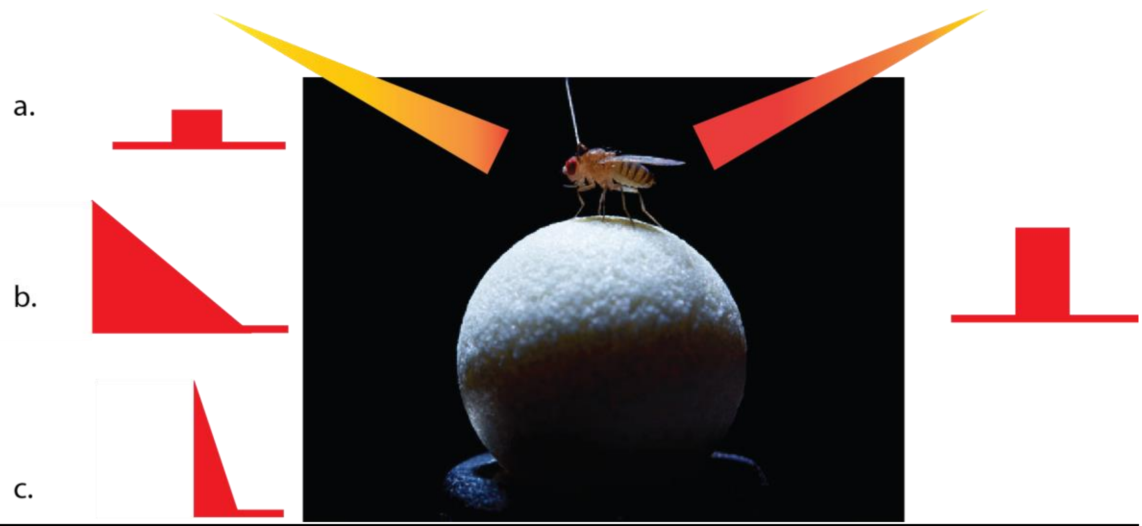
Controlling Fly Brains and Behaviors with Light– Simpson Lab (Multidisciplinary Project)

This project is available as a multi-disciplinary project that may include 1 ME team and 1 EE team of students. Students would be required to enroll in ENGR 195 for 1 additional unit of credit each quarter.

Research Sponsor: The Simpson Lab studies the neural basis of motor sequences. We use grooming behavior in fruit flies as a model system and our research combines genetic manipulation of neural activity with computational quantification of behavior to determine how brains manage competing priorities. This CAPSTONE project will be co-advised by Dr. Simpson (MCDB) and Dr. Theogarajan (ECE).

Project Description: To control mechanosensory inputs to fly bristles with light and record grooming movements in response, we need you to

- Build a tiny "treadmill" (5mm)
- Design two focused lasers/LEDs (50µm spot size) with separate power controls
- Set up synchronized video camera recording of behavior
- Implement leg tracking and trajectory analysis
- Integrate into a user-friendly rig for biological experiments



Concept schematic for a tethered fly on a treadmill with competing light stimuli. a. Different levels of activation on anterior and posterior bristles. Does a shallow (b.) or steep (c.) temporal gradient of light activation evoke a shift from anterior to posterior grooming? (photo adapted from Jamie Chung, Wired Magazine 2011.)

Project Scope: This project includes construction of a treadmill based on established plans, as well as designing and building a system to target light and control power levels. While there are some rigs in the literature to use as models, this particular application is novel and will require interaction with experimentalists to establish optimal parameters.

Team Requirements: Practical mechanical and electrical engineering skills, familiarity with optics and control systems, and ability to program in Matlab (and/or Labview).

There are limited lab funds available to support the project. The team will be required to apply for a URCA grant to help defray the cost of consumable materials for the project.

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Background: Flies detect dust using mechanosensory neurons in their bristles. When all bristles are stimulated, flies groom in an anterior to posterior progression. We propose that the choice of which body part to groom is determined by the relative amounts of dust on different body parts, or by how the dust levels on each body part change with time. To test these hypotheses, we will set up competition between sensory stimuli with precise spatial and temporal control using light to trigger activation of mechanosensory neurons. We can produce "optogenetic" flies expressing light-gated ion channels CsChrimson and Channelrhodopsin, and we know how to quantify fly grooming, but we need YOU to design and build an apparatus that allows us to 1) precisely target light to specific bristle areas for neuron activation, and 2) concurrently monitor leg movements during grooming behavior. This instrument will help us determine *how the nervous system compares sensory information in space and time to choose appropriate motor programs in sequence.* For further information, see https://labs.mcdb.ucsb.edu/simpson/julie/

References for fly treadmill design:
https://www.janelia.org/open-science/drosophila-ball

References for possible optogenetics light control system:
https://www.thorlabs.us/navigation.cfm?guide_id=2187
http://www.microlaser.com/FiberOptic/FiberFocuser.html
References for possible movement tracking software:
http://www.unc.edu/~thedrick/software1.html
Bender, Simpson, Ritzman PLOS 2010
Kain, de Bivort Nature Communications 2013

References for using light to control fly behavior:
http://www.ncbi.nlm.nih.gov/m/pubmed/
Klapoetke et al 2014 csChrimson
Bath et al Nature Methods 2014 FlyMAD
Wu et al PNAS 2014 ALTOMS