

# Variational principles in physics and beyond

## - Undergraduate research project -

### Supervisor

Stilianos Louca, Assistant Professor, Biology, Presidential Initiative in Data Science

### Project breadth

Independent literature research and preparation of a critical overview.

### Project background

Variational principles (principles of "least action") have a long history in physics, where they provide alternative formulations of classical laws in mechanics (e.g., leading to the Lagrange equations of motion), thermodynamics, optics and electromagnetism, as well as elegant generalizations to quantum physics and relativity theory. Variational principles can provide new deep insight into a physical theory, for example through the Noether theorem which predicts that any differentiable symmetry implies a conservation law (e.g., rotational symmetry implies conservation of angular momentum in classical mechanics). Despite their success in physics, the extension of variational principles to biology, for example as a formulation of ecological-evolutionary principles, remains elusive.

### Student objective

Perform a literature search on the history and current state of variational principles across all natural sciences, especially physics, chemistry and biology. Synthesize the results of this research in a report (3-5 pages), with a particular focus on gaps and potential future research directions in ecology and evolution theory and microbial biogeochemistry.

### Potential benefits to student

- Opportunity for physics students to apply their skills to understanding the fundamental principles of Life!
- Gain expert insight into a deep scientific topic
- Opportunity to lead into an honors thesis or even continue as a PhD student working on this topic, depending on performance and the conclusions of the report.
- Research credit
- Super flexible work schedule, work-from-home if desired

### Prerequisites and commitments

- Good knowledge of theoretical physics (mid- to upper-undergraduate level)
- Interest in theoretical ecology and evolution
- Attention to detail and scientific rigor
- Decent writing skills
- Independent thinking

### Application procedure

Contact Stilianos Louca by email (contact details at [www.loucalab.com](http://www.loucalab.com)). Please include a CV, a recent transcript of courses, and any relevant prior work/research experience.