Automating Biology: Scalable Web Infrastructure for the DAMP Lab Workflow Manager

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Engineers can simulate rocket launches, airflow dynamics, and entire virtual environments from a computer, but biology experiments traditionally require manual operations one at a time. Welcome to the era of "cloud computing," where the lab work of biology experiments is increasingly shifting towards a workflow of designing and conducting completely online. As the manual benchwork of wet lab experiments of biological research increasingly shifts to these cloud labs, the intersection of software engineering and biology has become the new frontier for scientific discovery. A central component of this work addresses the APIs, or, "points of exposure," inherent in moving sensitive information online. To defend against malicious actors who might use code-injection attacks to overload a system, we explore the established practice of defensive API design utilizing AuthGuards and JSON Web Tokens (JWT). Beyond security, we address a significant barrier to cloud lab adoption; many biologists have little experience with integrating automation systems into their experimental workflows. Using frontend design principles, the UI ensures the visual and color hierarchy of the user interface reduces cognitive load and prevents the accidental activation of irreversible operations. Furthermore, by restructuring workflows into modular bundles, we enhance reproducibility and scalability, ensuring that complex protocols can be replicated while eliminating inconsistencies caused by human error. Building more accessible tools for the specify-design-build-test cycle enables faster research that can effectively transition from academia to society. Ultimately, this project demonstrates how merging software and wetware creates the integrated environment necessary to accelerate the future of synthetic biology.