Mentoring & Teaching Statement – Chen Li, Johns Hopkins University

Education Vision

My education vision is to provide/instill diverse students at all levels with:

1. The broad training necessary for integrating disciplines to solve challenging problems.
2. The spirit that cutting-edge science can be done through table-top experiments and simple modeling.
3. The aspiration to pursue life-long careers in research and STEM fields.

Research Mentoring

Though I loved and exceled in STEM curriculum, it was not until doing hands-on, table-top research myself that I truly appreciated the spirit of science (daring to delve into the unknown[1], while being comfortable feeling stupid[2]) and the intellectual reward of doing it and aspired to be a life-long STEM researcher. As a first-generation college student, I believe **all students should be exposed to this early to help them pursue STEM and research careers, regardless of their educational, socioeconomic, and ethnic backgrounds**. I have striven to provide this to the younger generation. As a senior PhD student, I mentored 4 students in physics and mechanical engineering. As a postdoc, I furthered learned to mentor by mentoring 22 students in biology, mechanical engineering, and electrical engineering. Since starting at JHU in 2016, I have mentored **104 students** and 1 postdoc with diverse background across mechanical engineering, robotics, engineering mechanics, biology, physics, electrical engineering, computer science, etc. I have consistently made efforts to broaden participation, with over a quarter of mentees being women (minority in my fields) and/or under-represented ethnic groups. See my CV for detail.

<u>PhD students mentoring</u>

I have mentored 7 PhD students working fully in my lab and 3 rotation PhD students. **I give all these PhD students very close mentorship**, especially over the first 3 years of their doctoral studies, until they have fully gone through a project from conception to publication. For every PhD student, I devote at least 30 minutes each week, and often over an hour, to advise on their research. For students that focus on experimental work, I regularly visit the lab each week to check and advise on their experiments. All PhD students present their progress at our weekly lab meetings and, once they complete coursework after 2 years, provide daily updates with immediate feedback from me over emails to iterate on their research. Another of my major effort is to **spend a very large amount of time training them to write scientific papers and give scientific presentations**. For each student's manuscript, I go through several rounds of careful comments and edits often over 1-2 months, first commenting on a high level focusing on the scientific novelty, approach, logic, structure, and implications, then sentence-by-sentence editing, always making comments to explain why I revise or suggest changes the way I do. For each conference talk, I also do the same, with multiple rounds of comments from high level to detail over 1-2 weeks, often coupled with multiple practices. In both paper writing and presentation preparation, I **emphasize communicating to a broad audience and highlighting interdisciplinary connections**. Although this vigorous process has lengthened the process of preparing talks and publishing papers, the vigorous training pays off, by enabling students to become critical thinkers and strong scientific communicators, which help them as they advance in their PhD and beyond, and my students learn to increasingly appreciate this as they grow and even after they leave. As each PhD student advances, I then steadily reduce my close involvement, **letting them struggle more to develop independence**. Although many of them work on distinct research directions, I frequently advise PhD students to actively learn from each other, more senior ones to actively mentor junior ones, and junior ones to actively seek advice from seniors. Finally, I also provide my PhD students **ample opportunities to attend top conferences across fields** related to our work to present their work, see other research, and get to know people who may be future colleagues and employers. Since starting at JHU, I have supported my students to given a total of **89 presentations** (74 talks, 15 posters) across 4 biology, 4 engineering, and 1 physics conferences. Among these, about 70 of these were led by my PhD students.

All these vigorous training efforts have fostered my PhD students to lead cultivating a **very positive lab culture**, which has strongly facilitated them and more junior mentees (see next section) to become highly productive. On average, my PhD students are expected to have published 3 high quality papers or have nearly done so by the end of their 5th year, and this provides them with a strong foundation for the next step. My first graduated PhD student, Ratan Othayoth, was a **Finalist for Life Sciences Research Foundation Postdoctoral Fellowship**. He is now doing postdoctoral research on neuroscience at HHMI's Janelia Research Campus. My second graduated PhD student, Qiyuan Fu, is now doing postdoctoral research at EPFL Biorobotics Lab (with Auke Ijspeert) to develop a salamander robot capable of local feedback and studying feedback control principles. Four PhD students (Eugene Lin, Divya Ramesh, Ratan Othayoth, Yuanfeng Han) were **Finalists for a Best Student Paper Award** at Society for Integrative & Comparative Biology Annual Conference, Division of Comparative Biomechanics (SICB DCB).

Undergraduate, master, and high school students mentoring

I structure my group to include undergraduate, master, and high school students as an **integral part of our research endeavor**. I have mentored 56 undergraduate (34 are from JHU, 22 are visiting summer interns), 32 master, and 6 high school students (**94 total**) on table-top, hands-on lab research. This is well above the departmental average (JHU ME is a small program, enrolling ~10 undergraduate and ~30 master students each year). I devote at least 15 minutes each week to every student to review their progress and provide immediate feedback. This is done through two regular email updates each week and a short research presentation at weekly lab meetings required for all lab members. In addition, I assign a PhD student to mentor each one of them, who meet them in person frequently in the lab and provide prompt, detailed email responses for feedback and advice. These frequent iterations help these more junior lab students stay on course and learn the scientific inquiry process. My PhD students also learn from this experience to become better mentors. Finally, I supported several non-PhD students to present at conferences.

This close, interactive, rigorous training has facilitated the growth of these students. **Over 40%** of my 77 master, undergraduate, and high school mentees have contributed sufficiently to earn authorship on a conference abstracts. **Over 15%** have earned authorship on a peer-reviewed paper. **40%** of them have continued onto top undergraduate or graduate programs in STEM fields, whereas **over 10%** onto top companies in the technology industry (based on information from those who have graduated and stayed in touch). One summer intern undergraduate won **Finalist for Outstanding Locomotion Paper** with his first-authored conference paper at International Conference on Robotics & Automation, together with a PhD student. One female master student was selected as **Finalist for a Best Student Paper Award** at the SICB DCB. One undergraduate won a nationally competitive **Robotics Institute Summer Scholar** from Carnegie Mellon University. Five undergraduate mentees have won Departmental awards **8 times** for outstanding research achievements and outstanding overall achievement. **One African American high school mentee co-authored two journal papers**, won two awards at Baltimore Science Fair, and won full scholarships from many universities.

Postdoctoral fellow mentoring

I mentored a postdoctoral fellow, Sean Gart, in 2016-2018, who had a PhD training in bio-inspired fluid mechanics. I worked very closely with him during his entire stay to help him quickly learn to do research in the field of locomotion and terradynamics that were unfamiliar to him. By the end of his 2.5 year stay, Sean had published 3 papers in top journals and landed a **permanent position** at Army Research Lab as a research scientist in their Autonomous Systems Division. He continues to research robot locomotion in complex terrain at ARL to help expand the emerging field of terradynamics.

Documenting resources for training students

Since starting my lab at JHU, I have made a consistent effort to work with my students to **document research protocols, good practices, and scientific know-how**. We have established a comprehensive lab manual using my lab website and Dropbox, and we refer all new lab members to go through the most essential training when joining the lab and then other parts as needed. I emphasize the importance for all my mentees to have a **better appreciation of the scientific inquiry process early on**, especially how it differs from learning well-established textbook knowledge throughout most of one's education, by pointing them to excellent advice I benefited from early on in my research career (https://li.me.jhu.edu/resources/).

Educational Outreach

My lab also has a track record of K-12 and public outreach, reaching over 360 students and their families, many from under-represented, under-served communities in Baltimore. See my CV for detail.

Courses Developed & Taught

At JHU, I have developed three new upper-level undergraduate and graduate courses: Locomotion Mechanics: Fundamentals (3 credits), Locomotion Mechanics: Recent Advances (3 credits), and Comparative Biomechanics (3 credits). See my CV for course description, topics, and course development.

Both my Locomotion Mechanics courses have attracted a large class of students consistently, averaging ~20 students each semester (this is large for JHU Mechanical Engineering, which only enrolls ~10 undergraduate + ~30 master students per year). I only taught Comparative Biomechanics once, because of the higher interests from engineering students in my two locomotion courses that involve robots.

Course Evaluation

Semester	Name	Enrolled (UG, Grad)	Evaluation (out of 5 maximum)
Fall 23	Loco. Mech.: Fundamentals	19	TBD
Spring 23	Loco. Mech.: Fundamentals	33	4.2
Fall 22	Loco. Mech.: Recent Advances	13	4.0
Fall 21	Loco. Mech.: Fundamentals	22	4.2
Spring 21	Loco. Mech.: Recent Advances	20	4.0
Fall 20	Loco. Mech.: Fundamentals	17	4.2
Spring 20	Loco. Mech.: Recent Advances	18	4.2
Fall 19	Loco. Mech.: Fundamentals	18	4.6
Spring 19	Loco. Mech.: Fundamentals	15	4.1
Fall 18	Comparative Biomechanics	4	N/A (fewer than 5 students)
Fall 17	Loco. Mech.: Fundamentals	16	4.4
Spring 17	Loco. Mech.: Fundamentals	29	3.7
Spring 16	Loco. Mech.: Fundamentals	33	3.8

- Teaching relief in Fall 16 (new hire), Spring 18 (child birth), and Spring 21 (pandemic impact).

Strength of Courses

1. One strength of my courses is the **interdisciplinary thinking and integration**. Although the course content is rooted in mechanics and physics, I have incorporated a large dose of biology in my locomotion courses for the engineering students. This improves their appreciation of how animals are different from robots, but how one can gain fundamental understanding of the physical principles of animal locomotion, which can then be translated to improve robots, as well as how engineering and physics informs biology.

2. Another strength of my courses is that they give an **intuitive picture of how highly complex systems work**. Locomotion and comparative/organismal biomechanics research is highly interdisciplinary. To create these courses, I spent much efforts studying research papers, creating illustrated explanations of basic concepts and principles, simplifying technical detail, and better integrating them on high level. I also made great efforts to obtain a lot of videos (several hundred for each locomotion course and 100+ for the biomechanics course) and condense and synthesize research slides that I obtained from 20+ colleagues who are leaders of the field. These efforts have made the complex concepts, ideas, approaches, and findings more easily understandable, especially as most of the engineering students are not familiar with biological and bio-inspired locomotor systems (particularly the physics/mechanics aspects).

3. A third, particularly unique strength of my locomotion courses is that they provide a little **education about the scientific inquiry process**, by exposing students to cutting-edge research in the field of animal and robot locomotion. In my lectures, I often dissect research articles from leading scientists, going through the challenging yet rewarding process of identifying knowledge gap, designing experiments, developing methodology, obtaining, analyzing, and interpreting data, drawing conclusions, and identifying limitations.

My efforts have been **well appreciated**, as evidenced by anonymous student evaluations: "The content was extremely interesting. The breadth of the things covered was huge and it was cool seeing the physics we learned in our classes being applied to make models and understand systems." "This class teaches a lot about research and conducting experiments, which is applicable to many subjects." "The professor does a really good job of introducing the students to research that has been done to advance the field." "Being able to learn … actual, current research on locomotion was fascinating. We rarely get current research, so this was a treat.” “If someone wants to understand how research is done, this is the course to take.” “The information covered in this is very novel and makes me want to do research in this field.” “I wished I had a class like this at an earlier stage of my studies which might have totally changed the path I’m pursuing.”

Future Course Development

Adding Hands-On Projects to Existing Courses

I plan to add hands-on projects to my two locomotion courses. To suit students with different levels of preparation of skills needed, I will have simpler projects of recreating bio-inspired robots in the literature and challenging projects of creating new robots after studying physical principles of latest animal research.

Preparing Future Faculty

I plan to develop and teach a course to graduate students and postdocs on how to prepare for finding a job at a major research institution and an academic career. Such a career is intellectually deeply satisfying, especially for those who are curious about nature and love to create. The academic job market and scientific research enterprise are becoming increasingly competitive. Besides making outstanding research contributions and developing unique cutting-edge expertise, it helps to better understand how to prepare for the challenges of finding a faculty position and starting an independent group. In these respects, I have benefited tremendously from excellent mentorship by my doctoral, postdoctoral, and faculty advisors and caring colleagues. I would love to help curious and aspiring students and postdocs a little as I can.

For academic career, I will use Burroughs Wellcome Fund/HHMI’s excellent book, “Making the Right Moves – A Practical Guide to Scientific Management for Postdocs and New Faculty”. For job search, I will use Karen Kelsky’s excellent book, “The Professor Is In: The Essential Guide to Turning Your Ph.D. into a Job”. For scientific writing, I will use Joshua Schimel’s outstanding book, “Writing Science”.

References

1. Alon, U. *Why science demands a leap into the unknown*. *TED Talk* (2013).
2. Schwartz, M. A. The importance of stupidity in scientific research. *J. Cell Sci.* 121, 1771 (2008).