CMSE 410/890: Bioinformatics and Computational Biology

1. Description

Welcome to the Spring 2022 edition of **Bioinformatics and Computational Biology**, an introduction to the inner-workings of methods in bioinformatics and computational biology: analytical techniques, algorithms, and statistical/machine-learning approaches developed to address key questions in biology and medicine.

In this course, students will also learn how to formulate problems for quantitative inquiry, design computational projects, think critically about data & methods, do reproducible research, and communicate findings.

This website https://bit.ly/compbio2022 contains up-to-date information about everything related to this class. The class Slack workspace https://compbio2022.slack.com/ will be the space for all live announcements and discussions. If you're enrolled, an invitation should be in your MSU email. If not, email Arjun ASAP.

1.1. Enrollment

Open to both undergraduate and graduate students. Counts toward the CMSE minor, graduate certificates, and dual PhD. Please email Heather Johnson at john1451@msu.edu for an override.

1.2. Prerequisites

Basically, it would be assumed that you:

- know how to code in one of the mainstream languages like Python or R,
- have an understanding of basic statistics and probability, and
- have studied basic genetics, molecular biology, and cellular biology.

MSU courses that you can take to satisfy these prerequisites: CMSE 201 or CMSE 301-304 or equivalent with programming experience and two semesters of introductory biology (LB 144 and 145 OR BS 161 and 162 OR BS 181H and 182H, or equivalent). Statistics at the level of STT 231 is strongly recommended.

1.2.1. Preparatory Learning Materials

A document containing links to a bunch of excellent resources for brushing-up your Unix, Python/R, Statistics, and Biology is available on the class website.

2. Instructor

Name	**Arjun Krishnan**
Pronouns	He/him/his
Affiliation	Dept. Computational Mathematics, Science, and Engineering Dept. Biochemistry and Molecular Biology
Office	2507H Engineering Building

Name	Arjun Krishnan
Contact	Email: arjun@msu.edu Twitter: @compbiologist Website: https://thekrishnanlab.org

3. Schedule, Calendar, and Student Hours

Dates	Jan 10 – May 01, 2022
Weekly	Mon, Wed, and Fri 09:10 am - 10:00 am
Location	ZoomLand (check the course Slack workspace: https://compbio2022.slack.com/ for details)

3.1. Note on all schedules

All aspects of our course's schedule will be maintained in a living shared google sheet document (link available on Slack). This doc contains the i) Full course calendar, ii) Paper presentation schedule, iii) Student hour appointments, iv) Midterm presentation schedule, and v) Final presentation schedule.

3.2. Class Calendar

The calendar below contains the class schedule and the links to the lecture slides and reading materials.

Date	Module	Topic
Day_-03 Mon, Jan 10	Introductions	Course Overview
Day_-02 Wed, Jan 12	Introductions	Intro to Bioinfo & CompBio
Day_-01 Fri, Jan 14	Refreshers	Probability and statisticsBuilding models based on data
Day_00 Mon, Jan 17	No class	No class
Day_01 Wed, Jan 19	Refreshers	Computing
Day_02 Fri, Jan 21	Refreshers	Building models based on data
Day_03 Mon, Jan 24	Sequence Alignment	Dynamic programming
Day_04 Wed, Jan 26	Sequence Alignment	Substitution matrices
Day_05 Fri, Jan 28	Sequence Alignment	Fast local alignment; Paper discussion
Day_06 Mon, Jan 31	Genome Assembly and Annotation	Assembly with de Bruijin graphs
Day_07 Wed, Feb 02	Genome Assembly and Annotation	Gene prediction with hidden Markov models
Day_08 Fri, Feb 04	Genome Assembly and Annotation	Paper discussion
Day_09 Mon, Feb 07	Comparative Genomics; Phylogenetics	Whole-genome alignment; Suffix trees
Day_10 Wed, Feb 09	Comparative Genomics; Phylogenetics	Molecular evolution; Tree construction
Day_11 Fri, Feb 11	Comparative Genomics; Phylogenetics	Paper discussion

Date	Module	Topic
Day_12 Mon, Feb 14	Quantitative Genetics	GWAS; Statistical inference; Multiple testing
Day_13 Wed, Feb 16	Quantitative Genetics	Regularized linear regression; Polygenic risk score
Day_14 Fri, Feb 18	Quantitative Genetics	Paper discussion
Day_15 Mon, Feb 21	Regulatory Genomics	DNA binding sites; Position weight matrices; ChIP-seq
Day_16 Wed, Feb 23	Regulatory Genomics	Expectation-Maximization; Gibbs sampling
Day_17 Fri, Feb 25	Regulatory Genomics	Paper discussion
Day_18 Mon, Feb 28	CompBio Primers	Organizing and managing a project
Day_19 Wed, Mar 02	CompBio Primers	Kickstarting a project
Day_20 Fri, Mar 04	CompBio Primers	Presenting data and results
Day_21 Mon, Mar 07	No Class	*Note:* Spring Break
Day_22 Wed, Mar 09	No Class	*Note:* Spring Break
Day_23 Fri, Mar 11	No Class	*Note:* Spring Break
Day_24 Mon, Mar 14	Functional Genomics	Similarity measures; Clustering
Day_25 Wed, Mar 16	Functional Genomics	Differential expression; Functional enrichment
Day_26 Fri, Mar 18	Functional Genomics	Paper discussion
Day_27 Mon, Mar 21	Single-cell Genomics	Dimensionality reduction
Day-28 Wed, Mar 23	Single-cell Genomics	Supervised machine learning
Day_29 Fri, Mar 25	Single-cell Genomics	Paper discussion
Day_30 Mon, Mar 28	Protein Structure Prediction and Dynamics	Contact prediction; Maximum entropy modeling
Day_31 Wed, Mar 30	Protein Structure Prediction and Dynamics	Molecular dynamics
Day_32 Fri, Apr 01	Protein Structure Prediction and Dynamics	Paper discussion
Day_33 Mon, Apr 04	Biological Networks	Topology, Motif, Rewiring
Day_34 Wed, Apr 06	Biological Networks	Reconstruction, Propagation
Day_35 Fri, Apr 08	Biological Networks	Paper discussion
Day_36 Mon, Apr 11	Modeling Cellular Pathways	Dynamical modeling, Simple motifs, Bifurcations
Day_37 Wed, Apr 13	Modeling Cellular Pathways	State space; Cell cycle models
Day_38 Fri, Apr 15	Modeling Cellular Pathways	Paper discussion
Day_39 Mon, Apr 18	Whole-cell Models; Digital Evolution	Genome-scale metabolic models
Day_40 Wed, Apr 20	Whole-cell Models; Digital Evolution	Constraint-based modeling
Day_41 Fri, Apr 22	Whole-cell Models; Digital Evolution	Artificial life
Day_42 Mon, Apr 25	Final Project Submission	Work on project and report

Date	Module	Topic
Day_43 Wed, Apr 27	Final Project Submission	Work on project and report
Day_44 Fri, Apr 29	Final Project Submission	Work on project and report
Day_45 Tue, May 03	Student presentations	*Note:* Diff. day/time: Tue, May 03, 12:45 – 2:45p

3.3. Project Milestones

Milestone	Due date
1. Reserach profile	Fri, Jan 22
2. Project topic	Fri, Feb 03
3. Project pre-proposal	Fri, Feb 11
4. Project proposal	Fri, Feb 18
5. Proposal reviews	Fri, Feb 25
6. Mid-term project presentation recordings	Fri, Mar 18
7. Mid-course Project presentation reviews	Fri, Mar 25
8. Final project report	Fri, Apr 29
9. Final project poster presentations	*Note:* Diff. day/time | Tue, May 03, 12:45 – 2:45p

3.4. Student Hours

- TBD

I will block these time from my schedule and be present for you to talk to me one-on-one. Couple of things to note:

1. While I'm happy to chat with you over zoom, many times, just sending me a message on Slack with your questions/concerns might work as well. So, if you have specific Qs in mind, just shoot me a message and let's see if we can resolve it then and there.
2. If you would indeed like to meet over zoom, please try to meet me during this time. But, don't worry if you can't make it during this window for some reason. Again, just send me a message on Slack and we'll find a time that works for both of us.

4. Website and Communication

4.1. Course website

The GitHub repo https://bit.ly/compbio2022 will serve as the course website.

4.2. Communication

The primary mode of communication in this course (including major announcements), will be the course Slack account. All of you should have invitations to join this account in your MSU email.

Emails Although the bulk of the communication will take place via Slack, at times (rarely), we will send out important course information via email. This email is sent to your MSU email address (the one that ends in “@msu.edu”). You are responsible for all information sent out to your University email account, and for checking this account on a regular basis.

5. Course Activities and Grading

5.1. Class Participation | ~25% of the grade

Each week is dedicated to one module where we will discuss multiple topics. For each module, Arjun will give lectures on Monday, Wednesday, and half of Friday. Then, a small group of students (based on a schedule determined at the beginning of the semester) will lead a discussion based on a paper relevant to that module.

5.1.1. Lecture

During the lectures, Arjun will teach critcal concepts while frequently soliciting comments, questions, and answers. Learners will also be asked to engage in group-based activities and discussions following specified prompts.

5.1.2. Paper discussion

You will also take turns to present the assigned paper during each topic's "Paper discussion" class. Make sure you sign-up.

- Two students together present each paper.
- The presentation should focus on the computational/analytical parts, not necessarily on detailed biological background & conclusions.
    1. What is the problem the authors are trying to solve? [description of the problem along with why it is important]
    2. What are their claims about the *then* current practices and their limitations? [existing approaches to solve the problem & their pros-and-cons]
    3. What’s their approach? What’s new in it and what is their rationale for it being potentially successful? [description of the *new ideas*, their *merits* in comparison to existing ones, and *rationale*]
    4. What are the major contributions and limitations of this paper?
    5. What are some open questions and next steps (for addressing the limitations)?

Your role as a learner in this class is to:

- Do the pre-class assignments and additional readings.
- Show up to class.
- Work in groups during in-class discussion sessions.
- **Ask questions** about computational or biological concepts (because no one will have the perfect background).
- Correct me when I am wrong.

5.1.3. Meeting Arjun

Grade points are also allocated for meeting Arjun at least *thrice* over the semester during the student hours to discuss the project and the lecture materials:

1. Week of Jan 24 to introduce yourself and discuss project ideas, potential mentors, and relevant papers.
2. Week of Mar 21 to discuss project progress, proposal reviews, and revised project plan.
3. Any other time during the semester to discuss topics covered in any particular lecture.

5.1.4. Interacting with Your Learning Group

Take advantage of the in-class learning groups you are part of. I am asking you to meet remotely with your learning group once every week – perhaps on Thursday or before class on Friday – over a video call. You can coordinate the time works for all of you and how you will do the video call. When you meet online, you can:

- Go over the lecture slides for that week and ask/answer questions.
- Discuss the assignment due on Friday.
- Bring unresolved questions to the Friday online class and ask me those Qs.
- Or, just say HI and continue to do your work in the company of your peers.

5.2. Assignments | ~25% of the grade

For each topic, you will be given an assignment after the topic's first "Lecture" class on Monday that you are required to work on and submit before beginning of the "paper discussion" class on Friday the same week. Links to the assignment will be posted on this page next to the topic on the Course Calendar and specific instructions about each assignment and what/how to submit will be posted on Slack.

5.3. Semester Project and Presentation | ~50% of the grade

A major goal of this course is to prepare you for performing original research in computational biology, and for effectively presenting your ideas and research. The semester project will serve as the most practical way to do exactly that.

Projects can take any one of the following flavors:

- Design and implement a new computational method for a task in biology
- Improve an existing method
- Perform an evaluation of several existing methods
- Develop a fully-reproducible documentation and codebase for an existing analysis in a paper

5.3.1. Expected final outcomes

The outcomes of this semester-long project should include:

1. Well-documented code to:
    - Download and process the data
    - Perform the computational analysis and generate all the results
    - Visualize the results as multiple tables/plots
2. Detailed final report containing the following sections (see the `Final project report` section below):
    - Problems and goals
    - Datasets
    - Computational approach
    - Summary of key findings
    - Challenges
    - Reflections and future directions
    - Acknowledgements
    - References
    - Glossary
3. A final project presentation.
    - This may be a poster if we can do the finals in-person. If not, this shall be a lightning talk. See details below.

5.3.2. Project milestones throughout the semester

There are **nine** **project milestones** throughout the course that will help you stay on track, enabling you to complete a substantial project.

1. Research profile

> Due: Fri, Jan 22

Complete this form `<LINK>` with a write-up of your research profile (three short paragraphs) containing a description the following:

1. Your previous research experience:
    - Include topics/problems you have worked on and the computational skills/tools you have used.
2. Areas of research interest in bioinformatics / computational biology:
    - Check out this course's modules and topics (on the class website) for some guidance.
3. Type of project that best fits your interests
    - You can pick one among the following – i) designing new approaches, ii) improving existing methods, iii) comparing & benchmarking multiple methods, iv) developing fully-reproducible documentation & codebase for an existing analysis – or something else.
    - If you are undergrad taking the 410 version of this course AND if you do not have any prior research experience, I strongly recomment type iv, which is to build a case study of an specific analysis in a published paper.

2. Project topics

> Due: Wed, Feb 03

Briefly describe project ideas and submit it using this form `<LINK>` .

1. Your previous research experience:
    - Include topics/problems you have worked on and the computational skills/tools you have used.
2. Areas of research interest in bioinformatics / computational biology:
    - Check out this course's modules and topics (on the class website) for some guidance.
3. Type of project that best fits your interests
    - You can pick one among the following – designing new approaches, improving existing methods, comparing & benchmarking multiple methods, developing fully-reproducible documentation & codebase for an existing analysis – or something else.

You need to provide a:

1. Project title
2. Potential project mentor/advisor: The faculty member, graduate student, or postdoc you're going to work with who might advise you on this project.
3. Abstract (250 words): In your abstract, make sure you include answers to the following four questions: 1) What is the problem? 2) How is it addressed currently & what are the limitations? 3) What is your approach to addressing it & why is likely to be successful?, and 4) If successful, why does it matter (what is the impact)?

NOTE: Meet with Arjun during the week of Jan 24 to introduce yourself and discuss project ideas, potential mentors, and relevant papers.

3. Project pre-proposal

> Due: Fri, Feb 11

Prepare a two-page pre-proposal based on the following guidelines and submit it using this form `<LINK>` .

- Length, page settings:
    - 2-pages (including figure & references; sections listed below)
    - 1-inch margins
- Font specifications:
    - 1.15 line spacing
    - Arial, Times New Roman, or Helvetica font
    - 11pt font size for all text including figure/table titles/legends.
- Sections:

- Page 1:
  - Title, your name, and your project mentor/advisor's name.
  - Write short paragraphs answering the following four questions:
    1. What is the topic/problem?
    2. How is it addressed currently & what are the limitations?
    3. What is your approach to addressing it & why is likely to be successful?
    4. If successful, why does it matter (what is the impact)?
- Page 2:
  - Graphical abstract:
    - A graphical illustration that summarizes your project idea. For e.g., something like the ones in these papers: https://www.cell.com/cell-systems/fulltext/S2405-4712(18)30438-1 or https://www.cell.com/cell-systems/fulltext/S2405-4712(18)30509-X. Keep it simple but informative.
  - References:
    - short list of papers pertinent to your project that you have read or plan on reading).

4. Project proposal

> Due: Fri, Feb 18

Write a full project proposal based on the following guidelines and submit it using this form `<LINK>` .

- Length, page settings:
  - 5-pages (including figures & references; sections listed below)
  - 1-inch margins
- Font specifications:
  - 1.15 line spacing
  - Arial, Times New Roman, or Helvetica font
  - 11pt font size for all text including figure/table titles/legends.
- Sections:
  1. Background, goals, and significance:
     - What is the problem you are hoping to address?
     - What is the current approach & its limitations?
     - What will you do & why is it likely to succeed?
     - If what you propose is successful, what is the broader impact?
  2. Datasets:
     - What datasets will you use?
     - Where are these data from?
     - What exactly do these data contain?
     - How are the data formatted?
  3. Computational methods/approach:
     - What are the analytical methods you will develop/use?
     - What are the specific software implementations you'll use?
     - Include a flowchart of your approach here.
  4. Evaluation plan:
     - How will you evaluate the results that you get from the method/software? Think in terms of how to test if a) your approach is working correctly without errors and b) your results make quantitative/biological sense and are meaningful.
  5. Potential challenges & alternative approaches:
     - What are some assumptions you are making about the problem and/or the data that may not bear true?
     - What are some potential limitations of your dataset or approach that might prevent you from achieving the goals you've set for this project?
     - What will you do as alternatives if your assumptions don't hold or you hit those limitations?
  6. Specific milestones:
     - What is the list of specific results/outcomes you will work on getting?
  7. References:

- List the papers that are relevant to your project. Make sure you cite each one of them in the text.

5. Proposal reviews

> Due: Fri, Feb 25

Check out the details below. I'm happy to hear any questions/thoughts you have and happy to clarify anything further. Submit your reviews using this form `<LINK>` by **11:59pm Fri, Feb 25**.

Reviewer assignments Your peer-review assignments are in the sheet 'Proposal Review Assignments' under the columns 'Reviewer 1' & 'Reviewer 2' in the shared class schedule Google Sheet. I will be the 3rd reviewer for all proposals. In that same sheet, you will also find a link to the PDFs of all the proposals.

Reviewer guidelines Before you dive in, carefully read these guidelines on writing an effective peer-review.

Review format (one per proposal) Organize each review based on the following sections:

1. Project title & Full name of Investigator
2. Summary statement: *In your own words*, write a short paragraph of what the project is about (problem/goals), how does the investigator propose to achieve their goals, and what might be the broad significance/impact if those goals are achieved.
3. Major comments and questions: In this section, write a numbered list of critical comments and questions, in the order of importance (highest to lowest). For each comment/question:
    - Indicate the part of the proposal you're referring to ('Introduction, page 1, paragraph 3', 'Figure 2', 'Approach, page 3, paragraph 4', etc.). It is also useful to briefly quote the specific text you're talking about (within quotation marks).
    - Justify with clear reasoning as to why this concern is being raised. Within each comment, you're welcome have nested parts addressing different aspects of the same issue you're raising.
    - If your critique is based on (the existence of) another paper, don't forget to include a citation to that paper right within your comments.
4. Additional comments and questions: In this section, write a numbered list of comments/questions that are:
    - Sections/paragraphs/figures that do convey the message but definitely warrant a rewrite or re-rendering for clarity.
    - Things that would be great to include in the project but not critical.
    - Additional thoughts on improving the project beyond the scope of the class.

Notes:

- Make sure you include all three types of comments: stuff that's good, stuff that's not working at all, and stuff that is valuable but needs improvement.
- Make sure you focus on the science and not just on the writing. You can do this by focusing just on asking yourself if the proposal contains answers to the questions laid out in the 'Project Proposal Instructions' above.

6. Mid-course project presentations

> Due: Fri, Mar 18

Record a video your presentation (maximum of 10 min), and submit a link to the video using this form `<LINK>` .

You are encouraged to make a google slides presentation and use those slides to present your project update. You can then use Zoom or Loom to record your video. Then, you can either upload the mp4 file to YouTube as an unlisted file or to a file sharing service like Google Drive or Dropbox and then provide the link to the video via this form.

Make sure to include the following information in your presentation:

- Broad area, some background, and what problem the project is going to address.
- Specific aims of the project, what achieving those aims will result in, and why do these results matter (why are they significant and what impact might they have on future work)
- Description of your approach in the form of a clear flowchart that contains the following information as it pertains to your project:
    - Raw data → Preprocessing & quality control → Preliminary/exploratory analysis → Analysis/Model-building steps → Expected outcomes.

- Results from a thorough exploration and sanity checks of data.
  - Tables & plots to showcase various aspects of your datasets/problem.
- Clear description of your methods and software.
  - Usage & I/O format for each.
- Results from your preliminary analysis
  - With simple baselines, samples datasets, and toy examples.
- As you cover each of the above elements, make sure to mention how you have modified or revised them based on the peer reviews.

7. Mid-course project presentation reviews

> Due: Fri, Mar 25

Review presentations by your peers based on the detailed rubric. You can find your review assignment in the "Midterm Presentation Reviews" in the shared class schedule google sheet and submit your reviews – once per review assignment – using this form `<LINK>`.

8. Final project report

> Due: Fri, Apr 29

Continue making substantial progress on proposed milestones. Complete milestones, finalize results, figures, and complete the following questionnaire *AS SPECIFICALLY AND DETAILED AS POSSIBLE* based on the guidelines below and submit it using this form `<LINK>`.

- Length, page settings:
  - 8–10 pages (including figures & references; sections listed below)
  - 1-inch margins
  - Not included in the 10-page limit: project Glossary attached as additional pages.
- Font specifications:
  - 1.15 line spacing
  - Arial, Times New Roman, or Helvetica font
  - 11pt font size for all text including figure/table titles/legends.
- Sections:
  1. **Problem and goals**
     - What is the broad problem you set out to work on at the beginning of the project?
     - What were the conceptual/technical motivations for choosing this problem?
     - Did the scope of the problem or the specific goals of the project evolve over the course of the semester? If so, how and why? Describe these in terms of three time-points: the beginning of the semester, mid-term, and now close to the end.
  2. **Datasets**
     - What datasets did you plan to use at the beginning of the project and where were they supposed to be from (i.e., data sources)? Use figures and/or tables in this description to succinctly describe the content/format of the data.
     - Where you able to obtain the datasets you wanted? If so, did they contain the data you wanted in the format you wanted? If not, why?
     - Did you have to change your data plan from the time you gave the mid-term presentation (e.g., needing to find more data or different data)? Why?
  3. **Computational approach**
     - This section and the next one (Sections 3 and 4) should form the bulk of your report.
     - Include a flowchart of the approach you originally proposed. This could be the one you used in your proposal or mid-term presentation.
     - Describe briefly the analysis plan you had (the one you included in your mid-term presentation)?
     - Describe in the form of a ***series of steps*** what you tried from mid-term until now. You can refer to each as Step 1, Step 2, etc.
       - For each step, describe: i) what you set out to do, ii) how you went about doing it, and iii) what was the outcome, and iv) what did you learn.

        - For each step, you are welcome to include figures, tables, etc., to illustrate your point.
4. **Summary of key findings and take homes**
    - Present the key technical/scientific findings from your project that you were able to obtain.
        - A key finding is something about a particular aspect of your project – the biological problem, data, conceptual idea, computational approach, software, etc – that brought out something new and/or interesting and helped you learn something new.
        - Remember: Key findings can and should inlcude both 'positive' and 'negative' results/outcomes as long as they were insightful in some way.
    - For each finding:
        - Write a descriptive sub-heading.
        - Include a figure or table (or something else) that demonstrates the main point.
        - Write a description of: i) what is being shown, ii) what are the major observations, and iii) what are the main take homes.
    - At the end of this section, as the last key findging, include "Code and data availability":
        - Here, briefly describe where your code and data are available.
        - Provide a link to your GitHub repo that contains your well-documented code.
        - Describe how successful you where in getting to a place where you have a full repo that you or someone else can use to reproduce your work.
5. **Challenges**
    - Where you able to get the specific results/outcomes you set out to get at the beginning of the semester? Comment about specific milestones.
    - What were some key technical/scientific challegnes you faced when working on this project?
    - What were some practical challenges you faced when working on this project?
6. **Reflection and future directions**
    - If you were to start this project afresh from scratch, what would you do differently in terms of the i) problem, ii) data, iii) approach, and iv) code?
    - What are some directions to extend your work in the future?
7. **Acknowledgements**
    - Here, mention the full names of everyone who helped with your project at different stages and describe their speicfic contribution. Include mentors, classmates, friends, colleagues, or anyone who helped you make progress in even a small way.
8. **References**
    - List the papers and online resources that you read for this project. Make sure you cite each one of them in the text in appropriate locations.

To the end of this report (not included in the 10-page limit), attach your project Glossary (what you were compiling throughout this semester) as additional pages.

9. Final project presentations

> Tue, May 03, 12:45 – 2:45p

You will be presenting a short talk about your project on this day.

Make your presentation using Google Slides and submit the following using this form `<LINK>` before **11:59p Fri, Apr 29**:

1. A link to the slides. NOTE: Please make sure the slides can be viewed by anyone with the link.
2. A PDF of the slides.

Here's are the guidelines for preparing your presentation:

Duration You will have 10 minutes to present your slides *and* take questions. So, you should plan to present for about 6–7 min and allow 3–4 min for Q&A. Since the duration of the finals is short and fixed, these allotted times will be followed *strictly*. Therefore, I suggest practicing your talk.

Content

1. Title slide (1 slide)
    - Include the title of your project along with your full name and affiliation (degree/program/department/etc.).
2. Problem and goals (1 slide)
    - What is the problem you are tackling? Why is it important? What goals did you want to achieve?
3. Key findings (1 or more slides)
    - One or more key technical/scientific findings.
        - As I described before, a key finding is something about a particular aspect of your project – the biological problem, data, conceptual idea, computational approach, software, etc – that brought out something new and/or interesting and *helped you learn something new*.
        - Remember that key finding can and should inlcude both *positive* and *negative* results/outcomes as long as they were insightful in some way.
    - For each key finding (one per slide), include a figure or table (or something else) that demonstrates the main point, describe the approach you took to get this result/outcome, and what are the major observations/take-homes.
4. Biological/computational concepts and computational skills learned through this project
    - Include a bullet list of some new things you learned on the biology and computational side. These could be concepts, skills, etc.
5. Reflections
    - If you were to start this project afresh from scratch, what would you do differently in terms of the i) problem, ii) data, iii) approach, and iv) code?
6. Acknowledgements
    - Here, mention the full names of everyone who helped with your project at different stages and describe their speicfic contribution. Include mentors, classmates, friends, colleagues, or anyone who helped you make progress in even a small way.

NOTE:

1. Especially during your presentation – and preferably throughout the final exam hour – I would like you to have your video on if possible.
2. All your presentations will be recorded for evaluation purposes.

5.4. Grading Information

Activity	Percentage
Assignments	~25%
Class participation	~25%
Project	~50%

5.4.1. Grading Scale

Point	Percentage
4.0	≥ 90%
3.5	≥ 85%
3.0	≥ 80%
2.5	≥ 75%
2.0	≥ 70%
1.5	≥ 65%

Point	Percentage
1.0	≥ 60%
0.0	< 60%

Note: Grades will not be curved. Your grade is based on your own effort and progress, not based on competition with your classmates.

6. Philosophy, Presence, Conduct, Honesty, and Accommodations

6.1. Land Acknowledgement

Let's begin by acknowledging that Michigan State University occupies the ancestral, traditional and contemporary lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa and Potawatomi peoples. The university resides on land ceded in the 1819 Treaty of Saginaw. Map: https://www.canr.msu.edu/nai/about/land-acknowledgements.

6.2. Teaching Philosophy

The cornerstone of my teaching philosophy is to consider each class as an inclusive collaborative learning community where we can all work together to enhance each other's learning. To foster this community, my goal is to make sure that our class is a space where all of you can join in, breathe, be seen & heard, be curious, and openly engage with the ideas.

You absolutely belong in this community and you will be valued and respected. My point of view is as follows:

- *Past*: Your unique background, training, and life experiences are your strengths that I and others can always learn from.
- *Present*: You have a life much bigger and multifaceted than your academic life within classrooms.
- *Future*: You are going to be my future colleagues within or outside academia.

Finally, I design and teach classes that maximize my learning and help me identify gaps in my knowledge and find better ways of discussing each of the many complex/interesting ideas.

In service of these goals, below are all the policies we will follow. If you have a concern about the policies and procedures of this class, please contact me.

6.3. Class Presence

First, if you sincerely engage with the class and put in earnest effort, you will do well. Your can do so by:

- Completing any pre-class readings.
- Showing up to the class on time and staying for the whole two hours.
- Responding to prompts from Arjun that punctuate the lectures: questions, polls, etc.
- Asking questions about statistical or practical concepts (because no one will have the perfect background).
- Working in groups when asked.
- Correcting me when I am wrong.

For these activities to truly result in learning and betterment, I need everyone's contribution to ensure that this class (and all its affiliated spaces including Slack) remain a psychologically safe environment where:

- If learners make a mistake, others (me included) will not penalize or think less of them for it, and
- Others will not resent or humiliate them when they ask for help or information.

I expect everyone to respect and trust each other so that every learner is imbued with the confidence that the group won't embarrass, reject, or punish someone for speaking up. To sustain this environment, all of us will listen, stay curious, and be honest while staying away from judgement, unsolicited advice giving, and interrupting.

6.4. Attendance

Now, all the above activities are heavily based on material presented and worked on in class. So, it is critical that you attend and participate fully every week. Consistent class presence and participation is required to do well in this course.

If you have a legitimate reason to miss class – such as job/grad-school/medical-school interviews, health/medical needs, or any other hard life circumstances – just let me know as soon as you can. I will *always* be willing to work with you to figure out how to accommodate your constraints/circumstances and how you may makeup for any lost time/points if needed. Same goes for meeting the multiple assignment deadlines. I know that things are pretty tough now. So, just keep me posted and I will support you.

If there are multiple absences without *any* notice or explanation, that will result reduction in points allocated for attendance. Similarly, not completing assignment or project milestones without *any* notice/explanation will result in reduction of points at the discretion of the instructor.

6.5. Code of Conduct

All conduct should serve the singular goal of sustaining a friendly, respectful, supportive, and fun environment where we can do our best work and have a great time doing it.

- Do work that you're proud of, anything from participating in a class activity to completing a full-blown research project.
- Be supportive of your classmates; respect each others' strengths, weaknesses, differences, and beliefs.
- Communicate openly & respectfully with everyone in the class. We can all begin by using the correct name and pronouns for everyone in this class.
- When you ask for help from your fellow learners, respect and appreciate their time and effort.

Respectful and responsible behavior is expected at all times, which includes not interrupting other students, turning your cell phone off, refraining from non-course-related use of electronic devices, and not using offensive or demeaning language in our discussions. Flagrant or repeated violations of this expectation may result in ejection from the classroom/session, grade-related penalties, and/or involvement of the university Ombudsperson.

I am unequivocally dedicated to providing a harassment-free experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, or religion (or lack thereof). I will not tolerate harassment of colleagues in any form. Behaviors that could be considered discriminatory or harassing, or unwanted sexual attention, will not be tolerated and will be immediately reported to the appropriate MSU office (which may include the MSU Police Department).

6.6. Discussing or Raising Concerns

If you experience, observe, or just want to talk through anything in regard to your or anyone else's safety and well-being, talk to me. I will not tolerate any discrimination or harassment. You can rest assured that you can come to me and I will listen and I will believe. I will support you and advocate for you with everthing within my power.

Note that, as a member of the university community, I have the responsibility to report any instances of sexual harassment, sexual violence and/or other forms of prohibited discrimination. If you would rather share information about sexual harassment, sexual violence or discrimination to a confidential employee who does not have this reporting responsibility, you can find a list of those individuals here. I especially recommend the Office of the University Ombudsperson that offers students a confidential and impartial place to discuss academic and nonacademic concerns. Staff in this office will assist you to define problems, explore options, outline strategies, review policies, find resources, and manage expectations while upholding the values of respect, integrity, diversity and freedom from bias or harassment.

6.7. Name and Pronoun

All people have the right to be addressed and referred to in accordance with their personal identity. Many people do not identify with the name on their birth certificate, school ID, or other forms of identification. At the beginning of this class, everyone indicates the name they use and their pronouns. If you would like to change your name, you can do that through StuInfo. Your gender marker can be changed by filing a request at the Office of the Registrar at the Hannah Administration Building. More information about MSU's preferred name policy can be found at: https://lbgtrc.msu.edu/trans-msu/msu-preferred-name-policy/. Please advise me at any point if you need to update your name and/or pronouns in my records.

6.8. Mental and Physical Health

University life, undergraduate/graduate studies, research, living away from home, and personal relationships – any of these can spring formidable challenges to our mental well-being in unsuspecting, surprising ways, nothing to say of doing all this in the backdrop of a global pandemic.

To mitigate these ill effects, I hope you are able to make time to take care of yourself (socialize remotely, exercise, eat healthy, sleep, blow off steam, etc.). I also hope that when you feel low, when your physical/mental wellness is being put to test, you will talk to a friend, a friendly colleague, or a close family member.

I always welcome you to talk to me. You can come to me anytime with any challenge you face and I will listen. I will do my best to learn about any issue you have (without any judgement, I promise), keep anything you share confidential, and offer my thoughts based on my experience. It is my wish, duty, and privilege to be of help in any way to ensure your mental (& physical) well-being so that you can get a great education and have a good time doing it.

Finally, I urge you to take advantage of many resources available on campus to support your health and wellness including the Counseling and Psychiatric Services. They are virtual now and hence, easy to reach out to.

6.9. Pandemic

First, congratulations on surviving 2020 and 2021! I'm amazed by and grateful for the seemingly limitless courage, hard work, and sacrifice of healthcare workers, other essential workers, and the people who stood up for social justice.

These two years have been incredibly tough for students, care givers (esp. parents of young children), and daily-wage workers -- difficulties that were hugely compounded due to also belonging to systematically minoritized/underrepresented/disadvantaged groups. In addition to these difficulties, my heart goes out to those who also have suffered the loss of loved ones.

I hope you are vaccinated and taking all the precautions to keep you and everyone around you safe.

However, let me make a few things clear:

- I am aware that, during these difficult circumstances, we all need a dose of both structure and flexibility.
- Let's strive to keep to this structure and schedule as much as possible.
- Meanwhile, I am always happy to work with you on a case-by-case basis to figure out different assignments, specifications, and due dates based on your specific circumstances/needs.

6.10. Learning Online

There is a permanent Zoom meeting (posted on the course Slack workspace), which anyone can use to attend the classes remotely. All of you should have invitations to join this Slack workspace in your MSU email.

6.10.1. Zoom Best Practices

- Please log-in in a timely manner.
- Please use a headphone (if you can) so that we can avoid audio feedback.
- I will *really* appreciate if you can keep your video on for as many class hours as you can. Your acknowledgement, questions, and comments together is the wind beneath my wings. Having said that, I am cognizant of the fact that you may be at your residence

or in a common area and each of you will have a unique circumstance in terms of convenience of working environment, other family-members/roommates, childcare/pet-care needs, spotty internet, etc. All of us will fully accommodate any of this.
- In case we end-up in-person, I will still keep the zoom space available but I will not be able to do justice to monitoring the Chat window for questions. So, please unmute yourself and speak-up to ask questions and provide your comments/answers.

6.11. Academic Honesty

Intellectual integrity is the foundation of the scientific enterprise. In all instances, you must do your own work and give proper credit to all sources that you use in your papers and oral presentations – any instance of submitting another person's work, ideas, or wording as your own counts as plagiarism. This includes failing to cite any direct quotations in your essays, research paper, class debate, or written presentation. The MSU College of Natural Science adheres to the policies of academic honesty as specified in the General Student Regulations 1.0, Protection of Scholarship and Grades, and in the all-University statement on Integrity of Scholarship and Grades, which are included in Spartan Life: Student Handbook and Resource Guide. Students who plagiarize will receive a 0.0 in the course. In addition, University policy requires that any cheating offense, regardless of the magnitude of the infraction or punishment decided upon by the professor, be reported immediately to the dean of the student's college.

It is important to note that **plagiarism in the context of this course includes, but is not limited to**, directly copying another student's solutions to in-class or homework problems; copying materials from online sources, textbooks, or other reference materials without citing those references in your source code or documentation, or having somebody else do your pre-class work, in-class work, or homework on your behalf. Any work that is done in collaboration with other students should state this explicitly, and have their names as well as yours listed clearly.

More broadly, we ask that students adhere to the Spartan Code of Honor academic pledge, as written by the Associated Students of Michigan State University (ASMSU): "As a Spartan, I will strive to uphold values of the highest ethical standard. I will practice honesty in my work, foster honesty in my peers, and take pride in knowing that honor is worth more than grades. I will carry these values beyond my time as a student at Michigan State University, continuing the endeavor to build personal integrity in all that I do."

6.12. Accommodations

If you have a university-documented learning difficulty or require other accommodations, please provide me with your VISA as soon as possible and speak with me about how I can assist you in your learning. If you do not have a VISA but have been documented with a learning difficulty or other problems for which you may still require accommodation, please contact MSU's Resource Center for People with Disabilities (at 517-884-RCPD or on the web) in order to acquire current documentation.