



Microbial Degradation Alchemy of Plastics: An Overview of Mechanisms, Enzymatic Processes and Environmental Implications

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Abstract:

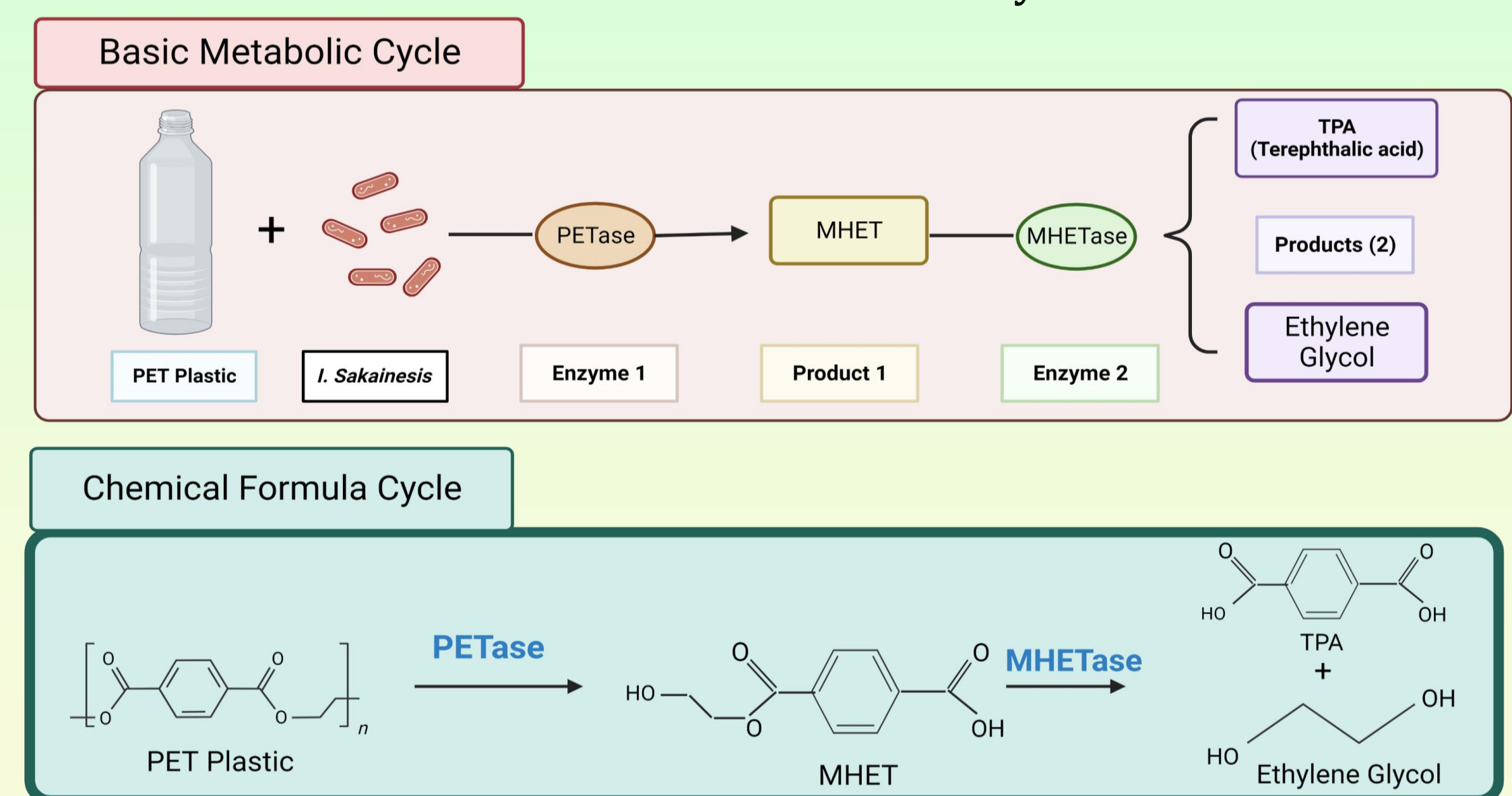
Plastics have increasingly dominated our material landscape due to their widespread use. With the surge in the production and distribution of plastic products, the threat of global plastic pollution has escalated. This issue has increasingly alarmed environmental researchers due to the pronounced negative impacts on flora and fauna. As research efforts intensify worldwide, there is encouraging advancement in pinpointing and comprehending microorganisms capable of breaking down these plastics. The recent studies depicted microbial entities that stand out for their remarkable capabilities in tackling plastic waste. Among these are bacteria from the genera *Ideonella*, *Pseudomonas*, *Enterobacter* and *Brevibacillus*, as well as fungi, especially those from the genera *Aspergillus* and *Penicillium*, which have showcased promising results in degrading plastics. This scholarly review aims to clarify the lasting understanding concerning the biodegradation of polymeric materials. We delve into the different roles of specific microorganisms adept at plastic degradation, highlighting the enzymatic mechanisms they employ. Our exploration further encompasses the processes these microorganisms utilize to convert intricate polymer chains into foundational monomers, which subsequently have potential reintegration into various biochemical pathways.

Introduction:

- Among the most promising avenues of research is the exploration of plastic-degrading bacteria. These microorganisms, equipped with specialized enzymatic machinery, possess the unique ability to break down polymeric chains of plastics into simpler, benign constituents. *Ideonella sakaiensis* and others, have been identified and characterized for their polyethylene terephthalate (PET)-degrading capabilities and metabolic pathways which revealed a potential biotechnological goldmine for developing effective biodegradation strategies.
- As we stand at the ridge of a potential sustainable renaissance, this introductory review delves into the current knowledge surrounding plastic-degrading bacteria. It synthesizes findings from recent investigations, highlighting the mechanisms by which these microorganisms assimilate and degrade various plastics.

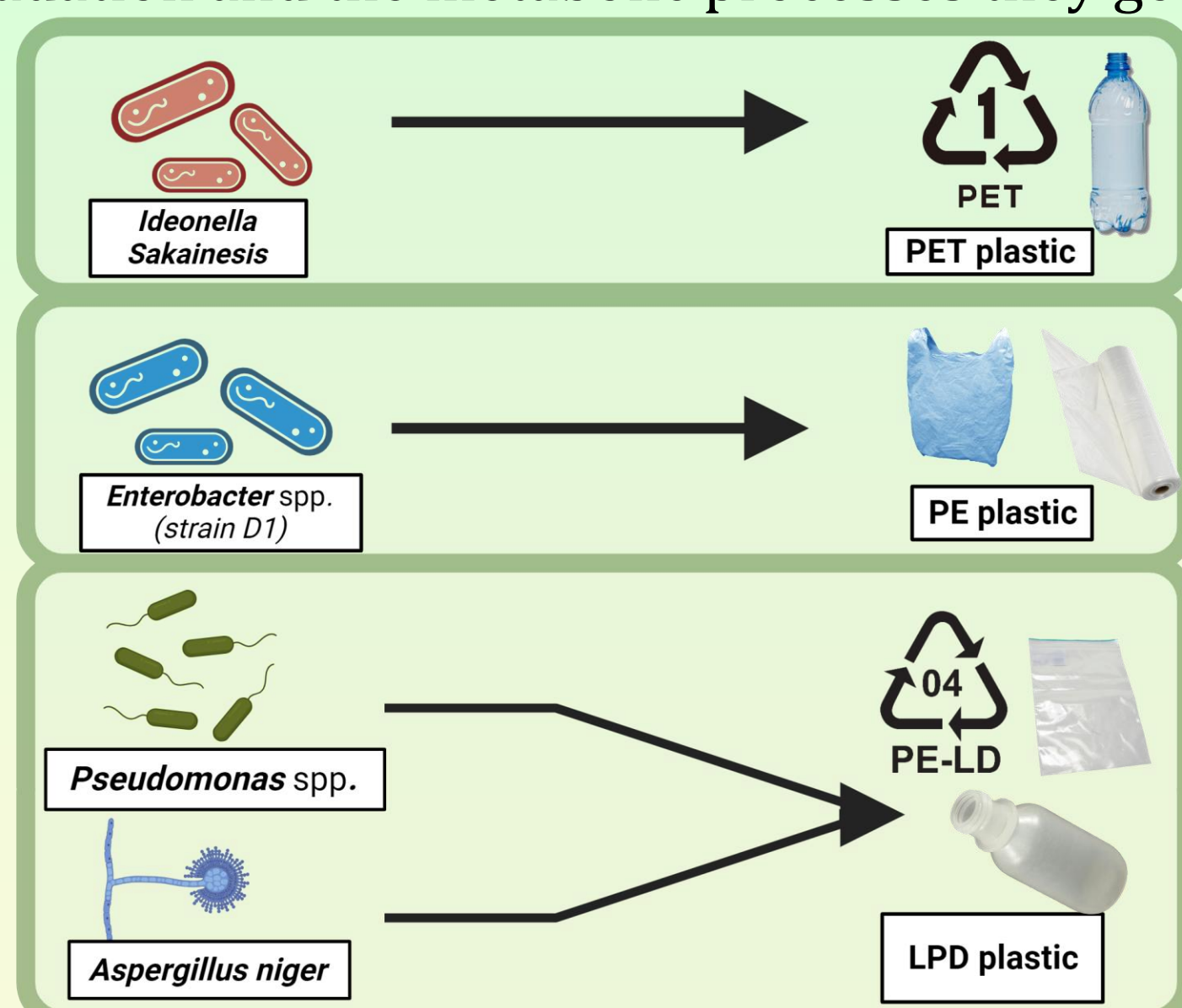
Pet Degradation via *Ideonella sakaiensis*

- This bacteria is one of the most known and appreciated microorganisms in plastic-biodegradation (Fig 2.).
- It mainly focuses on PET plastic (commonly used in the fabrication of water bottles) and with the help of secreting 2 special enzymes (PET-ase and MHET-ase), able to break down the complex nature of PET into much smaller monomers that could be re-used easier in other chemical cycles.

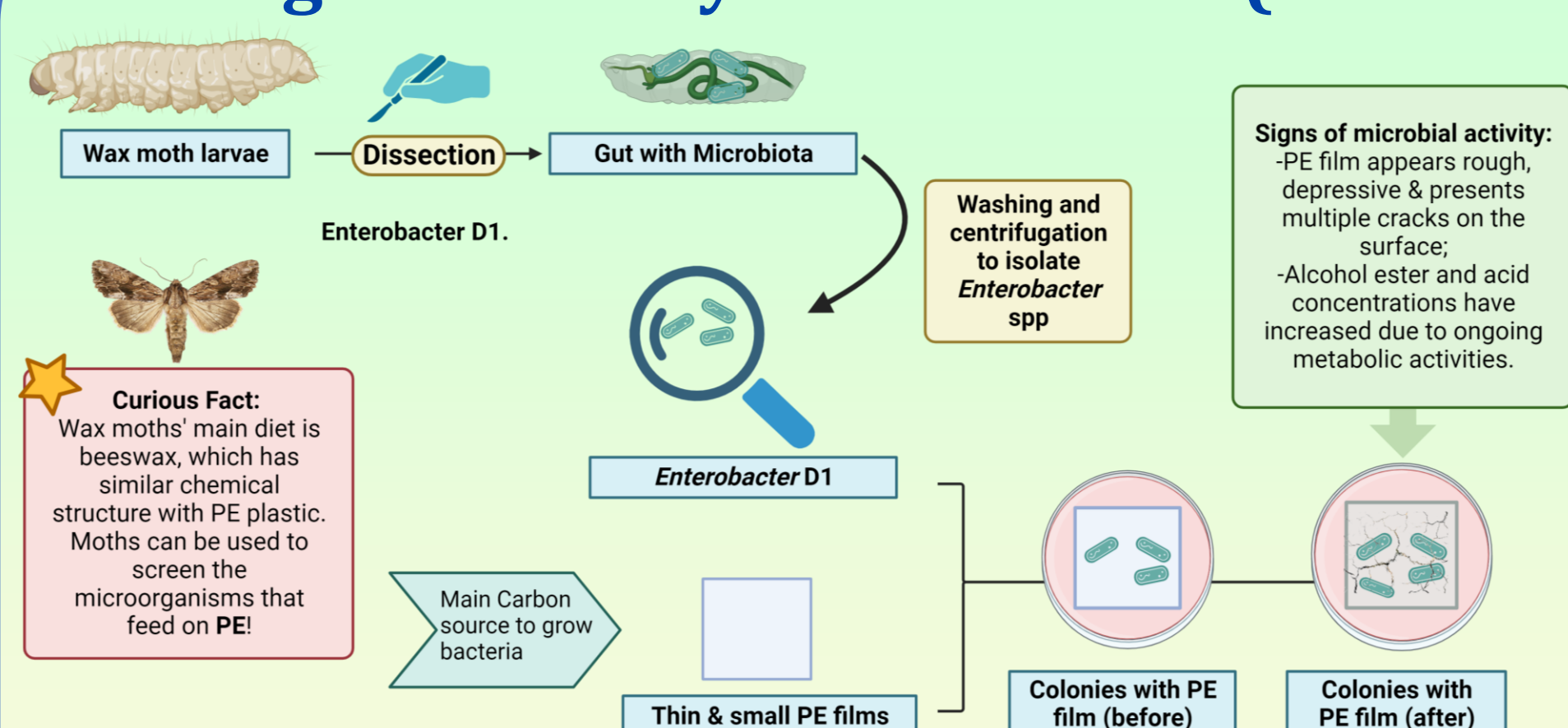


Microorganisms that Degrade Plastic

- Recent discoveries showed that there are many of potentially efficient plastic-degrading microorganisms, ranging from bacteria to fungi (Fig 1).
- To make explanations easier for us, we are going to cover as examples the most used microorganisms in plastic degradation and the metabolic processes they go through.



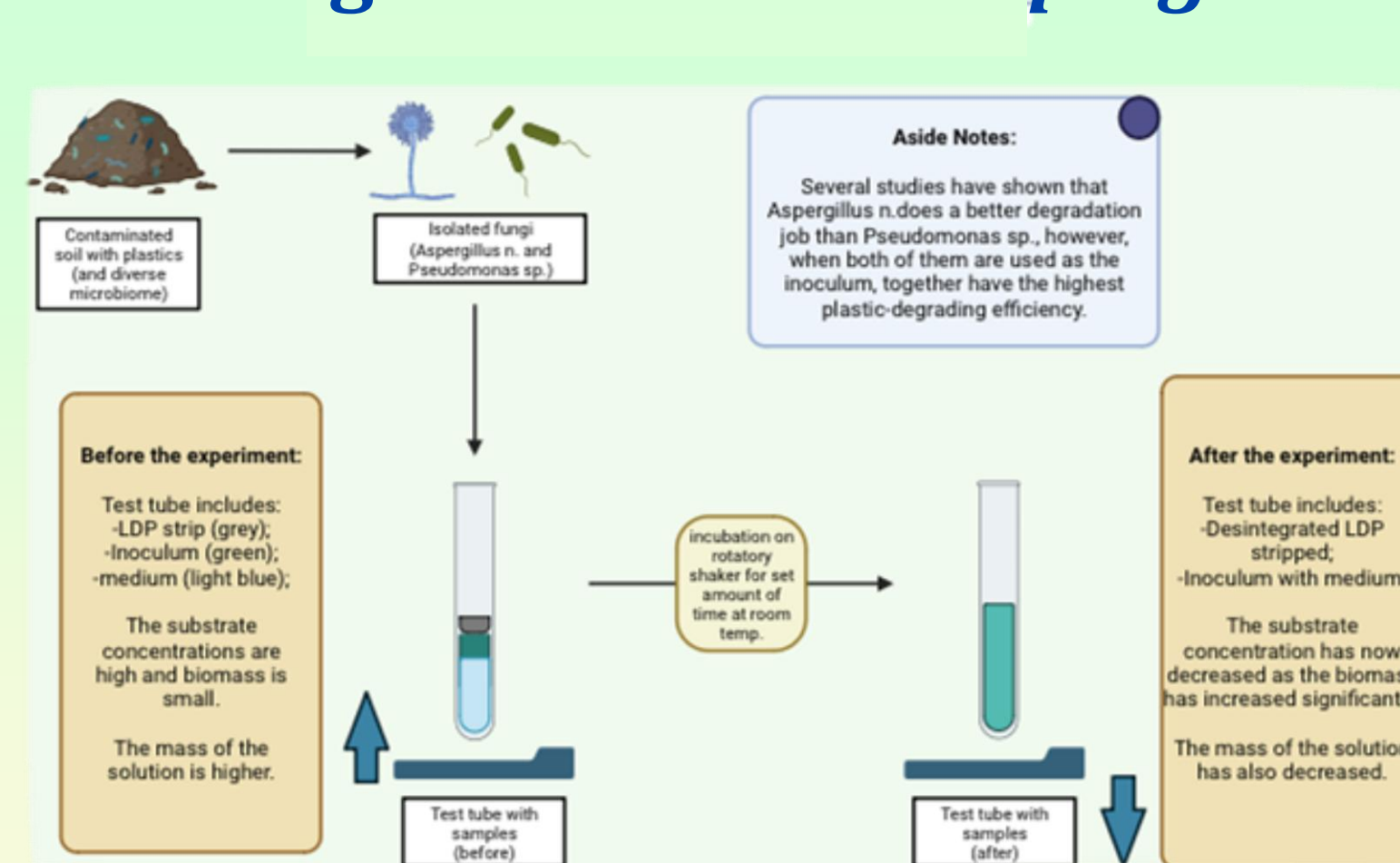
PE Degradation by *Enterobacter* (Strain D1)



Enterobacter D1 was isolated from the microbiota of the Wax Moth larvae (Fig 3.). The guts were obtained by dissection, washed and centrifuged to obtain the bacteria.

Thin and small PE films were used as the main carbon source for *Enterobacter* sp. The biomass will increase and the PE film should reveal cracks and depressions.

LDP Degradation with *Aspergillus Niger* & *Pseudomonas*



- This fungus and bacteria are commonly found in contaminated soil yet help in the degradation of LPD plastic (Fig 4).
- Their inoculum was introduced in a test tube or Petri dish along with the medium and a small LDP strip.
- After a set incubation time at room temperature in an rotary shaker, the biomass was increased and the mass & substrate concentrations decreased significantly.

Conclusions

These microorganisms offer a promising biotechnological solution to the pressing environmental challenges. Future research should focus on enhancing the efficacy of these bacteria and integrating them into holistic waste management systems. This strategy requires a collaborative approach, uniting the efforts of scientists, policymakers, and industry.