Enhancing Equity by Enriching Physiology Courses with Active Learning and Low-Stakes Assessments

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MCB 136: Physiology is a gateway course to many STEM and medical career paths

Hundreds of students take MCB 136 each year.

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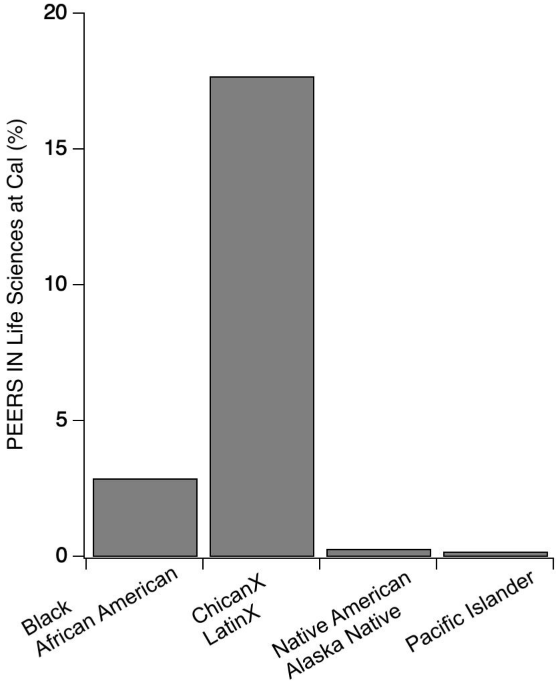
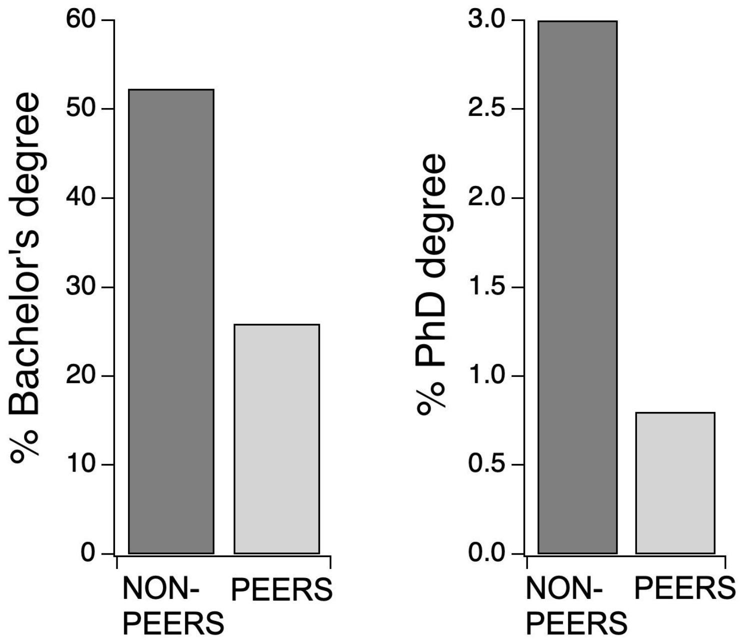


Persons excluded because of their ethnicity or race (PEERs) leave science at higher rates



see: 2019; Asai, 2020

Current STEM teaching methods perpetuate inequities and fail to prepare students for their goals

Opportunity gaps in STEM make it harder for underrepresented and marginalized students to:

- Build **science identity**
- **Succeed academically**
- **Persist** in science careers

see: Carlone and Johnson 2007; NSF 2019; NCSES, 2019; Asai, 2020

Active learning increases classroom achievement, especially for marginalized groups

RESEARCH ARTICLE | PSYCHOLOGICAL AND COGNITIVE SCIENCES | OPEN ACCESS

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman, Sarah L. Eddy, Miles McDonough, +3, and Mary Pat Wenderoth Authors Info & Affiliations

May 12, 2014 | 111 (23) 8410-8415 | https://doi.org/10.1073/pnas.1319030111

RESEARCH ARTICLE | PSYCHOLOGICAL AND COGNITIVE SCIENCES | OPEN ACCESS

Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology engineering, and math

Elli J. Theobald, Mariah J. Hill, Elisa Tran, +29, and Scott Freeman Authors Info & Affiliations

March 9, 2020 | 117 (12) 6476-6483 | https://doi.org/10.1073/pnas.1916903117

The potential to **reduce educational inequality** through pedagogical change motivates our redesign

Our redesign adds structure, modifies assessments, and focuses in-class time on student engagement

Before:

Most in-class time is instructor speaking

Focus on facts, recall

Most assessment in the form of high-stakes exams

Learning goals are implied

After:

Substantial student participation in class

Facts + process of science

Frequent opportunities for low-stakes assessment

Learning goals are explicit

Some of these changes were piloted in Fall 2021

Goals for Pilot:

1. Implement active learning in ~10% of lectures

2. Redesign grading policy with more frequent, low-stakes assessments (⅓ of total grade)

3. Assess effectiveness of our interventions

Low-stakes assessments

Entry/exit ticket

- 2-min quiz covering a key concept covered in pre-course materials & in-class materials
- Same quiz is given at the beginning & end of class
- Answer released at the end of class (real-time feedback)
- Allows students to track their learning gains

Lecture 10 quiz: *"Sensory transduction is defined as…"*

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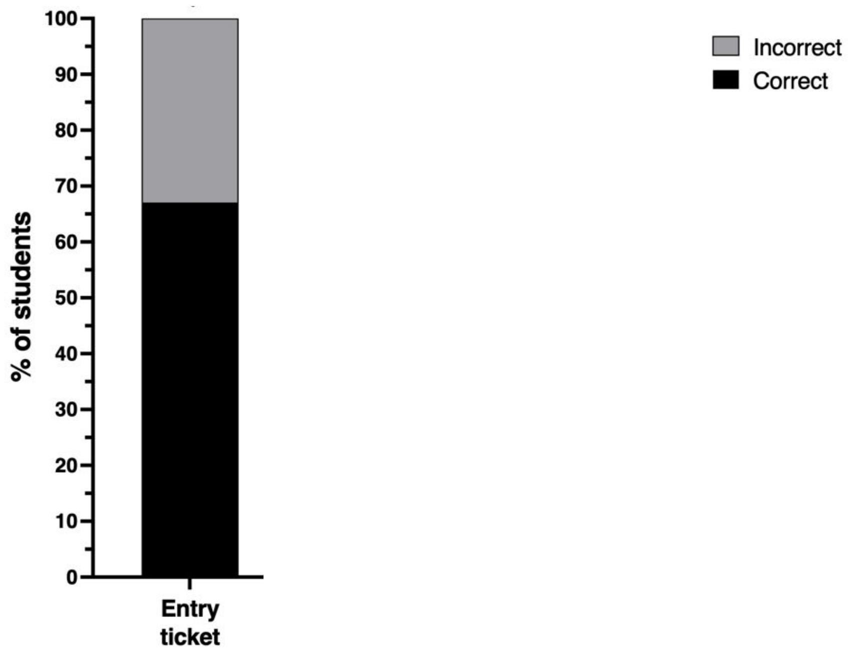

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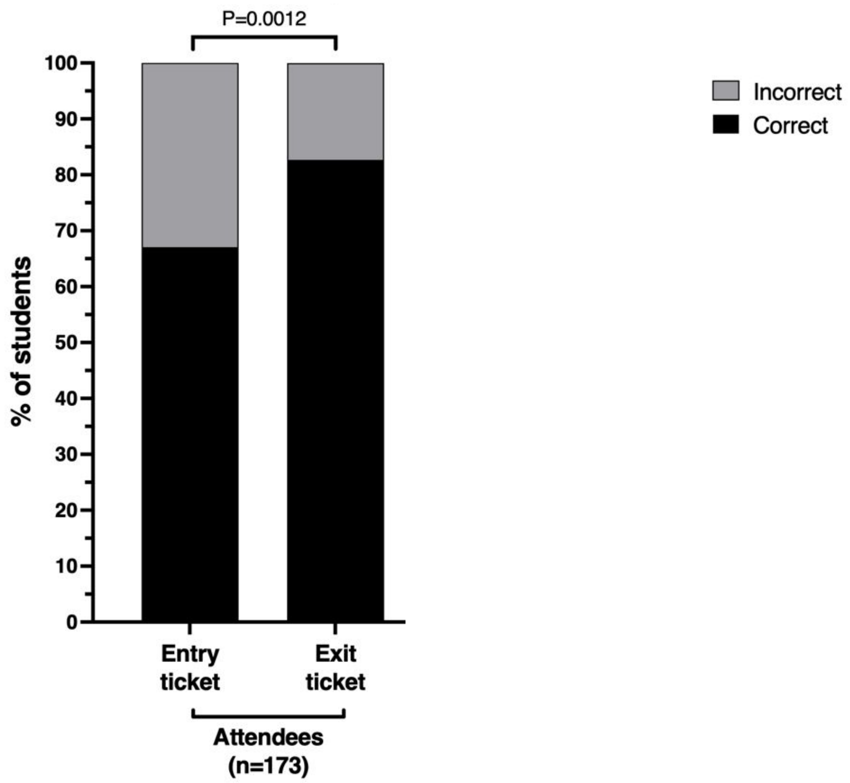

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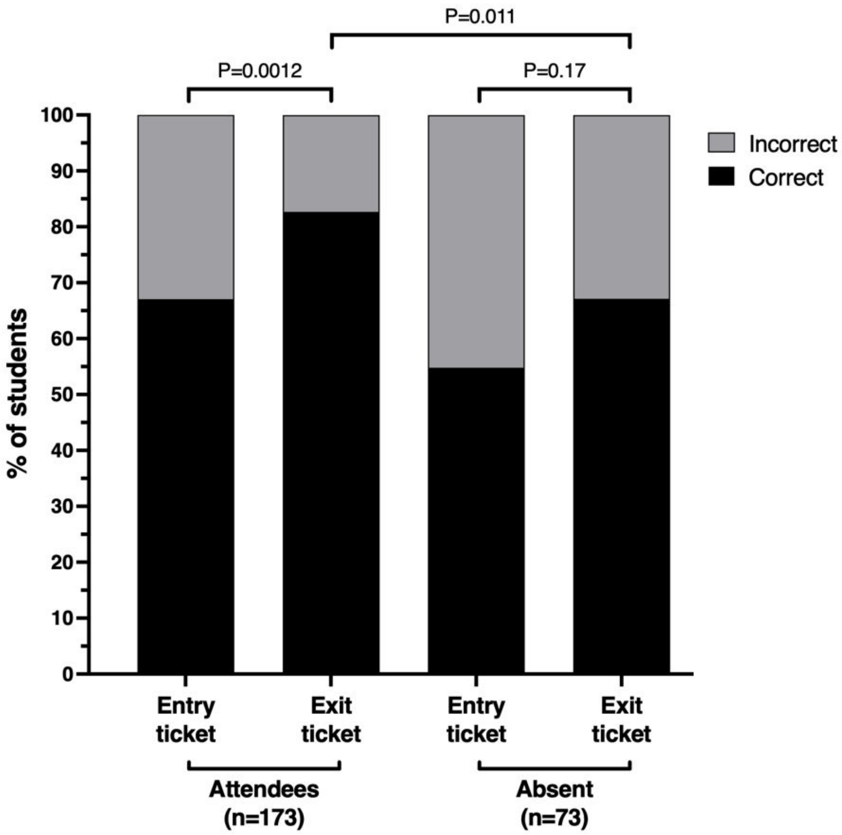
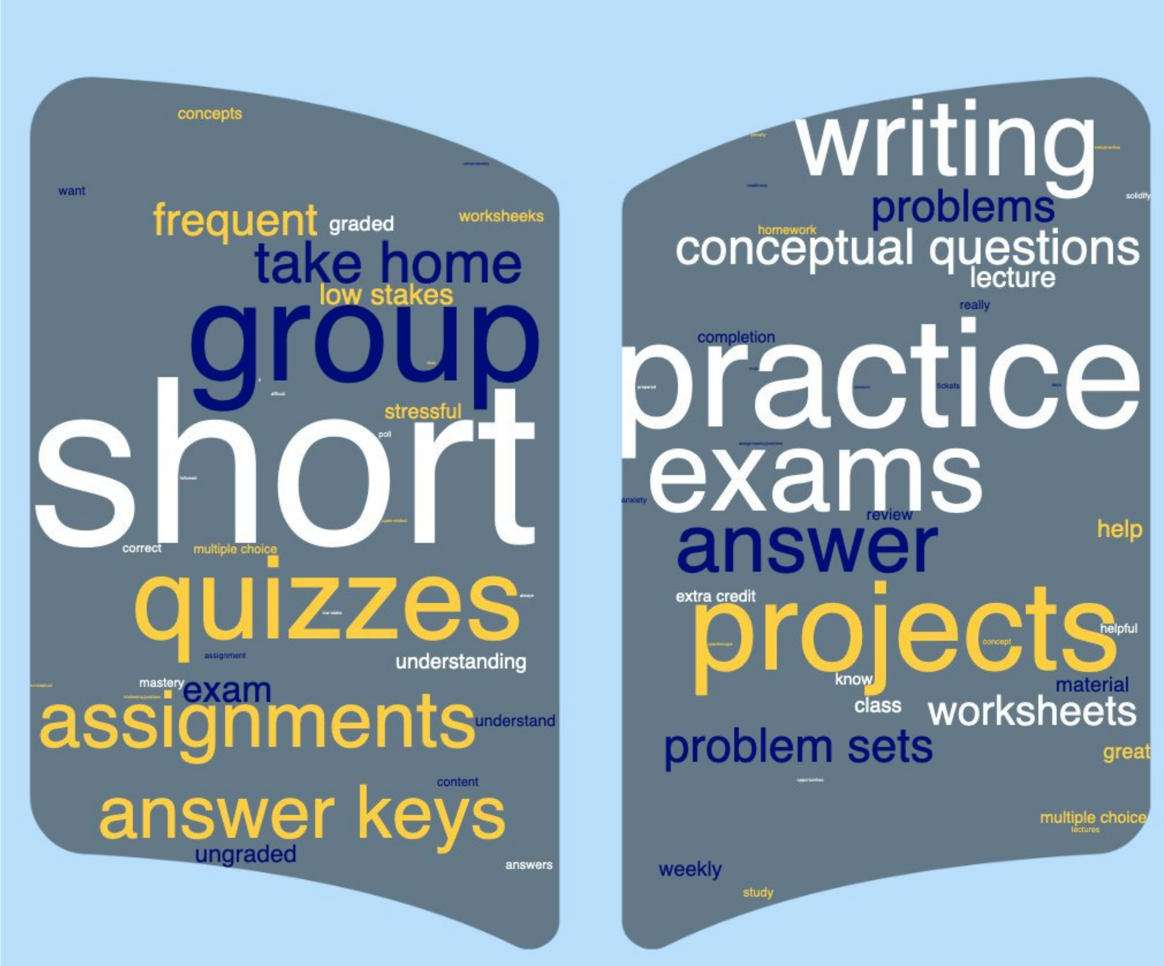


Mid-course survey

What type of assignments best allow you to assess your learning?



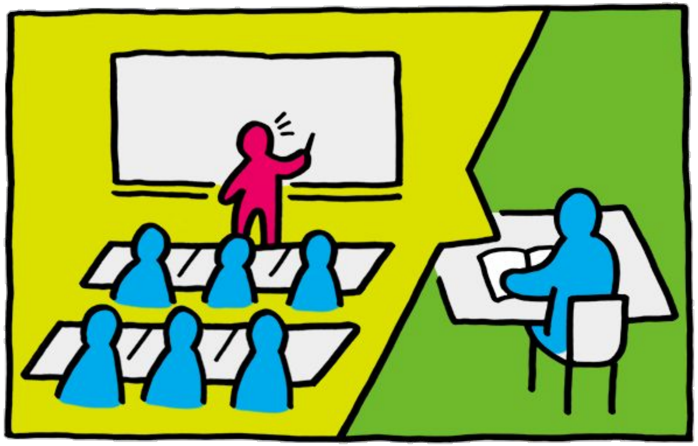
Lessons Learned from our Pilot

- Active learning exercises should **focus on the scientific process rather than memorization**.
- Students should **work through problems together** in class.
- **Consistent structure** is needed to anchor active learning exercises and reduce anxiety.
- **Low-stakes assessments with rapid feedback** promotes engagement & learning.
- **Mid-semester instructional assessments** (*e.g.*, surveys) are effective for gaining student buy-in and instituting course corrections

We are preparing comprehensive changes for Fall ‘22

The **Traditional** Model

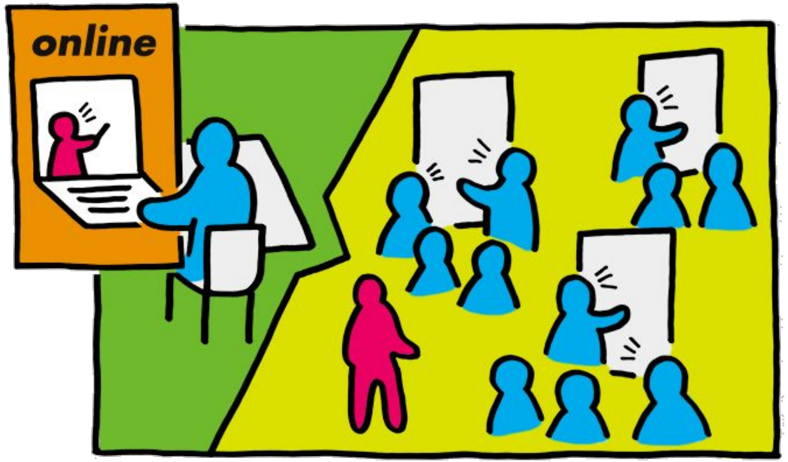
Knowledge **Acquisition**



Knowledge **Construction**

The **Flipped** Model

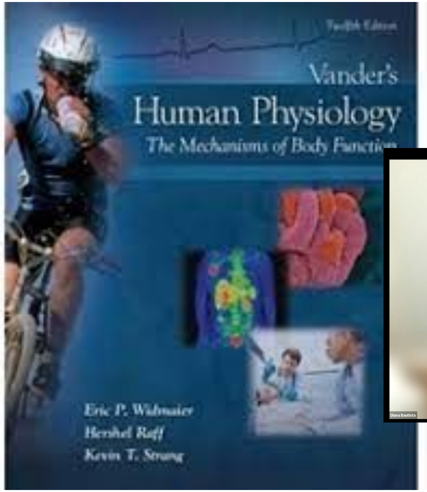
Knowledge **Acquisition**



Knowledge **Construction**

Knowledge acquisition of basic content will be done through guided pre-class readings/videos

Textbook



Lecture video

Guided Reading Questions

Reading: Vander's Human Physiology Chapter 4, "Movement of Molecules Across Cell Membranes" sections 4.1-4.3 (p. 97-110)

Membrane potential is ____

and is measured in _____ units.

The chemical and electrical differences across the membrane are two driving forces that together make up the ____________________ gradient

How would each of the following factors affect the flux of a positive ion into the cell?

- ↑ concentration on the ion outside the cell = ___________ (↑ or ↓) flux
- ↑ membrane ion channels for that ion = ___________ (↑ or ↓) flux
- ↑ area of the membrane = ___________ (↑ or ↓) flux

Lecture activities are structured to achieve explicit learning objectives

Each lecture has a slide with the day's learning objectives

Students track objectives as they are checked off

By the end of today you should be able to...

- ✅ Predict the way(s) a molecule/ion can pass through a lipid bilayer based on its chemical properties
- ✅ Categorize the different types of membrane transport in terms of their energy requirements, additional molecules involved, and direction of transport relative to an electrochemical gradient
- ✅ Compare the effects of different solutes on the osmolarity of a solution
- ✅ Describe the molecular features of the potassium channel that enable selective permeability to K+ only

Students test their knowledge of basic but essential concepts/facts covered in pre-class work

On your own:

Which of these molecules diffuse through the lipid bilayer?

1. Water
2. Amino acids
3. Lipids
4. Steroids
5. Na^+

Activities model how to organize related information

As we discuss the different types of membrane transport, fill out this chart

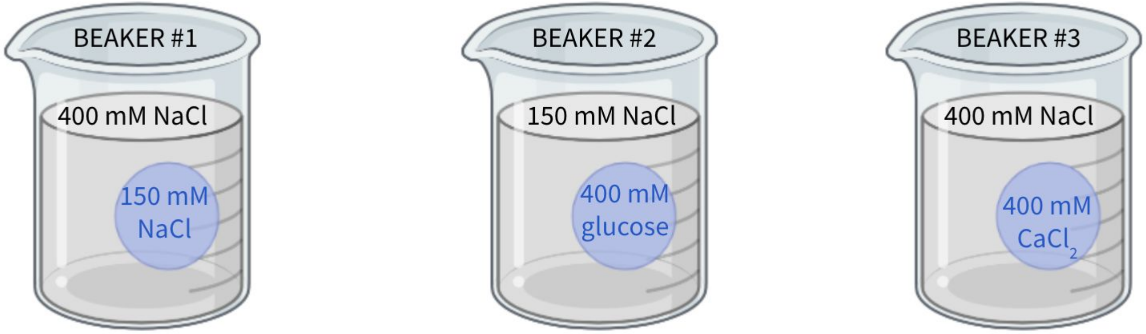
Type of transport	Energy source required?	Other molecules	Direction relative to EC gradient	Example
Simple diffusion				
Facilitated diffusion				
1° active transport				
2° active transport				

Students practice questions of comparable complexity and difficulty to graded assessments

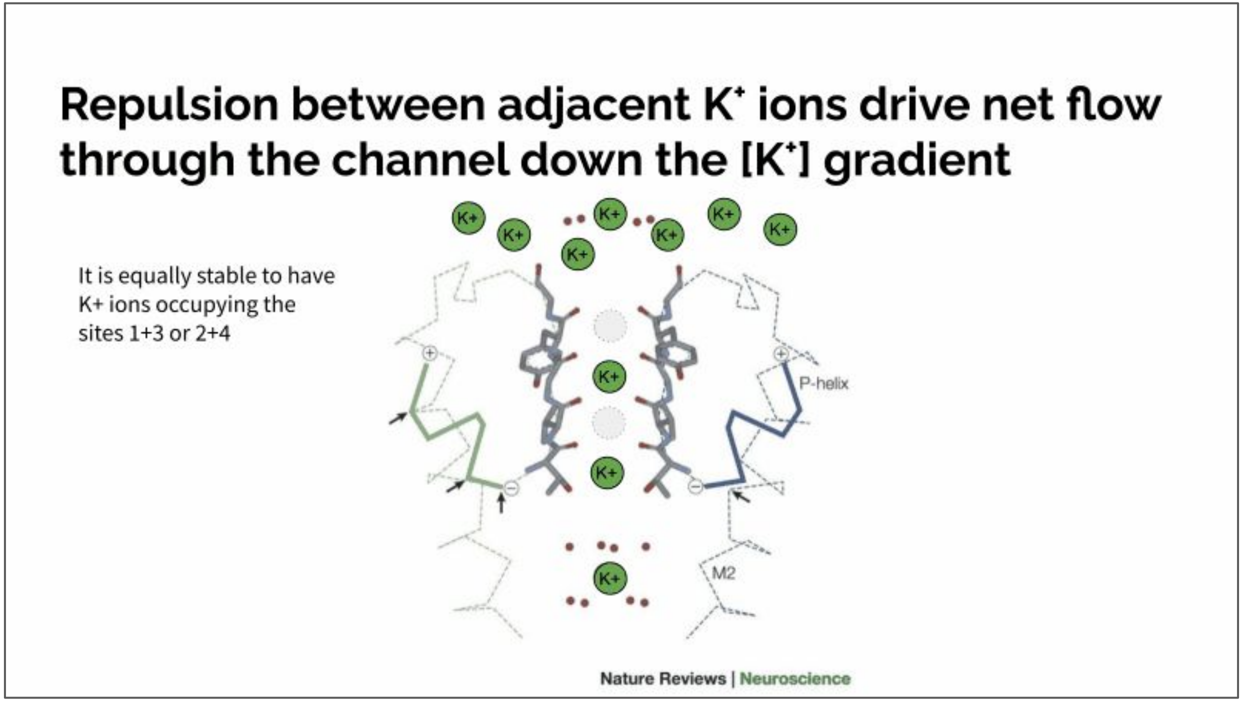
Practice problem:

Below are pictures of 3 beakers filled with three different solutions and each with a bag of a given solution in it. The bag is only permeable to water.

Over time, the bag in which beaker will swell and burst first?



Instructors spend extra time on difficult material



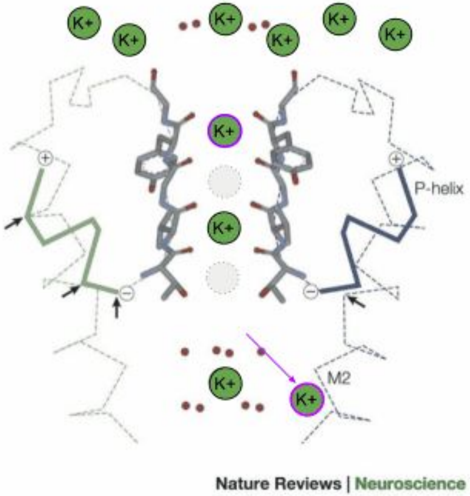
Students reflect on course-wide themes

Repulsion between adjacent K^+ ions drive net flow through the channel down the $[K^+]$ gradient

It is equally stable to have K+ ions occupying the sites 1+3 or 2+4

K+ ions are more likely to enter from the side with a higher concentration

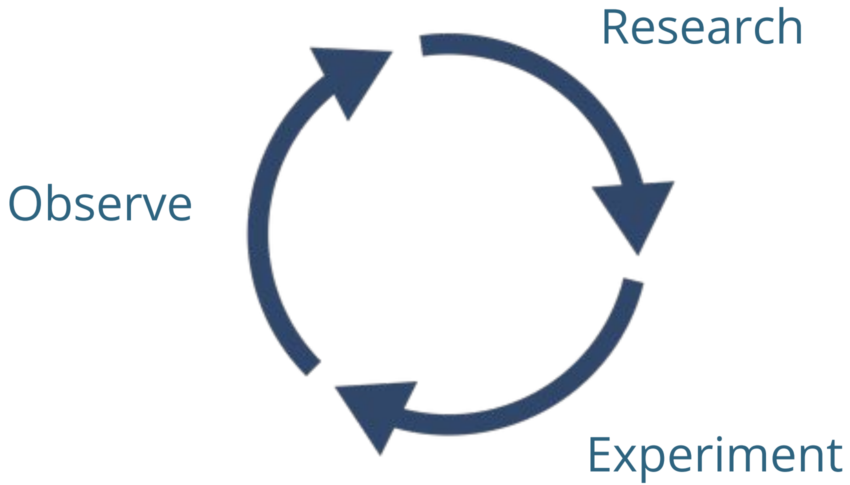
The net result is more movement of K+ to the less concentrated side



Discuss with a neighbor:

How do selective ion channels demonstrate the general physiological principle that "structure dictates function?"

Our curriculum redesign mirrors the iterative scientific process we are teaching our students



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