Details: Biological Discovery in Woods Hole

Summer Opportunity for Undergraduate Research

MBL

Department of Education

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Program Dates: June 13 – August 17, 2018

Application Deadline: Priority deadline – February 15, 2018; Final deadline – March 10, 2018| Online Application

Program Summary | Program Details | FAQ

Please read the entire summary and the FAQ before contacting MBL with questions. Any questions not covered in the program details and/or the FAQs must be sent to NSFREU@MBL.EDU. Please do not contact the education office at MBL as that will only delay any response. All application material must be uploaded electronically.

The Marine Biological Laboratory invites undergraduate students who are interested in pursuing careers in the life sciences to apply to the Biological Discovery in Woods Hole program. Faculty with expertise in molecular and cell biology, neurobiology & behavior, physiology, developmental biology, and evolutionary biology will guide ten highly motivated undergraduate students in this National Science Foundation – Research Experience for Undergraduates (NSF REU) program. Each undergraduate student will be placed in the laboratory of an MBL research scientist and fully participate in all laboratory exercises and activities. The program will provide a stipend of approximately $5000 to each student ($525/week), and room and board for the duration of the program. For priority consideration, applications are due by February 15, 2018. Students from small colleges or from underrepresented groups are especially encouraged to apply. Although the admission committee will continue to review and accept applications up until March 10, it is strongly suggested that your completed application be received by February 15, 2018 to allow time for consideration of your entire file. Students will begin to be notified by the end of March, 2018.

The Program: The Biological Discovery in Woods Hole (BDWH) Program is designed as an intensive, 10-week research experience for undergraduates at the Marine Biological Laboratory (MBL) in Woods Hole, MA. The major portion of each student's time will be dedicated to an individual research project under the direction of one of the participating mentors (see list below). The program will be conducted from June through mid-August each summer, and will integrate the students with the marine setting and the unique intellectual blend of year-round and summer investigators at the MBL to provide a diverse and varied undergraduate research experience. The program will focus on the molecular, cellular and physiological processes that give rise to and regulate complex physiological systems, and which ultimately mediate organismal behavior. Investigators use both marine and non marine models. The program's goal is to recruit highly motivated students, especially from under-represented groups and/or schools with limited research opportunities, and immerse them in research programs under the guidance of mentors selected from visiting summer investigators or year-round investigators at the MBL who are fully committed to enhancing the undergraduate research experience. To augment the research experience, students will participate in field trips, and attend weekly course meetings, seminars and/or luncheons that will explore a wide range of topics (e.g., graduate school application, ethics, career paths) to encourage the students to prepare and pursue a career in biological sciences. There will also be group activities, field trips and barbeques to provide peer interactions. Finally, the program will culminate with an undergraduate research symposium.

The Research Environment: The Marine Biological Laboratory is an international center for research, education, and training in biology. It was established in 1888 as an institute where marine organisms were used as model systems in the study of cell biology, neurobiology, and embryology. During the summer, the 270 year-round scientists and support staff of the MBL are joined by an additional 300 visiting scientists in our Whitman Center for visiting research, as well as 1200 graduate / postdoctoral students and faculty in our discovery courses, all from over 200 institutions throughout the world. Scientists are attracted to the MBL as well by the opportunity to collaborate with investigators at the other scientific institutions in Woods Hole. These include the Woods Hole Oceanographic Institution, the National Marine Fisheries Service, the United States Geological Survey, and the Woods Hole Research Center. In the small village of Woods Hole, this concentration of researchers and institutions results in a scientific community unparalleled in the world.

Research Facilities: The MBL houses a number of unique research facilities. These include a state-of-the-art Marine Resources Center, which provides for the latest approaches in husbandry and mariculture of marine organisms; advanced equipment for light microscopy combined with computer imaging; and the MBL/WHOI library, which is one of the most complete science libraries in the world. There are numerous opportunities to attend a variety of seminars and lectures. The MBL hosts many educational courses which run throughout the summer. Those courses draw their instructional faculty from leading researchers in the respective fields and each offers a daily lecture or seminar series which is open to the scientific community at large. The MBL Friday Night Lecture Series brings in speakers of particular note who are of interest to a wider audience. Additionally, a number of courses and groups sponsor informal evening or lunch-time seminars.

Eligibility: Undergraduate student participants will be supported with National Science Foundation funds and must be citizens or permanent residents of the United States or its possessions. An undergraduate student is a student who is enrolled in a degree program (part-time or full-time) leading to a bachelor’s degree. Students that will have graduated from their institution prior to the summer program are not eligible to apply. Students who are transferring from one institution to another and are enrolled at neither institution during the intervening summer may participate. High school graduates who have not yet enrolled and students who have received their bachelor’s degrees and are no longer enrolled as undergraduates generally are not eligible.

Stipend and Housing: Students will receive a stipend of approximately $5000 for the program. Room and board will be provided in MBL dormitories which are on the MBL campus, and a stone’s throw from the ocean. The rooms are shared, and the BDWH students are usually assigned rooms together.

To apply: We strongly encourage students to apply by the priority consideration date of February 15, 2018, although applications will be accepted until March 10, 2018. Students will be notified of application status in late March 2018, at which time students accepted into the program will receive additional registration and housing information. The on-line application form can be accessed after December 15, 2017. Students from under-represented groups and/or small colleges are especially encouraged to apply.

Each student must submit a CV/resume, short essays (maximum one page each) describing his or her reasons for wanting to participate in the program, their expectations for participation in the program and specific research areas or mentors of interest. Additionally, each student will be asked to upload a copy of his/her unofficial transcript on the online application and name two references. These references will be sent an email with directions on how to upload their letters of recommendation. Students are selected based on their academic credentials, essays and letters, with the aim of ensuring a diversity of students with respect to race, gender, geography, and academic background. Students are matched with faculty mentors based on course work, experience, and/or expressed research interest, as well as availability of mentors. Please note - students are applying to the program, and not to a specific mentor. Mentor selection on the application form is for the purposes of placement of selected students and is not a factor in the selection process. Although most students are assigned one of their top three mentor choices, we cannot guarantee that students will be placed in these labs.

Acceptance and Mentor Assignments: Notices of acceptance into the program will be sent to applicants beginning in late March. After the students confirm their participation in the program, they will receive a schedule of orientation activities, as well as a roster of all student and research mentor participants in the program and information on the MBL, including travel and housing. The program co-directors will then make tentative assignments of each student to a research mentor. These assignments take into account any preferences for particular research areas that the students express in their applications and previous research experiences (if any). A synopsis of the student's background is sent to the proposed mentor for review and approval and the mentor is instructed to contact the student by e-mail and/or phone to provide the student with background information and materials to be read to prepare the student for the research project.

Participant mentors and the projects they pursue:

Veronica Martinez Acosta, University of the Incarnate Word, TX: Our laboratory utilizes an annelid model system, *Lumbriculus variegatus*, to study wound healing and regeneration within the central nervous system (CNS). Lumbriculus is capable of regenerating an entirely new worm from a fragment that is 1/50th the size of the original animal. Perhaps what sets Lumbriculus apart from other regenerating model systems is the ability to recover neural anatomy, physiology, and behavior following injury along any portion of the anterior-posterior body axis. Our overall laboratory goal is to identify the cellular and molecular events triggered as a result of injury within the central nervous system (CNS) which promote regeneration and recovery of function versus deterioration. Over the past three years we have investigated the neuroanatomical and proteomic changes associated with regeneration in Lumbriculus. While we will continue to characterize the regenerative process at the anatomical and proteomic levels, we would like to utilize transcriptomic data to clone and sequence candidate genes for use in genetic expression analyses in real time, including the use of RNA seq and *in-situ* hybridization. Because regeneration may also involve novel regulatory mechanisms used during translation, we are also interested in carrying out ribosomal profiling of regenerating fragments so that we may determine more precisely the location and timing of expression at the genetic and proteomic level following wound formation in a system that is committed to successful regeneration and recovery of function. Our lab has successfully mentored primarily undergraduate students in the lab. Each student has the opportunity to be trained in confocal imaging, behavioral analysis, protein extraction, and and genome level analysis in a unique model system.

Irina Arkhipova, MBL: "*Mobile DNA and horizontal gene transfer in eukaryotic genome function and evolution*". Our lab investigates a variety of biological models, including filamentous gliding bacteria, ascomycete fungi, and bdelloid rotifers. We apply molecular genetics, biochemistry, and bioinformatic methods to address fundamental questions in evolutionary biology and comparative genomics. Student projects in recent years included expression and purification of domesticated reverse transcriptases from bacteria and construction of their mutant versions; isolation and characterization of loss-of-function mutant strains from a *Neurospora* mutagenesis screen; studies of *in vitro* activity of hammerhead ribozyme motifs from rotifers; *de novo* identification and annotation of transposable elements in sequenced eukaryotic genomes; and studies of enzymatic activity of non-canonical rotifer methyltransferases. Future projects may also include identification and characterization of extrachromosomal DNA forms and ribonucleoprotein particles in bdelloid rotifers. Students will be co-mentored by the PI and the post-docs in the lab, and will be fully engaged in the Bay Paul Center and the broader MBL scientific community, participating in weekly lab meetings, center meetings, and the end-of-summer MBL-wide undergraduate symposium.

Eric Edsinger, MBL: "Genomic, genetic, and imaging tools and resources for tropical pygmy cephalopods". Cephalopods are known for their alien-like systems, including jet propulsion, dynamic skin color and texture, and semi-autonomous prehensile arms with chemosensory suckers. They are also known for their large brains and problem-solving abilities, making them exceptional as invertebrates, with features similar to human but that evolved independently. As a model for both novel and parallel comparisons to the human brain, cephalopods can provide fundamental insights to organizing principles and both non-obvious and alternative solutions to complex problems in neuroscience, robotics, artificial intelligence, and synthetic biology. Despite cephalopods being so awesome and potentially powerful for research, a cephalopod lab rat, one that enables detailed mechanistic studies using cutting edge genetic tools in an organismal to behavioral context, does not yet exist. To fill this gap, my lab and others at the MBL and around the world are now working to establish cephalopod models for research, including use in development, physiology, neuroscience, microbiomes, and behavior. My focus is on pygmy squid for functional imaging and optogenetics, and on pygmy octopus for behavior and cognition. I am part of genome projects for each, and lead a larger effort to develop genetic tools in pygmy squid. Summer projects could include 1) comparative genomics and genome annotation, with work on pygmy cephalopod and various to numerous other genomes to explore gene families and gene sets in animal evolution, and produce new tools and resources for the community (Unix and Python experience a plus), 2) CRISPR-Cas9 genome editing of various target genes of interest, for instance, knocking out pigment biosynthesis in the ink sac and skin to create a more fully transparent hatchling, a "Casper" (as in Casper the Friendly Ghost) mutant, for live imaging, or 3) building transgenic tools that provide brain, muscle, or heart-specific expression for fluorescent protein reporters and calcium or voltage biosensors to use in live or functional light sheet and light field imaging. The lab is small, friendly, and driven, with lots of projects, collaborations, and activity. It could be an ideal environment for someone who, amidst towering skyscrapers, loves the idea of an empty car lot and the chance to start building.

Melina Hale, University of Chicago: "Sensation and movement in locomotor systems". The PI investigates mechanosensation by fish fins and how such sensation provides feedback from the periphery to modulate locomotor movement. We have found that fins have extensive arrays of afferent nerve fibers extending through the fin rays and into fin membranes. We have shown that the nerve fiber organization and function change through development and that evolutionarily the physiology is tuned to the mechanics of the fins. This work is informing engineered underwater propulsor systems as well as providing fundamental data on sensory systems and sensorimotor integration. We also study central neural circuits and how they are organized. The startle behavior of fishes and amphibians is controlled by a relatively small number of identifiable neurons and these cells have persisted and can be traced through fish lineages that diverged hundreds of millions of years ago, providing a unique opportunity to study neural circuit evolution in vertebrates. Undergraduates are involved in both projects, receive training in neurophysiogy, neuroanatomy and behavior. Each of the undergraduates who has worked in my lab for a year or more is on a publication and/or presentation at a national meeting.

Roger Hanlon, MBL: "Rapid adaptive camouflage system of cephalopods." There are two basic facets to this system: visual perception of backgrounds to help decide which camouflage pattern to deploy; and a motor output system that produces a camouflaged body pattern. The theoretical underpinning of this system is that, to achieve such speed of camouflage patterning (0.25-1.00 sec), there are parsimonious visual sampling rules that guide the deployment of a small number of camouflage pattern templates that achieve effective camouflage in a wide variety of visual backgrounds. Moreover, there is a refined neuromuscular control system of tens of thousands of pigmented chromatophore organs and iridescent cells in the skin to form the patterns. Students engage in live cuttlefish experiments – a visual sensorimotor assay – in which different backgrounds are presented to the animals, photographs are taken of the resultant camouflage pattern, and quantitative image analyses are performed to link visual input with motor output. In motor control experiments, students learn electrophysiology techniques to stimulate discrete groups of chromatophores and iridophores in the skin, and they engage in anatomical studies of pigments and reflectors using a variety of microscopy tools. Thus, students are exposed to neurobiology, sensory biology, anatomy, image analysis and ethology.

Marko Horb, MBL: "Genome editing in Xenopus". Advances in genome editing have made it possible to generate mutant animals in almost any organism. The current focus of the Horb lab is to improve genome editing in Xenopus and create new mutants. Current projects are focused on developing a new low temperature Cas9 and developing nuclear transfer in Xenopus. Undergraduate students will learn embryological and molecular biology techniques and develop an independent project to create a new knockout Xenopus model. In addition, research topics in the lab are focused on understanding cell fate specification in the anterior endoderm.

Julie Huber, WHOI: "Microbial Ecology of Deep-Sea Hydrothermal Vents". The PI investigates sub-seafloor microbial ecosystems in oceanic crust to resolve the extent, function, evolutionary dynamics, and biogeochemical impact of the deep marine biosphere. Work in the laboratory strives to unravel the mystery of what microbes live in subsea floor environments, how they harness energy from the fluids and rocks that surround them, their evolutionary trajectories, and how they contribute to marine biogeochemical cycles. This includes investigations at both well studied ecosystems, where time series data and repeat sampling opportunities allow for specific hypothesis building and testing, as well as studies of completely novel and unexplored systems, where first order questions demand information about basic microbial abundance and population structure. Students examine microbes in these ecosystems using a combination of experimental tools, including microbial cultivation and rapidly advancing molecular methods. While learning about the microbial ecology of the sub seafloor environment, students are exposed to classic microbiological techniques, such as cultivation and microscopy, as well as molecular biology, next generation sequencing, geochemistry, and in many cases, field work.

Elizabeth Jonas, **Yale University:** "Synaptic function, metabolic control and neuronal cell death". Dr. Jonas' current research concentrates on understanding synaptic function and neuronal cell death from the point of view of metabolic control, chiefly focusing on mechanisms of mitochondrial dysfunction in synapses within neurons undergoing developmental and neurodegenerative brain disorders. Projects in the laboratory for summer students have included measuring ATP levels in isolated hippocampal neurons using a FRET construct; measuring mitochondrial membrane potential; measuring Ca2+ uptake by mitochondria; immunocytochemistry to localize mitochondrial interacting proteins; use of specific therapeutic reagents to regulate mitochondrial function; measurements of synaptic plasticity in the setting of alterations in mitochondrial function; measurements of synaptic vesicle numbers and localization during synaptic plasticity.

David Mark Welch, MBL: "Evolution of DNA repair, recombination, and aging". The Mark Welch lab uses natural history and comparative genomics of rotifers, common marine and freshwater microinvertebrates, to understand novel mechanisms of DNA damage repair and the biology of aging. Undergraduates pursue independent research combining aspects of evolutionary genomics, molecular biology, biochemistry, and bioinformatics. Recent student projects have included determining the rate and extent of DNA damage repair through mutation accumulation experiments followed by next-gen sequencing of transcriptomes; comparative expression studies of genes involved in DNA repair; comparative analysis of miRNAs; examining the effect of oxidative damage on lifespan and fecundity; and comparing the effect of caloric restriction on lifespan and fecundity in closely related species. Future REU projects are likely to focus on exploring and characterizing systems involved in antioxidant defense and redox maintenance in bdelloid rotifers, a novel animal model that has evolved tolerance to desiccation and ionizing radiation, two environmental insults that cause extreme amounts of oxidative damage. Students participate in weekly lab and Center meetings and culminate their experience with a 30-40 minute presentation to the Center. Students meet extensively with the PI, grad students and postdoc to prepare their presentation, focusing on placing their project in a broader biological context and clear presentation of their methods and results.

Jessica Mark Welch, MBL: "Spatial organization of microbial communities at the micron scale." Complex assemblages of bacteria play a critical role in both human health and the functioning of healthy ecosystems. The physiological properties of bacteria depend on their local environment– including neighboring bacteria – so the properties of the community as a whole are a reflection of its micron-scale spatial structure. A key limitation in our understanding of microbial communities is a lack of information on this micron-scale structure. Research in my lab is focused on investigating the spatial organization of microbial communities in the human mouth, in the vertebrate gut, and on marine surfaces, using a technique we and colleagues have developed called Combinatorial Labeling and Spectral Imaging - Fluorescence *in situ* Hybridization (CLASI-FISH). Undergraduates in my lab use microscopy and image analysis as well as microbial cultivation and analysis of DNA sequences, all directed toward developing an understanding of the structure, function, and organization of microbial ecosystems.

Lydia Mäthger, MBL: "The visual functions of elaborate pupil shapes in animals". The eyes of many animals have pupils that constrict in response to light. The researches focuses on an almost unstudied group of pupils referred to as elaborate pupils because of their complex shapes, frills and protuberances. Examples are found in teleosts (bony fish), elasmobranchs (sharks, rays), and cephalopods (squid, cuttlefish). Their pupils are modified by addition of major dorsal occlusions and sometimes minor ventral ones. The result is a U or W-shaped aperture with elaborate pupil margins. It is unknown why elaborate pupils are shaped this way, how they affect image formation, or their visual and behavioral functions. Mäthger's research focuses on basic science while laying the foundations for potential application in technology and engineering, and the interdisciplinary approach combines experimental and computational techniques, including optical imaging, functional morphology and mathematical modeling. Students are exposed to all aspects of Mäthger's research: sensory ecology, anatomy, microscopy, image analysis and animal behavior.

Allen F. Mensinger, U Minn. Duluth: "Multi-modal sensory integration in the toadfish". The PI focuses on the neural mechanisms of behavior using the marine toadfish, Opsanus tau. He is investigating multi-modal sensory input of the auditory system and mechanosensory lateral line. Undergraduate students will be exposed to a wide range of skill sets before embarking on independent projects, including animal behavior, video imaging and analysis, microelectrode fabrication, neurophysiological data acquisition, neuroanatomy and histology. The student's project may include: 1) Relative contribution of canal and superficial neuromast to sound localization: Students test female fish with intact or partially ablated lateral line during phonotaxis experiments. 2) Central projections of the lateral line and utricle: Students use neural tracers to label the lateral line and auditory nerves to determine if and where there is overlapping input in the brain. 3) The relative contribution of the auditory system and lateral line during sound localization. Students will record and analyze neural activity from fish with chronically implanted electrodes during sound presentation.

T. Aran Mooney, WHOI: In the Sensory Ecology and Bioacoustics lab we study how marine animals use detect and respond to the cues around them, as well as the patterns of cues, signals and noise available to the animal. Our work focuses on cephalopod hearing and use of sound, cephalopod eco-physiology (physiology and behaviors in response to local environmental conditions such as oxygen and pH), marine mammal bioacoustics, and the bioacoustics of coral reefs. We often address how stressors such as low pH or ocean noise impacts behavior and physiology. Potential projects for an REU student include: (1) impacts of ocean acidification on squid, (2) analyses (and perhaps data collection) of coral reef soundscapes and larval responses to sound, (3) impacts of noise on cephalopods or other invertebrates, (4) using the ITAG to quantify the behavior and physiology of marine invertebrates. - See more at: http://www.whoi.edu/sites/amooney

Jennifer R. Morgan, **MBL:** "Mechanisms of regeneration in the vertebrate central nervous system." The lamprey is a basal vertebrate that accomplishes full functional recovery (i.e. swimming) after a complete spinal cord injury. This functional recovery is supported by rapid wound healing and repair of the lesion scar, robust axon regeneration, and synaptic reconnections. Projects in the lab are focused on understanding the molecular mechanisms that support successful spinal cord regeneration, with an emphasis on identifying evolutionarily conserved genes and pathways promoting neural regeneration in the vertebrate CNS. Student projects involve a variety of approaches, including but not limited to: bioinformatics, molecular biology, biochemistry, immunofluorescence, and behavior. Ultimately, the goal is to discover relevant genes and pathways that when manipulated could improve CNS repair and regeneration in non-regenerative models and conditions. These studies engage students in a wide range of topics ranging from molecular evolution to conserved mechanisms of cell/tissue regeneration to neural control of behavior.

Duygu Özpolat, MBL: I am a Hibbitt Fellow at the Marine Biological Laboratory working on stem cells and regeneration. At my lab the big question we want to answer is "What are the mechanisms of reproductive cell regeneration?" Reproductive cells are the cells that become eggs and sperm, and then have the potential to give rise to a whole organism. Many organisms (such as hydra, flatworms, earth worms, or sea stars) regenerate their reproductive organs and reproductive cells as a part of whole body regeneration, while vertebrates lack this ability. The mechanisms of regenerating the reproductive cells are not understood but is one of the most impactful regeneration abilities. Understanding the mechanisms of regenerating this cell type would provide insight into the "mother of all stem cells". To answer this question and many other questions regarding regeneration and stem cells, we combine many exciting techniques such as live-imaging, genome-editing, mRNA injections, and transgenesis. Dumeril's clam worm (Platynereis dumerilii), water nymph worm (Pristina leidyi), sea urchins, and sea stars are some of the organisms we use for this research. My website: http://bduyguozpolat.org/

Loretta Roberson, MBL: "Understanding the mechanisms of calcification in corals." Despite the importance of coral reefs to tropical, marine ecosystems, the biological components of the calcification process are poorly understood. Evidence suggests that corals regulate the movement of ions such as bicarbonate, calcium, and hydrogen to facilitate calcification and that some species are more tolerant of changes in their environment, yet the mechanisms behind these important processes and their molecular components are unknown. In particular, the details of how the symbiotic dinoflagellates (zooxanthellae) enhance calcification and their role in skeleton formation have not been identified to date. As threats such as climate change increase, understanding the mechanisms underlying coral calcification, and coral response to environmental change will be critical for the conservation of these fragile ecosystems. Interdisciplinary, multi-scale studies are therefore necessary to link molecular level changes to organismal and reef performance. For this study, students will be able to participate in and develop projects that include: population demographics of corals from Puerto Rico and Woods Hole, comparisons of calcification rates between tropical and temperate corals, the impact of environmental stressors on coral bleaching, changes in gene expression at different developmental stages, identification of genes involved in calcification, development of techniques for microscopic imaging of live corals, and next-generation sequencing of corals and coral symbionts.

Joshua Rosenthal, MBL: The central dogma of biology maintains that genetic information passes faithfully from DNA to RNA to proteins; however, with the help of diverse tools, sometimes it is modified within messenger RNA. RNA editing by deamination of adenosine to inosine (A-to-I) is a process used to alter genetic information. Unlike alternative splicing, which shuffles relatively large regions of RNA, editing targets single bases. Because inosine is interpreted as guanosine during translation, this process can recode codons. A-to-I RNA editing is catalyzed by the ADAR (adenosine deaminase that acts on RNA) family of enzymes. All multicellular animals, from cnidarians to mammals, express ADARs, but the extent to which they use them to recode is generally limited. In fact, transcriptome-wide screens have only uncovered about 25 conserved recoding RNA editing sites in mammals, and several hundred in *Drosophila*. These studies have led to the general assumption that recoding by RNA editing is extremely rare. Recent studies in my lab show that cephalopods break the rules. In fact, the behaviorally sophisticated Coleoids (squid, octopus and cuttlefish) edit the majority of their messenger RNAs. This ability to alter genetic information on the fly is an intriguing innovation. We know that it is happening at unprecedented levels, and that it is used primarily in the nervous system to alter proteins directly involved in neuronal signaling. Projects in my lab focus on five basic themes: 1) what are the mechanistic underpinnings of high-level RNA editing in cephalopods; 2) how does RNA editing affect protein function and electrical signaling; 3) does RNA editing respond to environmental factors, particularly those that are being affected by human activities; 4) how do RNA editing sites evolve; and 5) can we use RNA editing as a therapeutic to erase detrimental genetic mutations and manipulate protein function.

Rob Steele, University of California, Irvine: Dr. Steele is a member of a group of researchers who are using the cnidarian *Hydra* to study nervous system organization and function. The simple structure of its nervous system and its relatively limited behavioral repertoire make *Hydra* a powerful system for understanding how nervous system activity is translated into behavior. By combining the production of transgenic *Hydra* lines with state of the art imaging methods, we expect to be able to define the activity patterns of every nerve in the animal as it undergoes normal behavior. Possible students projects include the following:

1. Analysis of neuron firing patterns associated with various *Hydra* behavior
2. Screening for small molecules that alter *Hydra* behavior
3. Analysis of the consequences of alterations in the organization and composition of the *Hydra* nervous system produced by surgical and chemical means
4. Perturbation of *Hydra* neuron biochemistry by use of RNA interference
5. Bioinformatic and expression studies of genes involved in nervous system structure and function