BIOL 150: Living in a Variable Universe, Sections 002 *and* 004

Syllabus: Spring 2024

Course details

- **Lecture Time:** Tuesdays and Thursdays, 11:30am to 12:50pm (both sections combined)
- **Lab Time:** Thursdays 2:30pm to 5:20pm (section 002), Fridays 1:00pm to 2:50pm (section 004)
- **Lecture Location:** Kupfrian 106
- **Lab Location:** CKB 326
- **Instructors**
  - Dr. Gareth Russell
  - Dr. Eric Fortune
- **Office hours:** GR: Fridays 9–10am, Tuesdays 2:30–3:30pm. EF: TBD. *You must e-mail us before coming because our offices are behind swipe-card access.* GR: russell@njit.edu. EF: efortune@njit.edu.
- **Pre-requisites:** None.
- **Textbook:** None. All readings will be provided.
- **Computer:** *Students are expected to bring a laptop to class* with the following software package installed: Wolfram Mathematica. This will allow you to open and manipulate the lecture notebooks. This is the software that you will use for many labs and demonstrations. You can get it by following the instructions here. See also the "Technology" section below.

Class summary and philosophy

Humans have to deal with variability all the time, both on a personal level and as society. And quite frankly, we are not very good at it. Many contemporary problems, from floods to pandemics to racism, can be traced in part to a failure to understand, and/or cope with, some aspect of variability. Indeed we spend a lot of time trying to eliminate variability, but this itself can have deleterious effects.

We are both biologists, but as well as biology the course will look into non-biological topics such as the nature of the universe itself, what probability means, and so on. This is because we think these are questions that any informed citizen of the planet should have thought about at least once, and because they form the background to forms of variability that we experience in our everyday lives.

Active learning

This course incorporates active learning, supported by an award from NJIT's Institute for Teaching Excellence. Active learning involves actively engaging students with the course material through problem solving, case studies, visualization, discussions/reflections and other methods. Arguably all lab activities are an example of active learning, but in this course active learning activities will also occur during lectures. Your semester long research project, called "NJ Live!", is also designed as an active learning complement to the course material.

In this syllabus, active learning activities are colored purple.

Course structure

There are seven topics, and each topic is a two-week block of four lectures and two labs.

The course is based on a **facts — evidence — relevance** structure.

Each topic has a list of short **facts** (or propositions), which you will be given, and which we expect you to memorize. (You will be tested on them via quizzes.)

In lectures, we will present the background and **evidence** for these facts or propositions. There will be slides as part of these presentations, and you will be able to download those, but they will mostly contain graphics that won't make sense on their own, *so you must take your own notes during the lecture*. Plus we will be writing and drawing on the whiteboard. (Tip: studies have shown that taking notes *by hand* is the most effective in terms of retention and understanding.)

During most lectures, you will be asked to complete one or more short, anonymous surveys asking what you found interesting or surprising or difficult, and the results from these will be used to guide in-class discussions. As some of you are likely to be just starting out at NJIT, we will also poll you about

your own learning strategies and have some discussions about effective habits of learning (this is metacognition, or 'thinking about thinking'.) These are both forms of *active learning*.

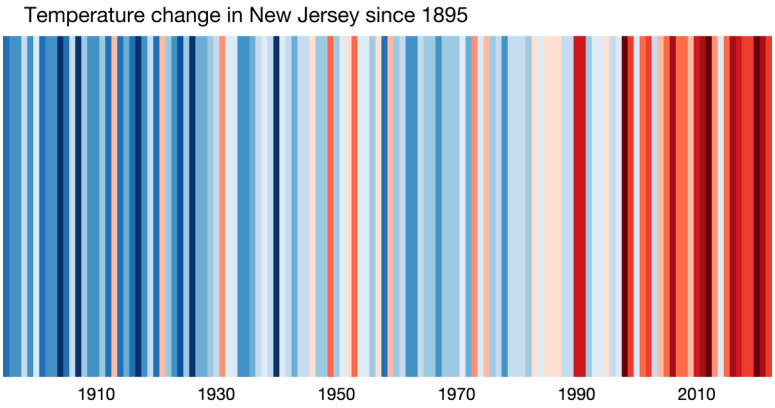
At the end of each topic, you will be asked to write a short reflection on that topic, in terms of its **relevance** (or not) to you, and to how you imagine your future.

NJ Live!

NJ Live! is a semester-long exploration of a data series from New Jersey (something that varies over time). This year it will be a temperature timeseries. We will add the data from the current semester in weekly increments, and compare Spring 2024 with previous years. We will consider how to best present the data, how to understand them, how to draw conclusions, and at the end, what it may (or may not) mean to you and your future.

Along the way you will learn strategies for effective visualization. You will also learn basic coding in the Wolfram Language, a general purpose high-level language with many useful capabilities.

The first and last labs are devoted to the NJ Live! project, and each other lab will have the first ~20 minutes dedicated to the weekly data update and an incremental task related to visualization or analysis of the developing data.



Assessment and grading

In-class quizzes, polls and reflections: 40%

This category includes are short but regular quizzes on facts, as well as polls on your reactions and reflections. The quizzes will be graded normally: for the polls you will get credit for completing them.

Individual lab reports: 30%

Individual lab reports will be graded mainly for completeness. If you show up, do the experiments, and fill out the required sections in the report template, you will do well. We are looking for engage-

ment and thought, rather than 'right' answers. You will lose points mainly if you miss sections or dash off one-word answers. Most people will be able to complete the experiments and the write-up during the lab period, and submit it before leaving. This is the best way!

"NJ Live" project report: 30%

The NJ Live report is something you will build up over the course of the semester, and polish in the final lab week, adding a short essay. There will be a short task each week, and we will go over it at the *beginning* of each lab period (before moving on to the topic of the week). In the lab session itself you should make sure that you understand the assignment thoroughly, and how to approach it. There should also be time to start it. But you won't necessarily *complete* that week's task during that time. **Finishing each week's task is your main form of homework in this course**.

There is no final exam in this course.

Technology

Lectures: In-class surveys and quizzes will be electronic and web-based, so you must bring a device capable of accessing them. A laptop is best, a tablet will be fine, and phone will work in a pinch but will be awkward to use, because some of the surveys will request short text paragraphs.

Labs: Most labs, and the semester-long project, require you to use the software package *Mathematica*, which you can get though NJIT — instructions are on the NJIT software portal. It runs on Windows, MacOS and Linux. It does *not* run on tablets, Chromebooks, etc. Given NJIT's computer policy, we expect that everyone will have either a Windows or MacOS-based device they can bring to lab. If you do not, you should contact one of the instructors immediately.

Course schedule

Each topic is a two-week block of four lectures and two labs.

Individual lecture and lab topics are in **bold**. In-class quizzes are in *italics*. Active learning activities are in purple.

Each lab still start with approximately 20 minutes devoted to that week's NJ Live update, and then transition to the topic of the week.

Important note: The detailed schedule, especially the active learning components, are subject to minor change, depending on how the course is progressing, what people are enjoying or having difficulty with, etc. Not to mention that sometimes current events provide new examples or topics for discussion!

Topic 1: The Origins of Variability

Jan 16. Lecture 1: **Introduction to the Course and your Instructors. Levels of Abstraction.**
Jan 18. Lecture 2: **Why is There Anything?** Fact background poll. Fact response poll and discussion.
Lab 1: ***NJ Live* Introduction and Mathematica Bootcamp.**

Jan 23. Lecture 3: **A Clockwork Universe?** Live demo: Galileo and the moons of Jupiter. Fact background poll. Fact response poll and discussion.
Jan 25. Lecture 4: **Strange Attractors.** *Topic 1 fact quiz*. Lorenz visualization. Topic 1 reflection and discussion.
Lab 2: **Chaos Lab.** NJ Live update session: Visualizing timeseries data I, scales and ranges.

Topic 2: Many Types of Variability

Jan 30. Lecture 5: **A Typology of Events.** Randomness game. Bayesian demonstration.
Feb 1. Lecture 6: **What is Normal Anyway?** Statistics visualizations. Fact background poll. Fact response poll and discussion.
Lab 3: **Fractal Lab** + NJ Live update session: Visualizing timeseries data II, color and style.

Feb 6. Lecture 7: **Fractals Everywhere!** Mandelbrot demonstration.
Feb 8. Lecture 8: **Long Tails are Critical.** *Topic 2 fact quiz*. Power law activities. Topic 2 reflection and discussion.
Lab 4: **Sandpile Lab** + NJ Live update session: Visualizing timeseries data III, means and extremes.

Topic 3: Biological Variability

Feb 13. Lecture 9: **The time of your life.** Hands on fossils! Response poll and discussion.
Feb 15. Lecture 10: **A diversity of diversities.** GBIF species exploration.
Lab 5: **Morphology Lab** + NJ Live update session: Visualizing timeseries data IV, bins and resolutions.

Feb 20. Lecture 11: **The tree of life.** Extinction triage discussion; which to save? Topic 3 reflection and discussion.
Feb 22. Lecture 12: **How many species and where are they?** *Topic 3 fact quiz*. Experiment proposals to estimate species richness. Topic 3 reflection and discussion.
Lab 6: **Genetics Lab** + NJ Live update session: Comparing the past with the present.

Topic 4: Neurological Variability

Feb 27. Lecture 13: **What organisms do.** Mind reading!
Feb 29. Lecture 14: **Escaping the prison of genetics.** Personal behavioral solutions to being caught in a genetic prison.

Lab 7: **Performance Lab** + NJ Live update session: Cycles and trends.

Mar 5. Lecture 15: **What brains do.** Fact background poll. Fact response poll and discussion.
Mar 7. Lecture 16: **Variability is a feature, not a bug.** *Topic 4 fact quiz*. Topic 4 reflection and discussion.
Lab 8: **Neuron Lab** + NJ Live update session: Signal and noise.

SPRING BREAK

Topic 5: The Benefits of Variability

Mar 19. Lecture 17: **Signal Variability.** The hills are alive with the sound of music.
Mar 21. Lecture 18: **Hydrology and the landscape.** Exploring the (Google) Earth.
Lab 9: **Noise Lab** + NJ Live update session: Fitting a timeseries model.

Mar 26. Lecture 19: **Redundancy and stability.** Ecosystem services exercise.
Mar 28. Lecture 20: **Cooperation and synergy.** *Topic 5 fact quiz*. Topic 5 reflection and discussion.
Lab 10: **Filter Lab** + NJ Live update session: Predicting the future.

Topic 6: Our Perception of Variability

Apr 2. Lecture 21: **Bright and Dark, High and Low.** Illusion examples + discussion: what do they tell us about ourselves?
Apr 4. Lecture 22: **Big and Small, Fast and Slow.** Universe zoom with response poll and discussion.
Lab 11: **Categorization Lab** + NJ Live update session: Variation in space.

Apr 9. Lecture 23: **(Im)perception of Risk.** Gamblers fallacy demonstration and other cognitive limitations.
Apr 11. Lecture 24: **Nature *and* Nurture.** *Topic 6 fact quiz*. Topic 6 reflection and discussion.
Lab 12: **Counting Lab** + NJ Live update session: Variation in people.

Topic 7: The Challenges of Variability

Apr 16. Lecture 25: **Climate Chaos.** Strategy discussion: doomsaying vs. cheerful optimism.
Apr 18. Lecture 26: **Life Support.** Nature and me: reflection and discussion.
Lab 13: **Earth Day Lab.** [No NJ Live update session this week.]

Apr 23. Lecture 27: **Black and White.** Significance vs. effect size demonstration. Discussion of stereotypes.
Apr 25. Lecture 28: **Wrapping It Up.** *Topic 7 fact quiz*. Topic 7 reflection and discussion.
Lab 14: ***NJ Live* Wrap-up Lab.**