

 **School of Systems Biology**

**BIOL 502 Adaptation in Biosystems.**

**BIOL 502-DL Adaptation in Biosystems.**

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

**Instructors**

**Lance Liotta**

**Office**: Institute for Advanced Biomedical Research, rm 2005,

***Science and Technology Campus***

**Office Hours:** By appointment

**Phone:** 703-993-9444

**Email:** lliotta@gmu.edu, best way to reach me

**Web page:** <http://capmm.gmu.edu/>

**Alessandra Luchini**

**Office**: Institute for Advanced Biomedical Research, rm 1013,

***Science and Technology Campus***

**Office Hours:** By appointment

**Phone:** 703-993-8945

**Email:** aluchini@gmu.edu, best way to reach me

**Web page:** <https://mymasonportal.gmu.edu/>

**BIOL 502 001 is an in-person section with in-class meetings**

**Room:** SciTech (PW): K. Johnson Hall 246

**Time:** Wednesday 4:30 PM – 7:10 PM

**BIOL 502 DL1 is an on-line live video section**

**Room:** on-line, Zoom links are available in Canva

**Time:** Monday 4:30 PM – 7:10 PM

**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 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 theme of the present class is to use 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 control theory, a choice of different levels of biological system investigation: structural biology, cell signaling and cellular networks, environmental network systems. Integration of 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. (Lance Liotta)
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. Ecological adaptation to various environments, variation, and bottle necks. Why some human diseases are ethnic specific. (Alessandra Luchini)

Instruction will include presentations, discussions, group work, debates, and challenges.

***How does this particular course fit into the student’s education requirement?***

This course provides an integrative and comprehensive understanding of biological networks and their adaptation mechanisms. It aligns with graduate science education requirements by covering critical concepts in systems biology, control theory, and various biological scales, from molecular interactions to ecosystem dynamics. The course equips students with a holistic view of biological resilience and adaptation, which is essential for careers in biological research, healthcare, environmental science, and related fields.

***Why is the course content arranged in this order?***

The course content is arranged to build foundational knowledge progressively. It begins with general principles of resiliency and robustness, moving from molecular to cellular levels, and then to organismal and ecological systems. This structure allows students to understand adaptation and robustness concepts at different biological scales before exploring specific examples, such as cancer, addiction, and ecosystem dynamics. The final topics on broader challenges, like pandemics and climate change, synthesize the learned principles, demonstrating their application in real-world scenarios and preparing students for complex problem-solving in their professional careers.

**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 essay questions. Students will have one week to answer to the questions. This assignment will be open book and carried out individually.

The mid-term exam will be graded according to the “Grading an Analytical Paper” rubric on https://stearnscenter.gmu.edu/knowledge-center/course-and-curriculum-redesign/grading/

*Final project*: Each student individually shall prepare a powerpoint presentation and a poster addressing a problem of their choice. Please submit the powerpoint presentation and the poster via Canva.

Both the presentation and the poster should contain the following information:

* What is the problem?
* What is the societal impact of the problem?
* Principles of the class that are relevant to the condition (e.g., adaptation, maladaptation, feedback control)
* What solutions are currently available to address the problem?
* How can you use the principles described in this class to design a new solution to the problem?
* How does the new solution compare and contrast with existing solutions?
* Outline a research plan to test your idea.
* What are the ethical implications of the research (e.g., human subject studies, animal studies)?

All 8 items should be addressed for completeness.

The Final project will be graded using the following rubric

<https://stearnscenter.gmu.edu/wp-content/uploads/12-CT-rubric-landscape-8-10.pdf>

**Expectations for participation:**

* Students prepare for and actively engage in class discussion (e.g., demonstrate active listening, not distracted by electronics or peers)
* Students thoughtfully engage in in-class assignments and activities
* Students constructively participate in group activities
* Students participate in class discussion by
	+ raising informed discussion points;
	+ connecting discussion to reading material, news, and relevant experiences;
	+ asking questions;
	+ listening to other perspectives;
	+ sharing the floor with others; and
	+ posting thoughtfully to course discussion boards.

Class participation rubric

|  |  |  |  |
| --- | --- | --- | --- |
|  | Strong work | Needs development | Unsatisfactory |
| Listening | Actively and respectfully listens to peers and instructor | Sometimes displays lack of interest in comments of others | Projects lack of interest or disrespect for others |
| Preparation | Arrives fully prepared with all assignments completed, and notes on reading, observations, questions | Sometimes arrives unprepared or with only superficial preparation | Exhibits little evidence of having read or thought about assigned material |
| Quality of contributions | Comments are relevant and reflect understanding of: assigned text(s); previous remarks of other students; and insights about assigned material | Comments sometimes irrelevant, betray lack of preparation, or indicate lack of attention to previous remarks of other students | Comments reflect little understanding of either the assignment or previous remarks in seminar |
| Frequency of participation | Actively participates at appropriate times | Sometimes participates but at other times is “tuned out” | Seldom participates and is generally not engaged |

**Course Learning Outcomes:**

 Demonstrate applications of acquired information

 Formulate an original research topic

 Demonstrate proficiency and excellence in the core concepts

**Course Goals and Objectives:**

**Factual Material.**

* Key Principles of Biological Resiliency and Robustness: Understanding how biological systems maintain stability and adapt to stress at various levels.
* Molecular Adaptation Mechanisms: Knowledge of how 3-dimensional conformation and energetic landscapes of molecules contribute to system stability.
* Cell Signaling Pathways: Detailed understanding of signaling pathways, including cytokines, growth factors, and electrical signaling.
* Human and Animal Physiology: Comprehensive knowledge of physiological processes in health and disease, including healing and developmental biology.
* Cancer Biology: Insight into cancer as a maladaptive system, including oncogenes, tumor suppressor genes, and mechanisms of drug resistance.
* Addiction and Chronic Pain Mechanisms: Understanding the adaptation of sensory systems to addictive substances and pain.
* Ecological Adaptation: Knowledge of how organisms and ecosystems adapt to environmental changes, and the impact of genetic variation and bottlenecks.

**Characteristics and Qualities.**

* Analytical Thinking: Ability to analyze complex biological data and derive meaningful interpretations.
* Adaptability: Understanding how biological systems adapt and the ability to apply this knowledge to various scenarios.
* Interdisciplinary Perspective: Integrating concepts from systems biology, control theory, and ecological networks to form a holistic view of biological adaptation.

**Abilities and Competencies.**

* Modeling and Simulation: Competence in using pre-existing mathematical models to simulate and predict biological network behavior.
* Critical Thinking: Evaluating and synthesizing information from diverse sources to understand how biological systems respond to stress and adapt.
* Research Skills: Developing thought research projects related to biological adaptation and resilience.
* Communication Skills: Effectively communicating complex biological concepts through presentations, discussions, and written reports.
* Collaborative Work: Working effectively in group settings to discuss, debate, and solve biological problems.
* Problem-Solving: Applying theoretical knowledge to practical challenges, such as disease treatment, environmental conservation, and understanding maladaptation in addiction and chronic pain.
* Professional Development: Gaining a sense of self and professional identity through integration of research and training, fostering cognitive synergy and capacity for independent scientific inquiry.

**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** |
| Aug 28 | Principles of resiliency and robustness in biological systems part 1. |
| Sept 4 | Principles of resiliency and robustness in biological systems part 2. |
| Sept 11 | Principles of robustness and adaptation at the molecular level. |
| Sept 18 | Overview of human and animal physiology in health and disease. |
| Sept 25 | Adaptations in energy production of eukaryotic cells |
| Oct 2 | Principles of cancer somatic evolution. |
| Oct 9 | Principles of robustness and adaptation in signaling networks in the cell. |
| Oct 16 | The class doesn’t meet. The students will work on their midterm.  |
| Oct 23 | How do we adapt to a looming apocalypse (pandemics, climate change, etc.). |
| Oct 30 | Maladaption in addiction and chronic pain |
| Nov 6 | Student’s presentations |
| Nov 13 | Students’ presentations |
| Nov 20 | Students’ presentations |
| Dec 4 | Students’ presentations |
| Dec 16 | Final Exam due |

**Campus Closure or Emergency Class Cancelation/Adjustment Policy**

*If the campus closes, or if a class meeting needs to be canceled or adjusted due to weather or other concern, students should check Canva for updates on how to continue learning and for information about any changes to events or assignments.*

**Participation/visibility policy**

For online classes, students should turn on their video to be considered present. However, non-video participation is allowed for students whose workspaces are not private or whose technology or family situations make live video streaming difficult. Students will be counted “present” without sharing a video of themselves if:

* Students will add comments to a chat or poll, perhaps at the beginning and ending of a class, or
* Students who submit brief class notes without sharing video (e.g., “Three major points and one question”), or
* Students who complete a “minute paper” to submit at the end of class (e.g., “The clearest point and the muddiest point for me from today’s class were \_\_\_”)

**Late-work policies.**

“Standard Deduction” Policy: any late assignment will earn a flat 10% grade deduction as long as they are completed within 7 days of the deadline.

“One Extension” Policy: for assignments that are delayed more than 7 days, any student will have the option to propose a reasonable deadline extension, subject to instructor’s approval, once during the semester (as long as they provide a plan for how they will complete the work). Ad-hoc discussion with the instructors will take place to establish the grade deduction.

**Make-up or revision work.**

The following make-up or revision work policy addresses a case when student access to or performance in the course is negatively affected by outside circumstances:

* “Discussion Forum Make-Up”: students who must miss a class meeting when their participation was expected can provide a summary, analysis, and/or additional contribution based on the day’s questions/materials, and post asynchronously by one week to earn equivalent credit

**Basic Course Technology Requirements (Two options)**

* Activities and assignments in this course will regularly use the Canva learning system, available at https://mymason.gmu.edu. Students are required to have regular, reliable access to a computer with an updated operating system (recommended: Windows 10 or Mac OSX 10.13 or higher) and a stable broadband Internet connection (cable modem, DSL, satellite broadband, etc., with a consistent 1.5 Mbps [megabits per second] download speed or higher. You can check your speed settings using the speed test on this website.)
* Activities and assignments in this course will regularly use web-conferencing software (Canva / Zoom). In addition to the requirements above, students are required to have a device with a functional camera and microphone. In an emergency, students can connect through a telephone call, but video connection is the expected norm.

**Course Materials and Student Privacy**

*All course materials posted to Canva or other course site are private to this class; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class.*

* *Videorecordings -- whether made by instructors or students -- of class meetings that include audio, visual, or textual information from other students are private and must not be shared outside the class*
* *Live video conference meetings (e.g. Zoom) that include audio, textual, or visual information from other students must be viewed privately and not shared with others in your household or recorded and shared outside the class*
* *Some/All of our synchronous meetings in this class will be recorded to provide necessary information for students in this class. Recordings will be stored on Blackboard [or other secure site] and will only be accessible to students taking this course during this semester.*
* *Students must use their Mason email account to receive important University information, including communications related to this class. I will not respond to messages sent from or send messages to a non-Mason email address.*

**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:**

* The integrity of the University community is affected by the individual choices made by each of us. As a Mason student, you should follow these fundamental principles at all times, as noted by the Honor Code: (1) All work submitted should be your own, without the use inappropriate assistance or resources, as defined by the assignment or faculty member; (2) When you use the work, the words, the images, or the ideas of others–including fellow students, online sites or tools, or your own prior creations–you must give full credit through accurate citations; (3) In creating your work, you should not take materials you are not authorized to use, or falsely represent ideas or processes regarding your work. If you are uncertain about the ground rules or ethical expectations regarding the integrity of your work on a particular assignment or exam, you should ask your instructor for clarification. Support for you to complete your work is available; no grade is important enough to justify academic misconduct.
* As in many classes, a number of projects in this class are designed to be completed within your study group. With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product. Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers on drafts of the work; however, it is not appropriate to give your paper to someone else to revise. You are responsible for making certain that there is no question that the work you hand in is your own, and that you follow the expectations of the Honor Code. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.
* Mason is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else’s work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.
* Any student use of Generative-AI tools should follow the fundamental principles of the Honor Code.

**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>

**Disability:**

* Disability Services at George Mason University is committed to upholding the letter and spirit of the laws that ensure equal treatment of people with disabilities. Under the administration of University Life, Disability Services implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities. Students can begin the registration process with Disability Services at any time during their enrollment at George Mason University. If you are seeking accommodations, please visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email:ods@gmu.edu | Phone: (703) 993-2474
* Disability Services at George Mason University is committed to providing equitable access to learning opportunities for all students by upholding the laws that ensure equal treatment of people with disabilities. If you are seeking accommodations for this class, please first visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. Then please discuss your approved accommodations with me. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email:ods@gmu.edu | Phone: (703) 993-2474

**Diversity:**

* Women and Gender Studies seeks to create a learning environment that fosters respect for people across identities. We welcome and value individuals and their differences, including gender expression and identity, race, economic status, sex, sexuality, ethnicity, national origin, first language, religion, age and ability. We encourage all members of the learning environment to engage with the material personally, but to also be open to exploring and learning from experiences different than their own.
* The School of Integrative Studies, an intentionally inclusive community, promotes and maintains an equitable and just work and learning environment. We welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.

**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.

**Sexual Harassment, Sexual Misconduct, and Interpersonal Violence**

George Mason University is committed to providing a learning, living and working environment that is free from discrimination and a campus that is free of sexual misconduct and other acts of interpersonal violence in order to promote community well-being and student success. GMU encourages students and employees who believe that they have been sexually harassed, sexually assaulted or subjected to sexual or interpersonal misconduct to seek assistance and support. [University Policy 1202: Sexual Harassment and Misconduct](https://universitypolicy.gmu.edu/policies/sexual-harassment-policy/) speaks to the specifics of Mason’s process, the ***Notice of mandatory reporting of sexual or interpersonal misconduct:*** *As faculty member, Drs. Liotta and Luchini designated as a “Non-Confidential Employee,” and must report all disclosures of sexual assault, sexual harassment, interpersonal violence, stalking, sexual exploitation, complicity, and retaliation to Mason’s Title IX Coordinator per University Policy 1202. If you wish to speak with someone confidentially, please contact one of Mason’s confidential resources, such as Student Support and Advocacy Center (SSAC) at 703-993-3686 or Counseling and Psychological Services (CAPS) at 703-993-2380. You may also seek assistance or support measures from Mason’s Title IX Coordinator by calling 703-993-8730, or emailing* *titleix@gmu.edu**.*