

**BIOL 502 Adaptation in Biosystems.**

***From molecular dynamics to ecology and evolution.***

**Instructors**

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**Principles of the course.**

Biological communication networks adapt and maintain robust function in the face of external stress, challenges or assaults. In order to survive, the cell, and the organism, must create meaning from a complex array of external and internal signals, and make decisions as to how it should respond. A central question in biologic networks, ranging from individual molecule interactions, to cells, organisms, and extending to large ecosystems is how do these complex networks evolve, adapt and heal without becoming fragile and crashing when subjected to external stress, change, or assault? Mathematical models published by Araujo in Nature Communications (1) provide a new paradigm for understanding how biological networks of any size or complexity adapt to changes over a wide dynamic range of inputs. A few classes of network modules embedded within the topology fabric of the network are strictly required for any network to achieve robust adaptation, thereby returning the network to baseline state. Based on this comprehensive theoretical discovery, the research theme of the present application is to gather experimental data to identify and model simple and scalable modular design principles that promote robust performance in biological systems of different scales, from biomolecule interactions, to evolutionary processes, including cell behavior and survival, and ecosystems. The theme of the proposed training program encompasses a novel integrative life science perspective, namely adaptation, or maladaptation, in the face of constant change. Adaptation to external sources of stress takes place at the level of the molecule, the cell signaling network, communication between cells, networks and populations of organisms, and entire ecosystems. Students will learn how biological systems react to stress and how maladaptation leads to disease, addiction, global climate change, or ecosystem collapse. Viewing living systems from this viewpoint provides a fresh and career-relevant framework for graduate science education. Our philosophy is exactly the opposite of conventional programs of instruction using a reductionist approach. Main training elements of the course encompass systems biology, principles of coding, control theory, biostatistics, a choice of different levels of biological system investigation: structural biology, cell signaling and cellular networks, environmental network systems. Integration of the research and training will foster development of cognitive synergy, sense of self, and professional capacity. Short modular lecture series will be offered by different instructors, covering the following topics:

1. Principles of resiliency and robustness in biological systems. How organisms adapt and survive in the face of disease related or environmental stresses. (Lance Liotta)
2. Principles of robustness and adaptation at the molecular level. How 3-dimensional conformation and energetic landscapes of molecules stabilize systems. (Amanda Haymond)
3. From molecules to signaling networks in the cell: Signaling pathways, cytokines, growth factors, autocrine and paracrine signaling, electrical signaling and how they follow principles of robustness and adaptation in face of stimuli. (Claudius Mueller)
4. Overview of human and animal physiology in health, and what may go wrong in disease. Healing processes and embryologic resilience in developmental systems: embryology and morphogenesis, wound healing. (Alessandra Luchini, Lance Liotta)
5. Principles of cancer somatic evolution. Cancer as an example of a maladapting system: oncogenes, tumor suppressor genes, chromosomal rearrangement, clonal cooperation, drug resistance. Principles of host adaptation to invading pathogens and microbiome. Role of microbiome in physiological homeostasis. (Virginia Espina)
6. Maladaption in addiction and chronic pain: adaptation of sensory systems in the brain to addictive substances and neurological pain signaling. (Lance Liotta)
7. Human populations: adaptation to various environments, variation, bottle necks and why some diseases are ethnic specific. (Alessandra Luchini)

**Course Grading**

Grades will be based on 1) mid-term take home exam, 2) final presentation (Power Point presentation and project description in a Word file) and 3) class participation (35%, 35%, 30%, respectively).

*Mid-term take home exam*: Students will be given three essay questions. Students will have one week to answer to the questions. This assignment will be open book and carried out individually.

*Final presentation*: in groups of four, students will propose a solution to a given challenge using the principles of the class. Students will prepare a power point presentation and deliver it to the class during the final three classes of the semester.

The presentation should include:

1. Description of the problem.
2. Explanation of why past solutions have failed.
3. Description of different radical ways of solving the problem. Choice of one solution and explanation of why it is the best idea.
4. Description of how to implement your idea.
5. Description of commercial potential and societal potential.

**Course Learning Outcomes:**

 Demonstrate applications of acquired information

 Formulate an original research topic

 Demonstrate proficiency and excellence in the core concepts

**Definition of Grades for Graduate Courses**

|  |  |  |
| --- | --- | --- |
| Grade | Quality Points | Graduate Courses |
| A+ | 4.00 | Satisfactory/Passing |
| A  | 4.00 | Satisfactory/Passing |
| A- | 3.67 | Satisfactory/Passing |
| B+ | 3.33 | Satisfactory/Passing |
| B  | 3.00 | Satisfactory/Passing |
| B- | 2.67 | Satisfactory\*/Passing |
| C  | 2.00 | Unsatisfactory/Passing |
| F  | 0.00 | Unsatisfactory/Failing |

\* Although a B- is a satisfactory grade for a course, students must maintain a 3.00 average in their degree program and present a 3.00 GPA for the courses listed on the graduation application.

Information about additional grade notations that apply to graduate students including “IN” Incomplete and “IP” In Progress as well as grading for undergraduate students may be found in the Academic Policies section of the catalog under [Grading System](http://catalog.gmu.edu/content.php?catoid=19&navoid=4065#grading). Graduate students are not required to take midterm exams.

**Weekly schedule**

|  |  |
| --- | --- |
| **Date** | **Topic** |
| Week 1 | Principles of resiliency and robustness in biological systems part 1. |
| Week 2 | Principles of resiliency and robustness in biological systems part 2. |
| Week 3 | Principles of robustness and adaptation at the molecular level. |
| Week 4 | Principles of robustness and adaptation in signaling networks in the cell part 1. |
| Week 5 | Principles of robustness and adaptation in signaling networks in the cell part 2. |
| Week 6 | Overview of human and animal physiology in health and disease part 1. |
| Week 7 | Overview of human and animal physiology in health and disease part 2. |
| Week 8 | Principles of cancer somatic evolution part 1. |
| Week 9 | Principles of cancer somatic evolution part 2. |
| Week 10 | Maladaption in addiction and chronic pain |
| Week 11 | Human populations: adaptation to various environments |
| Week 12 | Students’ presentations |
| Week 13 | Students’ presentations |
| Week 14 | Students’ presentations |

**Plagiarism:**

Plagiarism is the presentation of someone else’s ideas or work as one’s own. Students must give credit for any information that is not either the result of original research or common knowledge. If a student borrows ideas or information from another author, he/she must acknowledge the author in the body of the text and on the reference page. Students found plagiarizing are subject to the penalties outlined in the Policies and Procedures section of the University Catalog, which include a hearing by the Honor Code Committee and may include a failing grade for the work in question or for the entire course. The following website provides helpful information concerning plagiarism for both students and faculty: <http://oai.gmu.edu/the-mason-honor-code-2/plagiarism/>

**Honor Code:**

* George Mason University has an Honor Code, which requires all members of this community to maintain the highest standards of academic honesty and integrity. Cheating, plagiarism, lying, and stealing are all prohibited
* All violations of the Honor Code will be reported to the Honor Committee.
* See <http://oai.gmu.edu/the-mason-honor-code-2/> for more detailed information.

**Enrollment:**

* Students are responsible for verifying their enrollment in this class.
* Schedule adjustments should be made by the deadline published on the Registrar’s website.
* Note the add/drop dates in the Academic Calendar published on the Registrar’s website.
* After the last day to drop a class, withdrawing from this class requires the approval of the dean and is only allowed for nonacademic reasons.
* Undergraduate students may choose to exercise a selective withdrawal.
* See <http://registrar.gmu.edu> for selective withdrawal procedures.

**Ethics:**
Ethical behavior in the classroom is required of every student. The course will identify ethical policies and practices relevant to course topics.

**Technology:**

Students are expected to be competent in using current technology appropriate for this discipline. Such technology may include presentation software. Students are required to become familiar with Mason’s Responsible Use of Computing Policy #1301 <http://copyright.gmu.edu/?page_id=301>

**Diversity:**

Learning to work with and value diversity is essential in every class. Students are expected to exhibit an appreciation for multinational and gender diversity in the classroom.

**Civility:**

As a diverse community of learners, students must strive to work together in a setting of civility, tolerance, and respect for each other and for the instructor. Rules of classroom behavior (which apply to online as well as onsite courses) include but are not limited to the following:

* Conflicting opinions among members of a class are to be respected and responded to in a professional manner.
* Side conversations or other distracting behaviors including cell phone use or non-class online access are not to be engaged in during lectures, class discussions or presentations
* There are to be no offensive comments, language or gestures

Students not complying will be asked to cease immediately or leave the class session. **Students with Disabilities:**

If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Resources at 703.993.2474.  All academic accommodations must be arranged through that office.