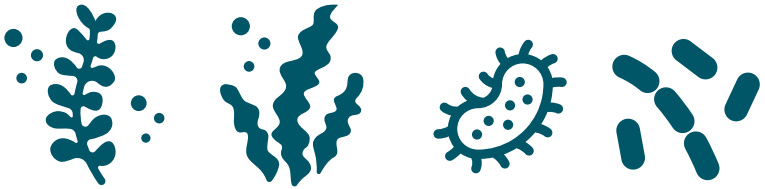
Rewriting and repurposing biology for bioplastic degradation

Dr Hafna Ahmed

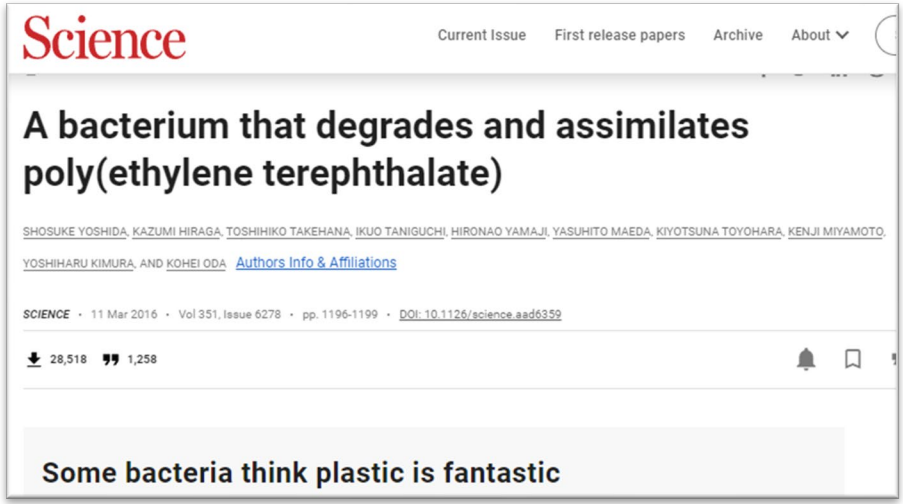
Ending Plastic Waste Mission
Advanced Engineering Biology FSP
May 2023



Organisms in nature adapt and evolve to thrive in their environment…

..including ‘eating’ plastic waste (slowly)

Plastic degrading organisms make specialised enzymes



Science

Current Issue First release papers Archive About

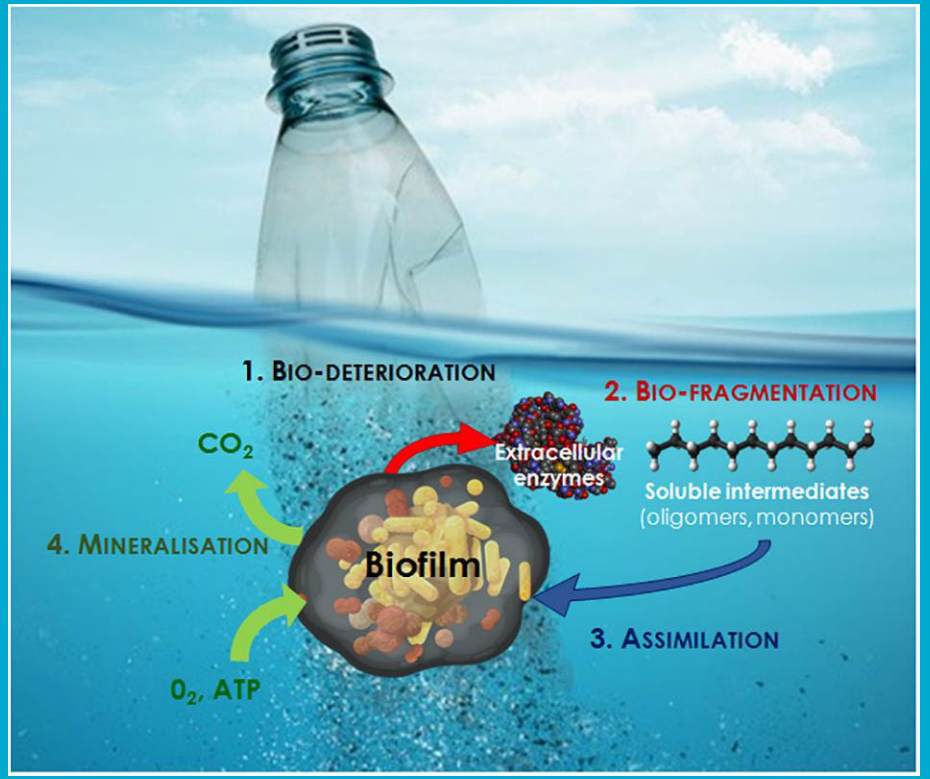
A bacterium that degrades and assimilates poly(ethylene terephthalate)

SHOSUKE YOSHIDA, KAZUMI HIRAGA, TOSHIHIKO TAKEHANA, IKUO TANIGUCHI, HIRONAO YAMAJI, YASUHITO MAEDA, KIYOTSUNA TOYOHARA, KENJI MIYAMOTO, YOSHIHARU KIMURA, AND KOHEI ODA Authors Info & Affiliations

SCIENCE · 11 Mar 2016 · Vol 351, Issue 6278 · pp. 1196-1199 · DOI: 10.1126/science.aad6359

28,518 1,258

Some bacteria think plastic is fantastic



Jacquin et al. (2019). Front Microbiol. 10. doi: 10.3389/fmicb.2019.00865

Bioplastic degrading enzymes

- Bioplastics are made from renewable materials – lower net carbon emissions
  - PLA, PBS/PBSA, PBAT, PHA/PHB
- ‘biodegradable’ and ‘compostable’… under specific conditions

Bacteria and enzymes to enhance bioplastic composting

Bioplastic degrading enzymes

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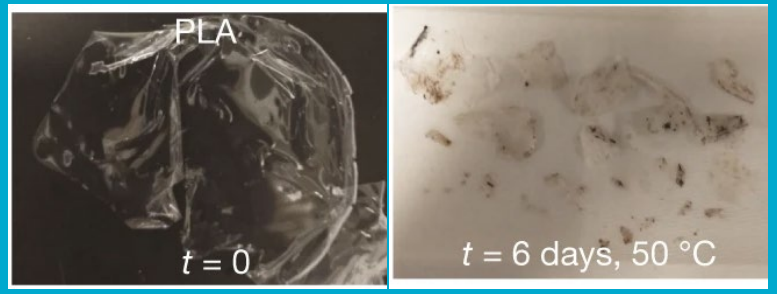
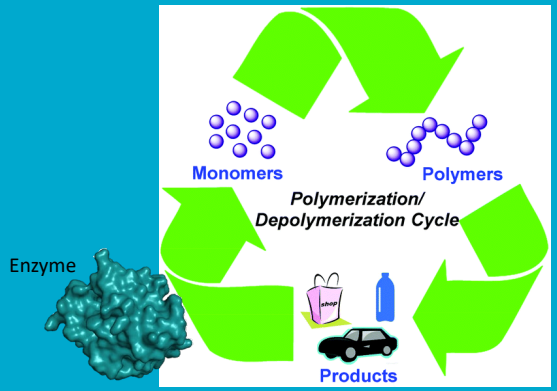
Bacteria and enzymes to enhance bioplastic composting

Enzymes embedded in bioplastics enhance composting



DelRe *et al.* (2021). *Nature* 592: 558–563.

Enzymes for plastic chemical recycling

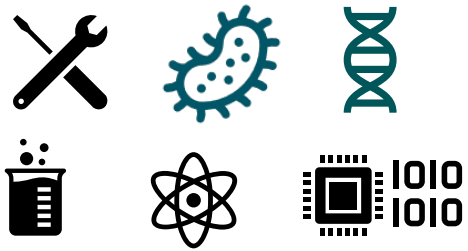


Hong & Chen (2017). Green Chemistry. 19: 3692-3706.

Optimising bio-plastic degrading enzymes

- Temperature tolerance
- High activity
- Stability and longevity
- Solvent tolerance
- plastic specificity

- Using engineering biology techniques



Optimising bio-plastic degrading enzymes

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- Using engineering biology techniques

Our team

Adj Prof Colin Scott
Team Leader,
Director CSIRO Biofoundry

Dr Hafna Ahmed
Research Scientist

Dr Lygie Esquirol
Postdoctoral Fellow

Nigel French
Senior Experimental Scientist

Other projects

Dr Oliver Mead
Research Scientist
Novel bioreactors

Dr Raquel Aguiar-Rocha
Postdoctoral Fellow
Rare earth biomining

Dr Miao Hu
Postdoctoral Fellow
PFAS degrading enzymes

CSIRO collaborations

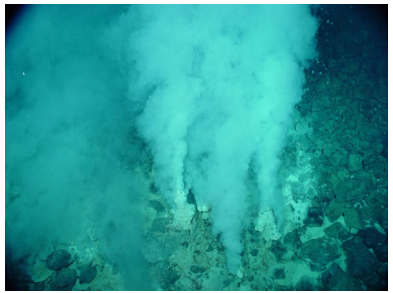
Adj Prof Rob Speight
Director CSIRO Advanced Engineering Biology Future Science Platform (AEB FSP)

Dr Alex Caputo
Protein Crystallography
CSIRO Manufacturing

Dr Andrew Warden
biomolecular modelling

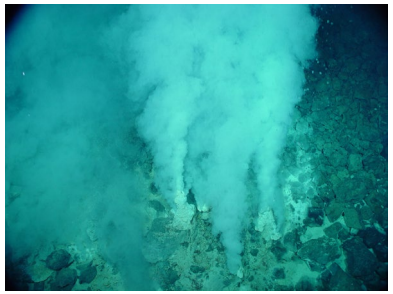
Project approach

Data-mining for enzymes with high temperature tolerance



Microbes living in
high temperature environments make
thermal tolerant enzymes

Data-mining for enzymes with high temperature tolerance

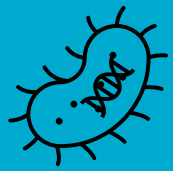


Microbes living in
high temperature environments make
thermal tolerant enzymes

DNA sequence of known plastic degrading enzyme

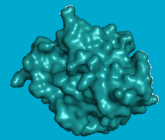
Public genome databases

DNA of similar enzymes from thermal tolerant bacteria



Engineered laboratory bacteria

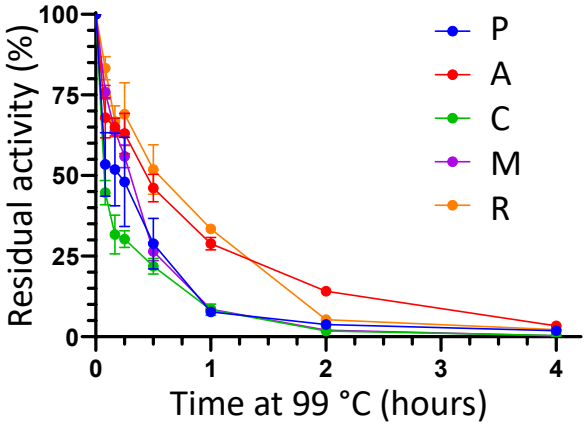
Culture bacteria



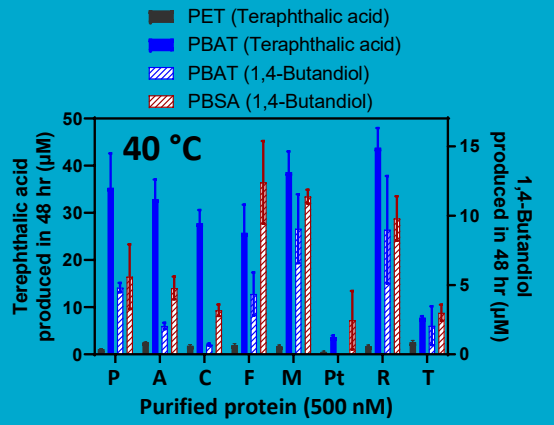
Isolate and characterise enzyme

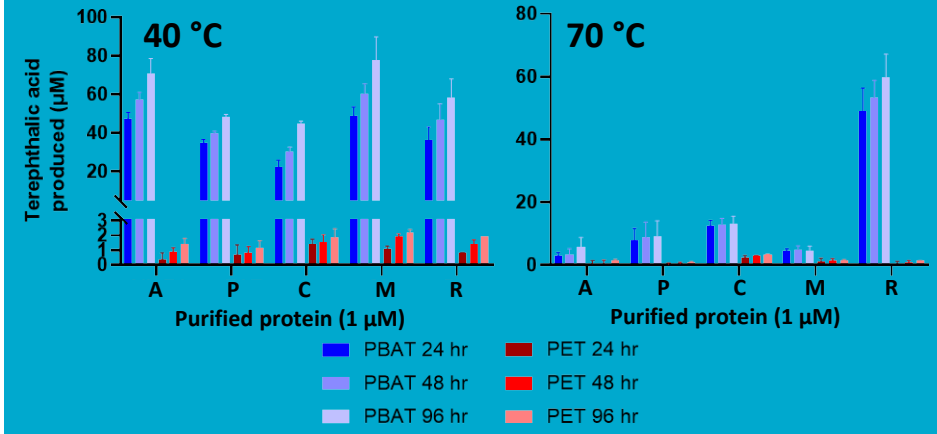
Characterising newly identified enzymes

- Thermal tolerance



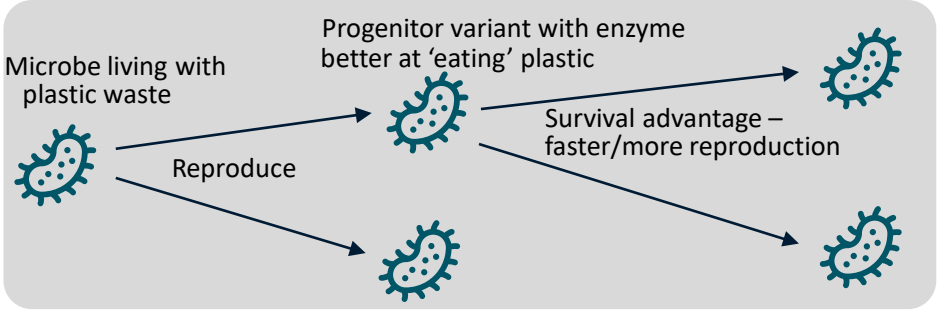
- Bioplastic degradation activity





Engineering bioplastic degrading enzymes

Accelerating the natural evolution process in the lab…



Engineering bioplastic degrading enzymes

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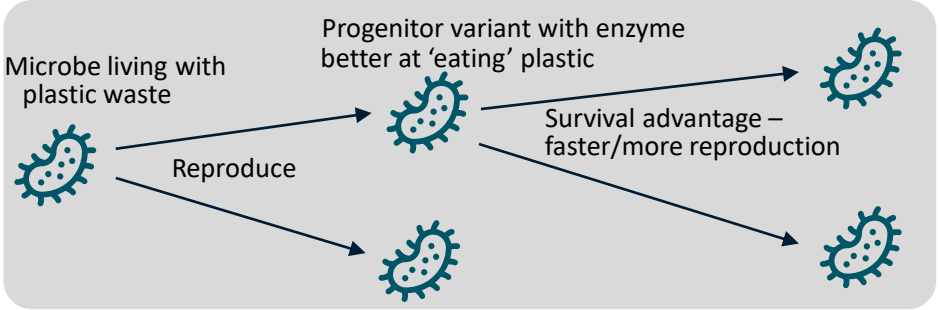
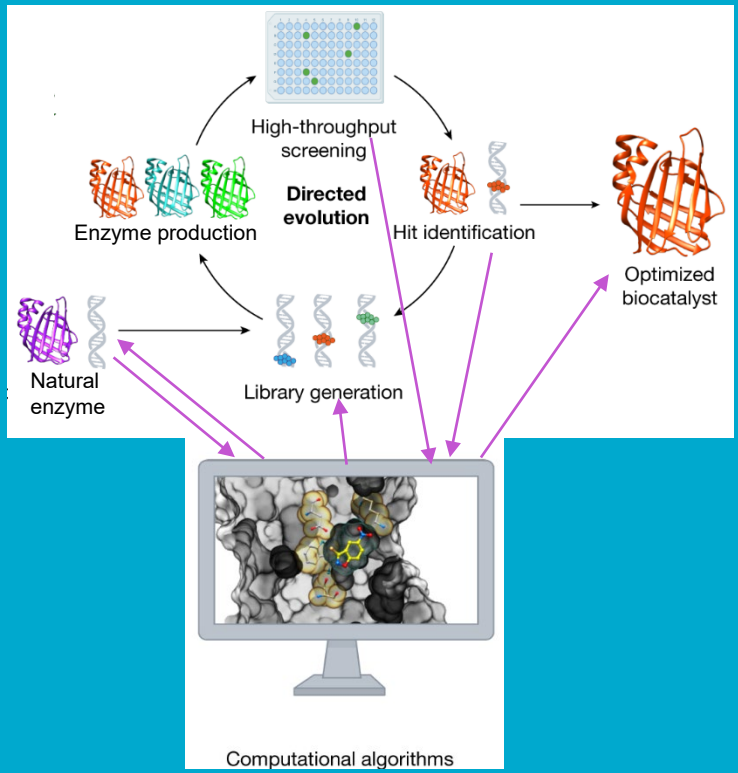


…using the latest computational tools



Adapted from Lovelock *et al.* (2022). The road to fully programmable protein catalysis. *Nature* 606: 49–58.

Thank you

Team
Prof Colin Scott (Director CSIRO Biofoundry)
Dr Lygie Esquirol (Postdoctoral Fellow)
Nigel French (Senior Experimental Scientist)

Crystallography and Biophysical characterisation
Dr Alex Caputo (Research Scientist, Manufacturing)
Sophia Newton (Crystallography Technician)

Advanced Engineering Biology FSP
Prof Rob Speight (Director)
Dr Andrew Warden (Data-Driven Molecular Design theme leader)