

BIOL 150 (Living in a) Variable Universe

Syllabus: Spring 2025

Course details

- **Lecture Time:** Tuesdays and Thursdays, 11:30am to 12:50pm.
- **Lab Time:** Thursdays 2:30pm to 5:20pm.
- **Lecture Location:** CKB 214.
- **Lab Location:** CKB 326.
- **Instructor:** Dr. Gareth Russell.
- **TA:** Mr. William Botta.
- **Office hours:** Fridays 9–10am, Tuesdays 2:30–3:30pm. *You must e-mail before coming because my office is behind swipe-card access.* russell@njit.edu
- **Pre-requisites:** None.
- **Textbook:** None. All readings will be provided.
- **Computer:** Students *must* bring a Windows or Macintosh laptop to all classes and labs with the *Wolfram* software installed (see below). Chromebooks and tablets cannot be used for this.

Class summary and philosophy

Humans have to deal with variability all the time, both on a personal level and as a 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.

This course is taught by 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. 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**.

Attendance

A class like this is neither effective, nor fun, if students are absent or even late. So every student is expected to attend every class and show up on time. There will be numerous in-class activities that will add points to your total, and there will be no make-ups for any of these. I will likely drop the lowest couple of scores, so you can miss that number without significant penalty.

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 and propositions**, which you will be given, and which you will need 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*.

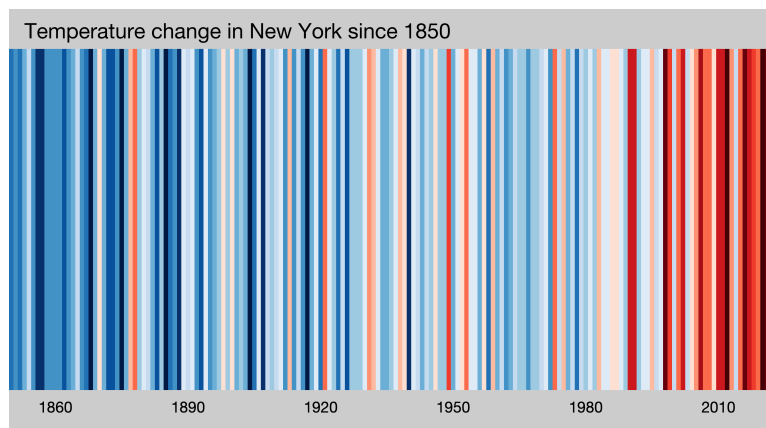
At the end of each topic, you will be asked to write a **short reflection on that topic**, in terms of its **relevance** (or not) to you, and to how you imagine your future.

Data Live!

Data Live! is a semester-long exploration of some data series that varies over time, on a daily or at most weekly basis. Last year it was terrestrial surface temperature. As the semester goes on we will add new data in weekly increments, and compare this semester 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 during each of other labs the first ~20 minutes will be dedicated to the weekly data update and a new task related to visualization or analysis of the developing data.



Assessment and grading

In-class short quizzes, polls, reflections and other activities: 40%

This category includes short but regular quizzes on facts, as well as **polls on your reactions** and **reflections**. These will happen in most classes. The quizzes will be graded normally: for the polls you will get

credit for completing them.

There are no make-ups for any in-class activity. (See “Absences and late arrivals” (Digital)) ~~penalty~~ ~~the lowest 20% of the grades described in the lowest 15% of the activity grades.~~ So, for example, if you ~~miss a quiz and 20 of the regular activities,~~ I would drop the lowest quiz score and the lowest three of the other grades.

Lab reports: 30%

Your 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 thoughtfully, you will do well. We are looking for engagement and thought, rather than ‘right’ answers. You will lose points mainly if you miss sections or dash off one-word answers. The labs are designed so that you should be able to complete the experiments *and* the write-up during the lab period, and submit it *before leaving*. This is the best way!

“Data Live” project report: 30%

The **Data 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. In most weeks there will be task for you to do, and we will go over it at the *beginning* of each lab period (before moving on to the lab 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 may 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.

Required technology

Most of the time in the classroom you will have **no devices out**. That means no phones, tablets or laptops. Why? It is obvious to any instructor, and backed up by numerous studies, that students with devices are only paying a small fraction of their attention to the class they are in. I have anonymously polled previous students *in this class* and they admitted it. Last year, as an experiment, I offered students a chance to be device-free for a period of time, for a very small amount of extra credit. All but one accepted, and after the trial was over I had them complete a survey, again anonymously, about their experience. Of the students that did it, all but one of those found the class much more enjoyable, and felt that they learned more as well.

Pen and paper (or pen and tablet). So what will you do in class? Just sit there listening? That is an option, but you won’t do very well. The best thing is to write or draw, with your hand, on paper. Again, science backs this up: students who do that retain more information than those who type notes (or don’t do anything). The act of writing (the activation of the necessary motor neurons) appears to improve memory acquisition. What if, like my own kids, you have been using a Chromebook at school since a young age and can’t write very well by hand? Notes don’t have to be, and probably shouldn’t

be, complete sentences. They should be ideas, keywords, and questions. We will talk about this in class. *There is one exception to the default no-devices rule: you can write on a tablet with a (digital) pencil. The tablet must be flat on the desk, and you cannot be looking at Instagram, etc with it as well. If you are, you will be asked to put it away and use paper instead.*

Devices for accessing the web. ‘No devices out’ is the default state. But often in class you will need to access a quiz, or look something up on the internet. So you do need to *bring* a device to every class. Just leave it in your bag until asked. Much of the time you will be able to use almost any device for these activities: phone, tablet or laptop. Phones are the least good, as some activities will require you to type short paragraphs of text. But they will work in a pinch.

A laptop for running code. NJIT requires a laptop with a certain minimum specification. You will need it for this class, most specifically for labs, but also for various interactive demonstrations and other supplemental materials. These are coded in the *Wolfram* software, available through NJIT — instructions are on the NJIT software portal. It runs on Windows, MacOS and Linux. It does *not* run on tablets or Chromebooks. If you do not have a suitable laptop, you should contact one of the instructors immediately.

Course policies

Absences and late arrivals

This class follows the policy of the Department of Biological Sciences. You should read it. If you can't follow this link, go to <https://biology.njit.edu/policy-absences>

Under NJIT's new policy, if you expect to miss class for religious observances, you “must submit a written list of dates to [your] instructors, ideally by the end of the second week of class, but no later than two weeks before the anticipated absence”. <https://www.njit.edu/registrar/njit-policy-student-absences-religious-observances>

AI and plagiarism

The pros and cons of AI are poorly understood. To most instructors, the potential cons far outweigh the potential pros in a classroom setting. Therefore, in this class, we won't be using ‘advanced’ AI tools such as ChaptGPT or other LLMs unless you can persuade me that there is good reason to. Feel free to make an argument. But as long as they are banned, if you use them and I catch it you will be reported to the Dean of Students. So don't use them.

Old fashioned copying of others' work, or use of their ideas without attribution, is as banned as it always had been.

BIOL 150 (Living in a) Variable Universe

(Tentative) schedule: Spring 2025

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 21. Lecture 1: **An Awesome Course**. No to distraction, yes to abstraction! Levels of knowledge. Emotions and learning. Writing and learning.

Jan 23. Lecture 2: **Why Is There Anything?** *Fact background poll*. *Fact response poll and discussion*.

Lab 1: **Data Live Brainstorming and Wolfram Bootcamp**.

Jan 28. Lecture 3: **A Clockwork Universe?** *Live demo: Galileo and the moons of Jupiter*. *Fact background poll*. *Fact response poll and discussion*.

Jan 30. Lecture 4: **Strange Attractors**. *Topic 1 fact quiz*. *Lorenz visualization*. *Three body problem*. *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

Feb 4. Lecture 5: **A Typology of Events**. *Randomness game*. *Bayesian demonstration*.

Feb 6. Lecture 6: **What is Normal Anyway?** *Statistics visualizations*. *Fact background poll*. *Fact response poll and discussion*.

Lab 6: **Fractal Lab** + *NJ Live update session: Visualizing timeseries data II, color and style*.

Feb 11. Lecture 7: **Fractals Everywhere!** *Mandelbrot demonstration*.

Feb 13. 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 18. Lecture 9: **The time of your life.** Hands on fossils! Response poll and discussion.

Feb 20. 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 25. Lecture 11: **The tree of life.** Extinction triage discussion; which to save? Topic 3 reflection and discussion.

Feb 27. 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

Mar 4. Lecture 13: **What organisms do.** Mind reading!

Mar 6. 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 11. Lecture 15: **What brains do.** Fact background poll. Fact response poll and discussion.

Mar 13. 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: Patterns around the world.

SPRING BREAK

Topic 5: The Benefits of Variability

Mar 25. Lecture 17: **Signal Variability.** The hills are alive with the sound of music.

Mar 27. Lecture 18: **Waters of Life.** Exploring the (Google) Earth.

Lab 9: **Perception Lab**

Apr 1. Lecture 19: **Life Support.** *Topic 5 fact quiz.* Brainstorming: valuing nature. Reflection: nature and me.

Apr 3. **NO LECTURE** (Wellness Day). Own time: Topic 5 reflection and discussion.

NO LAB (Wellness Day)

Topic 6: Our Perception of Variability

Apr 8. Lecture 21: **Bright and Dark, High and Low.** Illusion discussion: what do they tell us about ourselves?

Apr 10. Lecture 22: **Big and Small, Fast and Slow**. Universe zoom with response poll and discussion.
Lab 10: **Filter Lab** + NJ Live update session

Apr 15. Lecture 23: **(Im)perception of Risk**. Gamblers fallacy demonstration and other cognitive limitations.

Apr 17. Lecture 24: **Nature and Nurture**. Topic 6 fact quiz. Topic 6 reflection and discussion.

Lab 11: **Common Nonsense Lab** + NJ Live update session: Variation in people.

Topic 7: The Challenges of Variability

Apr 22. Lecture 25: **Climate Chaos**. Strategy discussion: doomsaying vs. cheerful optimism.

Apr 24. Lecture 26: **TBD**.

Lab 12: **Earth Day Lab**. [No NJ Live update session this week.]

Apr 29. Lecture 27: **Black and White**. Significance vs. effect size demonstration. Discussion of stereotypes.

May 1. Lecture 28: **Wrapping It Up**. Topic 7 fact quiz. Topic 7 reflection and discussion.

Lab 13: **NJ Live Wrap-up Lab**.

May 6. Lecture 29 (28). **???? (Missing lecture is lecture 20: The Wisdom of Crowds?)**