Project abstract (feel free to copy/paste)

The US generates approximately 3 billion pounds of used cooking oil every year, primarily from small and mid-sized restaurants (Zonneveld, 2024). While many large chains profit from established recycling contracts, smaller establishments – comprising nearly 90% of the industry – often pay high fees to dispose of their waste oil. This adds up to as much as $0.50 per pound, straining pre-existing limited budgets and ignoring a remarkable opportunity to promote sustainability.

BioCycle targets this problem by introducing a compact, open-source biodiesel reactor, utilizing ultrasonic cavitation alongside immobilized lipase enzymes to efficiently convert waste cooking oil into a drop-in biodiesel. We have two goals: to reduce restaurant overhead by replacing hauling costs with on-site recycling; and to give small businesses a direct path to environmental stewardship by transforming a major waste product into a low-carbon fuel. By combining existing novel enzyme-catalyzed transesterification techniques with ultrasonic technology, the resulting system will be 3D-printable, cost $895 to assemble, and be easily managed by non-specialist staff.

In implementing BioCycle, we will 3D-print structural components for the reactor, embed ultrasonic transducers around a reaction chamber, and integrate an Arduino controller for temperature and stirring automation. With MIT THINK's generous mentorship and funding, we will design and build the reactor, run pilot tests with local restaurants, and publish open-source plans to increase our impact. Through BioCycle the creation of a valuable, low-carbon energy source that can directly be used to power food trucks, heaters, and backup generators in and out of the restaurant industry will take place.

Why are you interested in THINK and do you feel like you're a good fit for THINK? (200-350 words)

Back in June of last year, Piyush talked with Aarnav about this problem and together they devised the biodiesel reactor solution. However, as the months progressed, we quickly realized that we wouldn't be able to progress any further than project ideation. Fast forward to December when we learned about the THINK program, we understood that our idea was indeed going to be possible and if we were selected, we could leverage THINK's offerings to expand our idea way beyond the scale we had initially envisioned.

We're very strongly drawn to THINK because bridges the gap between scientific exploration on our part and tangible, real-world impact on the world. Our project, BioCycle - a novel biodiesel reactor for small to mid-sized restaurants - represents exactly the sort of interdisciplinary endeavor that we believe thrives under THINK's ethos: it merges chemical engineering, mechanical engineering, and computer science to solve a pressing problem in waste management, while at the same time creating a win-win situation for all parties involved: the restaurants, the environment, us, and the THINK team. THINK's emphasis on mentorship, access to resources, and sparking a newfound interest in global innovation in high schoolers resonated with our aspiration to create solutions with the potential for great change.

Our strong background in scientific research, chemistry, business, and computer science uniquely position us to gain maximum value from THINK, and to bring a pragmatic, community-centric perspective in return.

What resources can THINK provide you that you don't already have access to in your community? (200-350 words)

While our local networks offer support for basic prototyping and some access to materials, we see MIT THINK as a one-of-a-kind source of strong technical mentorship, world-leading experience in problem-solving strategies, and a global perspective we simply cannot replicate at home. First and foremost, the program will connect us with passionate undergraduates and faculty at MIT who possess specialized expertise - especially in ultrasonic transducer technologies, enzyme-catalyzed reaction processes, and hardware integration. Having direct access to that knowledge and experience base would supercharge our ability to troubleshoot BioCycle's design and also to iterate on the more complex aspects, such as optimizing reaction kinetics or tuning temperate and pH feedback loops.

In addition, we have heard from THINK alumni that the program provides participants with networking opportunities that go significantly beyond what we can find in our high school clubs or local makerspaces. The camaraderie among THINK scholars would give us an incredible place, both during and after the project, for new ideas, potential pitfalls, and best practices in designing safe, scalable prototypes. This type of dynamic is hard to come by in our current environment and, quite frankly, is something that no other similar program can boast to offer.

Furthermore THINK's funding structure and logistical support would help us procure materials such as specialized ultrasonic transducers or high-grade immobilized lipase that would normally

be both cost-prohibitive and hard to source in our community. Guidance on acquiring parts in an economical yet high-quality manner would also be appreciated.

Altogether, the combination of expert mentorship, peer collaboration, and financial backing from THINK precisely fills the gaps that our home-based resources simply can't address, allowing us to fulfill our our long-awaited goal of BioCycle's success.

Interest: Tell us about your academic background as well as your personal interest in this project. We want to know where you are coming from, what previous research experience (if any) you have, and why you are interested in your area of research. (200-350 words)

Piyush has conducted novel epigenetic biomarker research under Dr. Derek Jacoby of the University of Victoria for the last 2 years culminating in a soon-to-be published paper (January 2025). He was the Chemistry main on the team that placed first in the U.S. Department of Energy's National Science Bowl Finals, received a 5 in AP Chemistry, and a 7 in IB Chemistry, all of which demonstrates his strong knowledge in chemistry. He founded DNAnalyzer, a patent-pending fiscally sponsored bioinformatics project that became a GitHub #1 Trending repository, showcasing his ability to coordinate global contributors.

Piyush is also the Executive Director of Mighty Crayon, a 501(c)(3) nonprofit that collects lightly-used crayons from its restaurant partners around the nation, including Applebee's and Red Robin, and ships them to underprivileged communities internationally. Several of these local partner restaurants have agreed to serve as pilot locations once BioCycle is operational.

Meanwhile, Aarnav has extensive experience working with many small businesses for DECA and beyond, and delivering solutions to them. Over the past year, he has built over 12 websites and other digital tools, each catered to the demands of the individual business. He built a platform to recruit new referees, addressing the national soccer referee shortage, and placed in the top 70 of 13,000 international DECA competitors, making the International Career Development Conference in his first year.

Aarnav and Piyush have worked together as Vice President and Treasurer of Interlake Programming Club, 2-time winners of the U.S. Congressional App Challenge, and now the MIT THINK project proposal. We are both very passionate about democratizing access to novel solutions, especially about bringing tangible, technology-based solutions to everyday problems

such as waste cooking oil disposal. We believe that our unique blend of qualities and skills in conducting scientific research and business management unites us advantageously in wanting to bring BioCycle to reality.

To succeed, we will convert our current theoretical understanding of enzymatic catalysis into practical knowledge, learn ultrasonic principles, and refine measurement techniques for fuel characterization. MIT THINK's guidance will help refine these skills, particularly in optimizing the system's design and assessing quality metrics.

Qualifications: Describe the skills you currently have as well as the skills you will need to learn to complete this project. (200-350 words)

Our partnership combines diverse yet complementary skillsets that position us well for our success under the THINK program.

Piyush brings a robust scientific foundation from his epigenetic biomarker research with Dr.Derek Jacoby at the UVic, where he learned to design experiments and analyze large datasets using machine learning models. He has also applied high-level chemistry knowledge in competitive settings, including the U.S. DOE's National Science Bowl and advanced coursework such as AP and IB Chemistry. This background equips him to tackle enzyme-catalyzed transesterification, chemical handling protocols, and analyze biodiesel conversion rates. Additionally, his leadership of Mighty Crayon underscores his ability to coordinate logistics across multiple stakeholders, an asset that was valuable when we interfaced with pilot restaurants.

Aarnav excels in turning conceptual ideas into tangible technological solutions. Over the years, he has built custom websites and data-driven applications for 12+ small businesses, allowing him to hone his programming skills. He also has experience in strategic pitching and market analysis through his involvement in DECA, where he placed in the top 70 out of 13,000, and his Business Management HL class. These capabilities, in conjunction with winning 2nd place at HackPNW, translate directly to designing the Arduino-based control system for BioCycle, assembling user-friendly dashboards for tracking process variables, and articulating BioCycle's value to potential partners.

Both Piyush and Aarnav have extensive experience with Arduino and Raspberry Pi equipment through workshops and IoT passion projects like garage door openers and automatic plan watering machines built in their free time.

Despite these strengths, we need to deepen our knowledge of ultrasonic transducer physics and cavitation dynamics, refining how we position and power transducers to maximize reaction efficiency. We'll also need to learn to perform advanced fuel characterization tests - measuring free fatty acids, ester content, and cloud point - to confirm our biodiesel meets industry standards. Otherwise, it could accidentally damage the engines of diesel vehicles. Finally, we aim to sharpen our hardware-integration expertise for real-time data logging, ensuring consistent temperature, pH, and agitation control. With these advancements, we can build a truly turnkey reactor that restaurants can operate confidently.