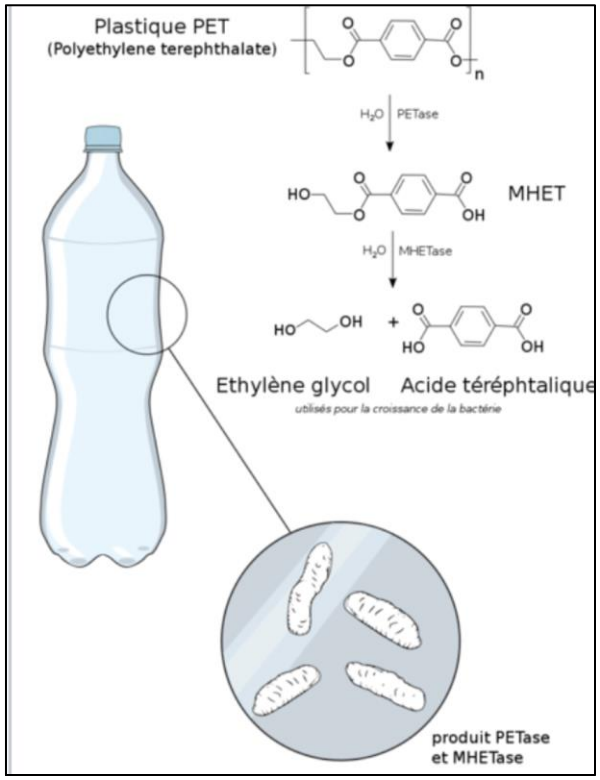


Figure 2: PETase and MHETase reaction pathway [4]

Researchers can deliberately induce mutations in enzymes and track how well they work. Scientists can then analyze the winners to evaluate their properties and further make enhancements. By closely measuring their shapes and monitoring their work, scientists can figure out how to adjust enzymes to work faster, or to keep them working in more challenging environments such those ocean patches filled with plastics.

Using supercomputers, scientists can also design their own enzymes using the ones they've found in nature as templates. They can calculate what a durable, fast-acting, plastic-breaking enzyme would look like using fast computing models.

Biological Data for Ideonella sakaiensis, 201-F6

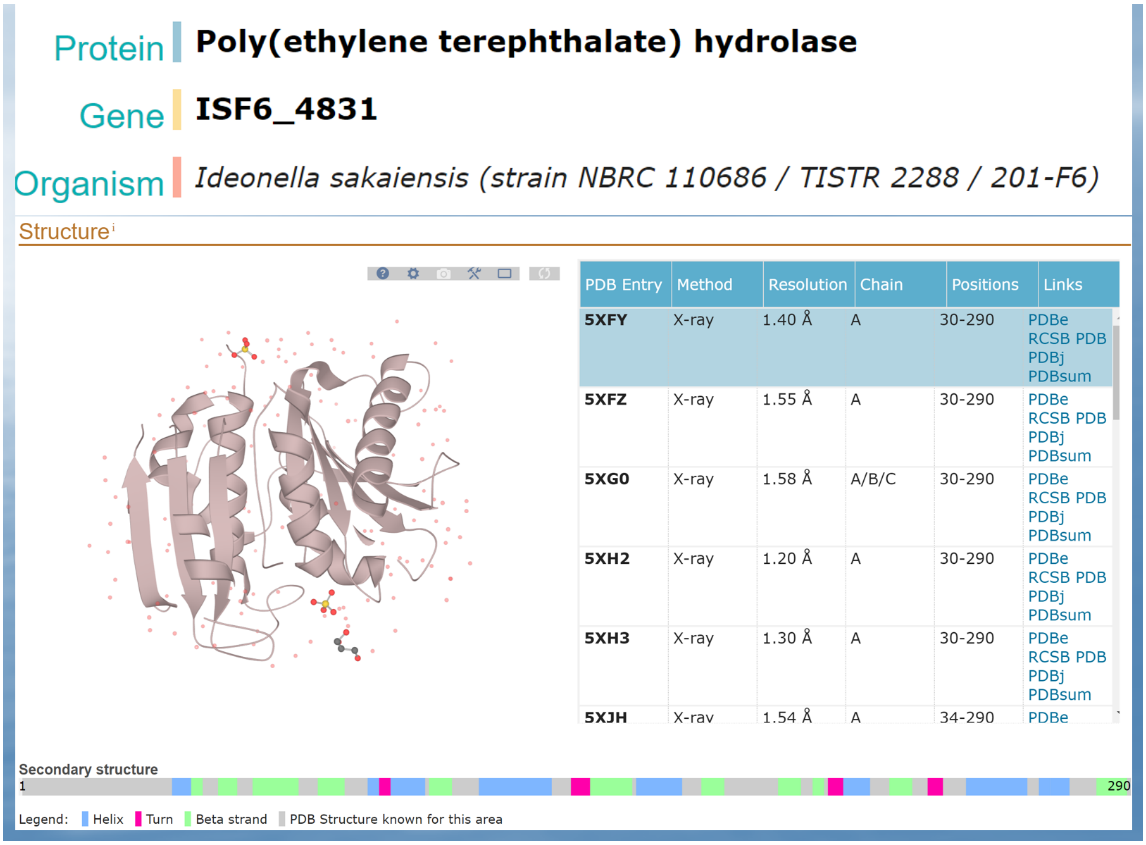


Figure 3: PETase Structure

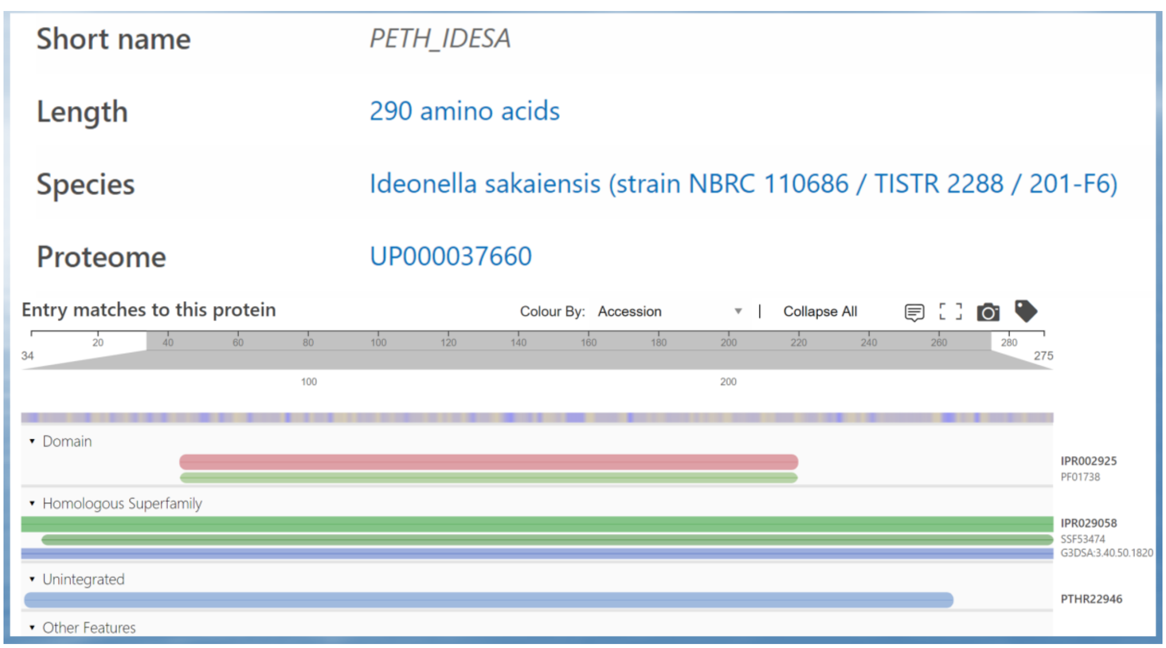


Figure 4: PETase Protein

PETase Applications and Risks

Ideally, we can produce super PETase mutants in different forms that can effectively degrade plastic in various environments including recycling plants, landfills and remote oceanic waste patches.

There are risks and alternatives:

- There could be unintended consequences such as dangerous chemical releases in process of manufacturing the mutants and degradation of PET. Many products such as cars and planes are made of plastic. What if PETase accidentally get a foothold on those products eating them?
- There are companies such as Carbios has been working to break PET plastics into their original components. This can then be used to make new plastic, minimizing the need for fossil fuels which commonly used to produce plastics[2].
- More effective waste management system, raise awareness and effective laws in using single-use plastic products to minimize plastic pollution.

The fact that mother nature is finding ways to heal herself resolving ill-effects brought upon by human innovations. PETase in natural form is one way that nature is healing from plastic pollution though slowly. We should be responsible to make corrective actions to reserve our planet for generations to come.

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