Biophysical studies of cell membranes and Research into student learning

Catherine Crouch and Kathleen Howard (Chem)

Catherine Crouch and Ben Geller

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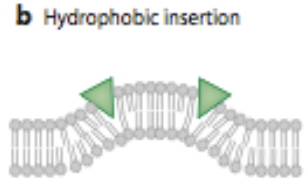
Cell membrane curvature

- Membrane shapes change in many critical cellular processes (such as movement, division)
- How are such changes caused by:
  - Protein structure
  - Membrane structure

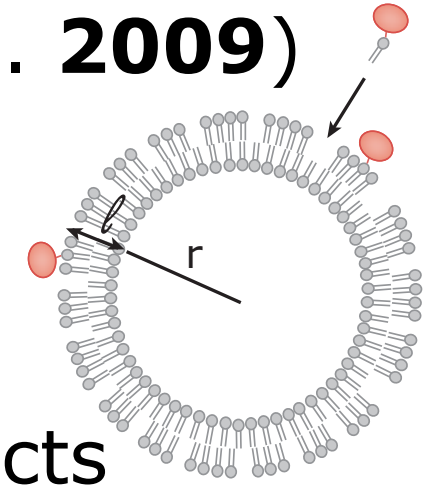
Possible simple mechanism



Proposed mechanism for surface binding proteins

(Bhatia, Stamou, *et al*, EMBO J. **2009**)

- Hydrophobic part wedges into membrane defects
- Higher curvature (bending membrane more) → more defects



Do membrane proteins use this mechanism?

Figures from Baumgart et al (2011), Bhatia et al (2009).

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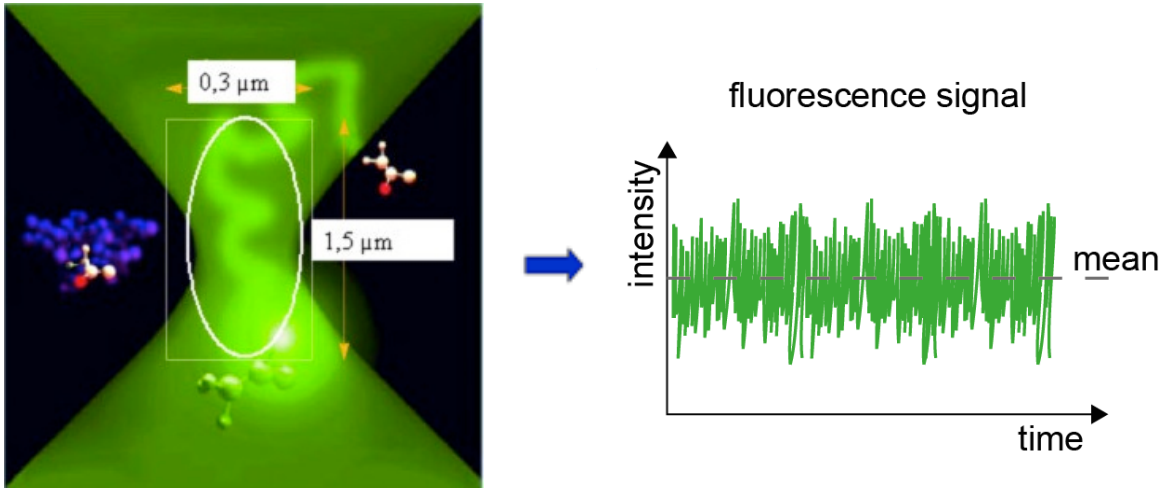
Experiments

- Need to understand and optimize physical properties of simple model system (vesicle with just the membrane protein of interest)
  - Light scattering
  - Fluorescence correlation spectroscopy

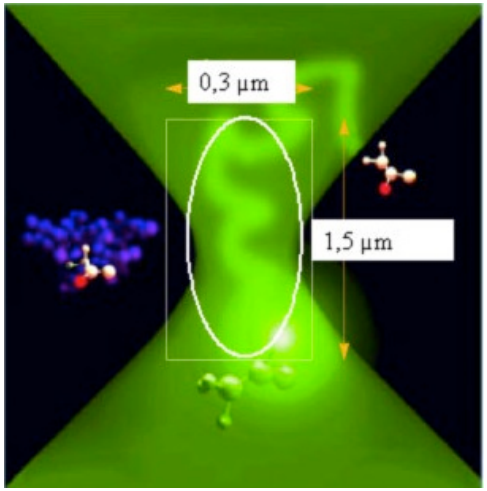
Fluorescence correlation spectroscopy

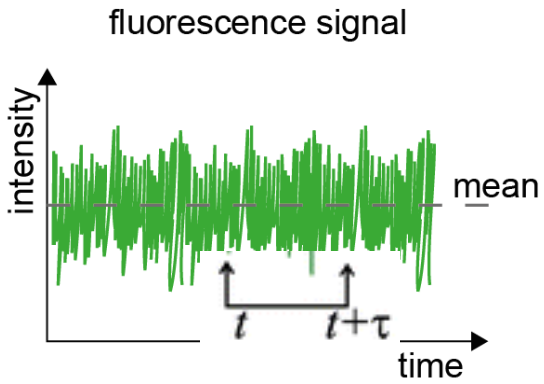
Probes diffusion of single fluorescent objects

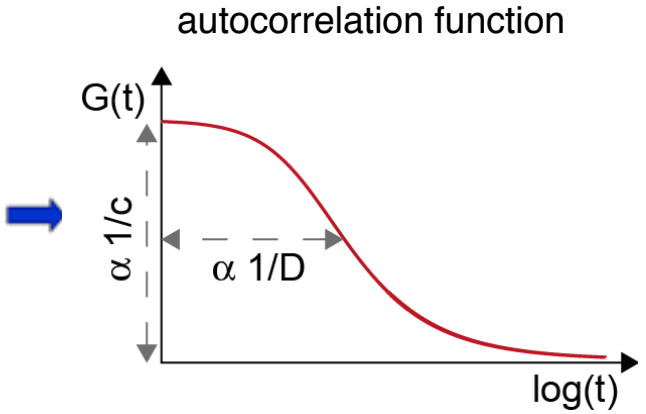


Fluorescence correlation spectroscopy

Probes diffusion of single fluorescent objects







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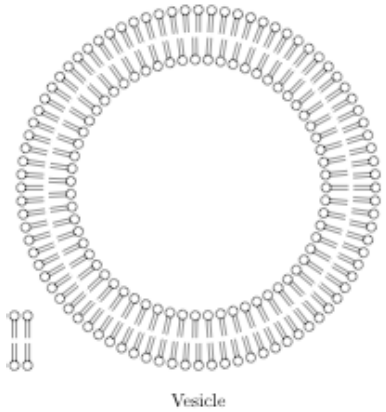
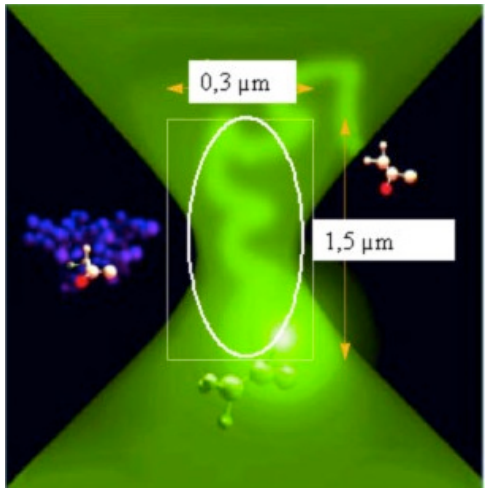
Vesicle dynamics

Can we observe *rotational* diffusion in vesicles with only a few fluorescent molecules?



Involves:

- Bench chemistry preparing vesicles
- Optical experiments
- Data analysis



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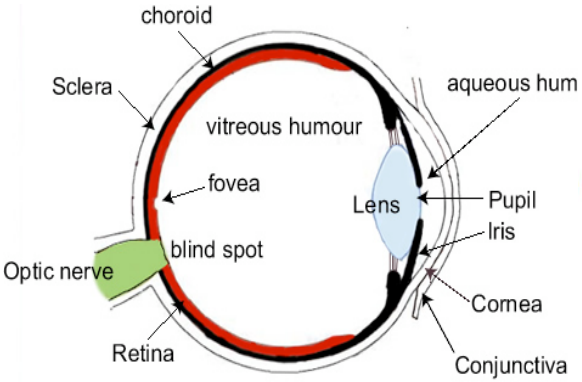
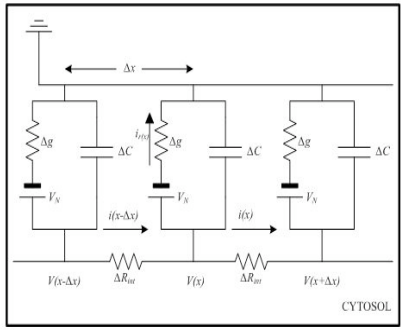
Do life science students use what they learned in physics later on?

Collaboration with Ben Geller, Sara Hiebert Burch (Biology), and colleagues at University of Maryland



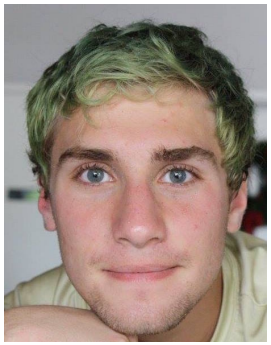


(Phillips, Kondev and Theriot 2009, 668)
Diagram 5 - A circuit of the voltage variation of an action potential

SWARTHMORE

Tessa Williams ‘17

Haley Gerardi ‘17



Max Franklin ‘19

Fai Wisittanawat‘13

Jess Li ‘19

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Research questions

- Do students carry what they learn in physics forward into later biology courses and research?
- What aspects of a physics course support students to do so?

SWARTHMORE

Methodology

- The best PER research combines **quantitative** (statistical) analysis of pre/post survey questions with more **qualitative** analysis (interviews, ethnographic classroom observation, open-ended survey questions)

- There is an opportunity to gain skills that are relevant to both teaching and research

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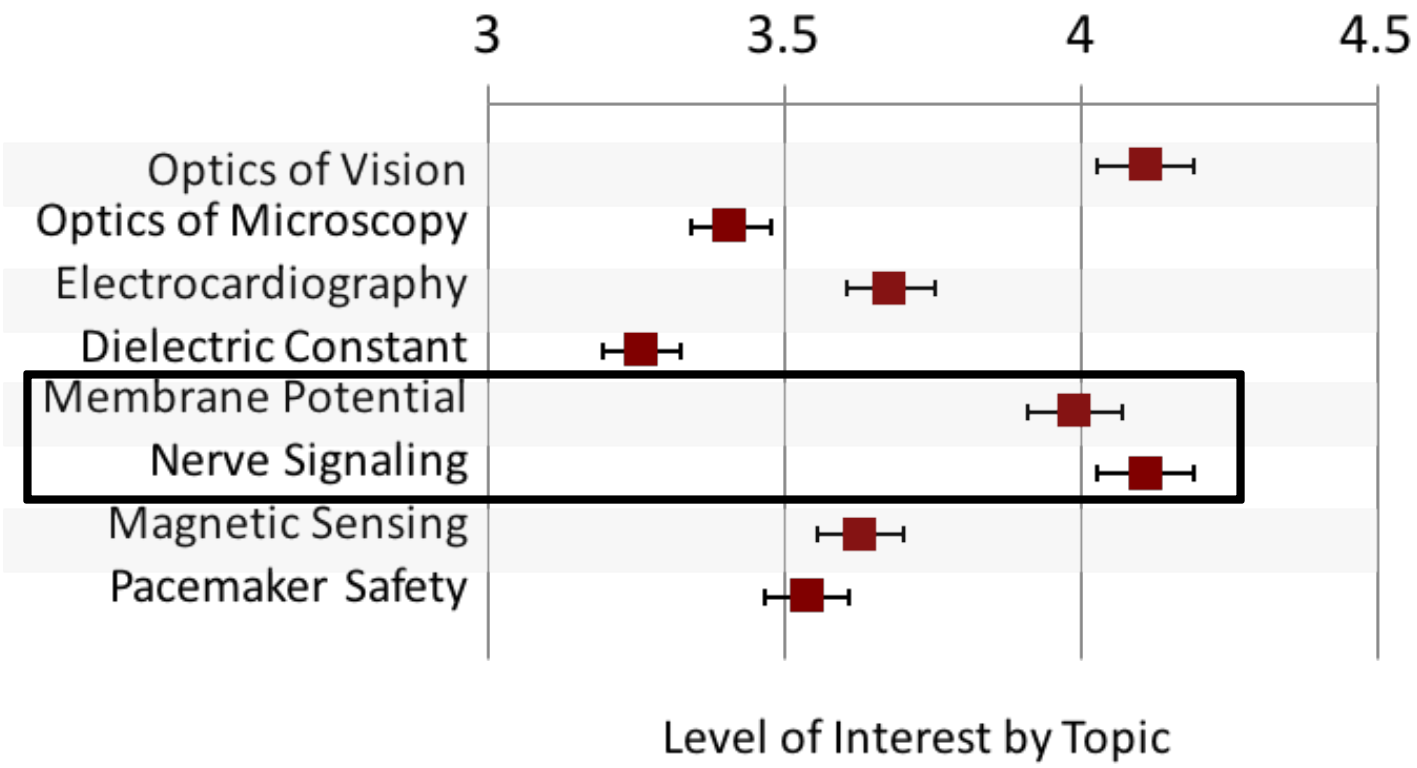
How interested were you in these life science contexts?



Data analyzed over 4 years (2012 - 2015), $N = 194$

Geller et al. (submitted)

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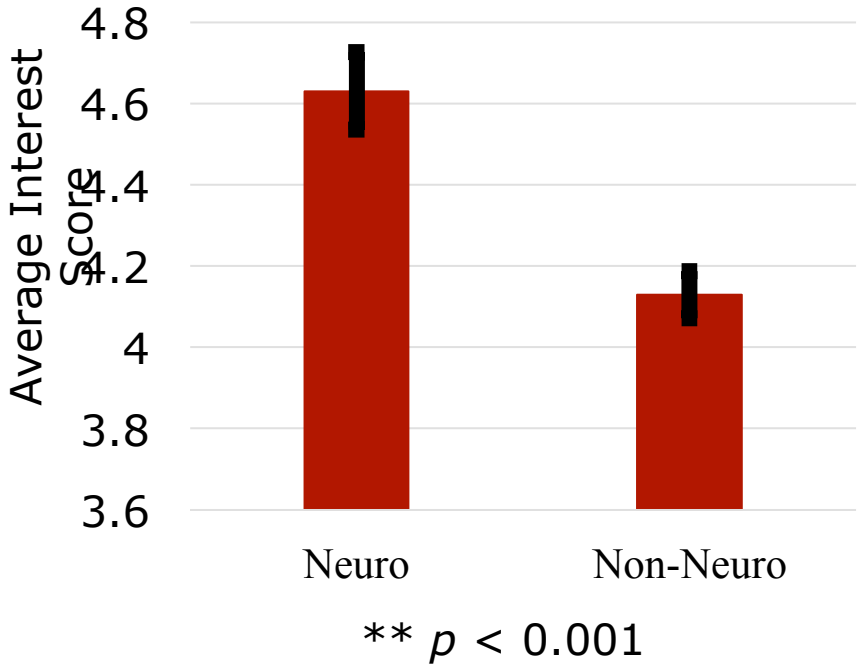
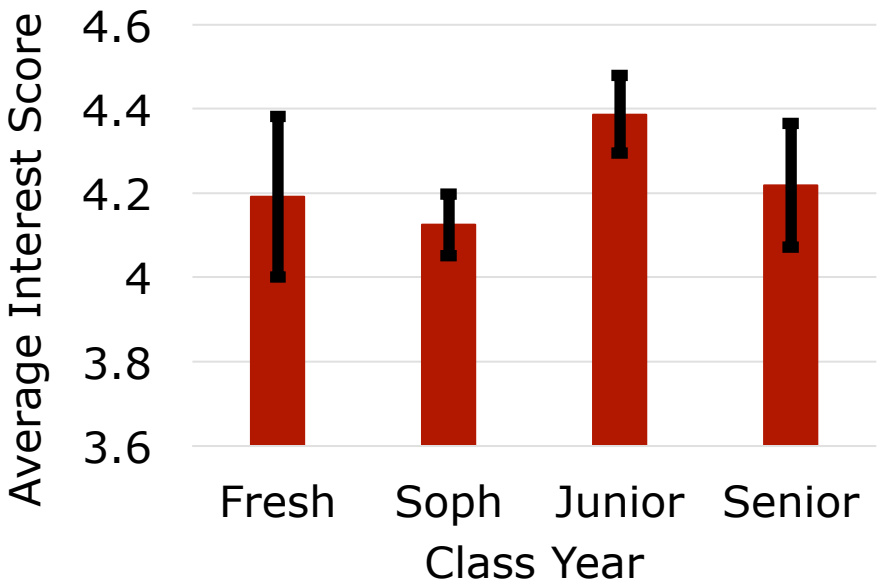
Does interest score depend on prior course experience?

Example 1: Neural Signaling



Prior course experience is not a simple proxy for class year

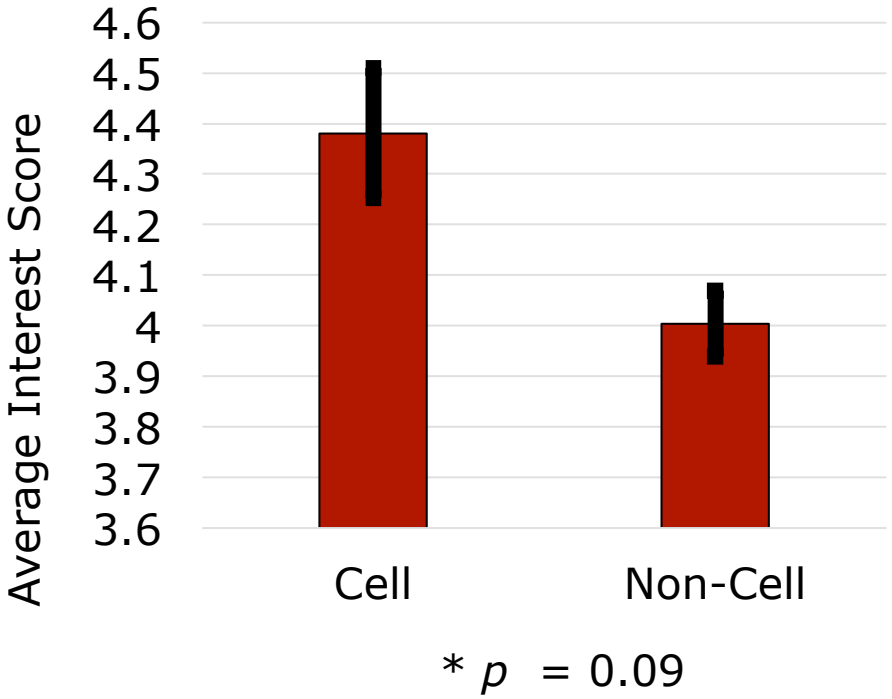


Data analyzed over 6 years (2012 - 2017), N =256

SWARTHMORE

Does interest score depend on prior course experience?

Example 2: Cell Membrane Potential



Prior course experience is again not a simple proxy for class year.

Same ~0.5 point bump is seen for the dielectric constant example among students who have taken biochemistry, where that topic is discussed.

Data analyzed over 6 years (2012 - 2017), N =256

SWARTHMORE

To learn more ....

Ben and I are always happy to talk about these exciting questions!

If you would like to do research with us during Summer 2018, please make an appointment to discuss this further with one or both of us

ccrouch1@swarthmore.edu (SC L39)

bgeller1@swarthmore.edu (SC L38)

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