Addressing Environmental Challenges: Case Studies about Designing Proteins with a Purpose

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Abstract: Enzyme design is a rapidly advancing field. Biochemistry educators should prepare students to think creatively about how enzymes can be modified for a given purpose. The biochemistry literature includes many examples that can be used to inform students about this field and capture their imaginations. Working with the Molecular CaseNet Faculty Mentoring Network, we have developed two case studies about enzymes designed to address environmental challenges.

"Directed evolution of *I. sakaiensis* PET Hydrolase"

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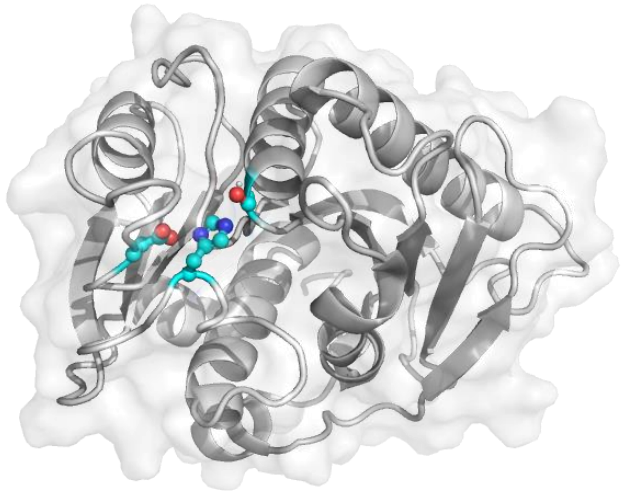

Figure 1: PET hydrolase. Made in PyMOL using PDB 6eqe. Catalytic triad (H237 S160 D206) is shown in cyan.

- Consider the context using a magazine article about enzymes and the global plastic problem
- Use KEGG to find information about the enzyme, and use PDB and Mol* to make figures showing the catalytic triad and substrate analog
- Explore an engineered disulfide variant that is more stable
  - Optional: Find or suggest other PETase variants
- Connect the case to ethical considerations of genetic engineering, recycling, and principles of green chemistry

"Enzymes vs. Forever Chemicals"

Emily F. Ruff

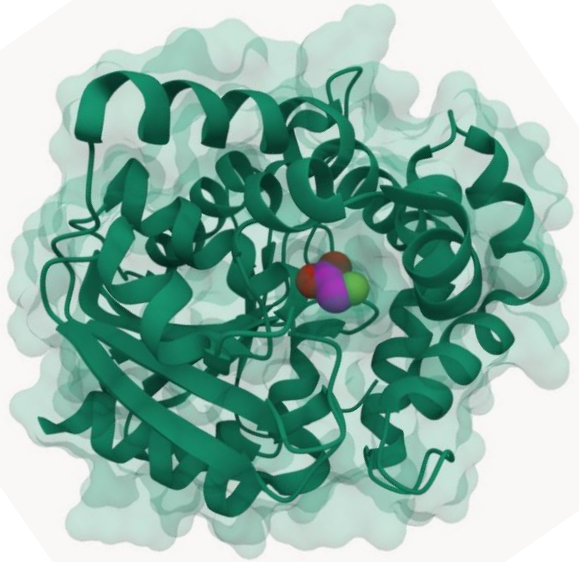

Figure 2: Fluoroacetate dehalogenase RPA1163. Made in Mol* using PDB 3r3v. Bound fluoroacetate is shown in magenta.

- Consider the context using an article from the popular press about PFAS water contamination in Wisconsin
- Compare the structures of PFAS and the fluoroacetate substrate
- Use Mol* and a PDB structure of fluoracetate dehalogenase RPA1163 to make figures showing the catalytic triad and substrate
- Use kinetic data and the enzyme structure to suggest roles for specific residues
- Connect the case to ethical considerations, green chemistry, and the removal of PFAS from water

Please let us know if you would be interested in testing one or more of these cases with your students! Email eruff@winona.edu or go to Molecular CaseNet for teaching notes, keys, and other information.

References:
1.Han X, Liu W, Huang JW, Ma J, Zheng Y, Ko TP, Xu L, Cheng YS, Chen CC, Guo RT. Structural insight into catalytic mechanism of PET hydrolase. Nat Commun. 2017 Dec 13;8(1):2106. doi: 10.1038/s41467-017-02255-z. PMID: 29235460; PMCID: PMC5727383.
2.Chan PW, Yakunin AF, Edwards EA, Pai EF. Mapping the reaction coordinates of enzymatic defluorination. J Am Chem Soc. 2011 May 18;133(19):7461-8. doi: 10.1021/ja200277d. Epub 2011 Apr 21. PMID: 21510690; PMCID: PMC3101105.