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Socioeconomic Status and Stress Response

Last spring, I began my laboratory work with Professor Wendy B. Mendes and psychology graduate student Betsy Sparrow in the Health and Psychophysiology Laboratory in the Psychology Department at Harvard University. In this laboratory, we examine physiological responses associated with stress, motivation and emotion, including changes in the autonomic nervous system and in hormone signaling.

▲ Kelly Fahl '06

Psychologists have identified maladaptive physiological responses to stress as a possible reason for the increased risk of coronary heart disease and hypertension among individuals of lower socioeconomic status (SES) (1,2). In the past, research examining stress responses has put higher SES individuals at an advantage because the stressors, or stress-inducing stimuli, have components that are similar to "school-based" or "white-collar" tasks such as mathematics or public speaking, confounding education and SES.

In my thesis work, I am developing and testing laboratory stressors that are not connected to educational background but that are still considered "stressful" in order to assess better the effects of lower SES on stress reactivity. Using the tasks that I am developing, our research group will examine the differences between benign and malignant physiological responses. Prior research suggests that chronic activation of malignant physiological responses can cause cumulative wear and tear in the cardiovascular system, leading to an increased risk of coronary heart disease and hypertension (3). To distinguish between benign and malignant stress responses, my research relies on such indices as impedance cardiography, blood pressure, electrocardiograms, pulse, skin conductance, and skin temperature. On the basis of such measurements, I examine the nature of stress reactivity during laboratory tasks, the degree of habituation to the task, and the speed with which the body returns to baseline levels of stress-related indices after a stress response.

My thesis work will include recruiting individuals from various SES levels and examining their stress responses to both standard laboratory tasks and the tasks that I have developed. Having examined physiological responses to non-biased laboratory tasks, we will be able to determine more conclusively whether stress reactivity helps to explain why lower SES individuals are at a greater risk of developing stress-related diseases.

—Kelly Fahl '06 is a Psychology concentrator in Leverett House.

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credit: Scott Kominers, HSR

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The Effects of Human Disturbance on Forest Dynamics in Singapore

Forests are continually subjected to natural disturbance by the elements and the organismic populations they sustain, such as pests, diseases, and herbivorous animals. The natural disturbance of a forest creates spatial gaps filled by "pioneer species" which favor abundant light. As pioneer trees die off, they are replaced by more shade-tolerant, slow-growing "climax species" which have germinated in the understory, bringing the system back to a steady-state. Left to the forces of nature, forest succession leads to a "dynamic equilibrium" where the replacement rate of trees is stable, and the species composition remains relatively constant (1).

The patterns of succession that arise from human disturbance are less certain. The tropical island nation of Singapore has a history of traumatic land-use; it was colonized and subsequently occupied by the British in 1819, starting a succession of tumultuous land-use progressions which reduced the forest cover to 7% in 1885 (2). Human impact persists as the city-nation launches into the twenty-first century with large-scale housing developments and extensive underground transit networks. The Singaporean government has endeavored to save pockets of nature for aesthetic and ecological purposes, resulting in a system of well-protected national parks within an ever-changing environment. Singapore provides the premise for a case study on the impact of human disturbance on forest dynamics.

The forest in Singapore's Bukit Timah Nature Reserve is said to demonstrate "hyperdynamism," in which the trees exhibit accelerated forest dynamics compared to their counterparts in analogous Asian forests (3). To quantify this phenomenon, I am working with Professor Paul Moorcroft and Dr. Stuart Davies to explore measurements of growth, recruitment, and mortality derived through statistical analysis on data sets collected by the Center for Tropical Forest Science at the Arnold Arboretum. I am examining my findings in the context of similarly accelerated dynamics discovered elsewhere in the tropics. As the world's population progresses on a trajectory of expansion, our decisions will increasingly and inevitably result in ecological consequences which affect both humans and nature. Understanding the dynamics of forest disturbance will allow for more accurate predictions regarding the impact of our future decisions.

- Pien Huang '06 is an Environmental Science and Public Policy concentrator in Dunster House.

▲ Pien Huang '06

credit: Jennifer Ang, HSR

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Optimism as a Predictor of Challenge and Threat Stress Responses in an Inter-Group Setting

Challenge is a psychological state associated with the feeling that a person's resources meet or exceed the demands of a situation or task. Threat, on the other hand, is a psychological state in which a person feels that his or her resources are deficient. These psychological states are often associated with certain physiological responses, namely, changes in cardiac output, vascular resistance, and the salivary levels of cortisol, a hormone involved in stress response. Based on these findings, the Health and Physiology Laboratory at Harvard University, under the direction of Professor Wendy Mendes, relies on the measurement of a person's physiological and hormonal responses to distinguish between challenge and threat reactivity in certain situations.

▲ Lisa Lareau '06

credit: Scott Kominers, HSR

My senior thesis research explores the extent to which disparate optimism among individuals can predict the physiological correlates of challenge versus threat responses to an inter-group encounter. It has been hypothesized that anxiety, stress, and threat underlie in-group favoritism, prejudice and discrimination. In fact, research in psychophysiology has shown that a person's tendency toward in-group favoritism is often reflected in biological responses to an inter-group encounter. Moreover, optimism, a belief that goals are attainable, has been shown to enhance an individual's ability to cope with psychological, and thus physiological, stress. Thus, optimism may result in more challenge-type appraisals of the demands of inter-group encounters, and less anxiety over an unfamiliar interaction.

If the power of optimism to buffer stress and promote general well-being can be understood or perhaps even harnessed for practical purposes, it could have powerful implications for the social stress of interacting with a person of another race. We might gain a better understanding of the complicated psychology of interactions between groups (e.g. Caucasians with African-Americans, men with women, etc.) by examining the potential moderators of challenge versus threat responses. In addition, reactivity and optimism are correlated with psychological and physical health outcomes, such as cardiovascular disease. The results of this research, insofar as they establish the relationship between optimism and physiological stress responses, may contribute to the creation of a specific index of lifetime risk for these complications.

—Lisa Lareau '06 is a Psychology concentrator in Leverett House.

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Shedding Light on Evolution Through the Kinetics of Ion Channels

Ion channels are proteins found in the cell membrane that open and close in order to regulate the flow of specific ions through the membrane. Sodium channels are a type of ion channel that allows only sodium ions (Na^+) to pass through, and that opens and closes based on the voltage difference across the cell membrane.

Professor Michael Brenner, an applied mathematician at the Harvard Division of Engineering and Applied Sciences, and I have been studying sodium channels together with Professor Bruce Bean, a neurobiologist at Harvard Medical School. By studying these channels, we hope to learn about evolution. There is a high degree of genetic and structural similarity among sodium channels across living species and across the various tissues in which they are found. In different situations, however, sodium channels can play different functional roles. For example, the sodium channels in neural cells are involved in the firing of neurons, while those in cardiac cells are involved in making the heart contract. Can we explain how differences in sodium channel kinetics – how channels open and close in a voltage-dependent manner – might lead to different kinds of function?

Researchers can develop mathematical models to describe the kinetics of ion channels. Many models have been proposed in the recent literature, and have been shown to agree with experimental data. However, such agreement alone does not necessarily validate the assumptions underlying such models. We would therefore like to use available data to develop a reliable method of validating or invalidating these models.

Lastly, by comparing the different kinetic models of sodium channels, we hope to be able to plot channels onto a phylogenetic tree, a diagram that arranges species based on how closely related they are. Typically, phylogenetic trees are constructed by simply comparing the nucleotide or amino acid sequences of genes or proteins, respectively, in various species. Researchers then infer evolutionary relationships among the species based on their relative positions on the tree. By examining differences in sodium channel kinetics, we propose a new method for inferring evolutionary relationships between sodium channels.

—*Elaine Angelino '06 is an Applied Mathematics concentrator in Currier House.*

▲ Elaine Angelino '06

credit: Scott Kominers, HSR

Move It or Lose It: A Search for Intracellular Spread Determinants in *Listeria monocytes*

I am conducting research in the laboratory of Dr. Darren Higgins in the Microbiology and Molecular Genetics Department at Harvard Medical School. Dr. Higgins' lab studies interactions between *Listeria monocytogenes*, a Gram-positive bacterium, and mammalian host cells. *L. monocytogenes* mainly infects pregnant women and the elderly, and can result in gastroenteritis, spontaneous abortion, and septicemia, or severe bacterial infection in the bloodstream. This organism is especially interesting because it is able to spread from one host cell to another without encountering the humoral immune system of the host. It accomplishes this by hijacking the host cell's cytoskeletal system: it recruits monomeric actin molecules, which are the building blocks of the cytoskeleton, and forms a tail that propels

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▲ Aimee Richard '06

credit: Photo courtesy of Aimee Richard

the bacterium into a neighboring cell. This spreading ability is critical to *L. monocytogenes*' virulence, but few proteins that contribute to this process have been identified or characterized.

My project seeks to find novel intracellular spread determinants in *L. monocytogenes*. I have created a library of mutants that possess random insertions throughout the genome. These mutants also express green fluorescent protein, making them uniformly fluorescent. To determine which of the mutants have spread defects, I infect a monolayer of host cells with the pool of mutants for six hours and sort infected cells using fluorescence-activated cell sorting (FACS). Cells infected by normal bacteria show low fluorescence because over time, the bacteria replicate and spread themselves and their fluorescence to neighboring cells. However, mutants that are unable to spread from one cell to another efficiently will become trapped within one host cell and continue replicating. As a result, these infected cells become highly fluorescent. After running the infected cells through the FACS machine, I pick out only the mutants – those cells with high fluorescence – and study them further to determine what gene has been altered by the insertion. I plan to determine the product and purpose of the gene and how it contributes to the bacterium's ability to spread in host cells.

—Aimee Richard '06 is a Biochemical Sciences concentrator in Lowell House.

Rare Earth Element Distribution: Measuring Anoxic Events in Carbonates from Northern Italy

▲ Fran Moore '06

credit: Jennifer Ang, HSR

I work in the laboratory for geochemical oceanography in the Department of Earth and Planetary Sciences. We study the carbonate rocks limestone and dolomite, which are precipitated directly from the ocean by organisms using calcite for their shells. We analyze these rocks to better understand of how the oceans, biosphere, and atmosphere operated over the course of Earth's history.

My research focuses on the Cretaceous, a period from 144 to 65 million years ago. The Cretaceous was a time of very warm climate with atmospheric carbon dioxide up to 12 times higher than modern levels. Layers of black shale with high organic carbon content are found throughout the globe, which is unusual because to get organic contents of up to 15 percent requires a deep ocean largely depleted of oxygen. For this reason the black shale horizons are known as ocean anoxic events (OAEs). There are two main possibilities for how the ocean became anoxic. A sluggish ocean circulation from a small equator-pole temperature gradient could have blocked replenishment of oxygen in deep waters. Alternatively, an increase in primary productivity yielded enough organic matter to overwhelm the redox potential of the water column, leading to an anoxic ocean. The black shales seem to be a CO_2 drawdown mechanism, a way of fixing carbon from the atmosphere and storing it in sediments.

I measure trace elements over these black shale events and am particularly interested in the rare earth elements. This series of 15 elements usually behaves homogenously but cerium (Ce) is relatively depleted in seawater because it can be oxidized from Ce^{3+} to Ce^{4+}. I am interested in how the Ce anomaly changes across several OAEs, which should give a better idea of when, and possibly how, the oceans became anoxic. I use an inductively-coupled plasma mass spectrometer and have developed a method to ensure the measurement of the carbonate, a genuine signal from the Cretaceous ocean.

—Fran Moore '06 is an Earth and Planetary Sciences concentrator in Leverett House.