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Potential of Enzymatic Solutions to Microplastic Pollution

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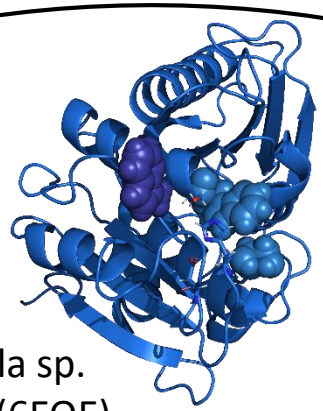
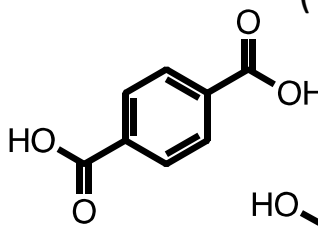
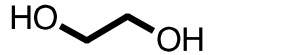
Enzymatic digestion of plastics to component monomers for re- and up-cycling



Ideonella sp.
PETase (6EQE)



Terephthalic acid
(TPA)



Ethylene glycol
(EG)

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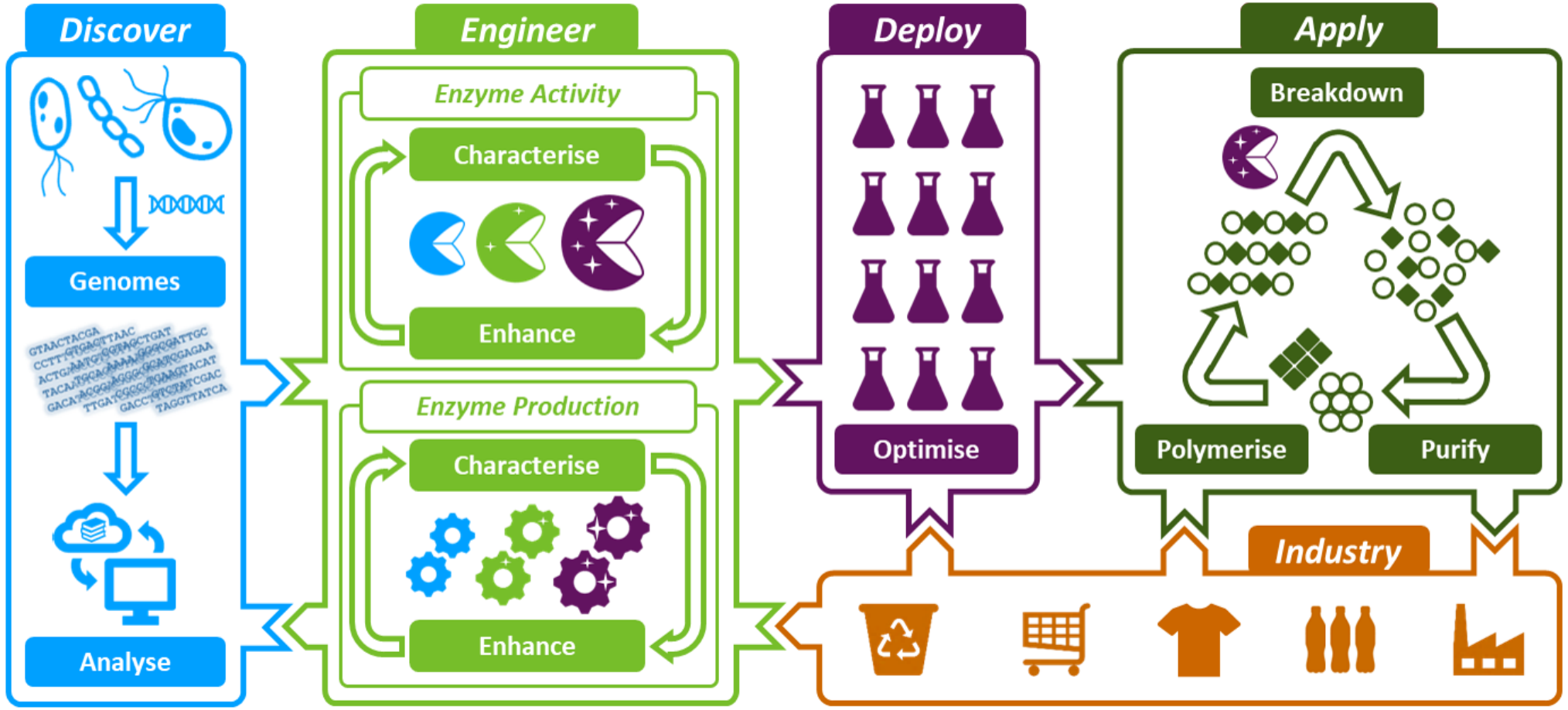
The Centre for Enzyme Innovation (CEI)



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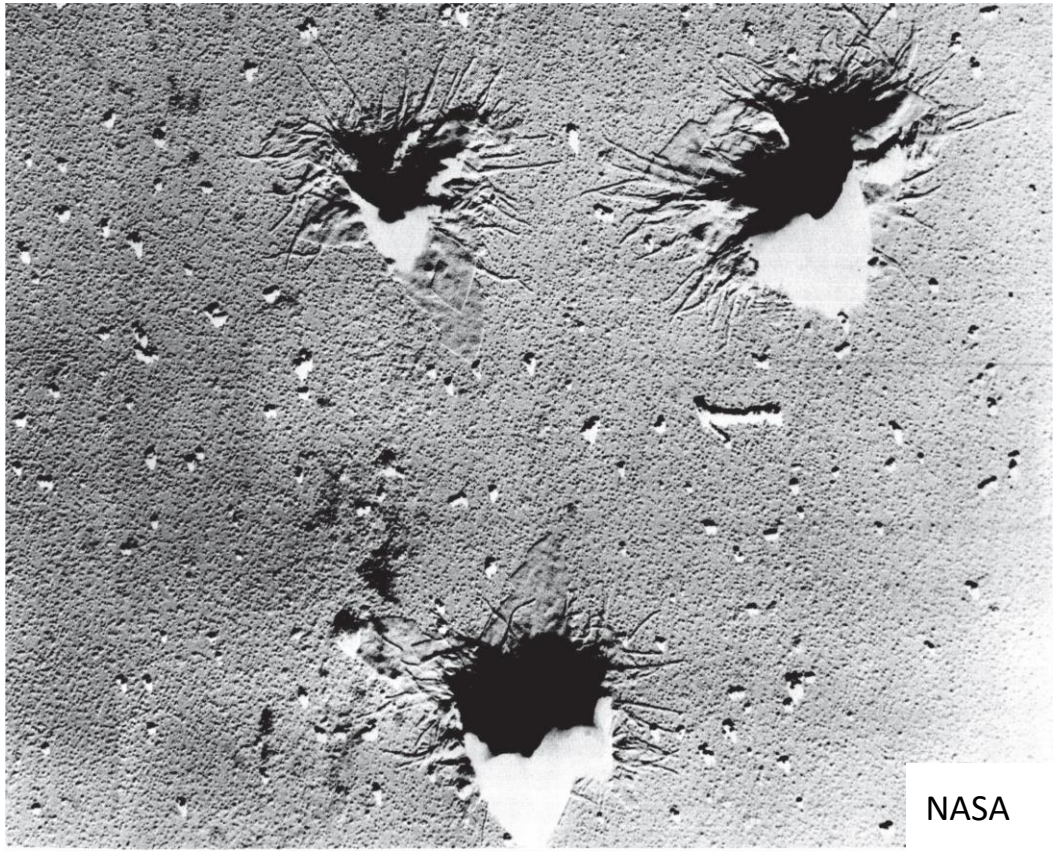
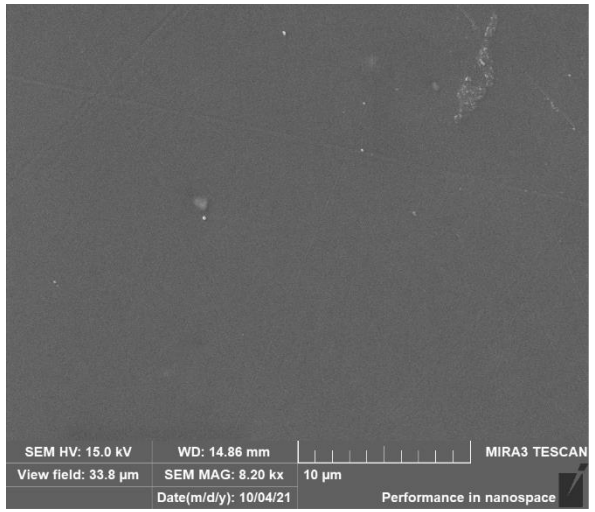
Enzymatic digestion targets amorphous regions of polyethylene terephthalate (PET)

Crystalline PET spherulites

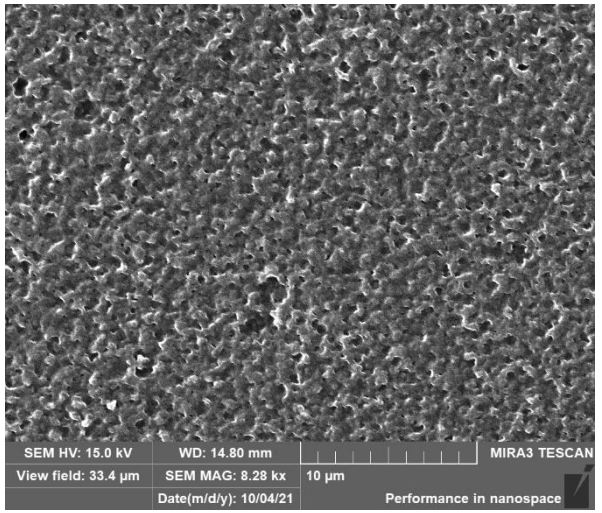


NASA

Amorphous PET treated with leaf compost cutinase (LCC) variant



Untreated Coupon



Coupon After Digestion

Rosie Graham (UoP)

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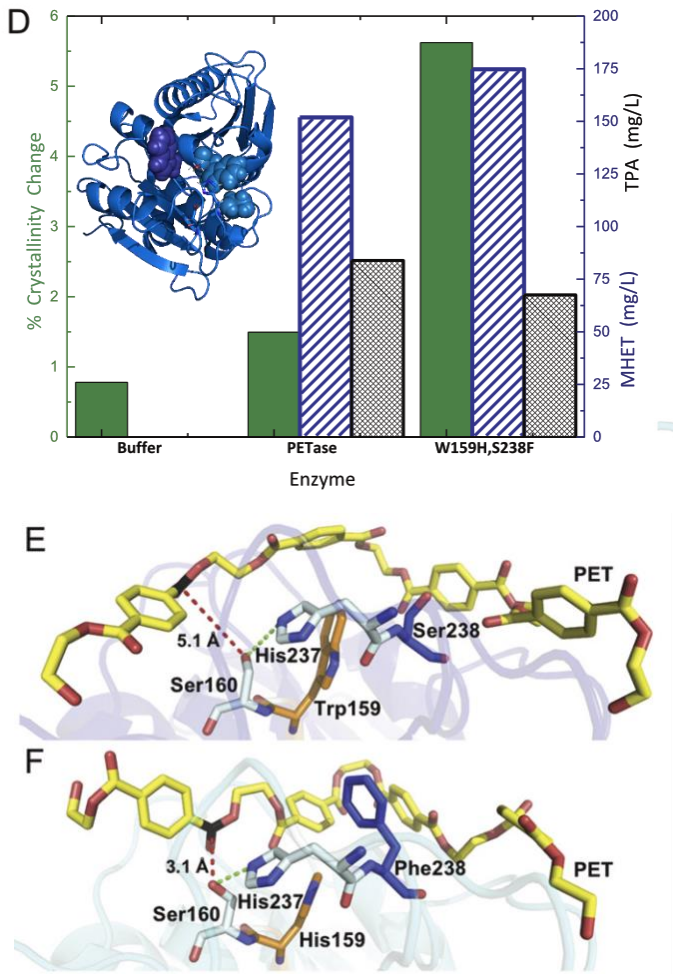
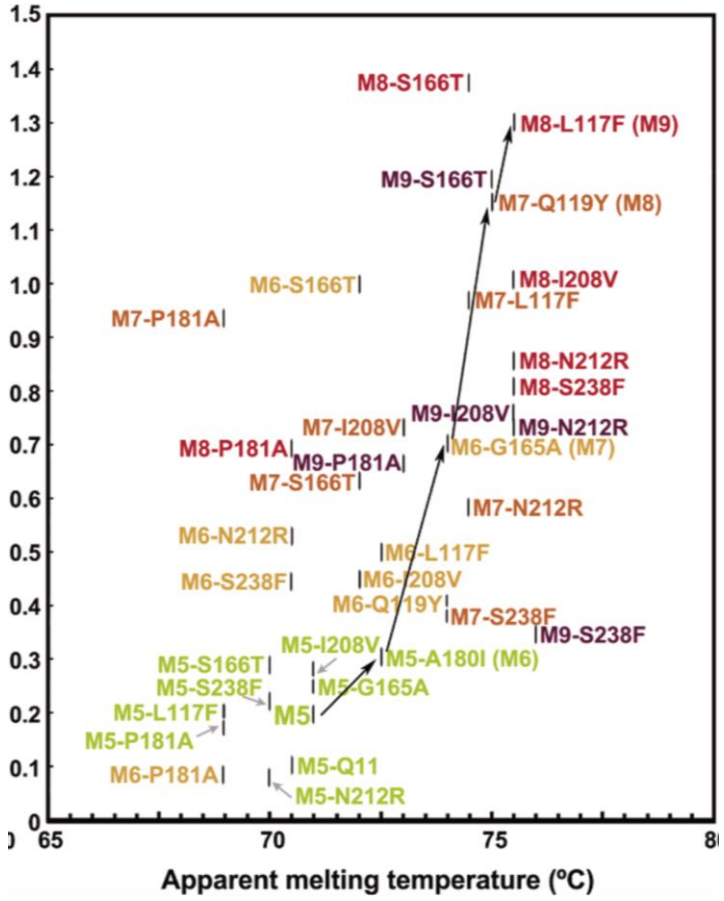
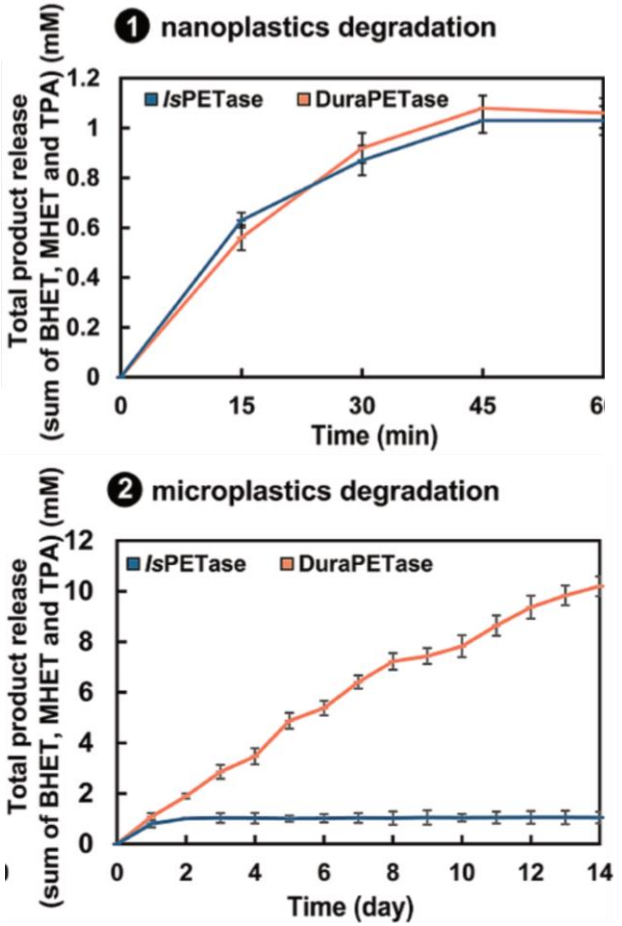
Natural PET degrading enzymes can be engineered for improved function

Austin et al. 10.1073/pnas.1718804115



Cui et al. 10.1021/acscatal.0c05126

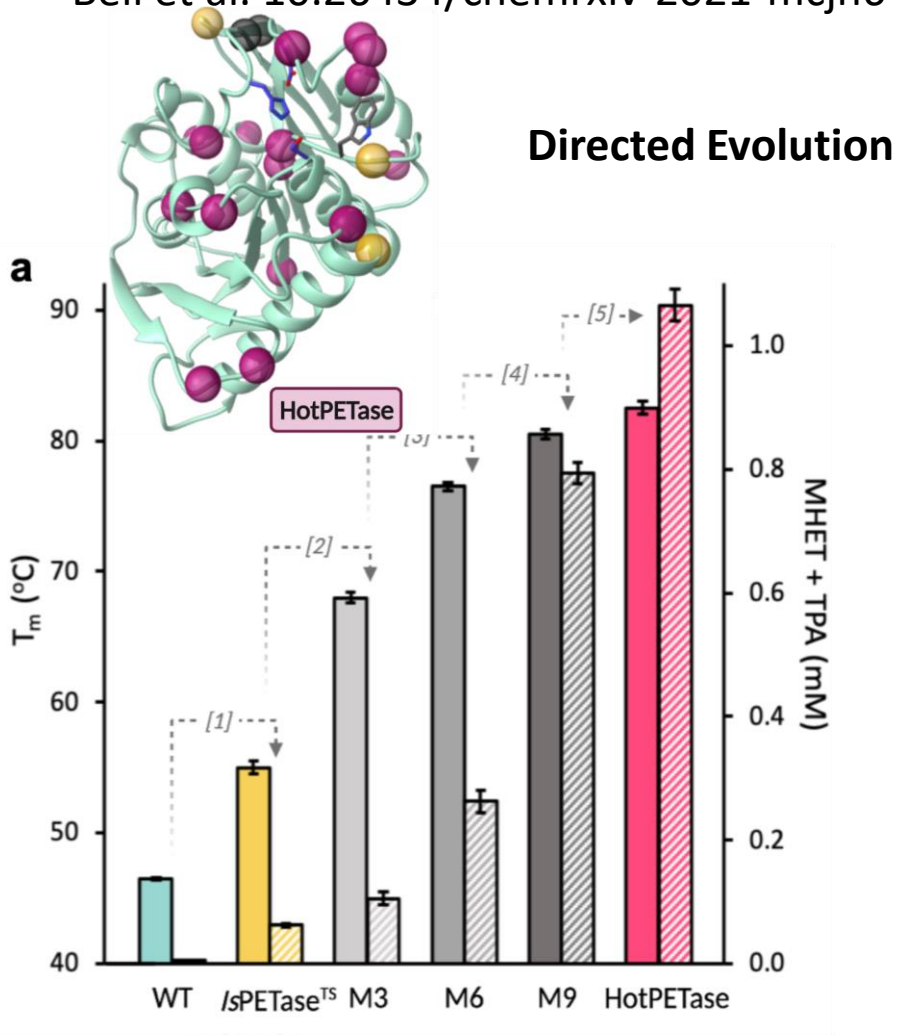


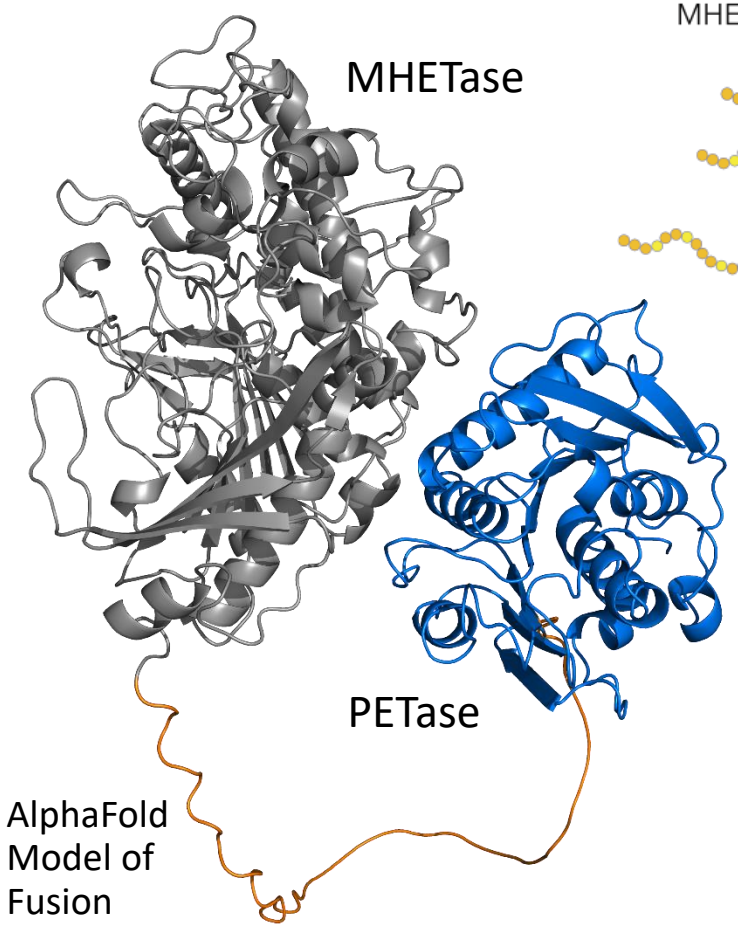


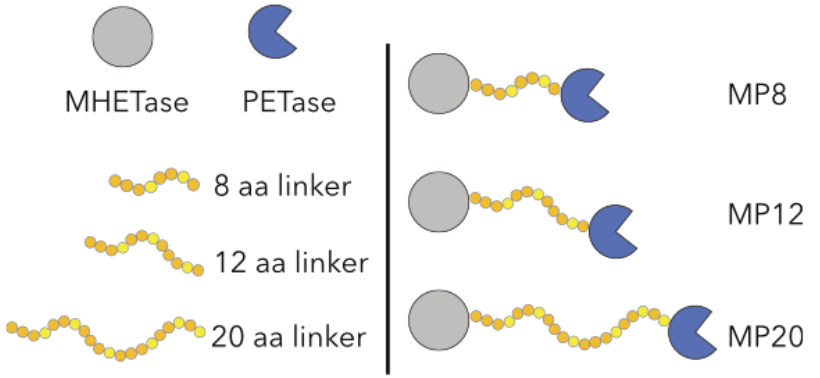
Natural PET degrading enzymes can be engineered for improved function

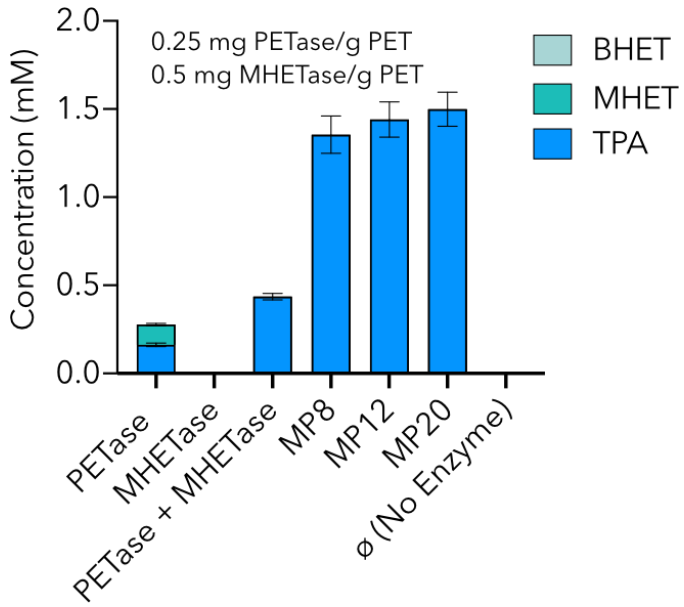
Bell et al. 10.26434/chemrxiv-2021-mcjh6

Knott et al. 10.1073/pnas.2006753117

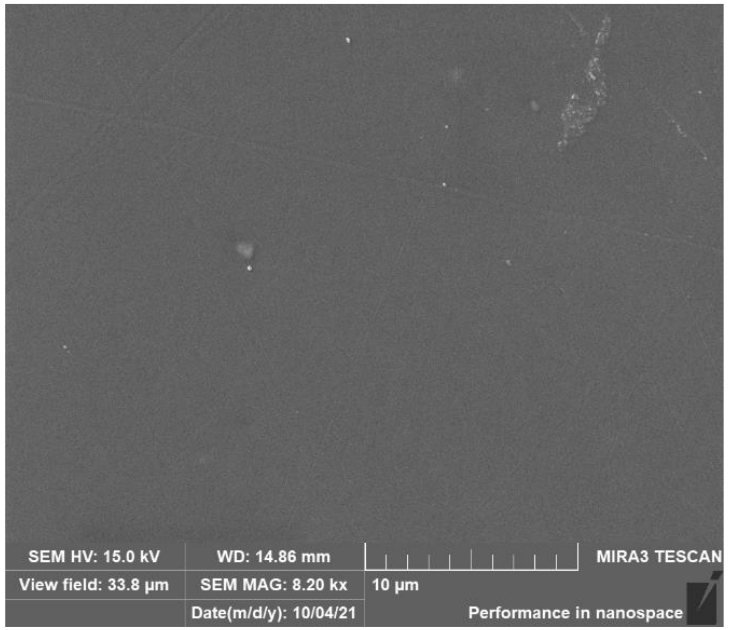


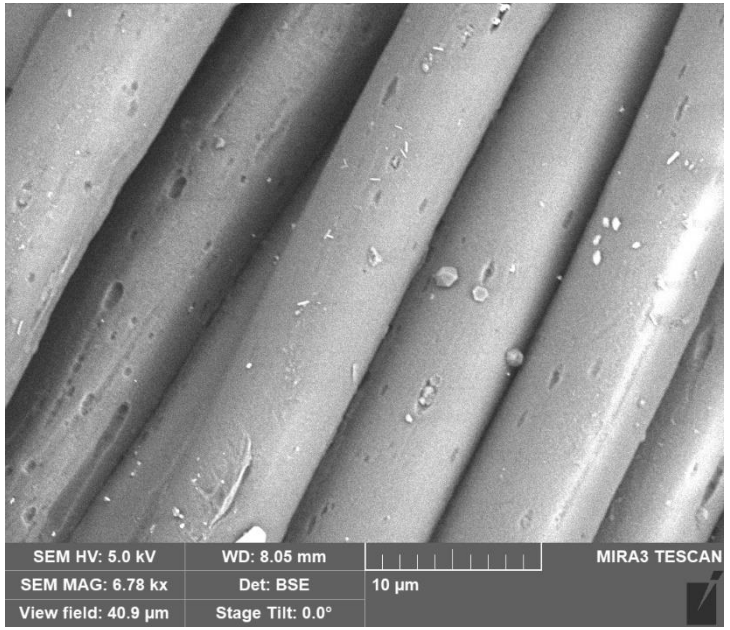






Microplastics arise from different sources via different mechanisms





Simon Cragg/Luisana Avilan

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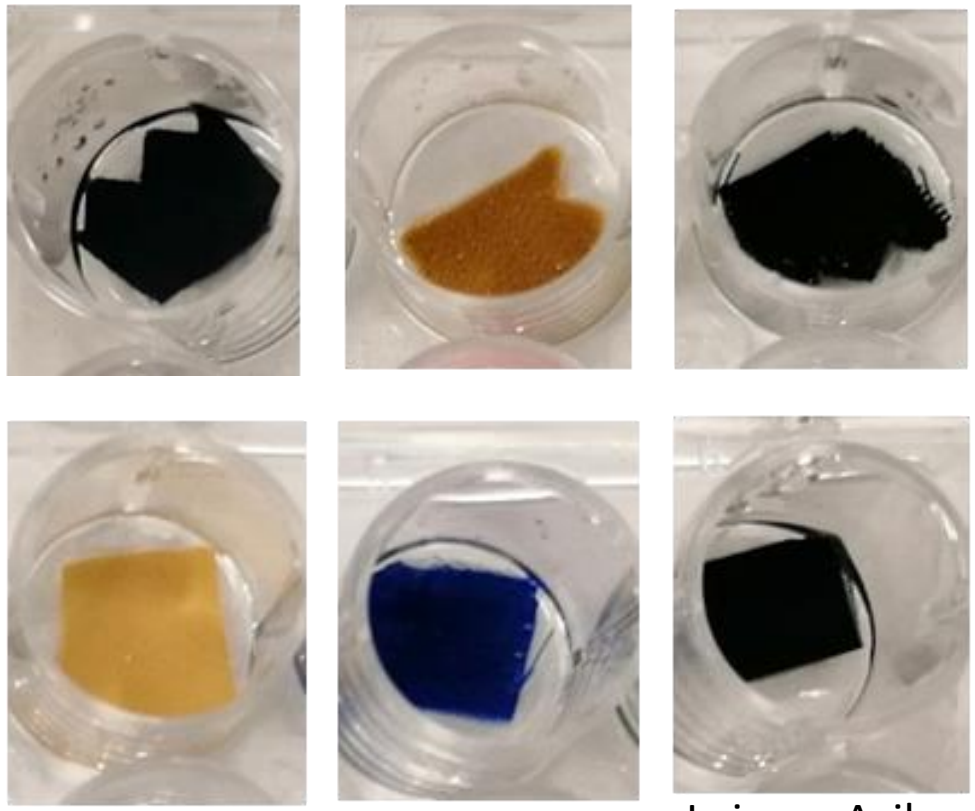
Pre-consumer fabrics and raw fibres are substantially resistant to IsPETase

Dyed PET polyester fabrics



Luisana Avilan

Wound raw PET fibre

But this may be ok: we may not want our enzymes attacking consumer fabrics in some applications…

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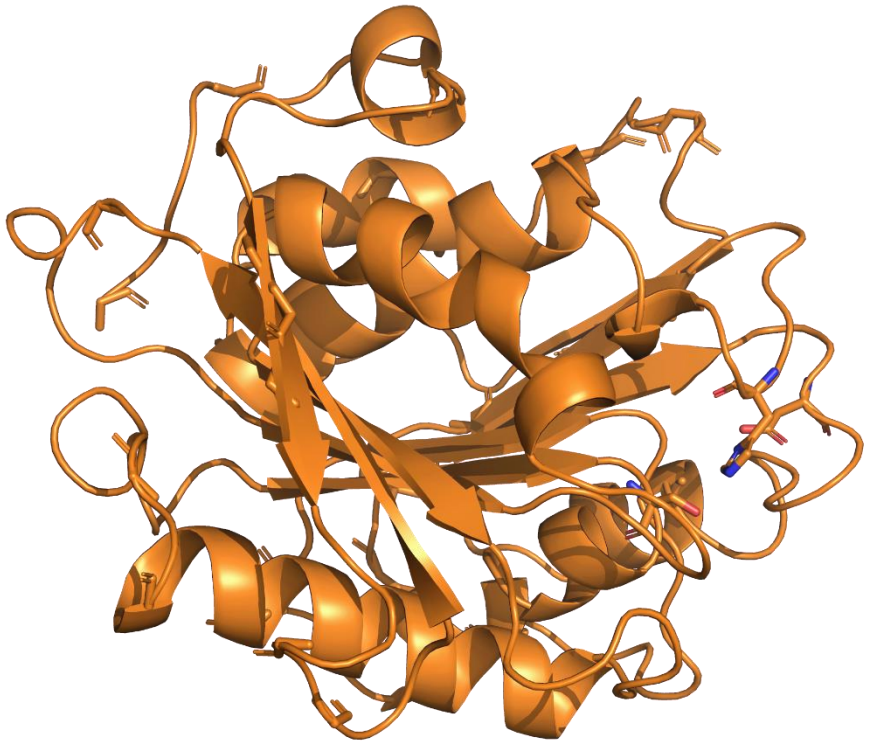
Large scale screening has revealed unexpected genetically encoded activities



We can engineering genetically encoded activities

pH optimum
Melting temperature
Cofactor binding (eg Ca^{2+})
Buffer optimum
Protein stability in reaction
Kinetics
Substrate binding
Etc.

Substrate specificity (pristine vs mechanically disrupted)

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Towards a microplastic circular economy using enzymes

Engineering low temperature, detergent resistant PET degrading enzymes for applications in consumer products (eg laundry powder)

Directed evolution of organisms within sewage treatment microbial mats to improve their export of PET degrading enzymes, and uptake/metabolism of released products

Capture of PET micro- and nano-plastics at origin or via filtration for integration into centralised waste plastic degradation and up-/re-cycling streams

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Acknowledgements

University of Portsmouth
Centre for Enzyme Innovation
Professor John McGeehan
Professor Andy Pickford
Professor Simon Cragg
Dr. Luisana Avilan
Liliana Oliveira
Rosie Graham

National Renewable Energy Laboratory (NREL), Golden, CO USA
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