Quantifying Molecular Diffusivity in the Agar Gel Model Brain

Luke Varkey RET Fellow 2006
Foreman High High School
RET Mentor: Dr. Patrick Rousche
Chicago Science Teacher Research (CSTR) Program – NSF-RET 2006

Motivation
- 30,000 Americans with amyotrophic lateral sclerosis (ALS).
  Ref: http://www.alsa.org/serving/adv_update.cfm
- Brain device interfaces: hope for the rehabilitation. (Rousche et al., 1998).

Background
- NEDDL at UIC is engaged in devising neuro-compatible electrodes-tissue interface.
- Diffusion of the surface coating in the brain is an important determinant for function of these neural interfaces.

Objectives
- Study diffusion of food dye in agar gel as a first approximation of the brain.
- Develop food dye diffusivity model.
- Quantify the dye diffusivity using numerical simulation correlated with experimental data.

Methods & Materials

Experiment
Petri-dish models
- Fig A1: Experimental Observation (t=0 min)
- Fig A2: Experimental Observation (t=120 min)
- Numerical Simulation: In B1 at time = 0 min until B2 at time = 120 min, there is a symmetric distribution of the dye in the gel.
- The diffusivity of the dye is isotropic. There is a good agreement between experimental observation (A2) and that predicted by the mathematical model (B2) at the final time step.

Results & Conclusion

Diffusion
- D is the diffusion coefficient of dye in agar gel
- x is the radial coordinate.
- C is the concentration of the dye

One Dimensional Fick’s Law
\[ \frac{dc}{dt} = D \frac{d^2C}{dx^2} \]

- Diffusion Coefficient of the dye is \( D = 2.1 \times 10^{-11} \text{m}^2/\text{sec.} \)
- The concentration of the dye at the boundary was zero at time = 120 min (Ref: Fig B2).
- The Diffusion was symmetric due to use of Petri dish model.

Application of Diffusion
- From these experimental and Mathematical models we have quantified the diffusivity of the dye in 0.5% agar gel. Diffusion of the surface coating (such as Nerve Growth Factor, NGF, used as therapeutic drug) of a device occurs by diffusion in the similar manner.
- Established experimental and computational models can be used to assess coefficient of diffusion of other substances.
- Diffusion plays a great role in the transduction of neuronal signals as well as in drug delivery problems studied by disciplines of bioengineering and pharmacology.

Teaching Modules
- BIO: Students complete a series of hands-on inquiry-based activities on diffusion and Osmotic pressure.

Acknowledgements
- NSF EEC-0502272 Grant Chicago Science Teacher Research (CSTR) Program Director, Prof. A. A. Linninger.
- NEDDL: Dr. Patrick Rousche, Devang Gandhi Doctoral Candidate, R. Das Graduate student.
- REU: Mark Choi, Sandy Deitch and Chika Chima-REUs.
- LPPD Team