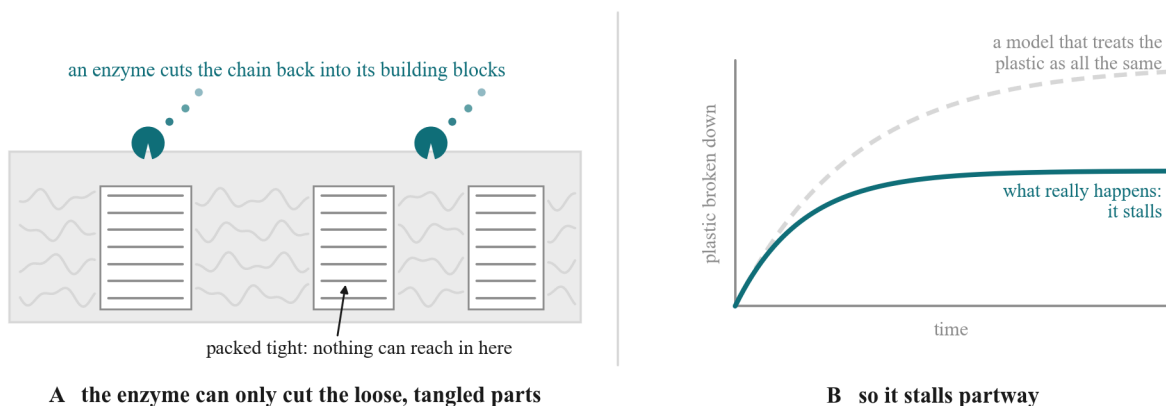


Microbial Biodegradation of Plastics Competition

Intuitive Understanding

Plastic lasts because nothing evolved to eat it. Some engineered enzymes now can: they cut the polymer chain back into the small molecules it was built from, which can be used to make new plastic. The catch is that they only reach the surface, and only where the chains lie loosely tangled. Where the chains are packed into neat crystals nothing can get in, so the reaction slows and stops long before the plastic is gone.



Why enzymatic degradation stalls, and what a model has to capture to predict it.

Project Scope

Plastic waste persists because the polymers we make are not the polymers anything evolved to eat. The world made 431 Mt of plastic in 2024 and recycles roughly 9% of it; PET alone accounts for about 29 Mt a year. That is beginning to change: LCC-ICCG depolymerised 90% of pre-treated post-consumer PET in 10 hours at 72 °C and 200 g/kg solids loading (Tournier et al., Nature 580, 2020), and FAST-PETase, five mutations off wild-type, cleared 51 different post-consumer products at 30-50 °C, some of them inside 24 hours (Lu et al., Nature 604, 2022). But the distance between those figures and a process that clears a real waste stream is still wide, and it is a modelling gap at least as much as a biological one.

The aim is to Model and Experimentally Characterise the Microbial Biodegradation of Plastics – a mechanistic kinetic and process model, built alongside and validated against laboratory work carried out in partnership with university labs. This is the combination of two tasks that should be completed by sub-teams working closely together.

The following sections will break down the requirements and expectations of each task.



However, it is important to remember that although these are outlined as separate tasks, they have significant reliance on information from each other – the model in Subtask 1 is only as good as the data produced in Subtask 2, and the experimental programme should be designed around what the model most needs to know.

Teams will be guided by members of academia on a regular basis throughout the year, and lab work will be supervised. That guidance is part of the project rather than an optional extra: teams are expected to arrive at each session with specific questions and something to show.

Subtask 1 – Mechanistic Modelling of Enzymatic and Microbial Degradation

1.1.1 This task is to develop a quantitative model of the degradation of a chosen polymer by a chosen enzyme or organism. Teams should fix the polymer and the biological system early (e.g. PET with PETase and its engineered variants, polyurethane, or a polyolefin with a defined consortium) and justify the choice against tractability, data availability, and what the lab can realistically support.

1.1.2 The model must be mechanistic rather than a fitted curve. Surface area available for attack, enzyme adsorption and turnover, polymer crystallinity and its evolution during degradation, the accumulation and inhibition effect of intermediates, and mass transfer all belong in the model, and the ones deliberately left out should be named as such. Crystallinity is the sharpest of these: product release has been observed to stall at around 22-27% crystallinity for LCC-ICCG and near 17% for DuraPETase, against roughly 10% for amorphous PET, so a model treating the substrate as uniform will not reproduce the stall.

1.1.3 Where the system is a live organism or consortium rather than an isolated enzyme, microbial growth must be represented: growth on the degradation products, competition and cross-feeding within the consortium, and the effect of environmental conditions (temperature, pH, salinity, and nutrient availability) on both growth and enzyme activity. The temperature window is narrower than enzyme stability alone suggests and should be modelled explicitly: PET begins to crystallise from about 70 °C, which caps the gain from running hotter even where the enzyme tolerates it, LCC-ICCG melting at 94 °C.

1.1.4 The model should be built in stages in a tool or language of the team's choosing (Python, MATLAB, etc), parameterised initially from the literature and then updated against the measurements coming out of Subtask 2 – with the two versions kept distinct so the effect of the team's own data is visible.

1.1.5 Scale-up is a required output. Teams must state what the model implies at process scale – reactor volume, residence time, enzyme or biomass loading, energy and pre-treatment requirement, and the resulting cost per tonne of plastic processed. Enzyme loading must be



quoted in mg per g of polymer so it can be set against the 3 mg/g LCC-ICCG required, and the cost per tonne argued against the mechanical recycling route for the same stream, cited. A model that only ever describes a flask is not enough.

1.1.6 A global sensitivity analysis is mandatory, to identify which parameters actually govern the rate. This is not an appendix exercise: its output should be used to direct the experimental programme in Subtask 2, so that lab time is spent measuring the things that matter.

1.1.7 We would like to see evidence of verification and validation of the model against published degradation data on comparable systems, before any of the team's own data is used to fit it.

1.1.8 The primary figure of merit is predictive accuracy against experiment – how well the model forecasts a condition it was not fitted to – rather than goodness of fit against training data. However, there is also significant weighting on other things such as:

- a) Modelling approach taken – the thoroughness, quality, and compliance with good coding practice such as PEP8.
- b) Project management and process – planning, recording of information, communication, risk capture etc.
- c) The consideration and justification of the level of modelling fidelity used. What assumptions have been used and how have they been captured? This is a powerful skill.
- d) Key points of learning during the task and how this is recorded. We want to see what you discover, how you explore options, what you learnt and how you then applied this.
- e) Novelty of the modelling approach or of the biological system chosen.
- f) First phase presentation.
- g) Final presentation and summary report.
- h) Cross-functionality working and integration between teams.
- i) Depth of research.
- j) Realism of the scale-up, energy, and cost assumptions.

1.1.9 The scope outlined isn't expected to be completed by the first deadline – this is for the finals. Progress up to the first phase is what will be assessed in the initial project down-selection. Students should utilise their relevant skills and interests to complete tasks they think will be useful and interesting, even if not explicitly listed here.



Subtask 2 – Experimental Programme in University Laboratories

2.1.1 This task carries out the laboratory work the model needs, in partnership with university labs. Access, supervision, and safety sign-off are arranged through the host institution, and teams must work within the constraints of the facility they are given rather than the one they would like.

2.1.2 A written experimental plan is mandatory before any bench work begins – hypothesis, variables, controls, replicates, measurement method, and expected uncertainty – reviewed with the academic mentor and revised until it is approved.

2.1.3 Measurement of degradation must be quantitative and traceable. We expect a mass loss or product-release measurement with a stated limit of detection (e.g. HPLC or UV for released monomers, or CO₂ evolution), alongside a surface technique (SEM, AFM, or contact angle) and a bulk technique (DSC or GPC for crystallinity and molecular weight), so that a rate can be attributed to a mechanism rather than just observed. Crystallinity should be reported as a percentage against a stated enthalpy of fusion for fully crystalline PET, conventionally 140 J/g, so that figures are comparable between teams and against the literature.

2.1.4 A specific and mandatory sub-topic is controls. Abiotic hydrolysis controls, sterile controls, and heat-killed enzyme controls must be run and reported alongside every result. A good deal of the published literature is weak on exactly this point, and we expect better here.

2.1.5 The experimental matrix must be designed against the sensitivity analysis produced in Subtask 1 – the conditions varied should be the ones the model says the answer depends on, so that the data returned genuinely reduces model uncertainty rather than confirming what was already known.

2.1.6 Reproducibility is assessed. Replicates are required, and raw data should be retained and published alongside the analysis scripts, such that a third party could re-derive every figure in the report from the files provided.

2.1.7 Safety and compliance are in scope and must be settled before work begins: containment level, waste handling and disposal of degradation products, and any biosafety or GMO approval required. A team that cannot get its plan approved has not designed a good experiment.

2.1.8 The main scoring criteria for this subtask is the rigour of the experimental design and the honesty of the reporting – a well-controlled null result is scored as highly as a positive one. However, the other criteria listed for Subtask 1 are also of importance.





Timeline

This competition has two phases. The first ends with the Phase 1 presentations on 12-16 January 2027, where each team presents its design to judges online and that presentation is the only deliverable; from there, 2 teams' designs are selected from each university for the in-person finals. Members from teams which did not get selected can apply to join the two selected teams for the remainder of the competition.

Alongside the two phases, teams meet their academic mentors fortnightly from 26 October 2026, with the checkpoints set out below.

The in-person finals consist of a 30 minute presentation, as well as the submission of a report; this has a limit of 8 pages (title, contents, and reference pages not included, appendix not included but will not be included in the scoring) and should cover the concept, the method of development, evidence of initial V&V, and key lessons learned. This should be delivered 2 weeks before the final presentation. We recommend including short snippets of code in the appendix for sections of interest. The report should cover both tasks.

6 October 2026	Applications Open
25 October 2026	Applications Close
20 October 2026	Teams formed
From 26 October 2026	Fortnightly academic mentor sessions begin
24-28 November 2026	Academic Mentor Check-In (Feedback given)
12-16 Jan 2027	Phase 1 Presentations (Feedback given)
9-13 February 2027	Academic Mentor Check-In (Feedback given)
20 March 2027	Finals