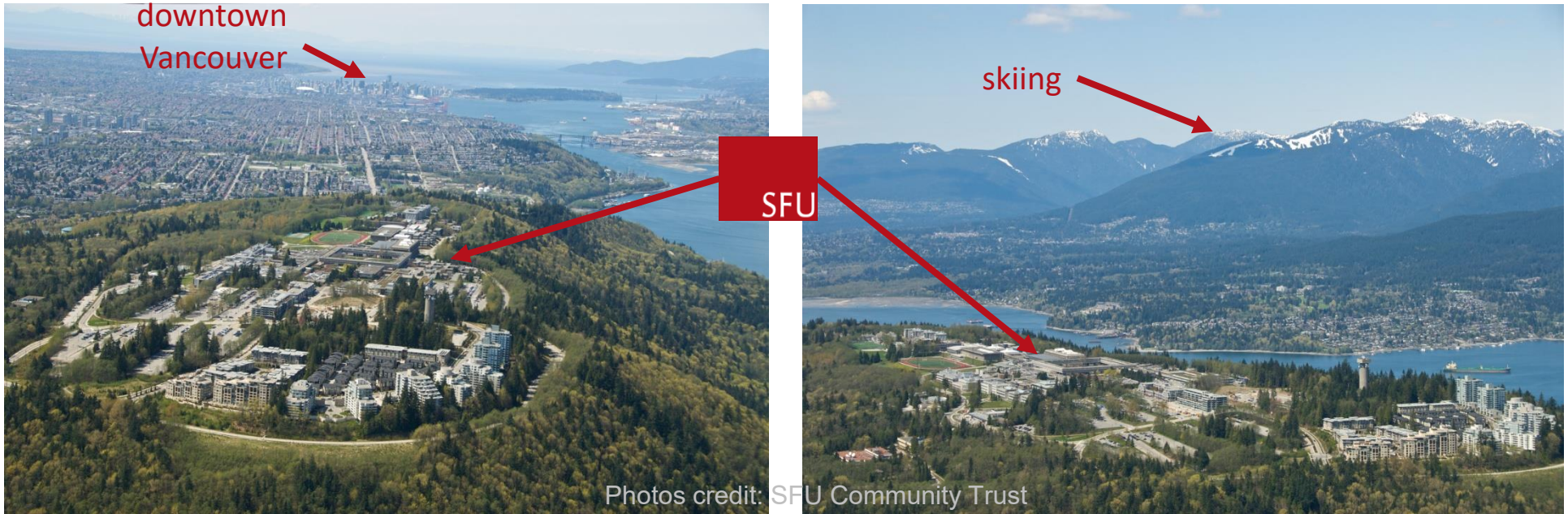
Engaging diverse student interests through independent projects

Nancy Forde

Department of Physics

Simon Fraser University, Burnaby, BC, Canada



What skills do we want students to take away from university?

One of my priorities:

I want my students to be confident in and exercise their ability to learn independently.

- Follow up and do inquiry-based learning about topics that interest them, topics in the news, etc.
- Critically assess information
- Share their knowledge with others

Independent learning: independent projects

Pros

- Directly engage students with a topic they find interesting
- Provide breadth and diversity to course learning
  - Not just instructor's view of the subject
- Students can demonstrate learning in a nonconventional format
- Skills are directly relevant to future careers
  - Research, communications skills

Cons

- Time demands on instructor:
  - Individualized assessment (particularly in large classes)
  - Individualized guidance on diverse topics
- Expertise demands on instructor:
  - How to support breadth of topics?
- Students may have difficulty identifying topic, format
  - Unused to control over their own learning

- Important to clearly define expectations via rubrics, timelines
- Potential topics list

Thermodynamics lecture course (Phys 344)

Introduction to Thermal Physics (Phys 344)

- Independent project of students' choosing: a concept, device, or scientist
- Poster session to present results to peers
- Assessment:
  - Mandatory: Evaluation of peers' posters (2% of final grade)
  - Presenting a poster (0-10% of final grade*)
    - Title and abstract (15%)
    - Poster presentation (85%)

Poster format for presentation

- Preparation time for presentation is less demanding than written format
  - Student time can focus on research, analysis
- Broaden scope of learning: peers learn from each other (not so easy with written format)
- Assessment by instructor can happen in real time (if there are not too many posters)
- Optional* poster introduced to reduce instructor time demands relative to previous offerings; 35% of students opted for a poster presentation

*Personalized grading scheme: each student determined the weighting of assignments in this offering, within constraints I provided

Biological Physics Lab course (Phys 433)

Biological Physics Laboratory (Phys 433)

- Lab-based independent research project
- First half of semester: learn techniques for answering different types of questions
- Second half of semester: design & execute own experimental research project (28% of course grade)
  - Research proposal (5%)
  - Planning and execution (10%)
  - Results (5%)
  - Title & Abstract (3%)
  - Presentation (5%)
- Poster session to present results to peers, departmental members

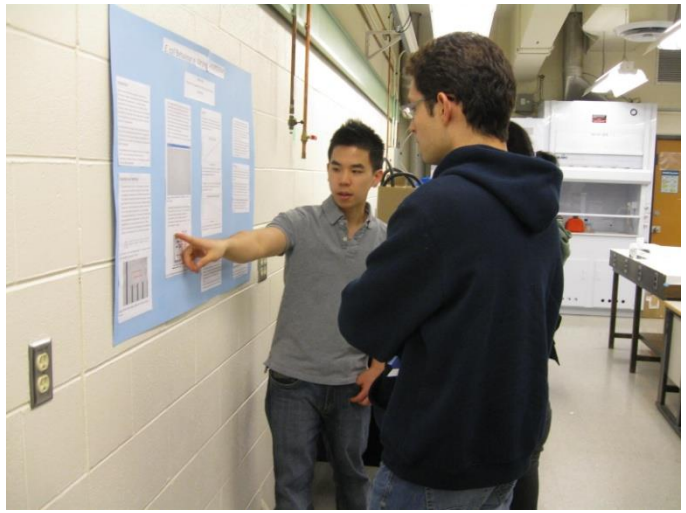
Poster format for presentation

- Preparation time for presentation is less demanding than written format
  - Student time can focus on research, analysis
- Broaden scope of learning: peers learn from each other (not so easy with written format)
- Assessment by instructor can happen in real time

*Course, independent project also successfully adapted for graduate students

Student feedback on Phys 433 independent projects

- Independent projects were universally viewed as the highlight of the course
- Students expressed surprise at how challenging it was to design their own experiments and how long basic steps took
- Students preferred working on their own to the idea of working in pairs on independent projects.



Topics included

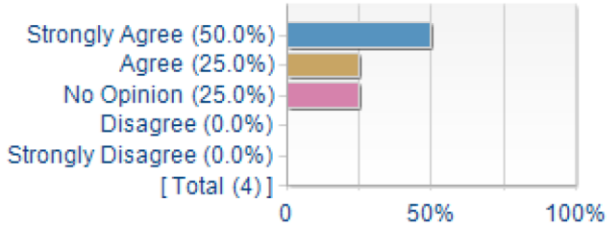
- Force generation by the unicellular algae *Chlamydomonas*; dependence on divalent ion concentration
- Size of DNA determined by FCS
- Stretching single DNA molecules with OT
- Thermodynamics of dye binding to DNA
- Quantification of *E. coli* concentration via FCS
- Wavelength-dependent phototaxis of *Chlamydomonas*
- Rotation speed and stall torque of *E. coli* flagellar motor
- Nutrient concentration dependence of chemotaxis by *E. coli*
- DNA topology probed by FCS
- Temperature-dependent modulation of membrane diffusivity in yeast
- Ionic strength dependence of collagen fibril formation kinetics
- Determination of agarose gel size from DNA electrophoretic mobility
- Building a PCR instrument from scratch (and it worked!)

Biological Physics lecture course (Phys 347)

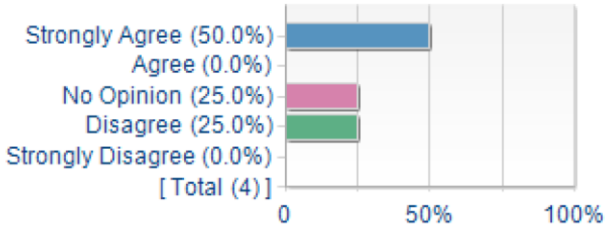
Independent project 2015 edition: 9 students; 15% of course grade

- Read influential biophysics paper from primary literature and present to class (15-20 minute presentation) (13%)
  - List of suggested papers provided, though freedom to extend beyond this
  + Breadth of topics: students learned about biophysics beyond explicit course content
  + Application of course knowledge to primary research
  + Evaluations completed during class time
  + Peer review engages classmates, provides broader feedback to presenters and to instructor
  - Takes a lot of class/tutorial time when class is large
- Peer review of and questions during peers' talks (2%)

My independent project gave me a deeper appreciation for biophysics research.



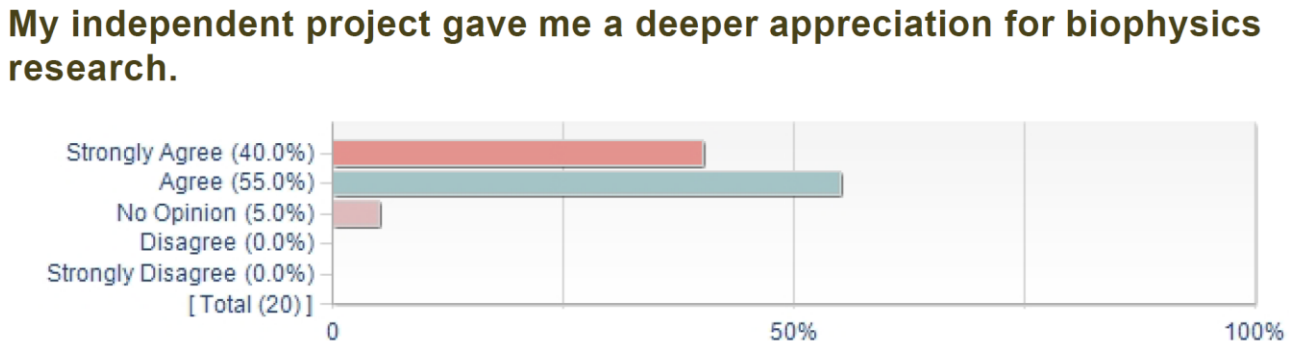
I learned a lot about biophysics from the independent project presentations of my classmates.



Phys 347: 2016 independent projects

20 students; 15% of course grade

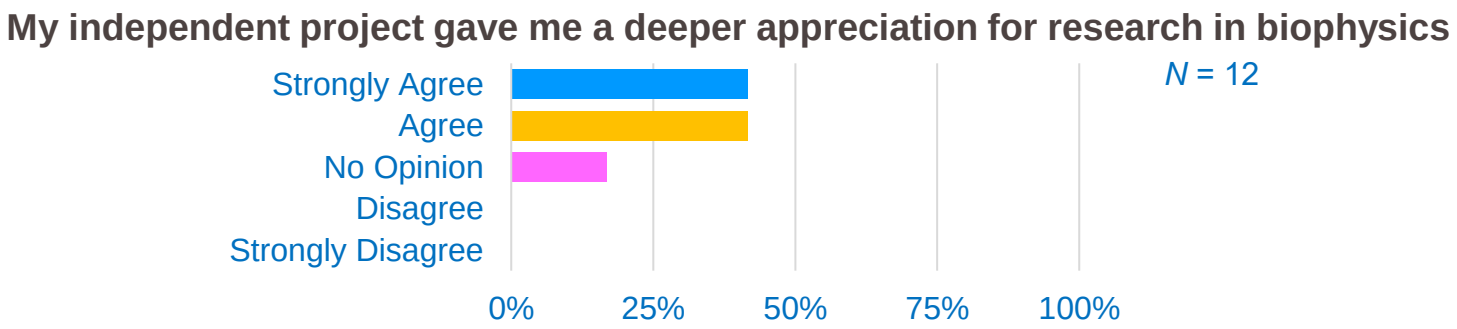
- Read influential biophysics paper from primary literature and present to class **or write a report** (13%)
  - List of suggested papers provided, though freedom to extend beyond this
  + Breadth of oral presentation topics: students learned about biophysics beyond explicit course content
  + Application of course knowledge to primary research
  + **Some** evaluations completed during class time
  + Peer review of talks engages classmates, provides broader feedback to presenters and to instructor
  - **No peer review of written reports, so no exposure to those topics**
- Peer review of and questions during peers' talks (2%)



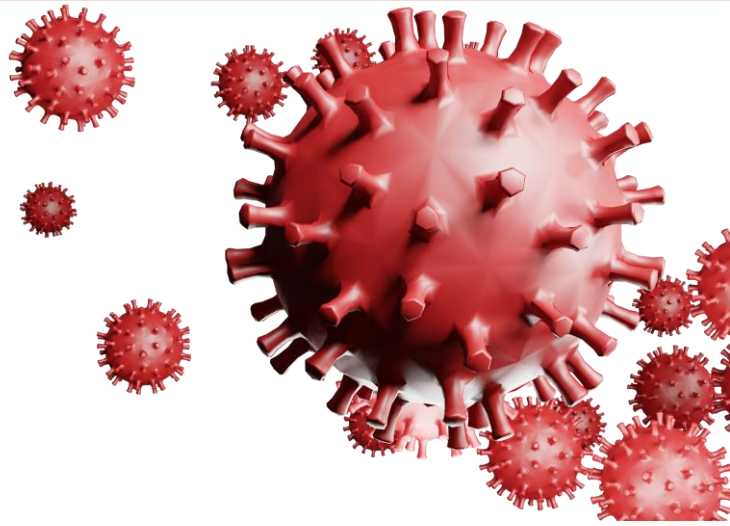
Phys 347: 2018 independent projects

14 students; 15% of course grade

- Read influential biophysics paper from primary literature and present to class or write a report (13%)
  - List of suggested papers provided, though freedom to extend beyond this
  + Breadth of oral presentation topics: students learned about biophysics beyond explicit course content
  + Application of course knowledge to primary research
  + Some evaluations completed during class time
  + Peer review of talks engages classmates, provides broader feedback to presenters and to instructor
  - No peer review of written reports, so no exposure to those topics
- Peer review of and questions during peers' talks (2%)
  - **Introduced distinct, qualitative peer assessments (exceptional, satisfactory, minimal, missing)**



Phys 347: Fall **2020** independent projects



25 students; **20%** of course grade. Course was fully online (real-time Zoom).

More student control: broadened scope of topics, formats, evaluations

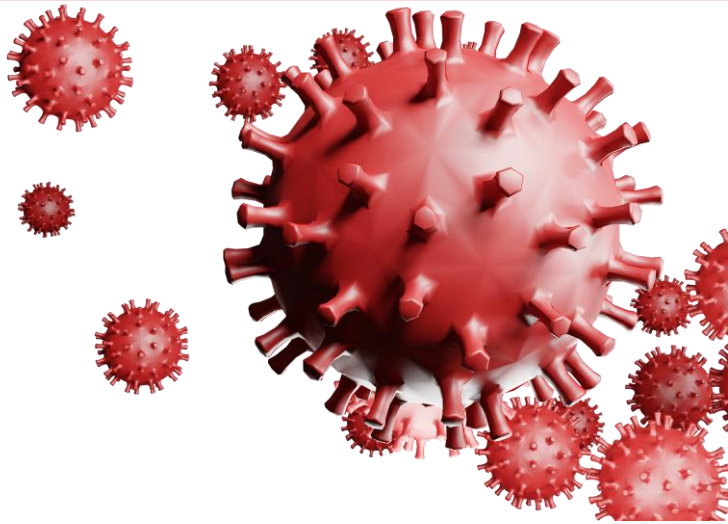
Specialized report (4 options) – targeted at peers

- Critique of a formative biophysics paper in the literature
- Report on an experimental or computational **technique** used in Biophysics
- **Theoretical / computational study**
- **Research proposal**

Overview project (4 options) – synthesize, communicate knowledge

- **Review article** about a particular biological system and what is known about the physics of some aspect(s) of it. Targeted at an incoming Phys 347 student.
- **Blog post** about a particular biological system and what is known about the physics of some aspect(s) of it. Targeted at a graduating high-school student.
- **Infographic** about a particular biological system and what is known about the physics of some aspect(s) of it. Targeted at a graduating high-school student.
- **Video** about a particular biological system and what is known about the physics of some aspect(s) of it. Targeted at a graduating high-school student.

Phys 347: Fall 2020 independent projects



Evaluation options

Option A Brief proposal – 10% Final report/project – 90%	Option B Brief proposal – 10% Peer review – 20% Final report/project – 70%
Option C Brief proposal – 10% Draft report/project – 40% Final report/project – 50%	Option D Brief proposal – 10% Peer review – 20% Draft report/project – 30% Final report/project – 40%

Phys 347: Fall 2020 independent projects

Pros

- Students had control over some aspect of their lives / learning
- Students could choose a style that suited their interests
  - Topic
  - Depth vs breadth
  - Audience to target
- No class time needed for presentations
- Peer review of *drafts* meant feedback was useful
  - Benefits to reviewer and reviewee
- Peer reviewers exposed to breadth of topics
- Peer review: experience with scientific process (as reviewer and author)

Cons

- Time demands on instructor:
  - Developing 8 (x2) rubrics*
  - Coordinating peer review assignments
  - Anonymizing peer review (double-blind)
  - Evaluating not just final submissions but also drafts, on a time crunch
  - Individualized guidance on diverse topics
- Expertise demands on instructor:
  - Supporting breadth of topics
  - Supporting distinct styles of presentation (e.g. blog, infographic)
- Amount of choice (for some students)
- Timing (for some students)

*Thanks to Joanne O'Meara (U Guelph) for sharing hers!

Phys 347: Fall 2020 independent projects

Comments
It helped me dig deeper into topics I was interested in, but having an assignment due at the same time was a bit difficult. Probably because I was feeling quite a bit of burnout towards the end of the semester, but i think everyone was (not because of 347, just everything else).
It went really well for me
The project helps expand course material to outside the classroom. The peer review part was awesome, students can reflect to own work while reviewing others' work.
I felt the project was fair, and encouraged discovery in the bio–physics field. It helped to generate interest in the course. Personal pet–peeve would be the overabundance of choice in how to do the project. It was a bit daunting at first, but I ended up doing a style I preferred so not really a complaint I suppose.
I think the research project is a nice thing to include, as most physics students are used to 2 midterms, assignments, and a final in most of their courses. The variety is always welcomed!
I liked having several options on whether to submit a draft and participate in peer review. I would have liked to project to be assigned a week or two earlier as the date for draft submission was somewhat tight. The project certainly exposed me to biophysics I would not have known of otherwise. In my case doing the project didn't help me to understand the other course material. However, it got me better acquainted with current biophysics research than any other part of the course.
I like the idea of the independent project, and I like how much flexibility we were given with it. I found the added workload a bit stressful, as I couldn't drop anything else in my life to compensate.
The project helped me to understand the subject deeply. But one thing I'm sorry about is that it was easy to understand my subject, but I wish students could see another topic and understand other topics as well. (maybe after submitting the final version?)
I think it was a good exercise. It was fun to see some of the class topics applied.
I really liked the freedom we got when it came to choosing the type of project and the grading scheme.

Phys 347: Fall 2022 independent projects

25 students; **15%** of course grade. In person! (after first two weeks…)

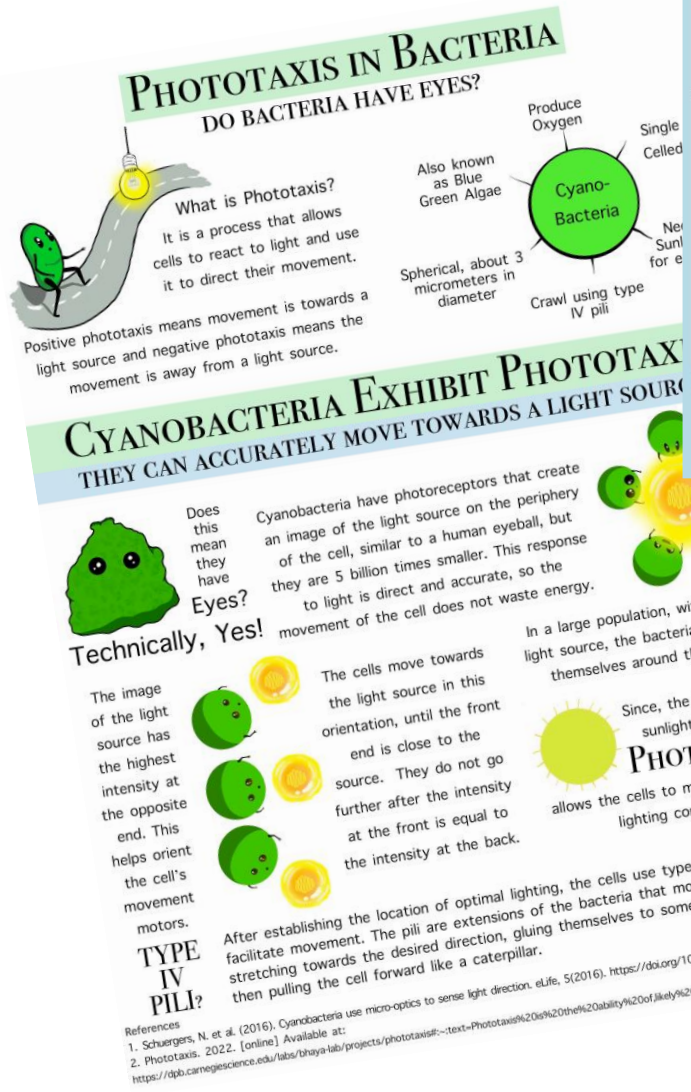
Only slight tweaks:

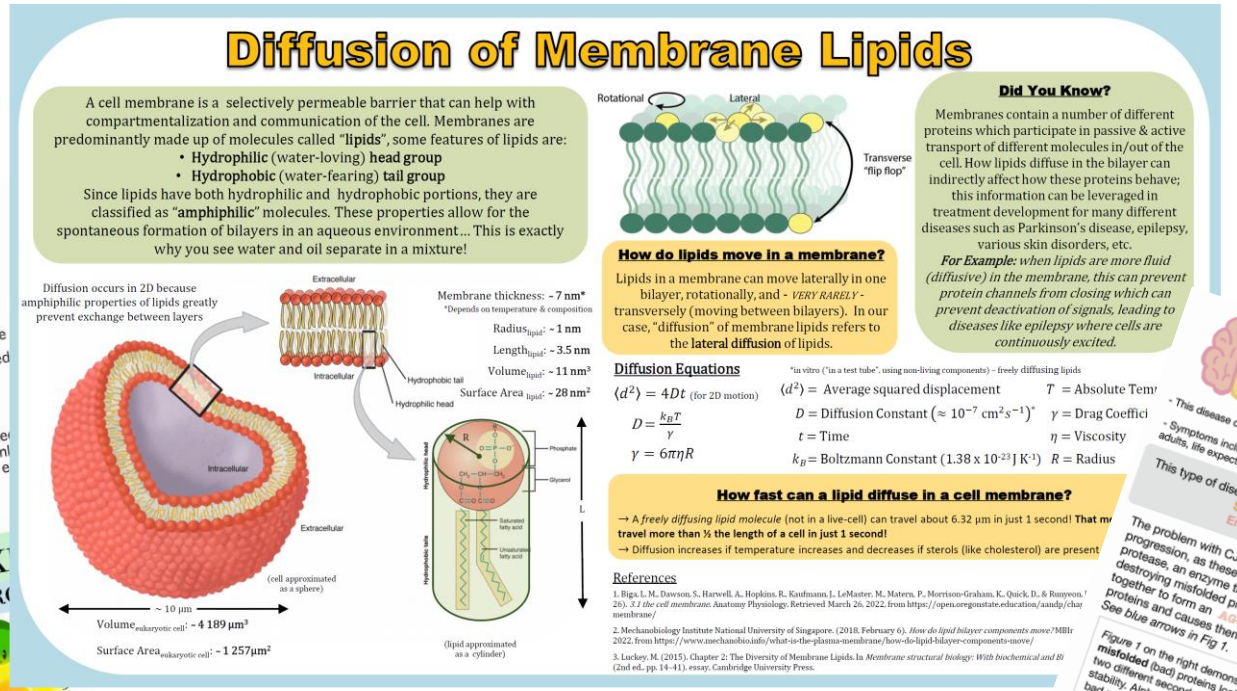
- Slightly less instructor workload
  - Rubrics and a system were in place!
- Slightly earlier deadlines for students
  - Challenging to balance exposure to topics in course with time to work on project

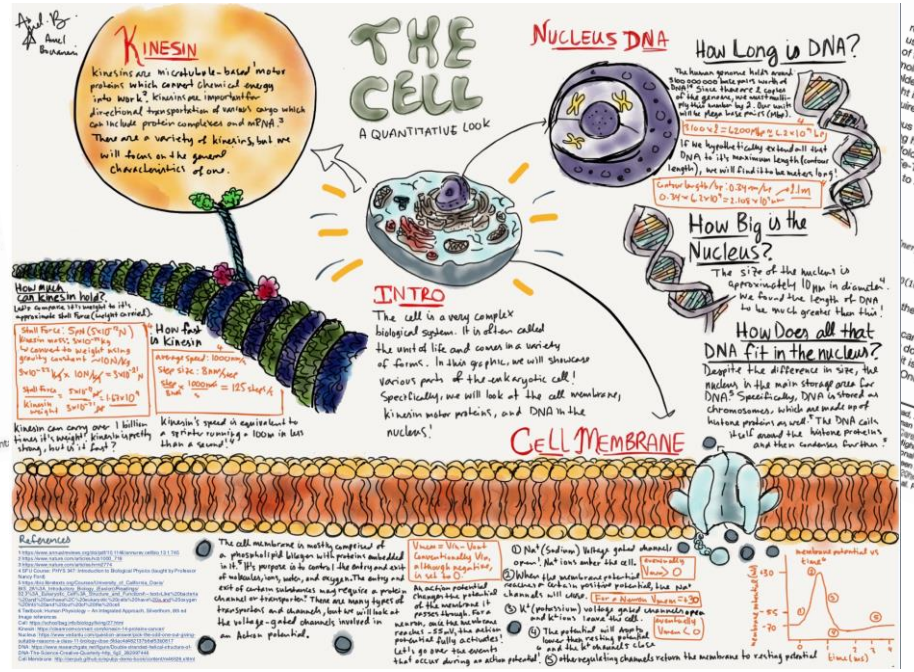
Next time: return to 20% weighting. It is truly an opportunity to demonstrate understanding of a topic.

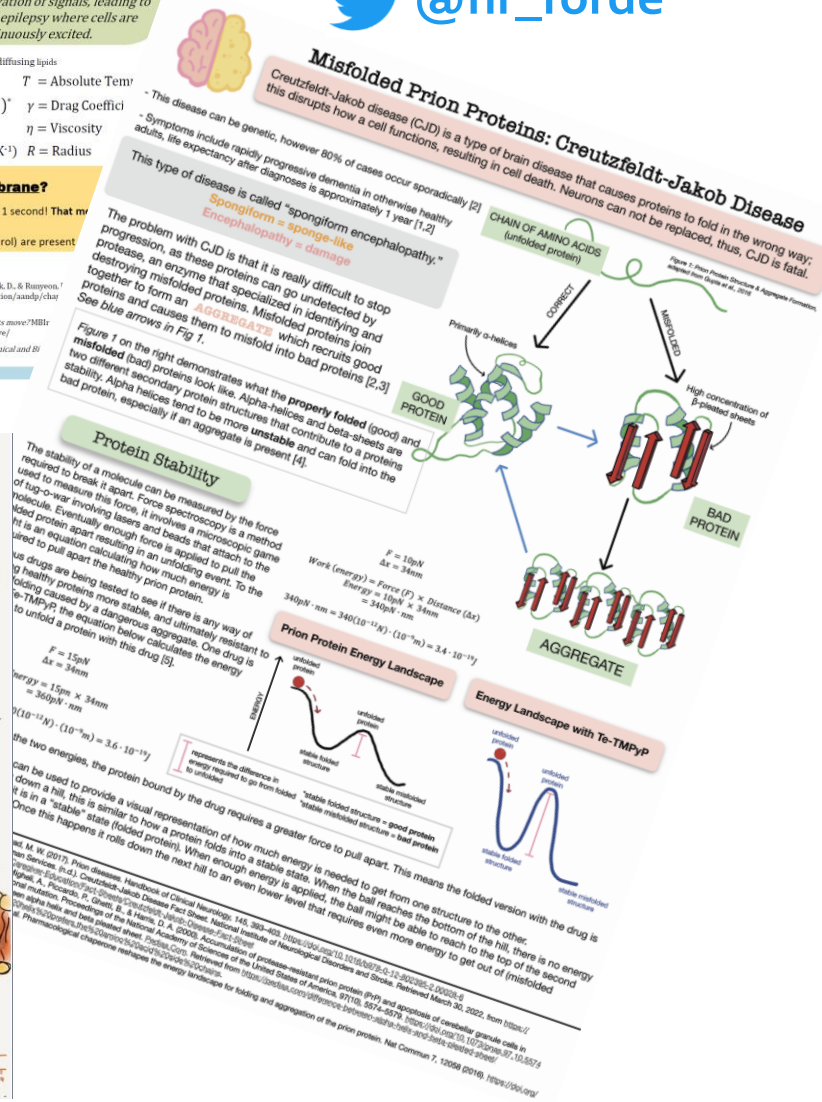
Comments
I loved working on the independent project, I would have liked to see some examples of previous years. However Dr Forde was very helpful in proving feedback and suggestions.
I loved that we had a great amount of freedom (but were somewhat directed) so I could choose a topic that I actually wanted to research! The due date for the project did sneak up on me and I know it did for a few others, mentioning it more in–class time would be awesome (though it is on us to know the due dates)
I really liked how you could choose if wanted take a draft, peer review, etc. I also liked how many options there were, and the topic freedom. The one thing I would change is maybe having us start the project a bit earlier to give more time on it.
I enjoyed the freedom of the project, as well as the many resources to help us get started.
For future offerings it might help to decrease the amount of formats possible. It was quite difficult to decide which format would work best for the project I had in mind. Overall, this project did improve my learning experience during this course.
most topics were not interesting enough
A good assignment to allow the student to learn new thing on their interst
I think that the amount of freedom was nice, allows us to choose a topic we are interested in and present it in a way we feel comfortable doing.
–Initially the freedom was overwhelming but I think it made sense to give lots of options since many students had different backgrounds in science. –Having a bunch of links to articles and papers was helpful to start researching possible topics.
It was a good project for learning more about where the class concepts could be applied.

Example Phys 347 infographics shared with permission from Nav Samra, Emma Lee, Amel Bouanani, Indea D'Aigle









I'd love to hear from you!

nforde@sfu.ca
@nr_forde