Research Program Statement | Manisha A. Munasinghe

A foundational question in evolutionary biology is the origin and maintenance of distinct species. New species form when a progenitor species is first partitioned such that gene flow between the two subgroups is limited. As these subgroups evolve in response to their environment, they accumulate genetic differences that build up morphological or behavioral barriers between the groups. These barriers lead to reproductive isolation, the final step in the speciation process.

My research program focuses on exploring the genetic, behavioral, and environmental factors that contribute to speciation by integrating population genetic theory and computer simulations that model historic processes with large-scale datasets containing whole-genome and -transcriptome information for populations of interest.

<u>Past and Current Work</u>

Eukaryotic genomes are partitioned between the nucleus, which stores autosomes and sex chromosomes, and certain organelles, like the mitochondria. These distinct genetic elements are differentially transmitted. Unlike autosomes that spend equal amounts of time in males and females, sex chromosomes spend either ⅔ of their time in the homogametic sex (i.e X or Z chromosome) or all of their time in the heterogametic sex (i.e Y or W chromosome). The mitochondrial genome, while present in both sexes, is exclusively maternally inherited. This transmission asymmetry can lead to genetic conflict, but we still lack a clear understanding of the sexually antagonistic interactions between these genes.

During my Ph.D., I first developed analytical models and computer simulations to examine how transmission asymmetries of nuclear, mitochondrial, and sex chromosome-linked genes may both cause and resolve sexual conflicts. We confirmed earlier results showing that sexually antagonistic mitochondrial variants (female advantageous, male disadvantageous) could invade populations and demonstrated that, while nearly all nuclear variants slowly spread throughout a population to counteract this effect, Y chromosomal variants spread substantially faster. **To explore mitochondrial-Y interactions, we generated 36 otherwise identical *Drosophila melanogaster* strains, differing only in the geographical origin of their mitochondrial genome and Y chromosome, and evaluated gene expression patterns across**

the lines to assay phenotypic differences. We found genes involved male fertility, metabolism, and immunity showed differential expression between these lines not only confirming theoretical expectations that mitochondrial and Y chromosomal genes interact but also showing that these interactions influence phenotypes that are crucial for organismal survival.

Future Work

My previous work demonstrates that asymmetry in the inheritance of genetic elements can both generate and resolve sexual conflict. We are now developing more sophisticated computer simulations that explore how these interactions impact speciation by first establishing interactions between two discrete populations, allowing migration between the two, and evaluating hybrid fitness. Finally, we will explore interactions between the mitochondrial and nuclear genome in humans by leveraging the most comprehensive transcriptomic dataset, The Genotype-Tissue Expression (GTEx) project. With over 10,000 samples generated from 53 tissues from 635 human donors, we can use sequencing data to call genetic variants and complex statistical models to identify interactions between mitochondrial variants and nuclear gene expression patterns.

Diversity Statement | Manisha A. Munasinghe

A commitment to not only educating but serving diverse communities is central to the mission of all academic institutions. In spite of this, we have historically failed to live up to this ideal. Hostile learning environments, lack of role models, and systemic barriers continue to make students, particularly underrepresented students, feel as if though they do not belong in our community. As a queer woman of color working in fields historically dominated by heterosexual, white males, I have witnessed firsthand how universities can both support or fail to include students. It is our responsibility, as those who hold power within academic communities, to advocate for the creation of inclusive, accessible spaces for all students, faculty, and staff.

Students increasingly represent a broad range of backgrounds, cultures, and experiences. As an educator, I try to create structured learning environments where students feel socially connected both to each other and to the broader academic community. The use of inclusive pedagogy that helps students develop and communicate their own ideas is key to this process. I also try to integrate Skype conversations with diverse researchers throughout the semester to expose students to the varied ways scientists join and contribute to the field. Outside of the formal classroom setting, I have partnered with other doctoral students to create demos introducing foundational population genetic theory to 7th to 9th-grade girls for the annual Expanding Your Horizons conference at Cornell. As President of the Computational Biology Graduate Student Association, I have planned several events designed to provide female graduate students in the field with informal mentorship opportunities to help them feel part of the larger community.

While it is our responsibility as educators to create inclusive classrooms, we must also acknowledge that structural barriers impede student success at nearly every institution. A true commitment to inclusion and equity requires the removal of these obstacles, both by investing financially in programs and resources that support underrepresented communities and by rewriting academic policy that disproportionately affects certain students. Throughout my two-years on the Cornell Graduate and Professional Student Assembly Executive Committee and my current position as a student-elected member of Cornell's Board of Trustees, I have routinely advocated on behalf of underrepresented graduate student communities. A recent example includes working with the General Committee of the Graduate School to revise the policy on Graduate Student Assistantships to clarify vacation time, as we realized that a lack of clarity here disproportionately affected international students who were being denied time off to go home for extended periods. I have also served as a graduate representative on both Cornell's Coalition on Mental Health and Mental Health Review Committee. These committees focus on identifying gaps in supporting the mental health of graduate students, particularly those from underrepresented backgrounds.

We must actively work to transform academia into a community where everyone is able to live and learn free of systemic barriers and hostile interactions. To do this, we must create inclusive classrooms, meaningful mentorship opportunities, and equitable university policies.

Teaching Philosophy Statement | Manisha A. Munasinghe

Our mission as educators is to disseminate knowledge, teach specific skills, and prepare students for their future careers. To do this, my teaching philosophy can be subdivided into three foundational pillars: (1) **clarity** of learning objectives and assessments, (2) **communicate** concepts to diverse audiences, and (3) **empower** students to solve new problems.

(1) Clarity - Students enter a learning environment with little knowledge of what they are expected to learn and how they will be evaluated. It is up to the instructor to articulate this. A combination of traditional lectures, active learning exercises, and auditory or visual supplements convey information to students in ways that best suit their preferences. Similarly, assorted assessment techniques, such as minute papers or problem sets, allow students to evaluate their mastery of the material and seek further assistance if needed. As a teaching assistant for Quantitative Genetics and Genomics (BIOMG 4830), I began lab by connecting the assignment first back to the broader course objectives and then to the types of questions used to evaluate their understanding of the topic. My goal is to use a variety of instructional tools to help students link abstract concepts to concrete techniques to higher-level problem-solving.

(2) Communication - Students will pursue careers in areas ranging from research science to public policy to business and more. These fields require individuals to communicate ideas and information to diverse audiences. Highly visible examples not only spark student interest but also allow students to evaluate differences in communication techniques. As a guest lecturer for Human Genomics (BIOMG 4870) on direct-to-consumer genetic tests, I had students evaluate differences between how Senator Elizabeth Warren communicated the results of her genetic ancestry tests with how businesses, such as 23andMe, and genetic researchers explain these results. This highlighted not only the dangers of miscommunication but also why we must work with other fields or local communities, in this case, indigenous groups, to effectively convey information. Incorporating various presentation styles, such as short oral presentations or longer written papers, allows students to practice communicating their ideas in different formats.

(3) Empower - Leading students to independent thinking, where they can tackle problems on their own, is my ultimate goal when teaching. Students must feel comfortable trying new techniques, potentially failing, and reaching out to colleagues for assistance. To do this, I integrate questions into assignments that allow students to connect the material to their own interests, and, at least once a semester, I provide students with an opportunity to peer review each other’s work. I want students to leave the classroom feeling like not only are they capable of contributing their own ideas to the field but that they are also able to critique and provide helpful feedback to others' ideas.

As an instructor, I want my students to clearly understand what concepts they are going to learn, how to share their work effectively, and how these skills can be applied to new problems.