

# ENVR 2900 TOPICS: NETWORKS AND BIOLOGY

Fall 2018 – ENVR 2900 – Northeastern University

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**NU PATH Categories:** Engaging with the Natural and Designed World & Analyzing and Using Data.

**Course Pages:** <http://scarpino.github.io/teaching/> and Blackboard.

## Main References:

- *Networks 2nd Edition* by Newman, M. (2018) Oxford University Press.
- *Scale: The Universal Laws of Growth, Innovations, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies* by West, G. (2017) Penguin Press NYC.
- Additional readings from the scientific and popular literature will be assigned as a part of homework assignments.

**Course Description:** From social networks and cities to ecosystems and evolution, methods from network science provide powerful tools for understanding and investigating the natural and modern world. This course covers the properties of diverse biological networks and explores foundational computational methods for analyzing, visualizing, and performing statistical investigations of networked data. Moving beyond description, a key objective of the course is to synthesize the diversity of biological networks and investigate how scientists have uncovered remarkable regularities in networked systems by applying approaches from scaling-theory to biological networks. Based on a series of case-studies, the assignments in this course will focus on how to elucidate the structure and function of biological networks using empirical data.

## Course Objectives:

1. Develop a foundational understanding of networks and how they can be used to understand diverse biological systems.
2. Understand how approaches from physics allow us to uncover remarkable regularities in networked systems.
3. Construct a computational toolkit for analyzing and visualizing networks.
4. Enhance critical and analytical thinking skills needed to interpret primary scientific literature.
5. Learn to evaluate popular writing on scientific issues.
6. Improve written and verbal communication skills.

**Learning outcomes:** Successful completion of this class will result in the following learning outcomes:

1. Apply the scientific method to study biological networks.
2. Communicate statistical and computational results to both scientific and non-scientific audiences.
3. Critically read, interpret, and explain concepts from the primary, scientific literature.
4. Explain why network science is a powerful tool for studying biological systems.

5. Identify various kinds of biological networks and computationally determine key aspects of their structure and function.

### Assignments & Grading Breakdown:

*Proposal - Research Project (10%)* – The main assignment for this course is a research project. Ideally, this project will be tailored to your individual areas of interest and career goals. For example, you might consider writing an “NSF-style” graduate research fellowship or postdoctoral fellowship application. Student can decide whether to focus these two pages on network science training or network science research. Formatting requirements will follow NSF guidelines for the biology postdoctoral competition, see <https://www.nsf.gov/pubs/2015/nsf15501/nsf15501.htm>, or for the GRFP, see [https://www.nsfgrfp.org/applicants/application\\_components/statements](https://www.nsfgrfp.org/applicants/application_components/statements). For the GRFP, and perhaps for postdoctoral fellowships, there are examples of successful and unsuccessful applications here <https://www.ogrants.org/programs#nsf-graduate-research-fellowship-program>. **The first aspect of this assignments will be a short paragraph describing the research area and the format, e.g., paper, application, etc., you plan to follow.**

*Pedagogical presentation on networks (10%)* – Each student (or team depending on the number enrolled in the course), will give a 15 minute tutorial on one aspect of networks to the class. I will work with each individual/team to identify an appropriate topic.

*Outline - Research Project (20%)* – Part two of your research project assignment consists of an outline and annotated bibliography. I will provide examples and a rubric.

*First draft - Research Project (15%)* – Papers should be formatted for a field-appropriate journal or fellowship application. Specific parameters for each student’s paper will be determined based on the outline and annotated bibliography. You will also be asked to give a brief, i.e. 12 minute, presentation on your work to the class.

*Peer review - Research Project (15%)* – Each student will provide a peer review of another student’s first draft. Grades will be based on the quality of your evaluation and on how effectively you communicate your suggestions. Again, I will provide examples and a rubric.

*Final draft - Research Project (20%)* – The majority of your grade on the final draft will be based on how well you respond to peer review comments, which will also include specific comments from me. I will provide examples and a rubric.

*Participation (10%)* – Your participation grade is based on your in-class work, attendance, and respect for the technology policy. More than three unexcused absences will result in a failing grade for the course.

**Prerequisites:** Biostatistics ENVR 2500 (or equivalent). What this translates to is that an introductory-level understanding of statistics is expected. Previous experience with introductory-level biology and using R for statistics/data analysis is beneficial, but not required.

### Important Dates:

Research Project Proposal .....	Sept. 18th
Add/Drop Deadline .....	Sept. 25th
Research Project Outline .....	Oct. 2nd
Research Project First Draft .....	Oct. 25th
Research Project Peer Review .....	Nov. 9th
Research Project Final Draft .....	Dec. 5th

**Course Schedule:**

Date(s)	Material	To Do
Week 1	Why Networks?	<i>Reading 1</i>
Week 2	Networks and Human Evolution	Prep. for network presentations
Week 3	The Basics of Networks	<b>Proposal Due &amp; Network presentations</b>
Week 4	Social Networks	<i>Reading 2</i>
Week 5	Social Networks - Case Studies	<b>Outline Due</b>
Week 6	Biochemical, Neural, & Ecological Networks	<i>Reading 3</i>
Week 7	Ecological Networks - Case Studies	<i>Reading 4</i>
Week 8	Evolutionary Networks & Gene Interaction Networks	<b>First Draft Due</b>
Week 9	Gene Interaction Networks - Case Studies	<i>Reading 5</i>
Week 10	Scaling of Biological Networks	<b>Peer Review Due</b>
Week 11	Research Presentation	—
Week 12	Contagion on Networks	<i>Reading 6</i>
Week 13	Contagion on Networks - Case Studies	<i>Reading 7</i>
Week 14	Scaling of Cities and Traffic Networks	<b>Final Papers Due</b>

**Readings:**

1. Chapter 1 - Networks: An Introduction.
2. Chapter 3 - Networks: An Introduction.
3. Chapter 5 - Networks: An Introduction.
4. Chapter 7 - Networks: An Introduction.
5. Chpts. 2 & 3 in Scale by West.
6. Chapter 17 - Networks: An Introduction.
7. Chpts. 5, 6, & 7 in Scale by West.

**Course policies:**

*I. Grades* – 100–93% (A), 92–90% (A-), 89–87% (B+), 86–83% (B), 82–80% (B-), 79–77% (C+), 76–73% (C), 72–70% (C-), 69–60% (D), <60% (F).

*II. Technology* – Please silence and put away all electronics before coming to class—there should be zero texting in class. Computers should be used only for course-related work and only when someone isn't addressing the class. Violation of these policies will negatively affect your participation grade (and your understanding of course material).

*III. Turning in assignments* – All assignments must be turned in on Blackboard.

*IV. Late assignments* – Late or missed assignments will be given a score of 0%. Please contact me if you have a documented emergency.

*V. Email* – I am happy to answer questions via email, but cannot promise to respond same-day. Please remember that email is a professional, mostly-permanent record, so please communicate in a respectful manner.

*VI. Academic honesty* – As in all Northeastern classes, academic honesty will be expected and departures will be dealt with appropriately. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation, see <http://www.northeastern.edu/osccr/academic-integrity-policy/> for guidelines.

**Absences:** Because the Northeastern University Health and Counseling Services Center does not provide notes for excused absences, you are on the “honor system” for attendance. However, you should remember that being dishonest about why you missed class can be considered a violation of the University’s academic honesty policy. I do not plan on taking daily attendance, but will instead assign non-graded in-class assignments. Each missed, and unexcused, in-class assignment will reduce your course grade by 1 percentage point. If you miss more than half of in-class assignment due to unexcused absences, you will be given a failing grade for the course.

**Academic assistance:** Anyone needing accommodation please contact me as soon as possible. Students who have disabilities may wish to consult the Disability Resource Center <http://www.northeastern.edu/drc/getting-started-with-the-drc> for aid with resources and accommodation. Those who wish to receive academic services and accommodations must present their accommodation letters from the DRC at the beginning of the semester so that accommodations can be arranged in a timely manner.

**Religious holidays:** You have the right to practice the religion of your choice and can make-up missed work due to your religious holidays. For those requesting an accommodation due to a religious holiday, please submit a schedule of your holidays to me by the end of the second full week of classes.

**Title IX:** The University strictly prohibits sex or gender discrimination in all university programs and activities. Information on how to report an incident of such discrimination (which includes sexual harassment and sexual assault) is located at <http://www.northeastern.edu/titleix>

**Tutoring and other resources:** The University and the College operate many free centers in support of student learning. The University operates a College Reading and Learning Association certified peer-tutoring center (see <http://www.northeastern.edu/csastutoring/> for more information).