Biophysics:
Diffusion through Biological Tissue

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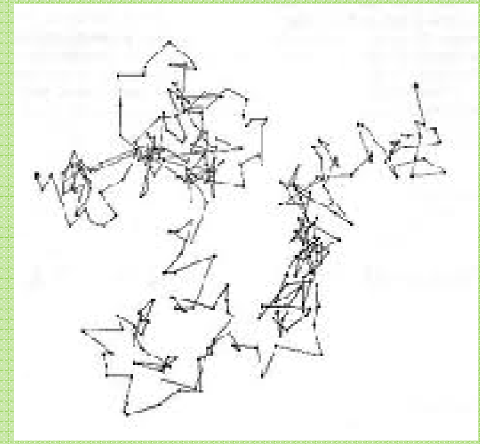
Diffusion

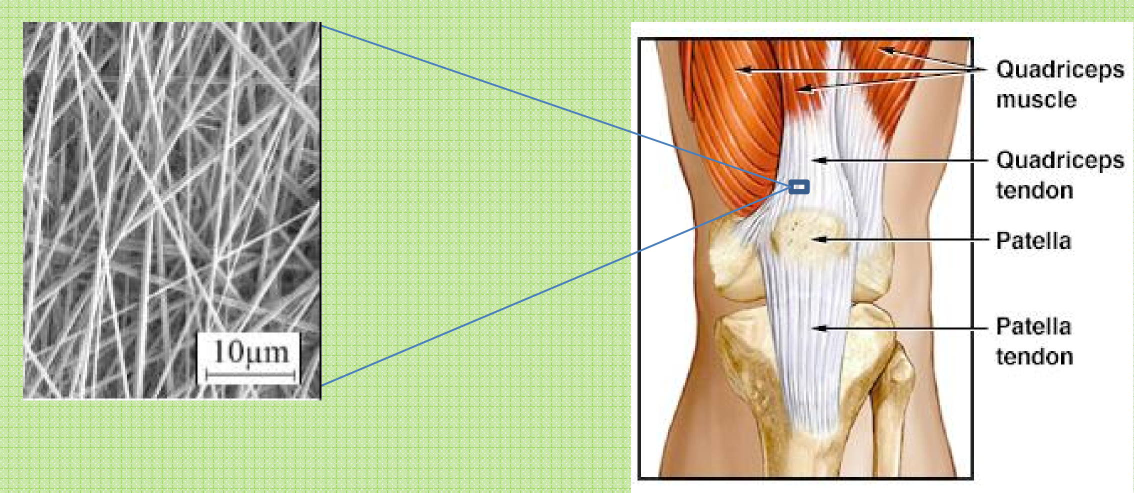
- What is it?
  – The net movement of particles from an area of high concentration to an area of low concentration.

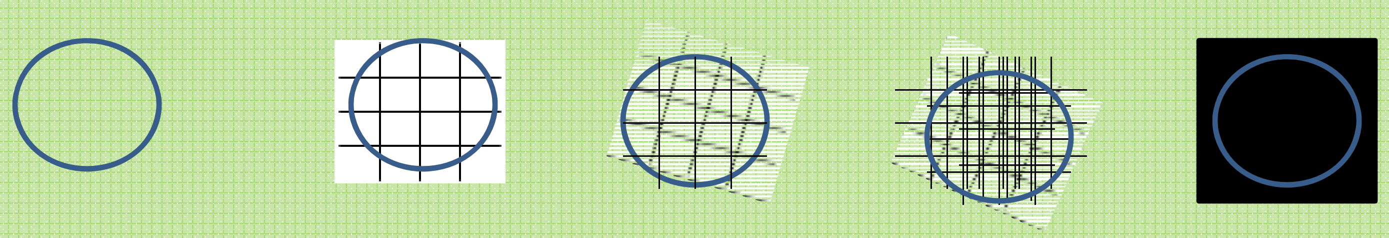
  – Constant random motion:
    - Brownian motion
    - "Random Walk"



Why study it?

- Diffusion is well defined for simple systems.
- There is a lot to be learned about more complex systems.



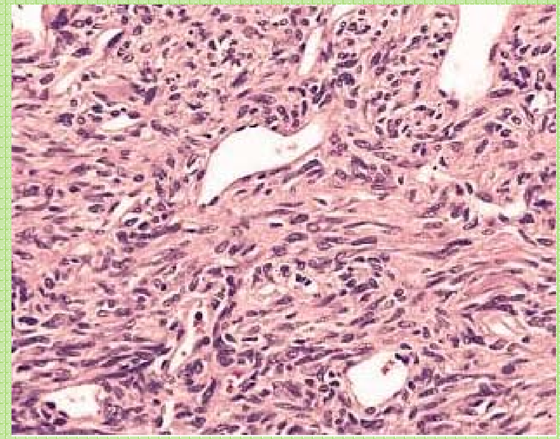


Research Applications

- Understanding of the transport properties of a cell
  - Perception of a cell:
    - Water sack with stuff floating around inside
    - Not true
    - By studying diffusion we can gain a better knowledge of the true characteristics of cells

Research Applications

- Cancer treatment
  - Nanoparticles are becoming a hot bed of research.
    - Supposed better drug transportation and targeting.

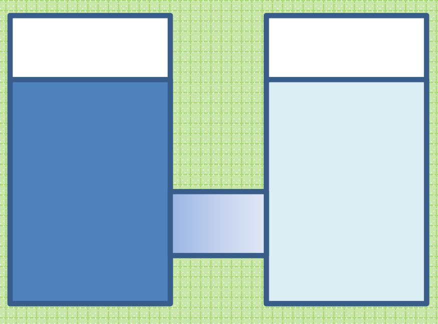


Experiment

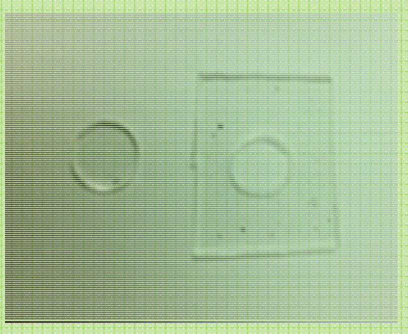
- Cell Design needs:
  - Two connected chambers.
    - High concentration and low concentration
  - Ability to hold a sample between the chambers
  - Interchangeability
  - Way to measure the concentration changes.

Cell:

- Two connected chambers



- Holding a sample/interchangeability
  - Compress a plug of a sample between the cells

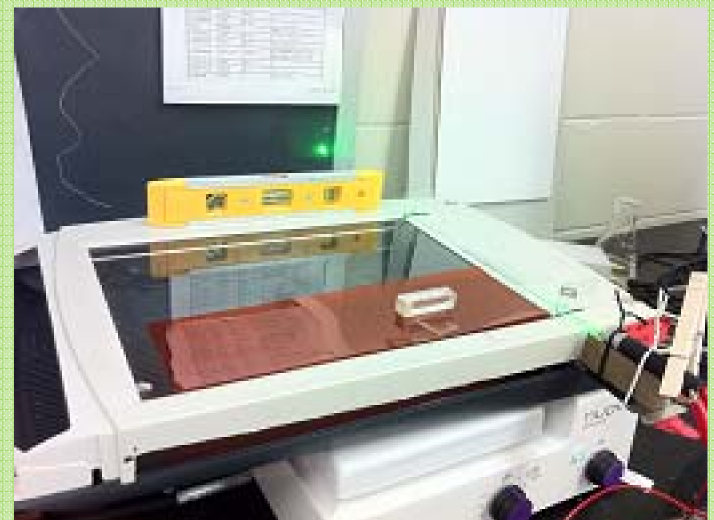


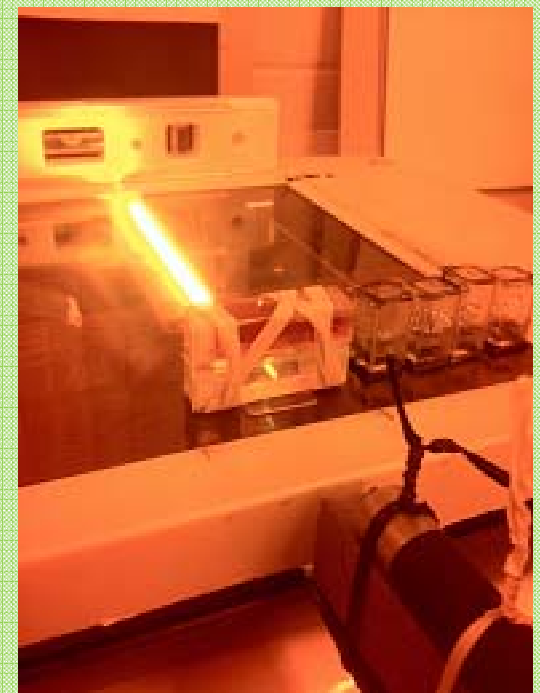
Making Measurements

- Needed a way to measure concentration changes without disturbing the system.
  - Use fluorescing dyes

    - Rhodamine and other fluorophores can easily be detected and can be used to tag other larger molecules

- System works on our nifty scanner:





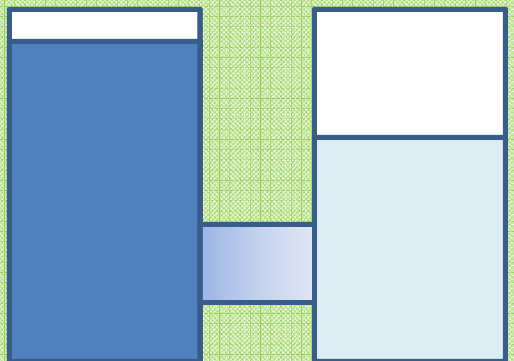
Problem

- After all the simple problems (leaking, etc) appeared to be solved in the system, the experiments were still not acing like they should.
- There was consistently a bulk amount of dye entering the system early in the experiment.

Problem

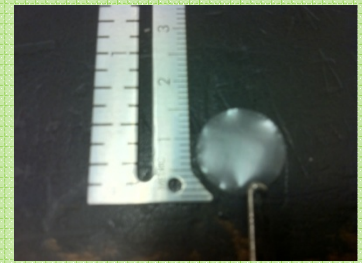
- Inherent problem in diffusion measurements:
  - Diffusion is a very slow process that is often drowned out by convection currents and other forces

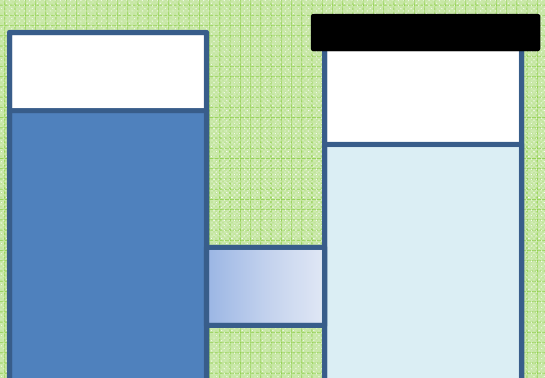
Problem Solving



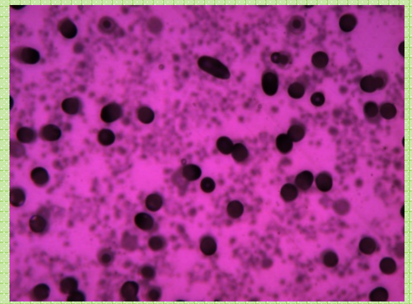
Hydraulic Pressure

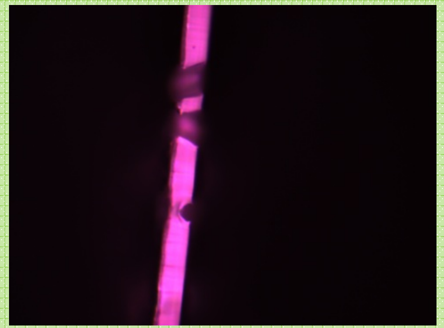
-Let it sit and added membranes to both ends of the “tunnel” to hopefully stop these convection currents



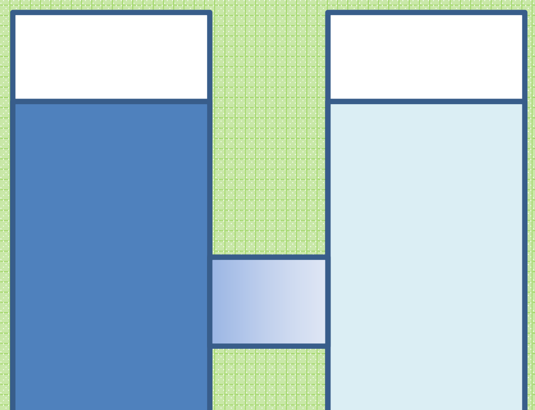


Capping

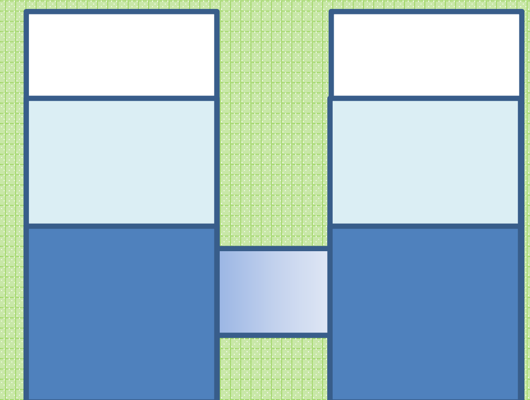




Problem Solving



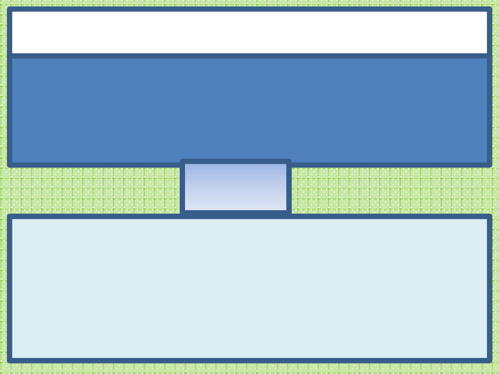
Density Effects

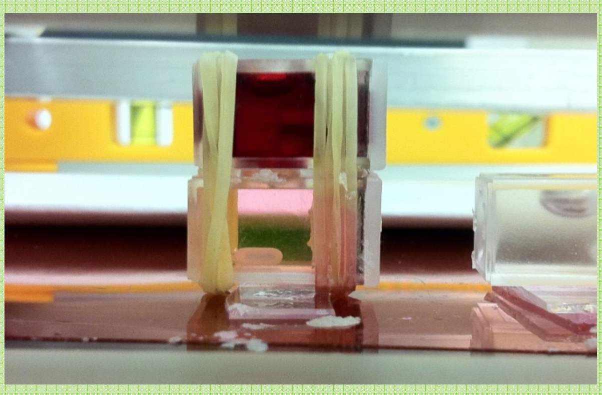


Lowest energy state

Need to change our approach

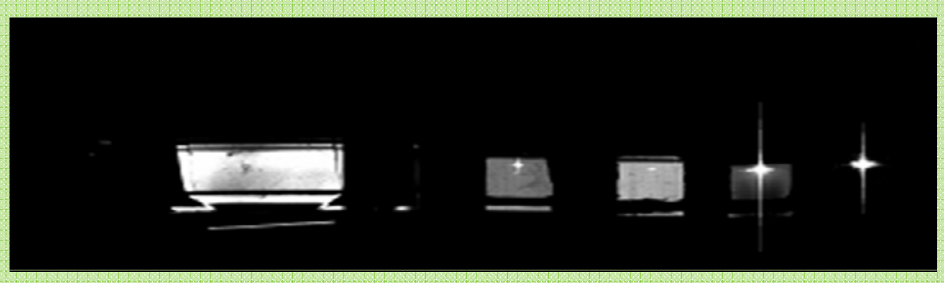
System 2.0





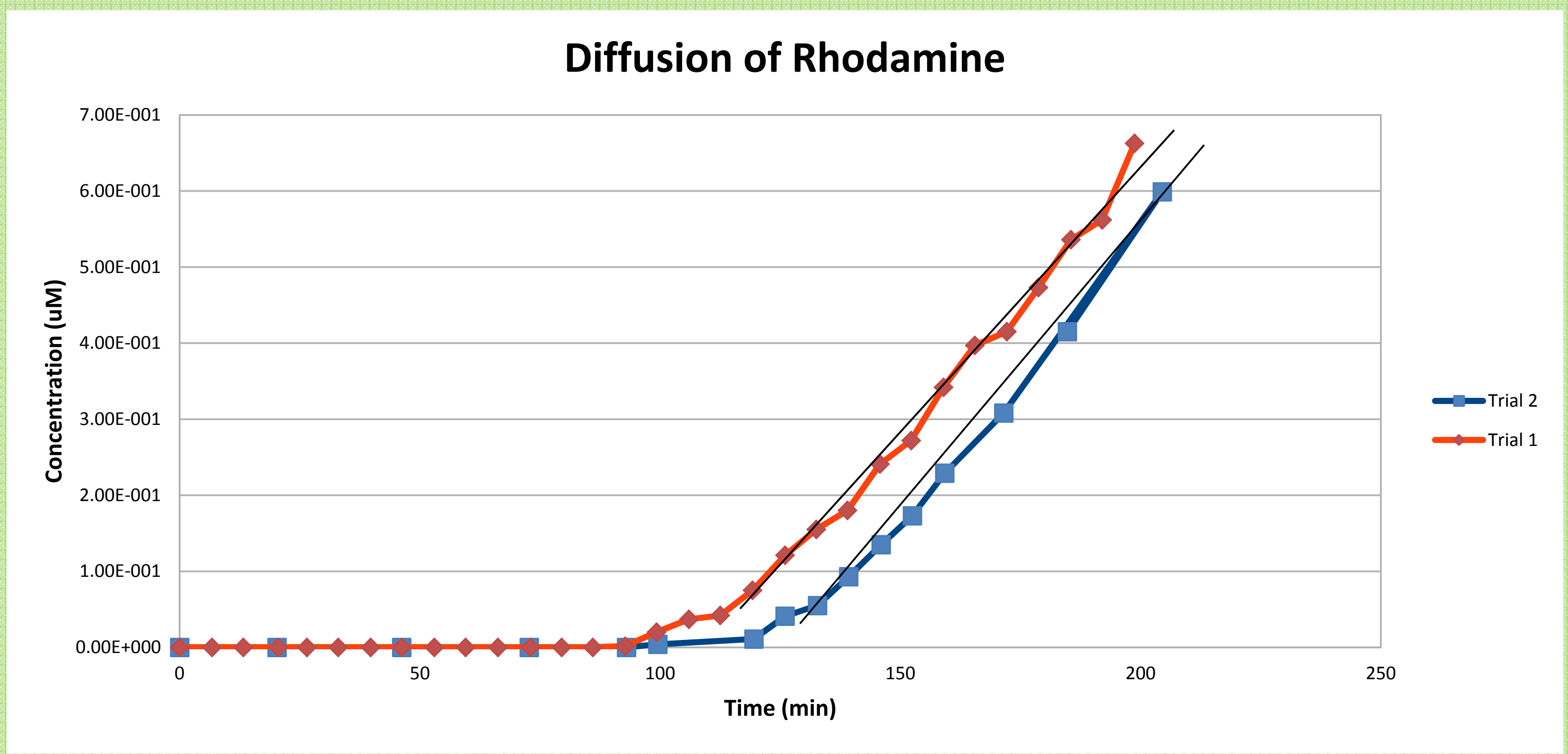
Density issues?

- Solved by making the bottom solution more dense than the dye



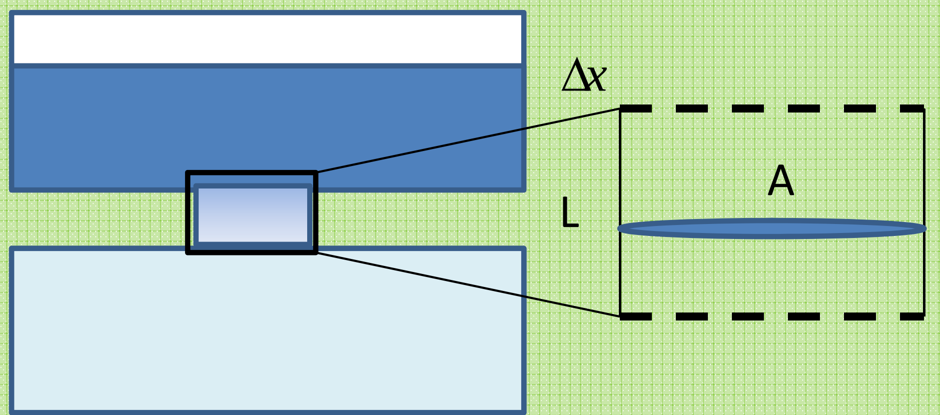
YAYYY!!!

DATA!



Rate of change (slope):
trial 1: .43uM/hr
trial 2: .41uM/hr

Steady State Model



$$\frac{\partial n}{\partial t} = fAD\frac{C_h - C_i}{\Delta x}$$

$$\frac{\partial n}{\partial t} = AD\frac{C_i - C_e}{L}$$

$$\frac{\partial n}{\partial t} = fAD\frac{C_i - 0}{\Delta x}$$

$$\frac{\partial C}{\partial t} = \frac{DAC_0}{VL}\left(\frac{1}{1+\frac{2\Delta x}{Lf}}\right)$$

- This gives an expected rate value which makes the measured value factor of 3 too slow…. Not sure why

Conclusion

- Successfully made a cell which can make diffusion measurements through biological tissue and gells
- Begin measuring the diffusion rate through agarose gel
- Move on to measuring diffusion through biological tissue