Saving Earth from Plastic Pollution: Enzymes and Environmental Ethics

iGEM Toronto

There is nowhere on Earth Untouched By Plastic



Not the Ocean...



Not Our Food...



...and not even our bodies

It takes...

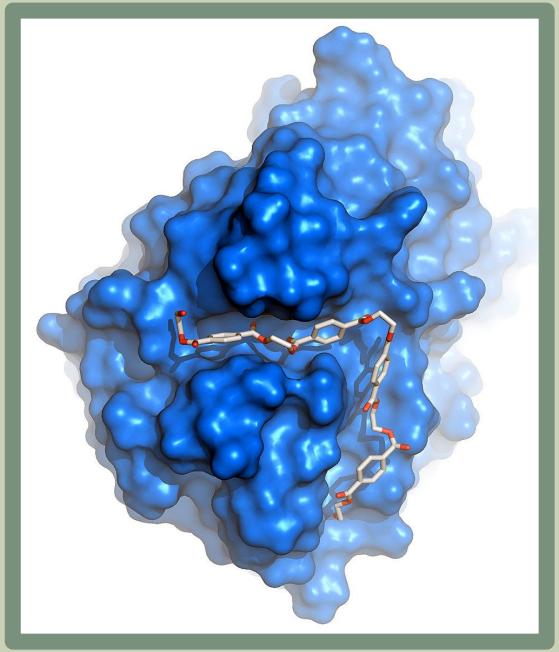
500 years

For plastic to decompose

Our project aims to do this in...

Hours

Meet PETase



- A plastic degrading enzyme first found in bacteria
- Previously, only 495 validated sequences of these enzymes known
- In 2024, our collaborative lab built a database(LOGAN) that has over 300 million candidate sequences
- Wet lab validation revealed some of these LOGAN enzymes outperformed the gold standard enzyme, FAST-PETase

Introducing PetaBite



Goal: Create an AI-based Workflow that allows one to Design highly efficient plastic-degrading enzymes for any condition

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01

Four Pillars of Bioethics

Beneficence: Designing for Real-World Benefit



- Targeting a shared harm of environmental & human health
- Pairs discovery with deployment strategy & economic viability



Non-Maleficence: Containing Risk, by Design

- Controlled systems for minimizing spread
- Kill-switches & controlled deactivation protocols
- Stakeholder engagement for minimizing risk
- Mitigating information risks → Avoiding misleading data



Autonomy: Informed, Transparent Engagement

- Stakeholder consultations over assumption

- PETAbite iGEM Wiki: Fully documented database mechanics, assays, stakeholder feedback



Justice: Equitable Distribution of Resources



- Prioritises communities disproportionately harmed by microplastics
- WWTP focus of the project → PETAdex as public infrastructure
- Serves as ‘open-science’, promoting open access and contribution





02

Social Disparities our project will address

Environmental Justice



The Problem

- Plastic pollution disproportionately impacts Indigenous, costal, and low-resource communities

PETaBite Solution

- Room-temperature PETase reduces energy costs
- Open-source PETadex increases accessibility

Health Equity





The Problem ?

- Plastic waste exported to countries with limited recycling infrastructure

PETaBite Solution

- Enables local PET degradation technologies
- Supports decentralized waste management

Health Equity

The Problem ?

- Communities near plastic waste facilities face greater pollution exposure





PETaBite Solution

- Reduces plastic waste entering the environment
- Supports healthier communities

Intergenerational Equity

The Problem

- Persistent plastics create long-term environmental burdens



PETaBite Solution

- PETaBite accelerates PET degradation with the aim of reducing future microplastic accumulation

03

Equitable Access and Design at Scale

Equitable Access at Scale



Access depends on more than technical performance



Infrastructure, affordability, governance, and local priorities shape who benefits



Stakeholder input helps us adapt the system before deployment

Stakeholder Outreach

Dr. Natasha Anwar



Molecular Pathologist on Pakistan's National Bioethics Committee for Research

"Successful implementation means looking beyond technical details and into practicality"



Mr. Excel Amaefule

Nigerian Researcher: Plastics and Wastewater Governance

"novel solutions often fail when they are not designed for the context they are meant to enter'.

Designing Beyond High-Infrastructure Settings





Image Source: Graham Builds and India Water Portal

Preventing Access From Becoming a Premium Service



Photo Source: Plymouth Marine Laboratory

Unequal Burden

The communities most exposed to plastic pollution may have the fewest resources to protect themselves



Photo Source: Food For Mzansi

Need-Based Deployment

Scaling should prioritize exposure and public need

Keeping Deployment Accountable

Local review is needed before real-world use

Benefit-sharing should include usability and data transparency



Open or humanitarian licensing can protect public access

Deployment should be shaped with local agencies and communities

04

Industry Applications and Changes to the Design

Stakeholder Feedback

Dr. Allen Grant

Professor in the Department of Chemical Engineering and Applied Chemistry at the University of Toronto





Dr. Julie Goddard

Director of Research in Biomaterials & Biointerfaces in Food and Agriculture at Cornell University



Rasha Maal-Bared

Principal scientist at the CDM Smith Research and Testing Laboratories in Bellevue

Industry Applications

Agriculture

- Drawing on the interview with Dr. Goddard from Cornell University
- Removal of contaminants from agricultural runoff
- Improvement of irrigation water quality



Bioremediation

- Target contaminant reduction in concentrated waste streams, especially landfill leachate.

Wastewater Treatment Plants (WWTP)

- Reduce microplastic accumulation in WWTP biosolid sludge streams.

Changes to the design #1: Scaling

1

Benefits

Parallel bioreactor systems increase efficiency, control, and reproducibility

2

Our Design

Current system scales up to 8 bioreactors

3

Design Change

Modify the bioreactor systems to support an increased industry-scale

Changes to the design #2: Reduce Energy usage/consumption

1

AI database

Implemented by optimizing the AI algorithm for PETadex based on green AI techniques or other relevant methods

2

Bioreactor

Explore alternative methods of heating the bioreactors (eg. heat pumps)

Changes to the design #3: Durability

1

Benefits

- Allows reduction of disruption in the usage workflow
- Improves the business model to better align with the circular economy



2

Methods

- Explore materials thoroughly (eg. durable sensors)
- Rigorous testing would be needed to verify the design's durability

Changes to the design #4: Biocontainment for open-environment use

Genetic Safeguards

- Incorporate genetic safeguards (e.g -: kill-switches) if engineered organisms are required



Risk Assessments

- Conduct ecological risk assessments before environmental deployment

Validation

- Validate environmental safety through controlled pilot studies before large-scale implementation

Thank You!