



DANISH
TECHNOLOGICAL
INSTITUTE

ENZYNOC: ADDRESSING DIFFICULT TO RECYCLE PLASTICS WITH ENZYMES

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A PART OF THE EUROPEAN R&D-NETWORK



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- CEA
- Fraunhofer
- TNO
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- RISE
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- AIT
- DTI

*EUROTECH is a special interest group originating from EARTO (the European Association of Research and Technology Organisations)



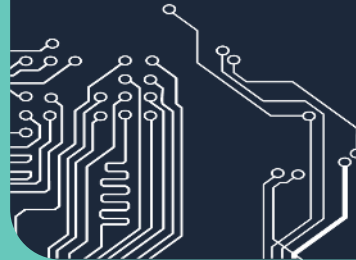
STRATEGIC FOCUS

**GREEN
TRANSITION**



FOODS
MATERIALS
ENERGY

DIGITALISATION



ENZYNOC

Research project funded by the Novo Nordisk Foundation

Project period: 2022-2028

Project members:

Prof. Daniel Otzen (Aarhus University)

Prof. Søren Thirup (Aarhus University)

Prof. Maria J. Ramos (University of Porto)

Prof. Pedro. A. Fernandes (University of Porto)

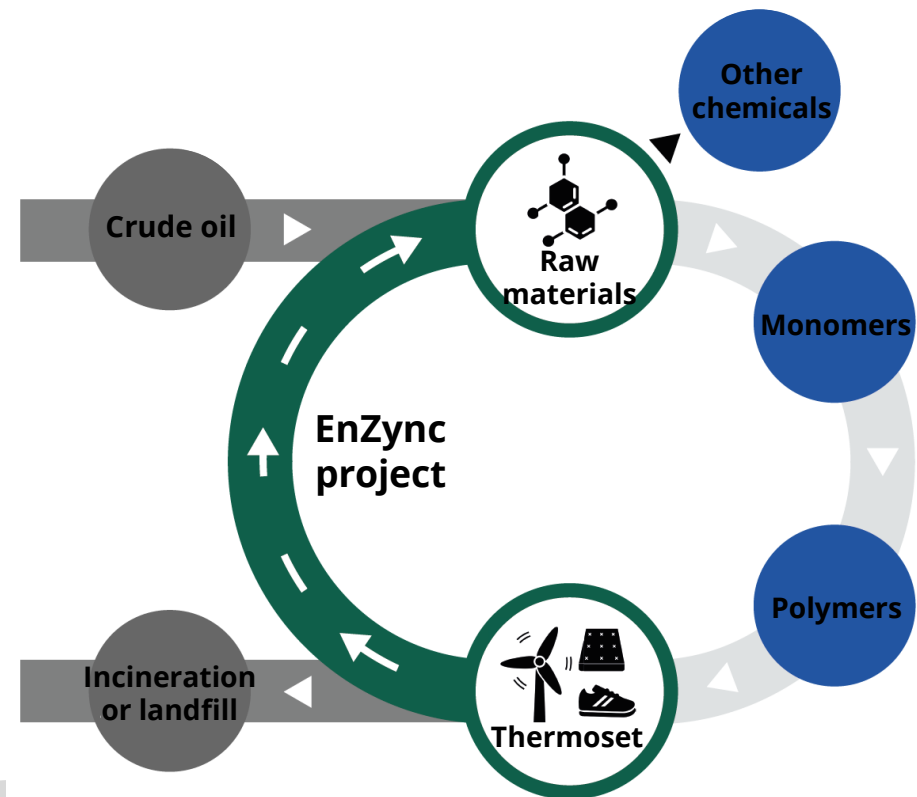
Prof. Peter Westh (Technical University of Denmark)

Prof. Jens Preben Morth (Technical University of Denmark)

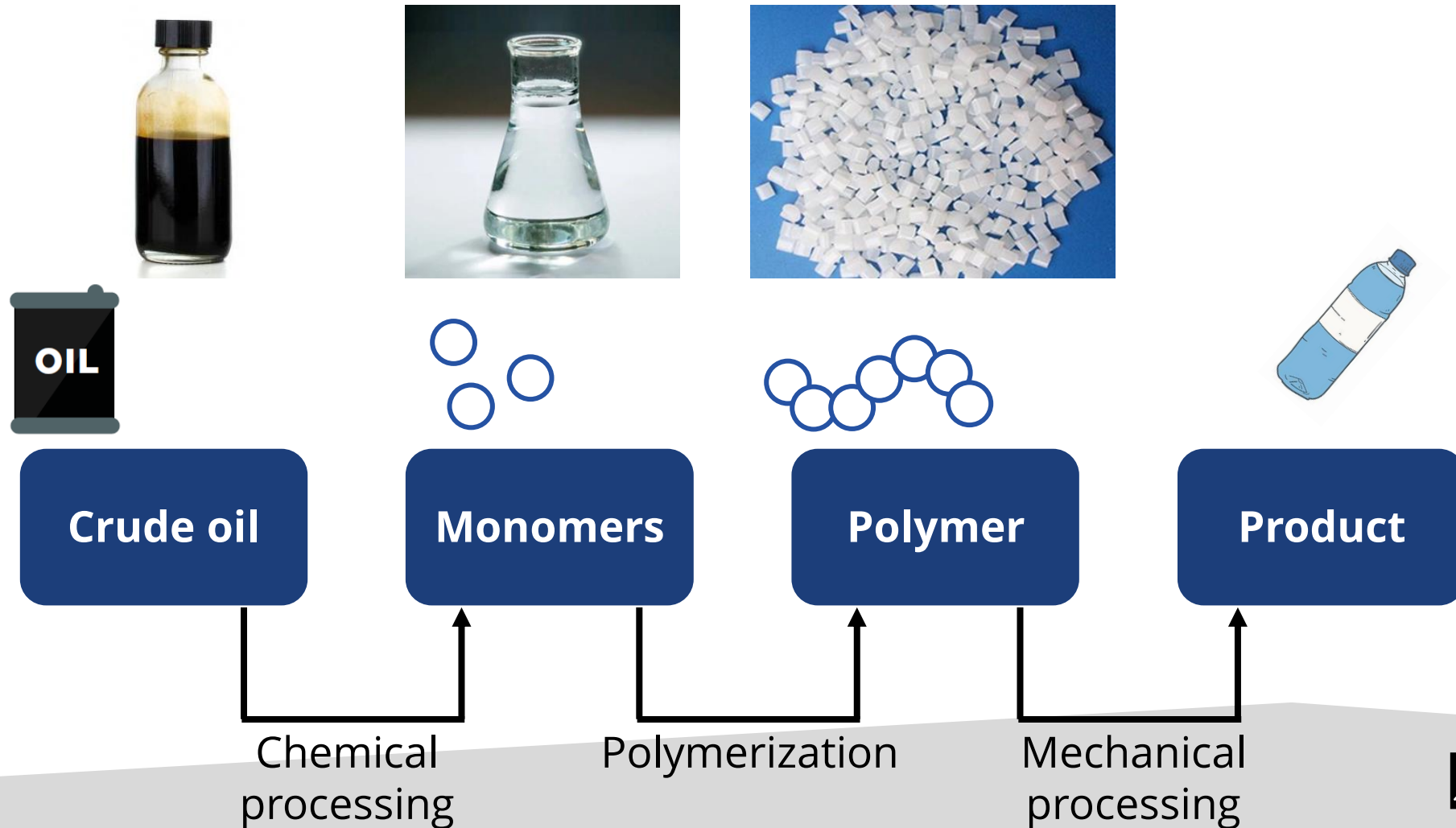
Prof. Uffe Mortensen (Technical University of Denmark)

Danish Technological Institute

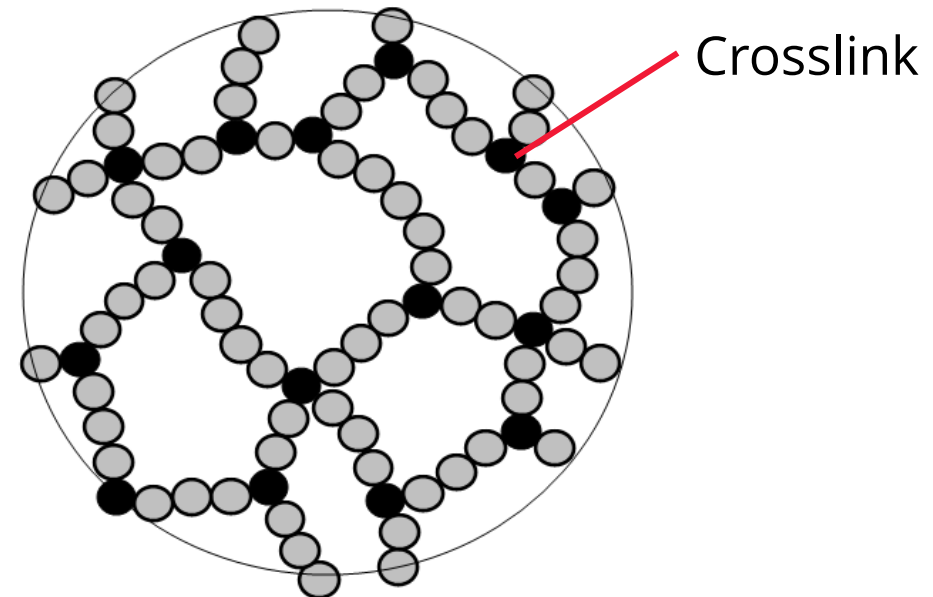
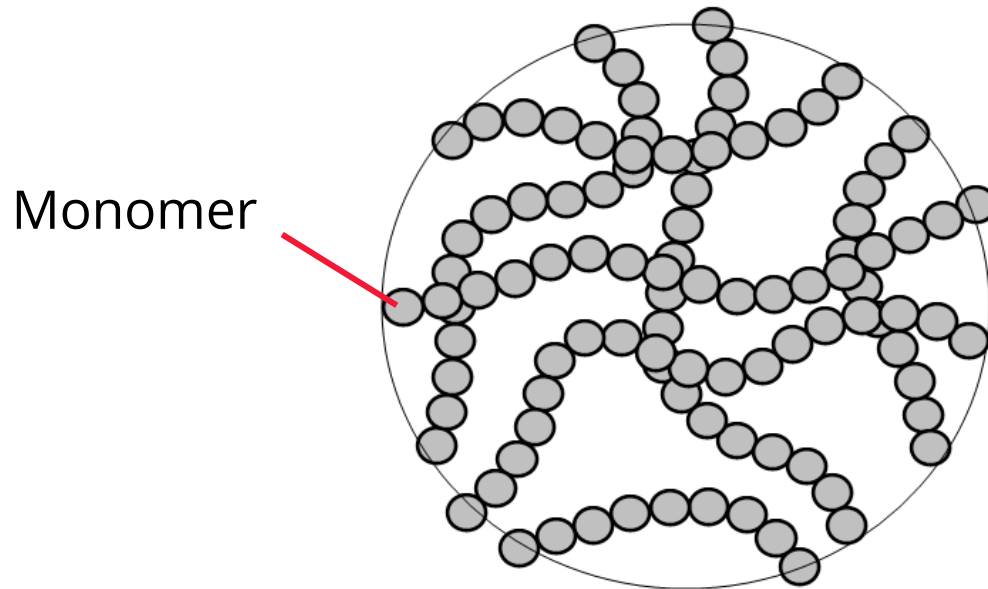
Vision: discovery and development of enzymes for recycling of plastic thermosets



PLASTICS ARE POLYMERS



THERE ARE TWO TYPES OF PLASTICS



Can be melted repeatedly



Thermoplastics
(not crosslinked)

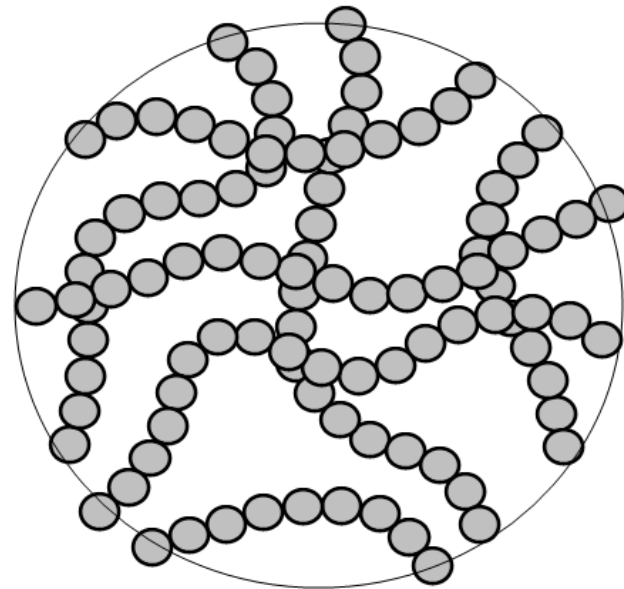
Thermosets
(crosslinked)



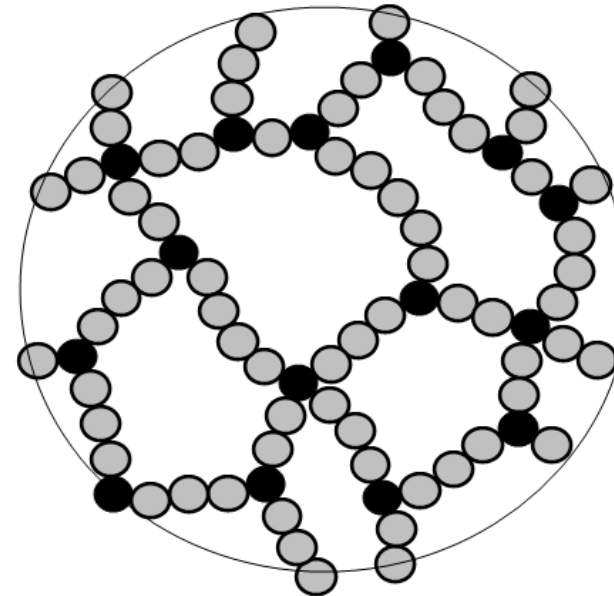
Once shaped, cannot be melted



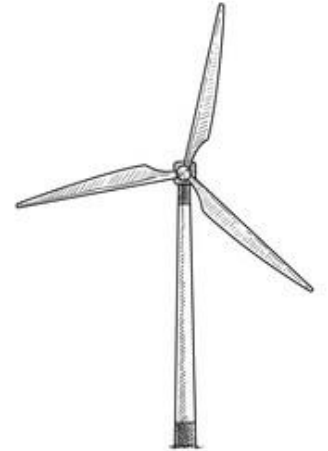
THERE ARE TWO TYPES OF PLASTICS



Thermoplastics
(not crosslinked)



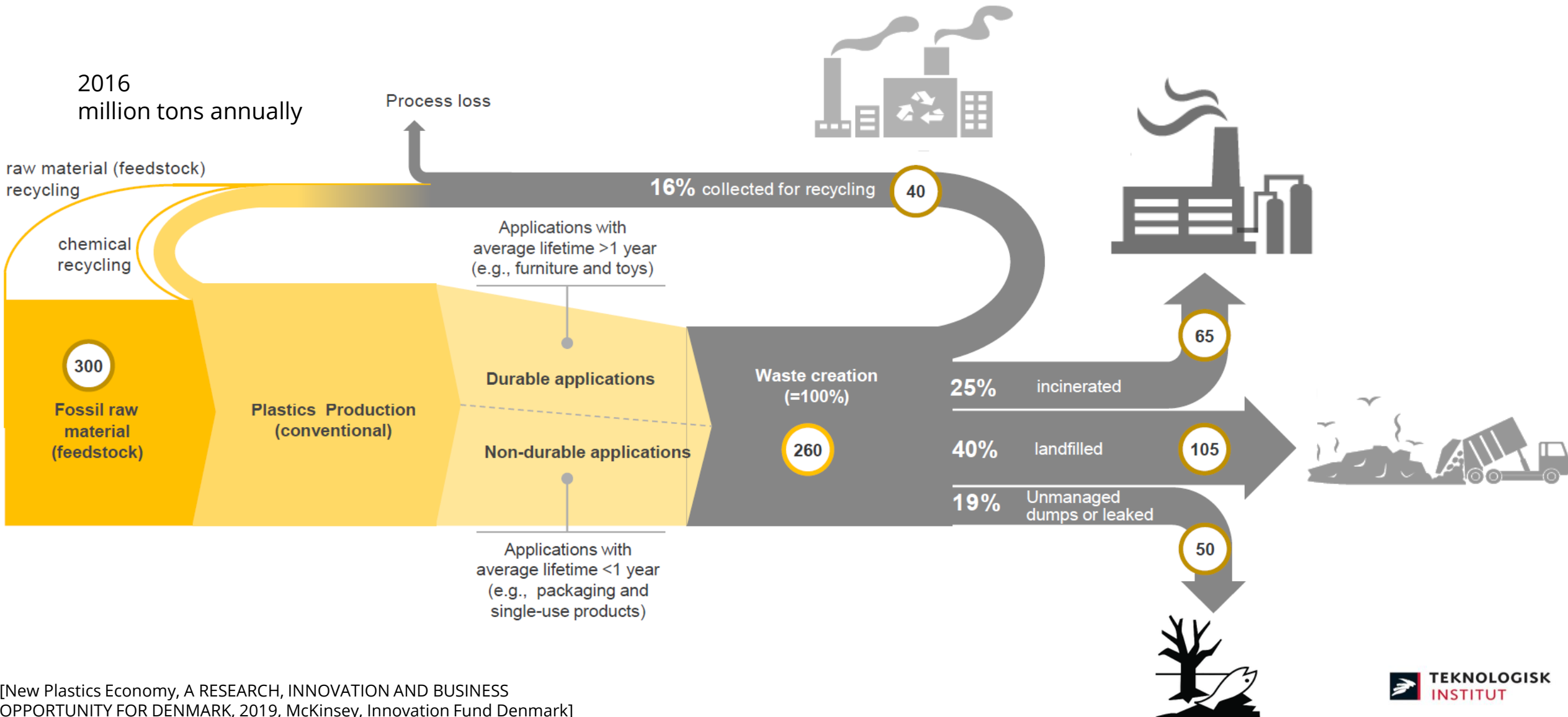
Thermosets
(crosslinked)



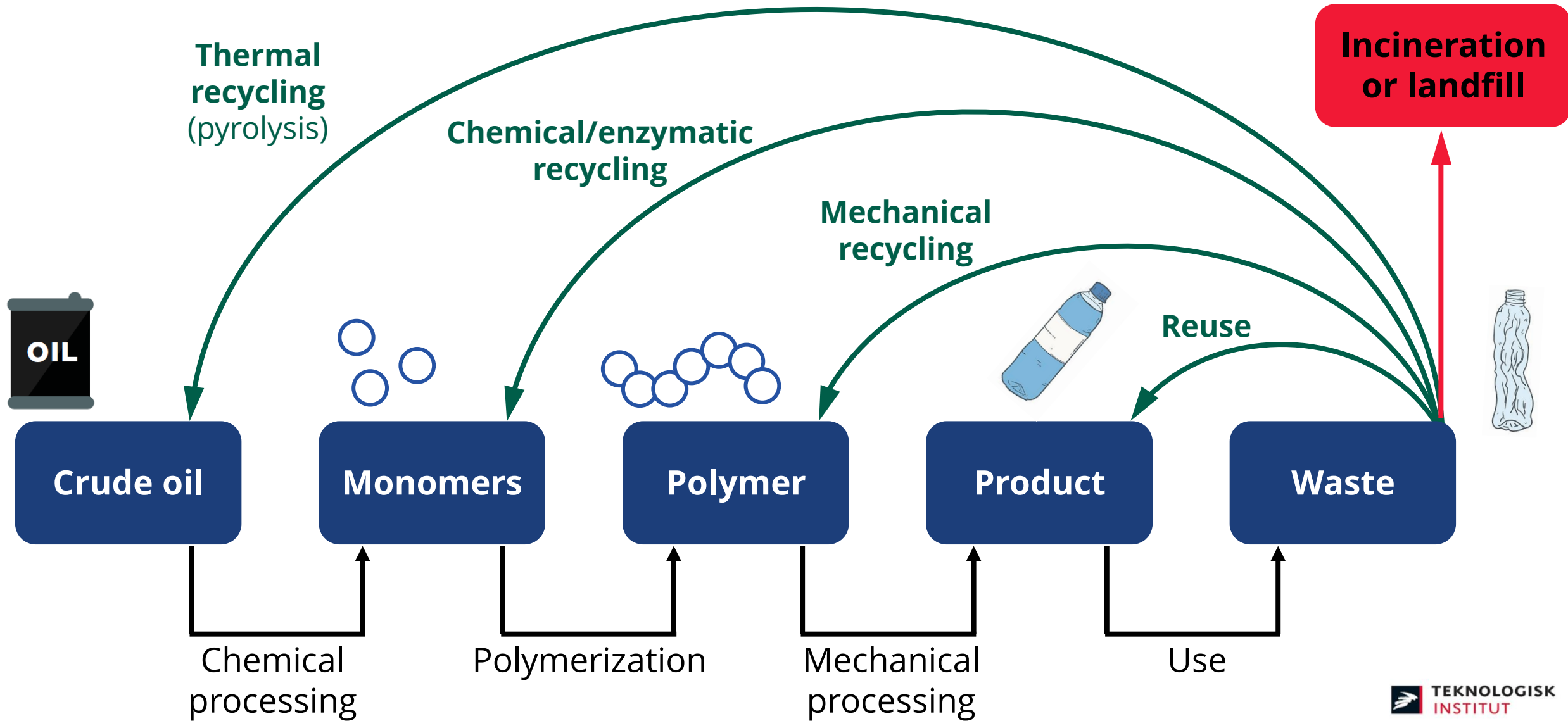
370 million tons plastic produced per year
(85% thermoplastic, 15% thermoset)



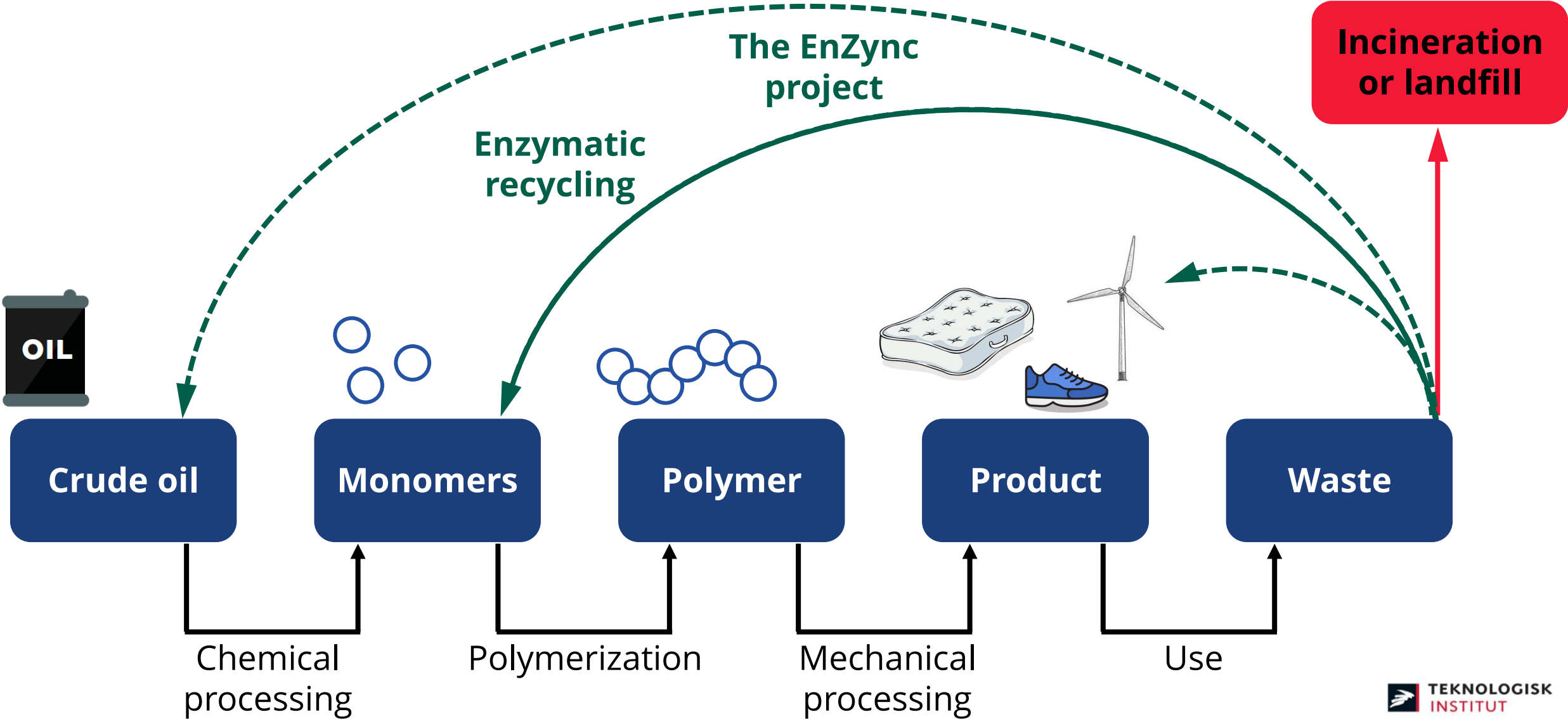
WHAT IS THE FATE OF PLASTIC WASTE?



STATE OF THE ART FOR PLASTIC RECYCLING: THERMOPLASTICS



STATE OF THE ART FOR PLASTIC RECYCLING : THERMOSETS



THE URGENCY OF RECYCLING INCREASES

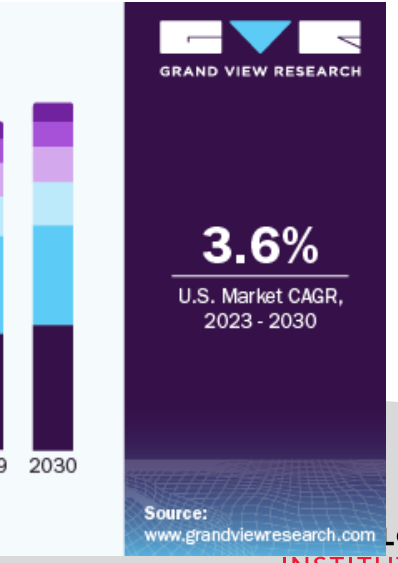
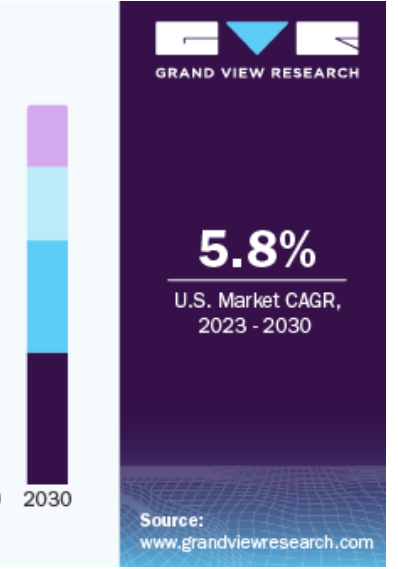
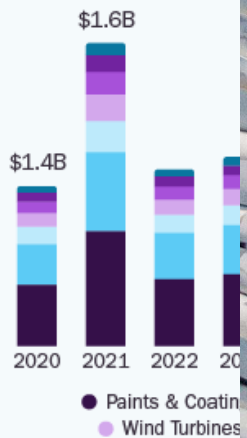
Legacy burden for plastic thermosets

Market expected to grow
High potential for substitution



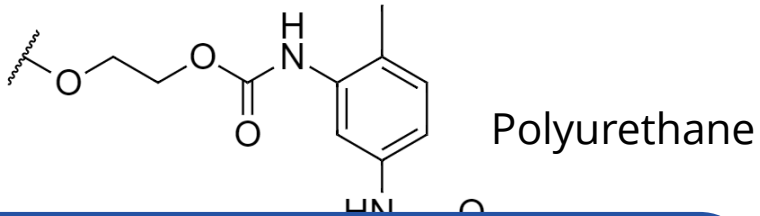
Single landfill in Wyoming, USA [Bloomberg]

U.S. Epoxy Resin Market Size, by Application, 2020-2024



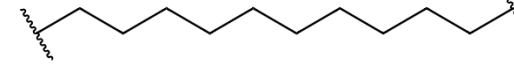
CHEMICAL COMPOSITION OF PLASTIC

Thermosets

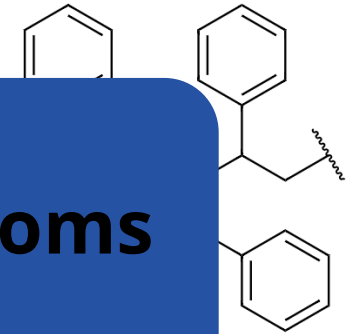


Thermoplastics

Polyethylene (PE)



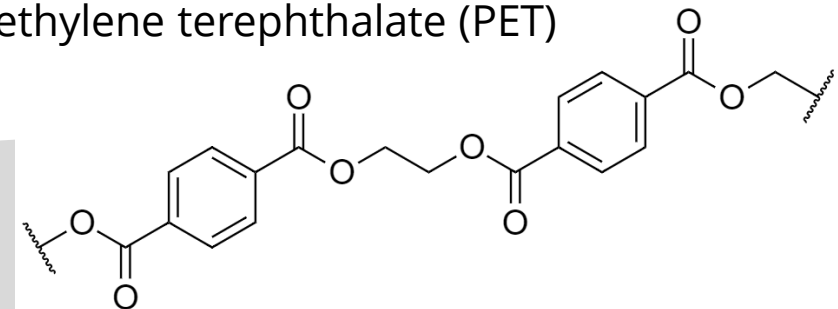
Polystyrene (PS)



Polypropylene (PP)

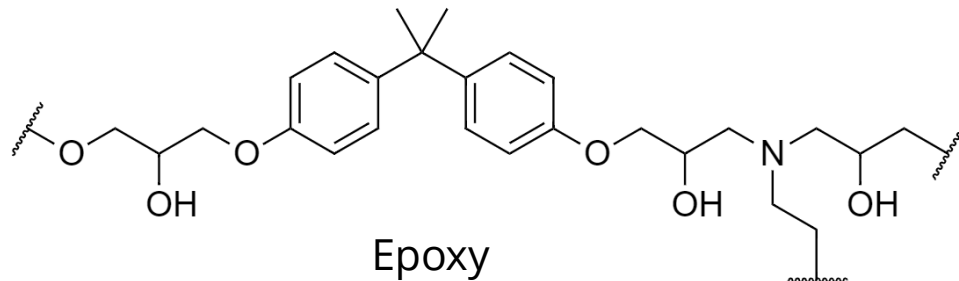


Polyethylene terephthalate (PET)



Heteroatoms
Potential enzymatically labile bonds

Few/no heteroatoms

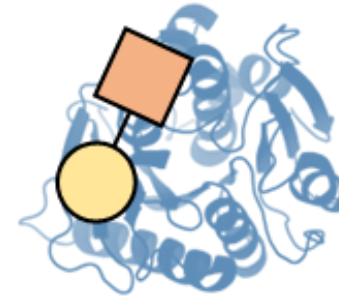


PROJECT WORKFLOW

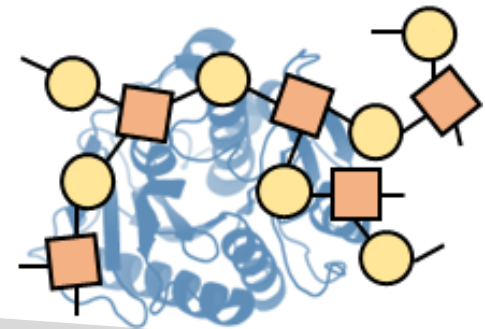
Discovery



Enzyme characterization



Material-enzyme understanding

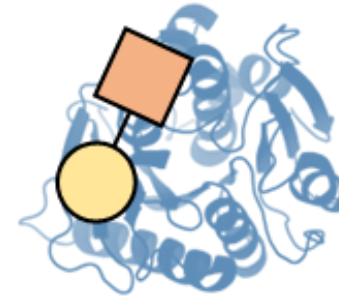


PROJECT WORKFLOW

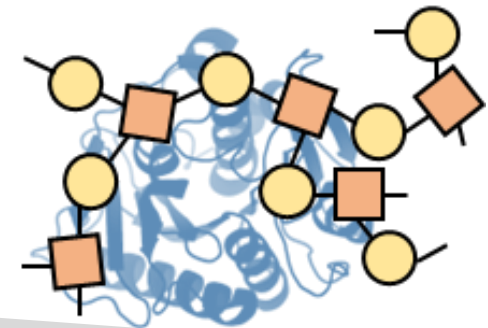
Discovery



Enzyme characterization

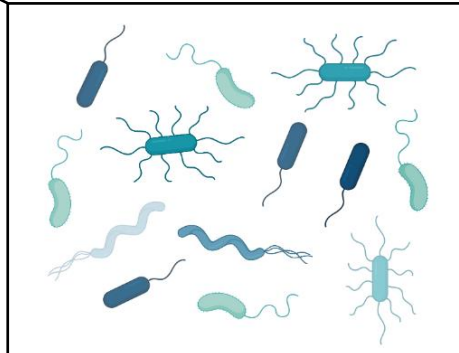
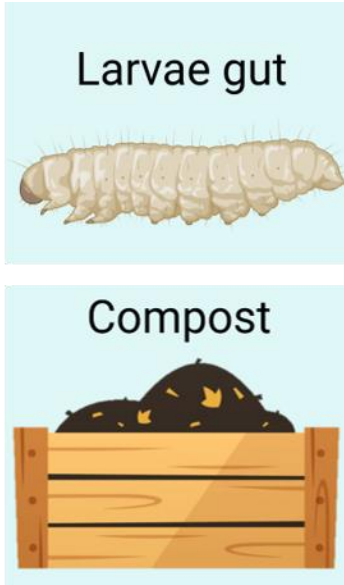
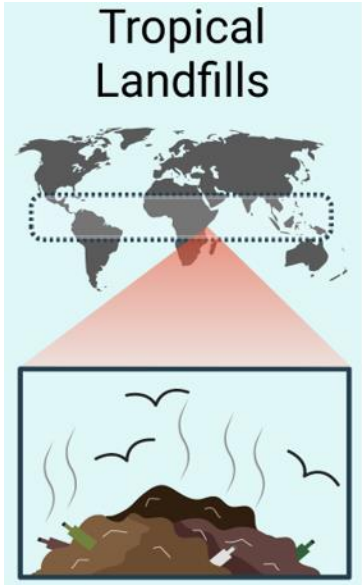


Material-enzyme understanding

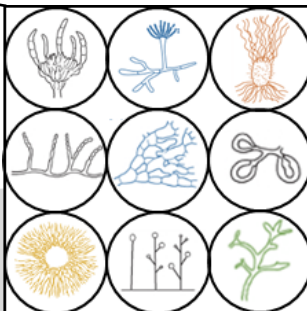
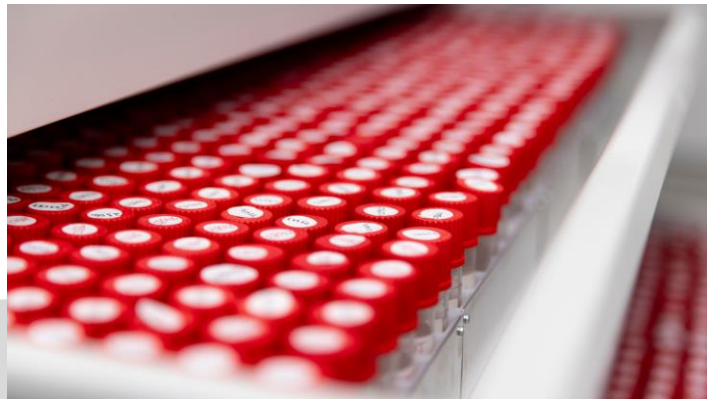


DISCOVERY FUNNEL

Microbiomes



Organism (fungi) collection

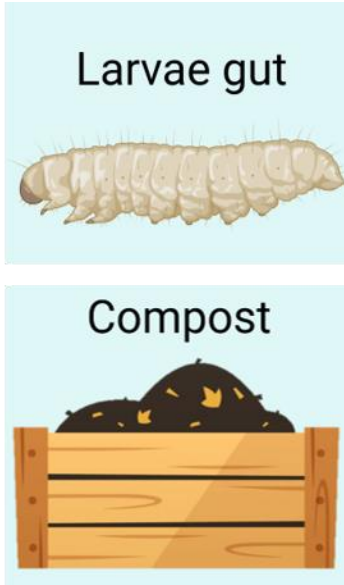
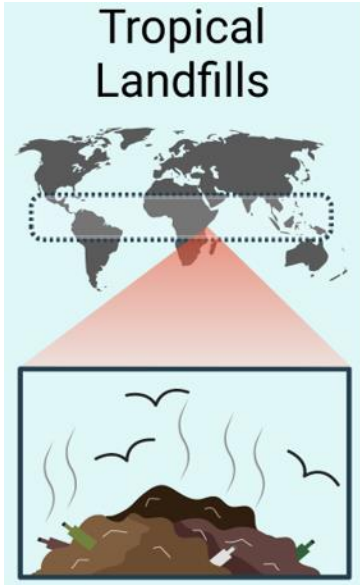


High throughput screening

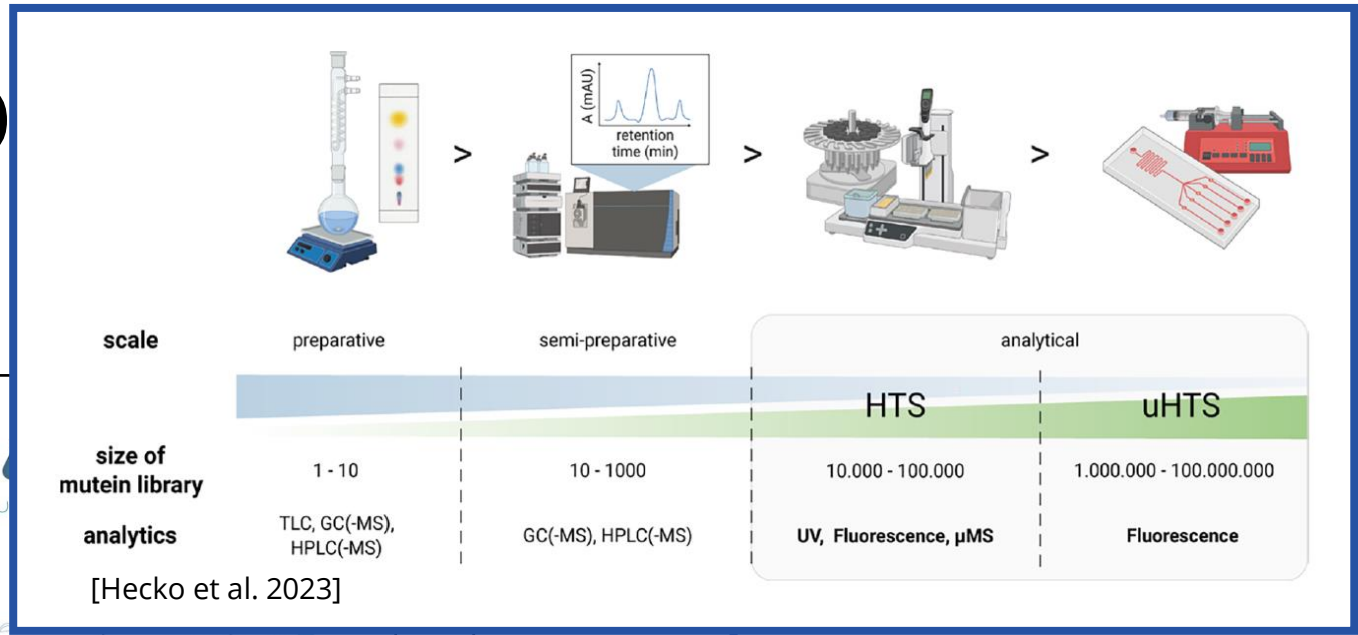
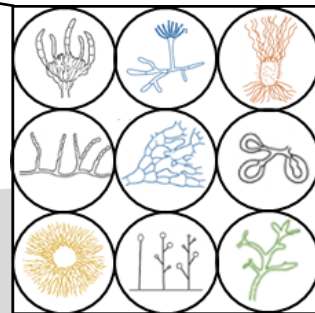


DISCO

Microbiomes



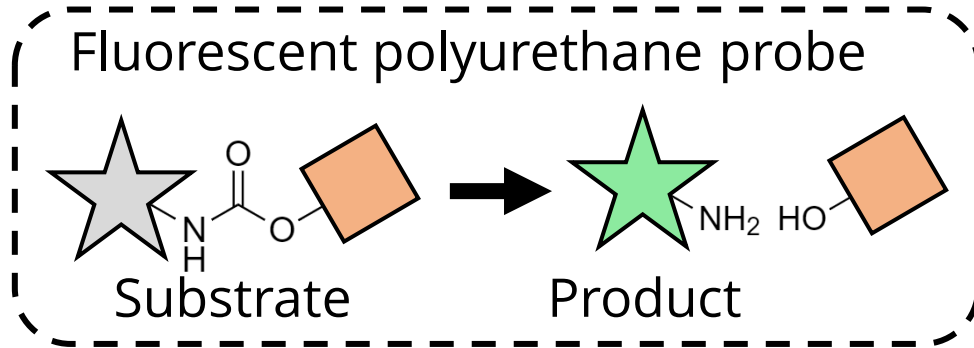
Organism (fungi) collection



High throughput screening



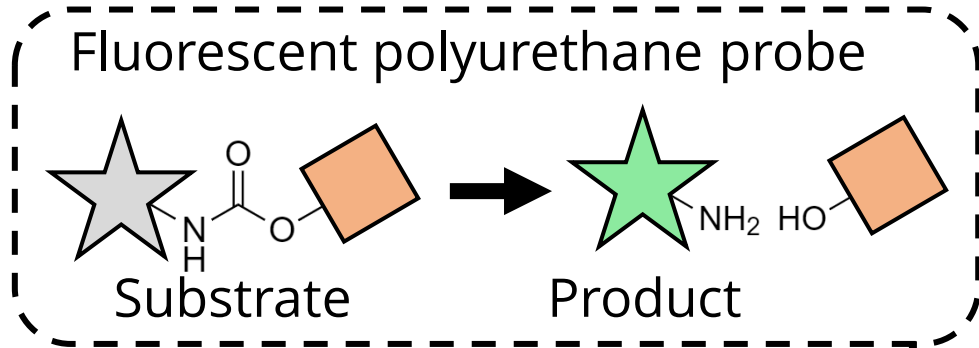
HIGH THROUGHPUT SCREENING



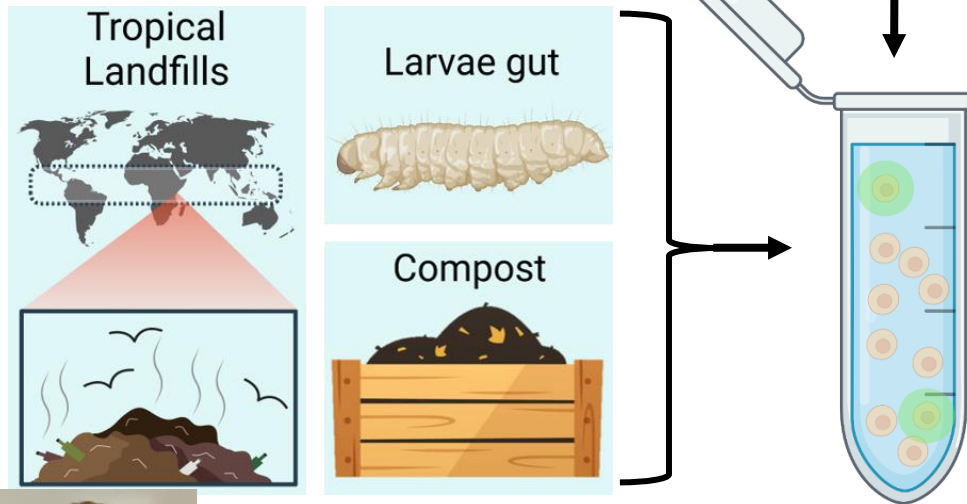
- ✓ validated against known PURases
- ✓ low/no toxicity
- ✓ substrate penetrates cells
- ✓ product does not leak out of cells



HIGH THROUGHPUT SCREENING



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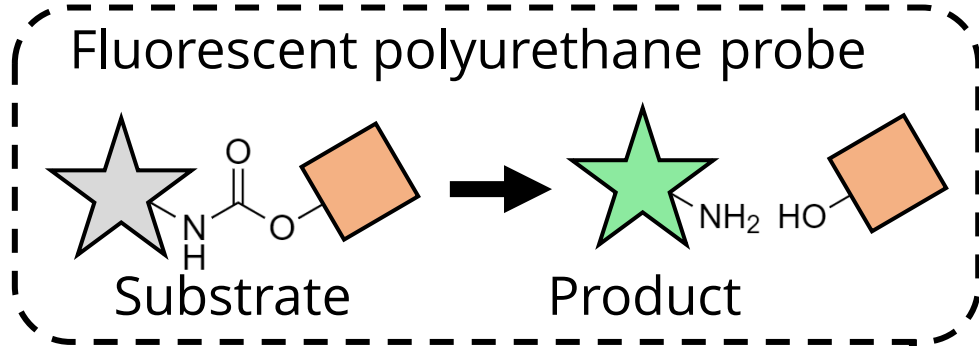


Experiments by Dr. Andreas Møllebjerg, Aarhus University

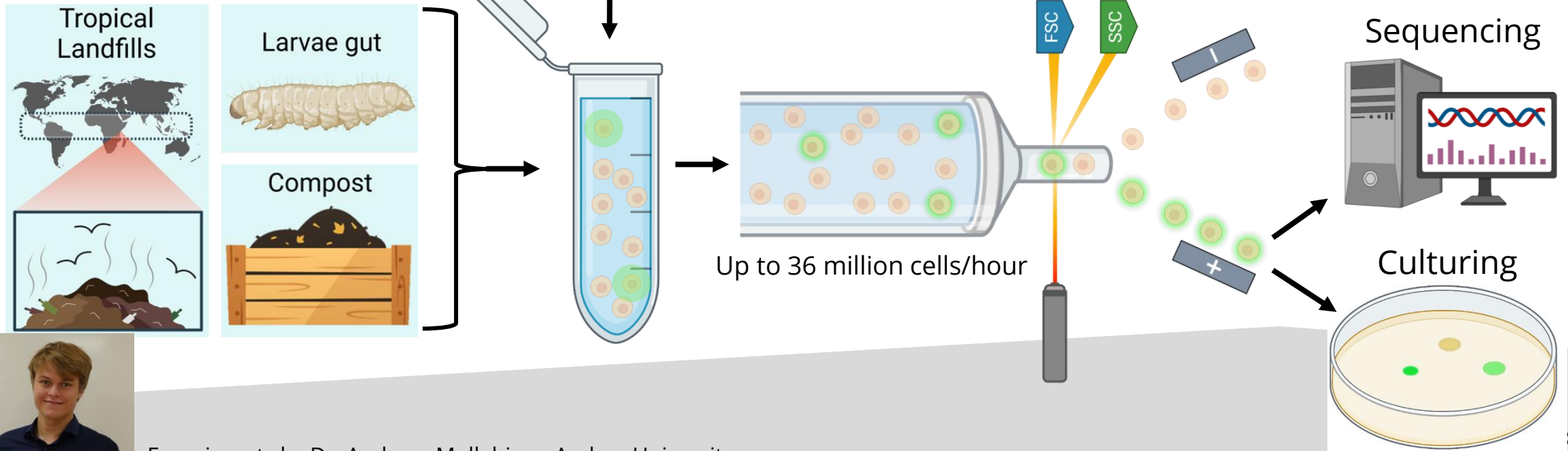


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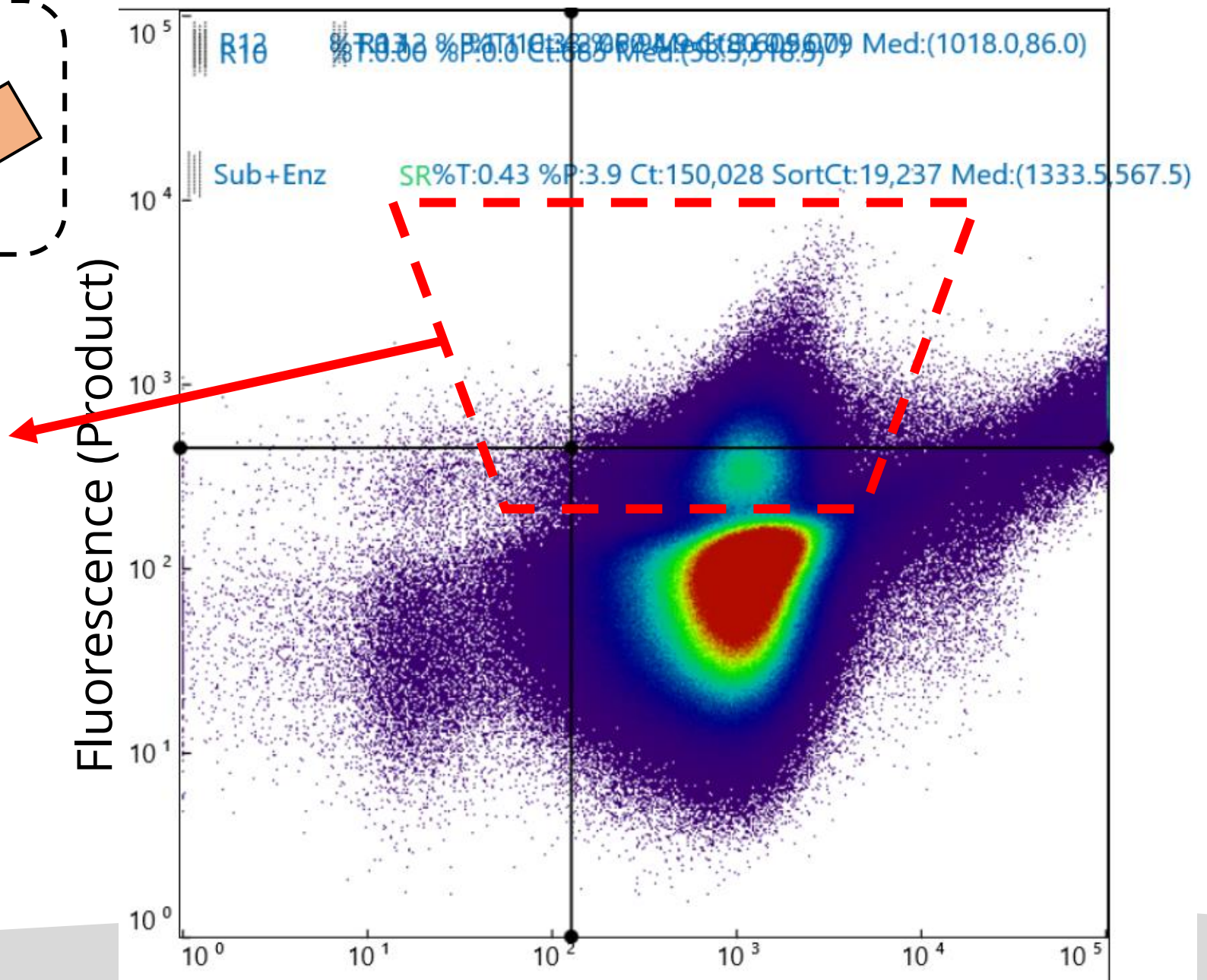
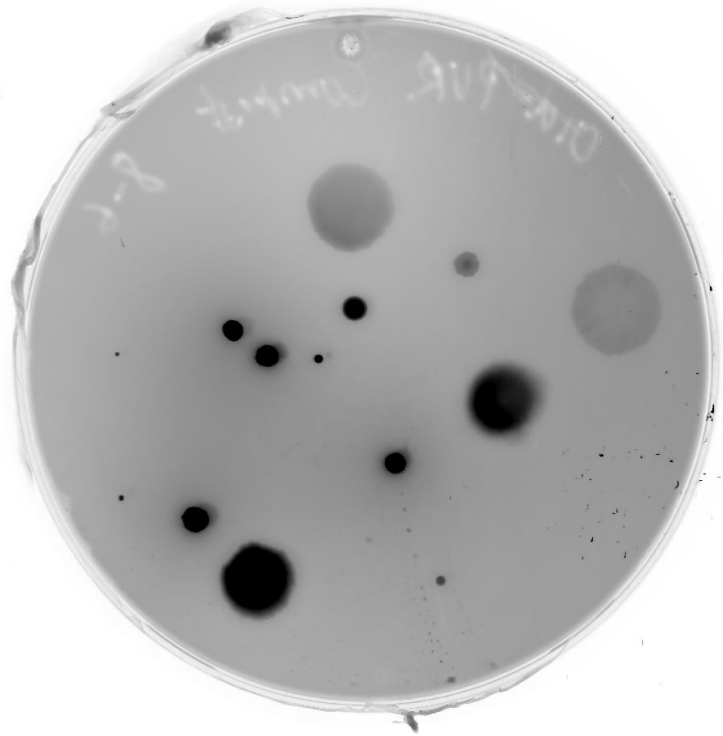
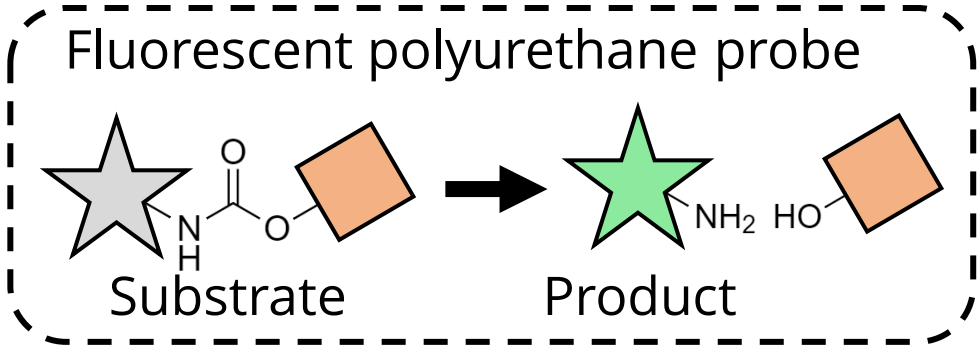
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Experiments by Dr. Andreas Møllebjerg, Aarhus University



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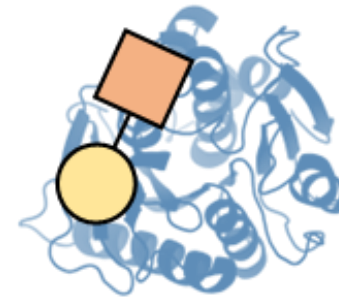
Fluorescence (Substrate)

PROJECT WORKFLOW

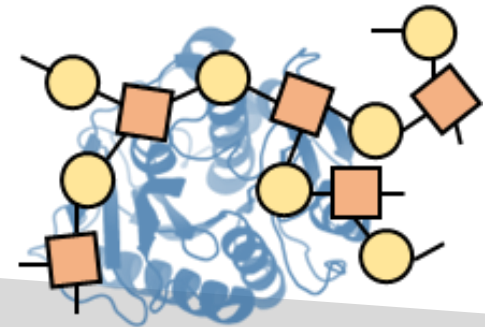
Discovery



Enzyme characterization



Material-enzyme understanding



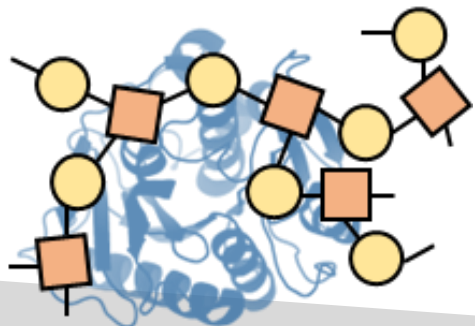
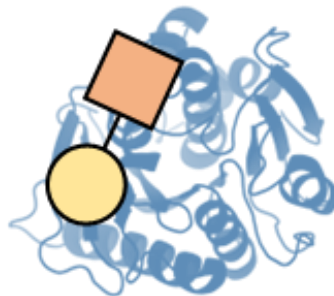
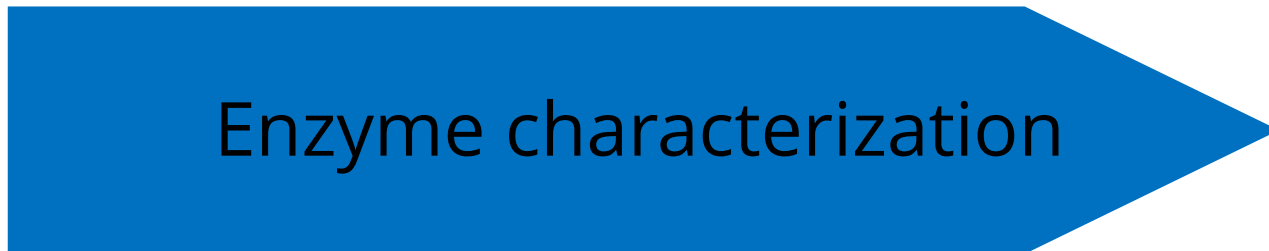
Targets:

Polyurethane

Epoxy

Polyester resin

PROJECT WORKFLOW



ACKNOWLEDGEMENTS



Aarhus University

Center director Prof. Daniel Otzen (Aarhus University),
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THANK YOU FOR YOUR ATTENTION!



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