- **Theme Music:** John Williams, *March of the Resistance* (from *The Force Awakens*)

- **Cartoon:** Randall Munroe, *xkcd*
Today

■ Going over the exam
■ Nernst potential
■ Electric current
- $\rho \sim e^{-r/\lambda}$
- This is like temperature in the Boltzmann distribution
- B is spread out over a larger length.
Exam 1, Question 1.2

\[ z = e^{-\varepsilon/k_B T} \]

\[ \frac{E_2}{E_0} = e^{-2\varepsilon/k_B T} = z^2 \]
I don’t know!

(But if it starts out at a low $T$ where almost all molecules are in the ground state, it increases so $A$ was also accepted.)
Exam 1, Question 1.4

- Decreases
Exam 1, Question 1.5

\[
\frac{1}{1 + z + z^2 + z^3}
\]
Exam 1, Question 2A.1

- $[k_C] = ML^3/T^2Q^2$
- $[E] = ML/T^2Q$
Exam 1, Question 2A.2

$n = 1$
Exam 1, Question 2B

$V_a = V_b > V_c > V_d$
Exam 1, Question 2C
Exam 1, Question 3

- (Example:)
- \( V_{\text{liver}} = (20 \, \text{cm})(10 \, \text{cm})(5 \, \text{cm}) \)
- \( = 1000 \, \text{cm}^3 = 1000 \, \text{mL} = 1 \, \text{L} \)
- \( = 10 \, \text{dL} \)
- Dosage = \( (3 \, \mu\text{g/dL})(10 \, \text{dL}) \)
- \( = 30 \, \mu\text{g} \)
Exam 1, Question 4
"The Big Square"

- **F** vector acting on an object
- **U** scalar for a system
- **E** vector at a point
- **V** scalar at a point

**Equations**

\[ \Delta U = -F \Delta x \]
\[ F = -\frac{\Delta U}{\Delta x} \]
\[ \Delta V = q \Delta V \]
\[ \Delta V = \frac{\Delta U}{q} \]
\[ F = qE \]
\[ E = \frac{F}{q} \]
\[ \Delta E = -E \Delta x \]
\[ E = -\frac{\Delta E}{\Delta x} \]
Exam 1, Question 5A

- Only 1 way to do it (filling up all 8 spots)
- \( W = 1 \)
- \( S = k_B \ln 1 = 0 \)
Exam 1, Question 5B1

\[ W_A = \frac{(8 \cdot 7 \cdot 6 \cdot 5 \cdot 4 \cdot 3)}{6!} = 28 \]
\[ W_B = \frac{(8 \cdot 7)}{2!} = 28 \]
\[ S_A = S_B = k_B \ln 28 \]
Exam 1, Question 5B2

\[ W_{AB} = W_A W_B = 28^2 = 784 \]
\[ S_{AB} = 2 \, k_B \ln 28 \]
Exam 1, Question 5C

- Both larger
- Spread out more evenly
  = More entropy
Exam 1, Question 5D

- Microstate = I
- Macrostate = B,C
Nernst potential

- Remember diffusion
- There is a net flow from high to low concentration

10 mM NaCl

5 mM NaCl
Nernst potential

- What if the membrane is permeable to some ions and not others?
- Then there is a net flow of charge
- Let’s say it’s permeable to Na\(^+\) but not Cl\(^-\)
Nernst potential

- Now there’s a potential difference!
- And an electric field!
- The electric field opposes the flow of charge, so the system reaches equilibrium

10 mM NaCl
5 mM NaCl
Nernst potential

- Once again, it’s energy vs. entropy!
- Effect of energy (forces):
  - Responding to electric field
- Effect of entropy (random motion):
  - Diffusion from high to low concentration
Nernst potential

- We can find the potential using the Boltzmann distribution
- \( \frac{c_1}{c_2} = e^{\frac{\Delta U}{k_B T} - \frac{q \Delta V}{k_B T}} \)
- \( -q \frac{\Delta V}{k_B T} = \ln \frac{c_1}{c_2} \)
- \( \Delta V = k_B T \frac{\Delta U}{q} \ln \frac{c_1}{c_2} \)