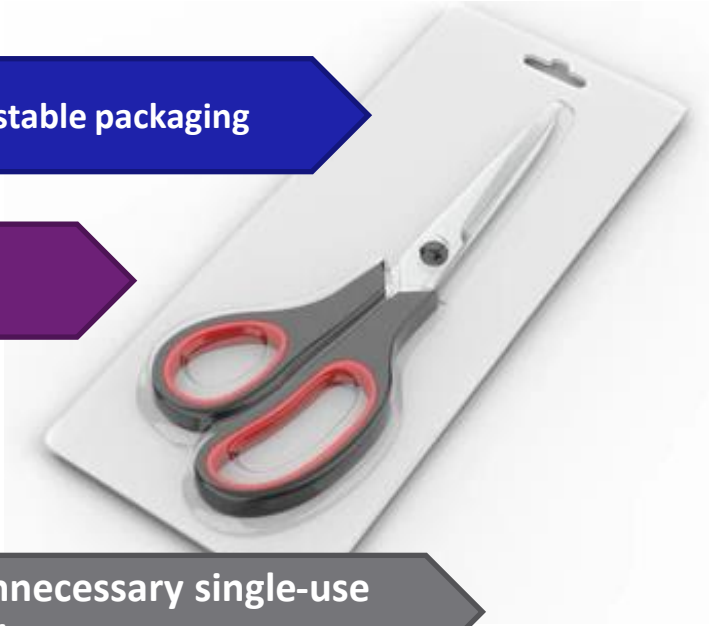
Enzymatic Biodegradation of Plastics

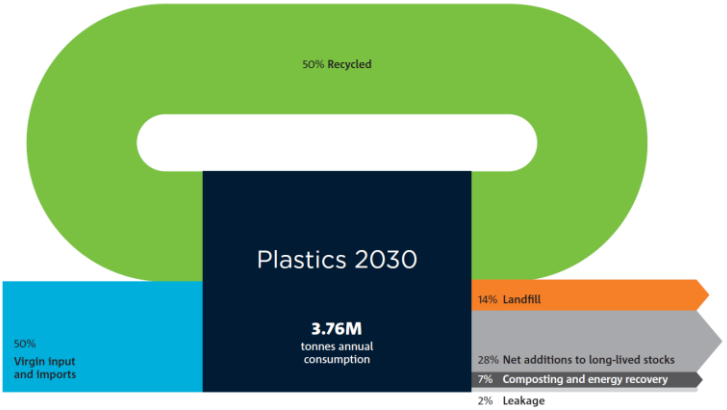
Albert Ardevol | 23rd May 2023 | Ending Plastic Waste Symposium

Australia's 2025 National Packaging Targets

- 100% reusable, recyclable or compostable packaging
- 70% of plastic packaging being recycled or composted
- 50% average recycled content included in packaging
- Phase out of problematic and unnecessary single-use plastic packaging

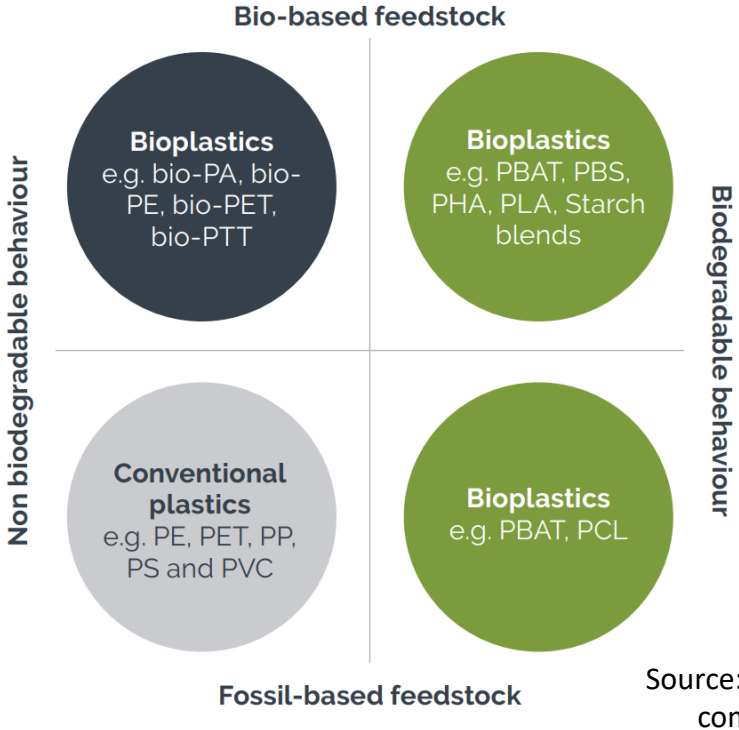


Sankey diagram of plastic flows for Australia



Circular economy roadmap for plastics, glass, paper and tyres. Pathways for unlocking future growth opportunities, CSIRO 2021

Complexity of the term *bioplastics*

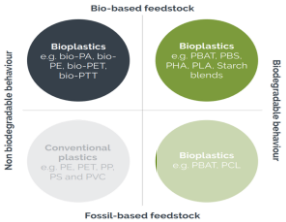


Source: APCO – Considerations for compostable plastic packaging

Global production capacities of bioplastics 2022

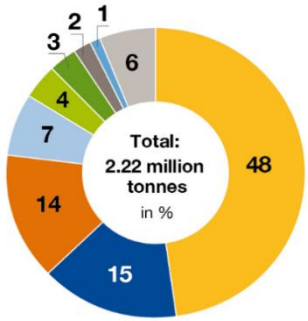
by type

48.5% Bio-based/non-biodegradable



51.5% Biodegradable

by market segment



- Packaging (flexible & rigid)
- Fibres (incl. woven & non-woven)
- Consumer goods
- Automotive & transport
- Agriculture & horticulture
- Electrics & electronics
- Coatings & adhesives
- Building & construction
- Others

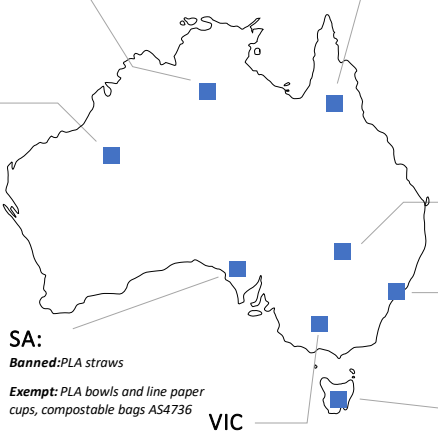
Source: KPMG

Single use plastics ban

- The ban will apply to items made from conventional plastic, **and those made from degradable, biodegradable and compostable plastic**.
- This recognises that all forms of plastic can be bad for the environment when littered.

- **Compostable plastic require processing at a specialised compost facility** to break down.

State regulation



QLD:

Banned:*unlidded PLA bowls and containers*

Exempt: *PLA straws and cutlery, lidded bowls certified compostable (home or industrial), PLA coated paperboard, compostable utility. /barrier bags (bin liners, dog bags)*

NT:

Exempt: *compostable AS4736 bags*

WA

Banned:*disposable plastic cups or plastic glasses or any kind used for cold drinks, disposable paper cups which have any form of plastic or bioplastic, disposable cups made purely from compostable plastic (PLA), unlidded bowls/ containers/straws (includes PLA coated paperboard products without lids)*

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SA:

Banned:*PLA straws*

Exempt: *PLA bowls and line paper cups, compostable bags AS4736*

VIC

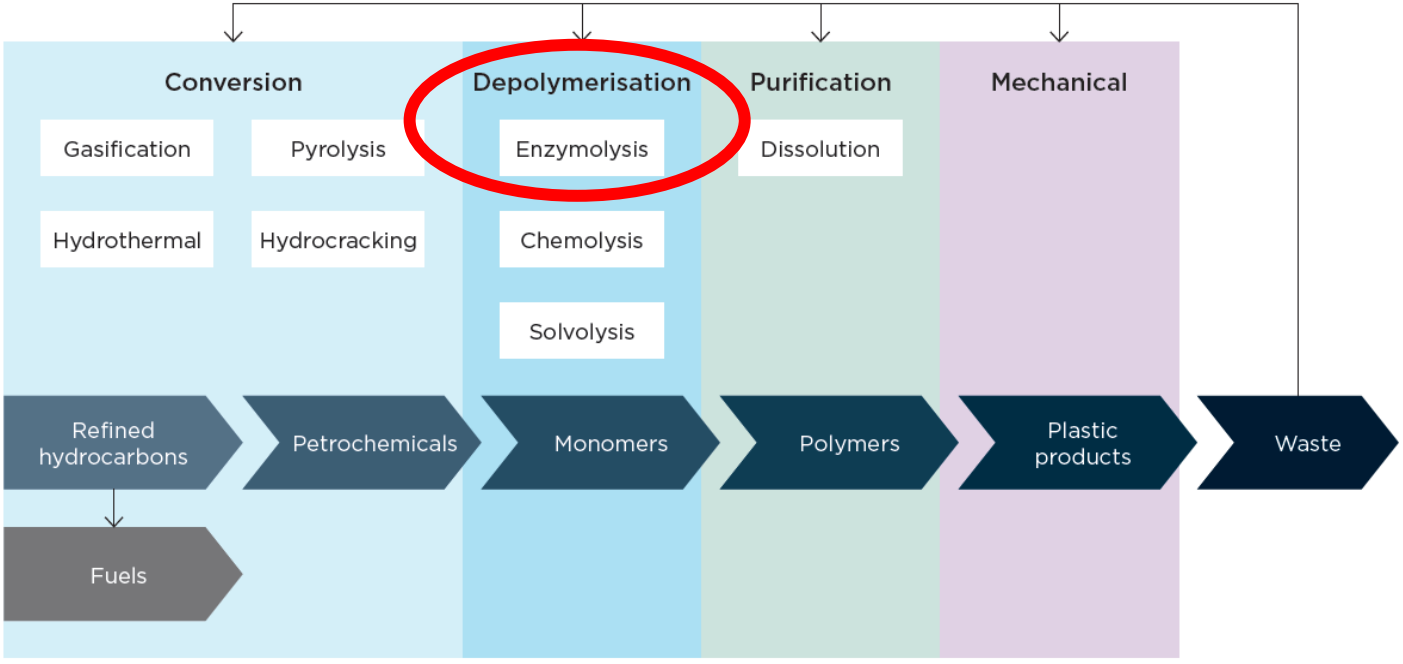
Banned:*PLA straws*

Exempt: *PLA cups, containers, lined cups, lined paperboard containers, compostable utility/barrier bags*

TAS

Exempt: *PLA products and compostable bags (home or industrial certified)*

Advanced Recycling



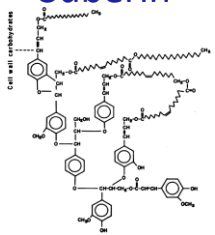
Are non-biodegradable plastics… biodegradable?

How pathogens attack plants

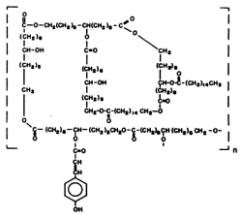
The **hydrophobic polyesters** cutin & suberin create a barrier that prevents water loss and gives protection against pathogens in plants

Pathogens have developed various cutinase and esterase enzymes capable of degrading these aliphatic polyesters

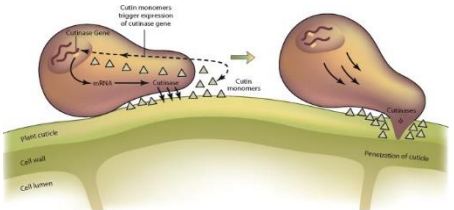
Suberin



Cutin



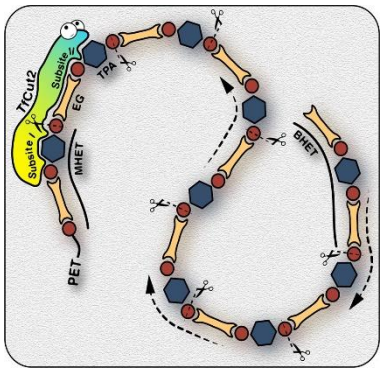
Cutinases & esterases

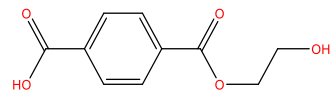


Kolattukudy, P. E. *Science* **1980** (208) 990-1000

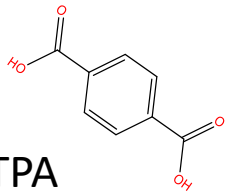
How pathogens attack…plastic?

Enzymes can depolymerize **PET** to its constituent monomers





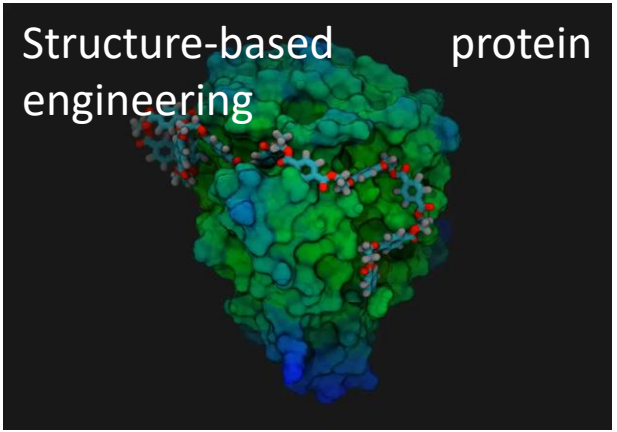
MHET

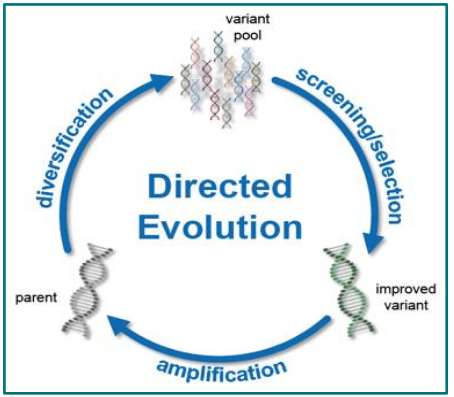


TPA

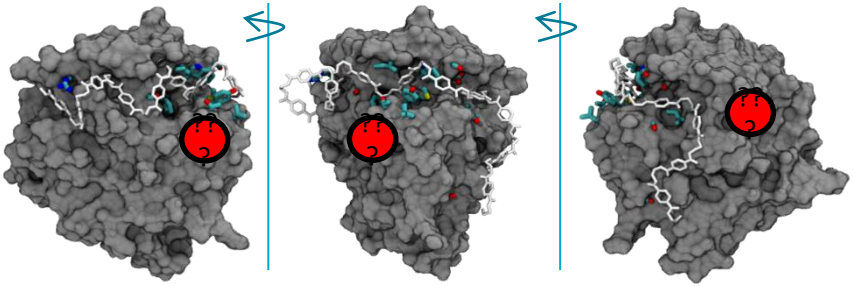
Falkenstein, P. et al. *ACS Catal.* **2023**, 13, XXX, 6919–6933

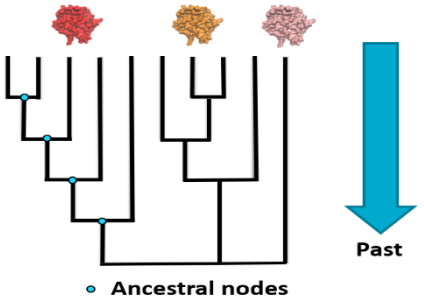
Enzyme engineering



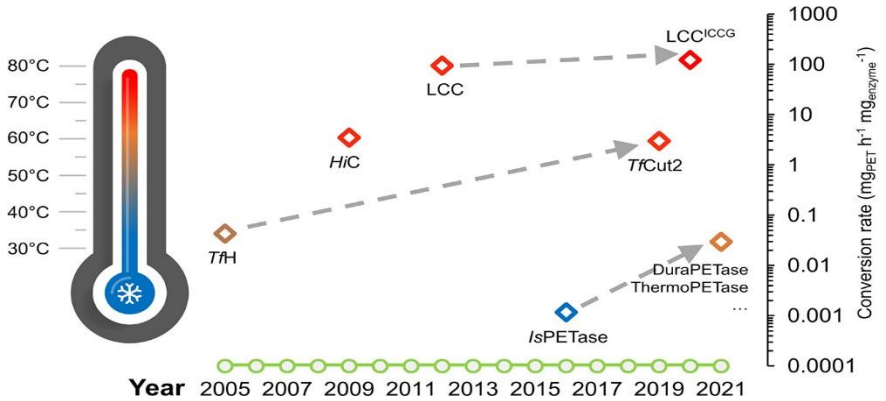


Ancestral sequence Reconstruction





PETase – Enzyme engineering



- Higher thermostability → Near T_G of PET
- Enhanced activity against crystalline PET → most PET is 30-40% crystalline
- Improved solubility → Mesophilic inhibition
- Purification of TPA → Additives & subproducts

Current landscape

CARBIOS https://www.carbios.com/en/

SAMSARA https://www.samsaraeco.com/

EPOCH BIODESIGN https://www.epochbiodesign.com/

CSIRO

UNIVERSITY OF PORTSMOUTH

Australian National University

bottle

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AEB FSP

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Australian National University

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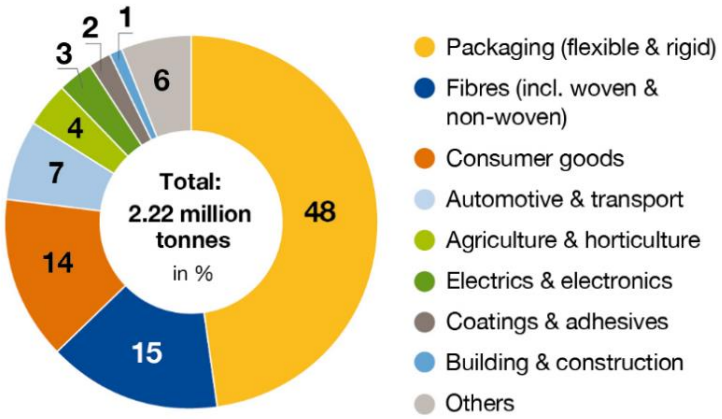
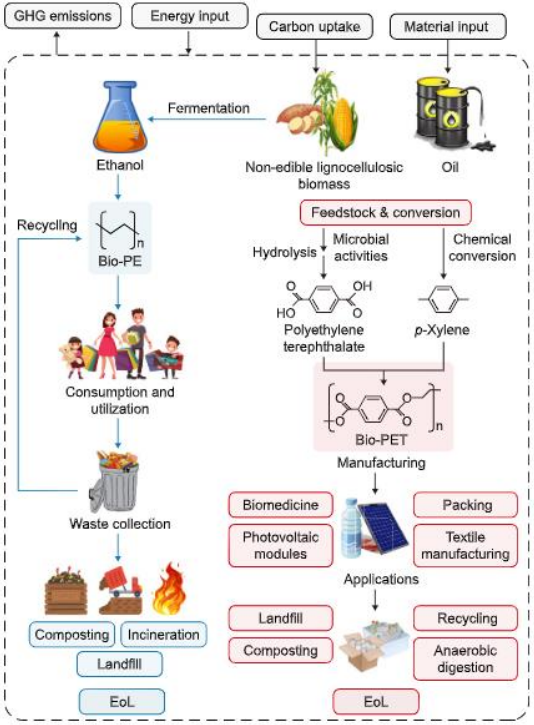
Global Production Capacities of bioplastics 2022

By market segment



Bio-PE & Bio-PET



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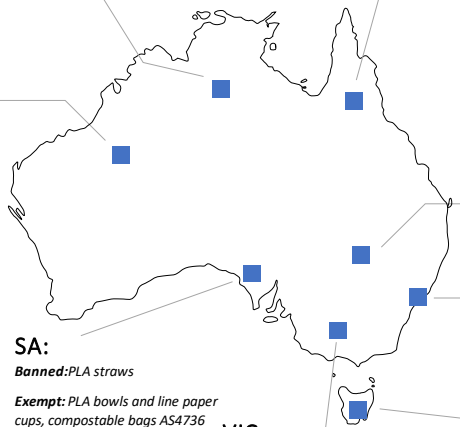

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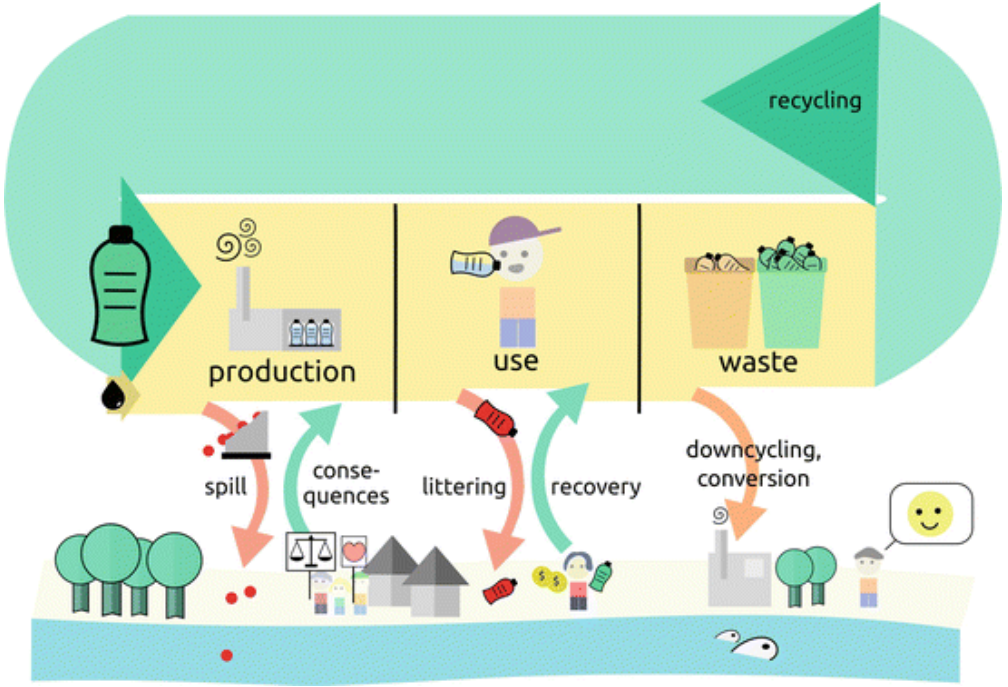
Microplastics: sources and mitigation



Learning from the past with Ancestral Sequence Reconstruction