Programmable DNA for Synthetic Biology

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My team's research focuses on employing nucleic acid molecules to study biological processes' structural properties, programming, and informatics. We are actively designing, building, and testing concepts related to Nucleic Acid Memory (NAM) and Chromatin Analogous Gene Expression (CAGE) devices. I will discuss the two major activities that are ongoing in my lab and talk about our efforts to integrate these concepts and perform on-command genetic regulation to diversify biological and non-biological applications:

Developing a DNA-Based Molecular Robot – Most medical diagnostic and therapeutic procedures depend on invasive methods and sophisticated tools. These medical practices are non-convenient for the patients, are costly and time-consuming, and require expensive equipment and professional resources. Therefore, there is a critical need for new medical devices and procedures that minimize the inconvenience, cost, and resource allocation. Our goal is to develop intelligent molecular robots that detect diseases and treat them by providing timely, inexpensive, and convenient responses. Our team builds programmable DNA-based robots that aim at i) detecting specific biomolecules, ii) generating amplified signals, and iii) regulating select genes. The robot responds to the existence of the microRNAs by overexpressing the accompanying therapeutic gene. Modifying and altering domain properties of DNA-based molecular machines is inexpensive, fast, and efficient. Hence, the proposed work potentially has a broad reach, given that we can readily change the robot to enable the detection of a host of biomolecules, including but not limited to various microRNAs.

DNA-based information storage system – Current data storage materials and techniques are approaching their economic and physical limits while the demand for memory increases exponentially. By the middle of this century, the world will experience catastrophic shortages of digital memory. Therefore, the memory industry has realized a critical need to explore alternative storage materials. In the absence of alternatives, an information storage crisis is imminent. Dark and Cold (rarely re-used) data storage techniques are costly and have tremendous environmental footprints, while the industry expects a significant capacity shortage soon. In response to the emerging need for alternate archival digital storage materials, our goal is to create a storage device that mirrors semiconductor industry features and utilizes enzymatically synthesized universal DNA as data Blocks. Like writing data into blank disks, the developed device will punch the data in the form of mutations and epigenetic modifications onto template DNA domains (bits). Our team has created a DNA-based data storage system that uses universal template DNA molecules to store data in response to the emerging need for alternate digital storage materials.

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