PROJECT SUMMARY

Intellectual Merit. Through collaborative efforts of faculty, research scientists, and technical staff from MIT's Biology Department and the Office of Educational Innovation and Technology (OEIT), we are striving to enrich science education by building educational software and curricular materials that (i) provide meaningful opportunities for students to engage in inquiry-based learning through interactive, realistic, computer-generated simulations of experiments, (ii) expose students to striking examples of actual data acquired from cutting-edge research, (iii) are useful across a range of educational levels, from high school to graduate school, through supported capacity for instructor-determined customization, (iv) can be easily implemented in existing course curricula, and (v) are freely and openly accessible worldwide via the internet.

We have previously developed, implemented locally, and are now widely disseminating two software tools, StarBiochem and StarGenetics, described in the full proposal. Now we seek to apply the experience and knowledge gained from these initiatives and the expertise of MIT's leading cell and molecular biology faculty to design a new tool to enrich the teaching and learning of cell and molecular biology concepts: an interactive, inquiry-based, virtual experiment simulator, called StarCellBio.

Current introductory cell and molecular biology instruction often relies heavily on text-based problems that provide *descriptions* of methods and data to promote student learning and to build critical thinking skills, but such approaches fall short of capturing the reasoning process involved when one actually *conducts experiments* in these fields. Bypassing the need for laboratory space, specialized equipment, expensive reagents, or even a classroom, StarCellBio will enable students to engage in this experimental reasoning process by providing virtual opportunities for them to determine what experiments are needed to answer particular biological questions, design and perform those experiments, analyze data generated, perform follow-up experiments, and draw conclusions from their own inquiries. The tool will also offer unprecedented opportunities for students to interact with real visual cell biology data in the course of their studies, as it will utilize microscopy image and time-lapse movie data in demonstrations of key topics, including cell cycle, intracellular localization and colocalization, trafficking, signaling, cell motility, cell diversity, and tissue organization. StarCellBio will incorporate such real data and computer-generated data in interactive simulations that involve choices of experimental treatments to generate a realistic array of possible experimental outcomes. Following a design model successfully employed in our other simulation software, the specific components of each StarCellBio experiment simulation will be defined by instructors using a modifiable template that will be made freely available online.

Once developed, a beta version of StarCellBio will be assessed for function and usability by faculty, students, and trained staff at MIT's Information Services and Technology's Usability Lab, and modified as needed. Early implementation and assessment in formal educational settings will occur in MIT's undergraduate Introductory and Cell Biology courses. Students will access StarCellBio via our website, where the tool and curricular materials will also be publicly available. Our evaluation plan, detailed in the full proposal and carried out with educational researchers from MIT's Teaching and Learning Lab, utilizes established research instruments and includes mixed-method approaches to (i) measure gains in student knowledge and comprehension of cell and molecular biology concepts, (ii) probe their development in ability to design, conduct, and reasonably interpret results of biological experiments, (iii) measure changes in students' attitudes and motivation towards pursuing further study in biology, and (iv) query overall student response to the StarCellBio tool.

Broader Impacts. Having addressed its intellectual merit and local impact above, we now discuss StarCellBio's broader impact. By its online presence, StarCellBio will have important utility for under-resourced institutions. Impact will be further broadened via efforts led by laboratory-trained Ph.D. researchers, who will present at national conferences, conduct training workshops, and continue outreach to other universities and colleges with special focus on reaching underrepresented minorities. We will continue working with public school teachers and museums to reach younger students through simulations appropriate for high school STEM classes. We will also continue outreach efforts to support higher education and E-learning internationally. Additional broad dissemination approaches will include online advertising campaigns and direct mailings to biology faculty at universities nationwide.