Synthetic cell-based and cell-free biosensors for water contamination in resource limited settings

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Abstract

This tutorial will introduce the principles, latest progress and challenges in developing synthetic biology enabled cell-based and cell-free biosensors for environmental toxins and pathogens. It will bring opportunities to developing new generation low-cost, portable and robust biosensors for use in resource limited settings. Cell-based biosensors have great potential to detect various toxic and pathogenic contaminants in aqueous environments. However, frequently they cannot meet practical requirements due to insufficient sensing performance. Here, we investigated a modular, cascaded signal amplifying methodology to address this issue. We first tuned intracellular receptor densities of the sensory module to increase sensitivity, and then engineered ultrasensitive activator-based multi-layered transcriptional amplifiers to sequentially amplify the transduced sensor signal and boost output expression level. We demonstrated these strategies by engineering ultrasensitive bacterial cell-based sensors for arsenic and mercury contamination. We next developed an encapsulated microbial sensor cell array for low-cost, portable and precise field monitoring, where the analyte concentration can be readily visualized via displaying an easy-to-interpret volume bar-like pattern. The ultrasensitive signal amplifying methodology along with the sensing platform will be widely applicable to many other cell-based sensors, paving the way for their real world applications in the environment and healthcare. Further, new low cost cell-free paper-based biosensors that produce visible outputs and can be freeze-dried for long-term storage are being developed to facilitate their reliable performance and ultra-portability in the field.

References

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