UBM-Group: Collaborative Research on the Arthropod Way of Life (CRAWL):
Interdisciplinary Training in Mathematical Biology

For this project, the Departments of Biological Sciences and Mathematics & Statistics at East Tennessee State University (ETSU) will be working with six students each year and placing them in long-term (summer plus fall and spring semesters) research projects in mathematical/quantitative biology. Integrated research teams (Math and Biology students together with Math and Biology mentors) will tackle significant questions at the interface of the two disciplines. The students will be actively involved in all phases of the projects from conception to completion, including experimental design and data collection/analysis, culminating in presentations and manuscript submission, thereby transforming our participants’ outlooks from traditional ‘passive students’ to ‘active researchers’. The projects will cover a wide range of biological/mathematical areas but will be unified and strengthened by focusing on related biological questions in three arthropod model systems (social spiders, flesh flies, and honey bees). This common focus will be further enhanced by using mathematical/statistical approaches applicable to all three systems. Therefore, we call this program Collaborative Research on the Arthropod Way of Life (CRAWL). Funding of this project will enable us to create an infrastructure for long-term, sustainable undergraduate research in quantitative biology. Our ultimate goal is to develop a thriving culture of undergraduate research by creating a reward structure that benefits both students and professors. A major component of our approach will be implementation of projects that are amenable to undergraduate research but also have a high probability of yielding quality publications. We are setting the bar at a high level: we expect and will diligently work toward at least one publication for every participant. Accordingly, the CRAWL program will include substantial summer support for student research as well as continuing involvement during the academic year, thus enabling students to maintain long-term continuity with their projects. This will remove a major barrier to sustained progress in our undergraduate research program.

Intellectual Merit: Students will gain skills in biology and math through no less than full participation in the research process. A major component of our proposed CRAWL program is long-term immersion in a research project, involving each student in every stage of the scientific process. Major emphases will be: (1) the hypothetico-deductive approach to problem-solving, (2) rigorous experimental design developed by the entire team, thus ensuring a truly integrative approach, (3) introduction to critical thinking and the application of mathematical and biological skills via workshops, (4) “on-the-job” learning of critical skills for data collection, data management, statistical analyses, and mathematical modeling, (5) dissemination of results at both the local and national levels, (6) undergoing the publication process, including creation of publication-quality graphs & tables, scientific writing, and responding to reviewer critiques. We have developed projects that address fundamental questions in the areas of spatiotemporal dynamics of intraspecific interactions (aggression in spiders and flies, communication in honey bees) and the neurohormonal underpinnings and ecological implications of these behaviors. Our analytical approaches will include time-series analyses, spatial analyses, agent-based modeling, graph theoretic analyses, logistic regression modeling, and diffusion-based mathematical models.

With its inter-connected biological and mathematical themes, joint mentorship, and team approach, we view CRAWL as a model for efficiently integrating undergraduates into established research programs. Therefore, we will conduct a robust assessment of our students' learning gains and experiences associated with the program and disseminate our findings via publication and professional presentations.

Broader Impacts: Beyond the involvement of students in research projects, the overall goal of CRAWL is to generate a research culture in biology and math at ETSU by building an infrastructure that will ensure its sustainability. Critical to its success, the excitement of the discovery process must be translated into classroom and teaching laboratory experiences for students not directly supported by the program. We intend for CRAWL to have a synergistic effect on the overall curriculum at ETSU as projects and results are incorporated as modules into upper division math and biology courses. In addition, several of the research projects will be adapted as teaching laboratories. We also intend for our CRAWL students to be “research ambassadors” by giving guest lectures and presentations in both introductory and upper level courses. Our CRAWL students will be recruited from under-represented groups in the Southern Appalachian region.