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Developing aptamers and 21st century skills through innovative course-based aptamer research

Among the growing list of aptamer applications, innovative aptamer Course-Based Undergraduate Research Experiences (CUREs) have merged the scientific demand of aptamers with the positive student outcomes realized through authentic research experiences. This demand for additional aptamers is propelled by the broad utility of aptamers to serve in therapeutic, diagnostic, and sensor applications. The Aptamer Stream of the Freshman Research Initiative at The University of Texas at Austin (UT-Austin) addresses this need by identifying and characterizing aptamers as well as developing 21st century skills.

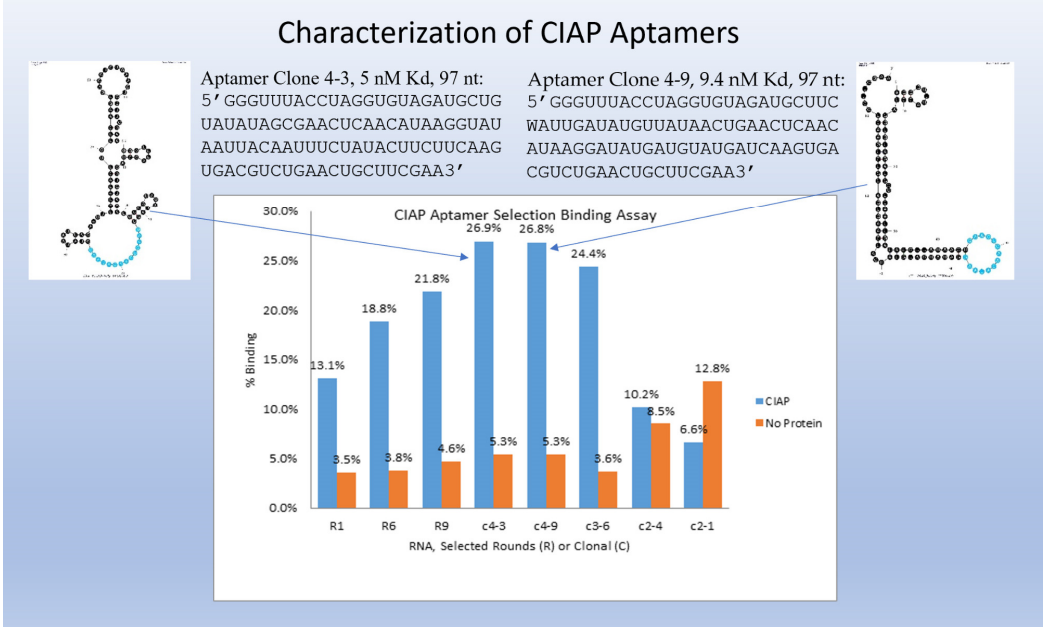

Fig. 1. Calf intestinal alkaline phosphatase (CIAP) binding aptamer radiation binding assay results. The data indicate the selected RNA pools have an increased affinity for CIAP, as the round increased (i.e., CIAP binds more selected Round 9 pool than selected Round 6 or 1 pool). Clones 4-3, 4-9, and 3-6 bind slightly more than the selected rounds.

The UT-Austin Aptamer Stream CURE provides undergraduates a unique opportunity to execute an aptamer project of their own design while building critical thinking and technical lab skills crucial to their post-degree plans. Student researchers have the opportunity to learn and develop their aptamer-based and molecular biology content knowledge in weekly large group and small group meetings, while conducting guided lab work for 6-8 hours/week. In vitro aptamer selections (aka SELEX) are utilized as an educational tool and as the methodology to identify aptamers. Through this experience, undergraduates advance their understanding of laboratory concepts and techniques in a short period of only fourteen weeks, quickly becoming confident, competent researchers.

One of the early positive research outcomes was the identification and characterization of potential RNA aptamers with high specificity for the target molecule, CIAP (calf intestinal alkaline phosphatase). These

CIAP aptamers (5 nM and 9.4 nM Kd), shown in Figure 1, have the possibility to be used in diagnostic or sensor applications as, for example, a reporter system. While the assay development continues, this research has provided many notable contributions, including the establishment of aptamer positive controls (e.g. radiation binding assays), development of teaching lab best practices, as well as the connection and development of a network of resources and expertise. This success story provides evidence that CUREs can serve as an integral component to the advancement of aptamer research.

Further, to measure the impact of the UT-Austin Aptamer Stream CURE in meeting the needs for authentic aptamer research and undergraduate skill development, a pre/post research survey was distributed among lab participants (Fig. 2). The data indicate attitudes towards STEM research in the key areas of self efficacy, identity and belonging in STEM, grit, and preparedness to persist in STEM increased from the initial to final survey. Among the 21st century learning skills (core competencies for the scientific field), the data further suggest that students show statistically significant ($p < 0.01$) increases in their self-reported ability to communicate effectively, locate and interpret information, interpret and analyze data, engage in self-directed learning, and work effectively on a team. Figure 2 additionally outlines a few key student testimonials highlighting the impact and value of the UT-Austin Aptamer Stream CURE as well as the specific skills undergraduates learned. When asked to elaborate on their experience, students indicated they most valued and benefited from the hands-on learning experience of designing and executing their own research project. CUREs show great potential as a broad means for educational instruction, providing meaningful research experiences and the understanding of complex scientific topics.

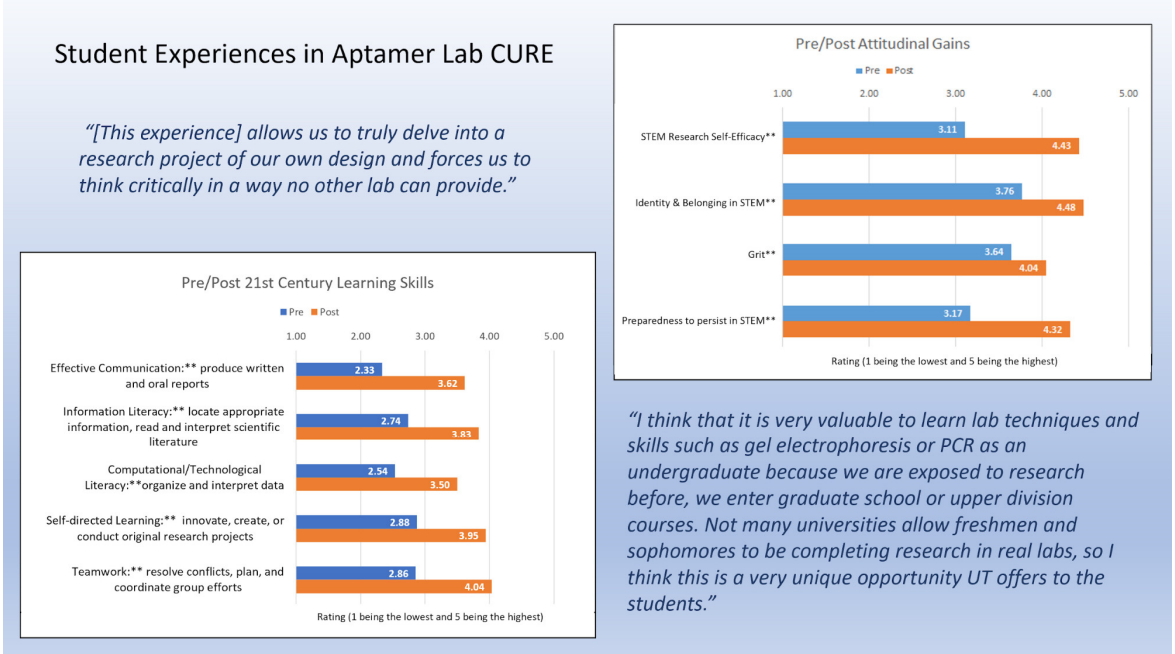

Fig. 2. Assessment of 21st Century Learning skill development and attitudinal gains based on ratings from undergraduate student evaluations (1 being the lowest, 5 being the highest).

In all, this work described, for the first time, the use of aptamers in an educational setting, highlighted the positive student outcomes of the aptamer research experience and presented the research findings relative to novel CIAP aptamers. Aptamer research has the potential to radically transform traditional laboratory education by empowering students to engage in independent inquiry. Perhaps this new approach to education and aptamer research will open the doors to similar types of research experiences, benefitting both the aptamer community and undergraduate education as a whole.

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