Physics 176/276
Quantitative Molecular Biology

Lecture VIII: Physics of the biological sensing of chemicals

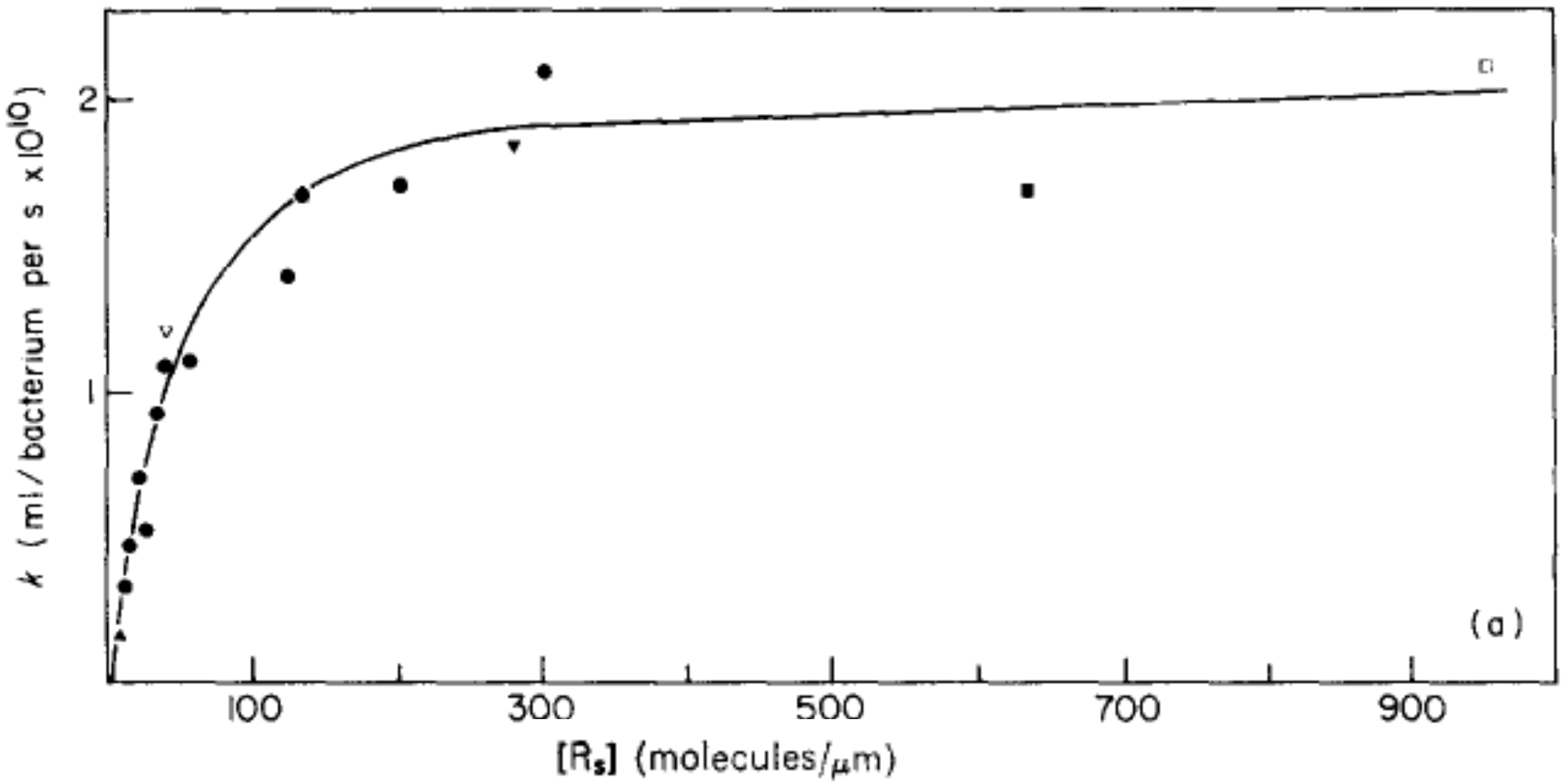
Reminder Course Evaluation

Students will have the opportunity to evaluate the course between Monday, January 27 at 12:00 AM and Monday, February 3 at 11:59 PM.

Link: https://academicaffairs.ucsd.edu/Modules/Evals

“Paradox” of the adsorption rate of phages

M. Schwartz,
J. Mol. Biol.
1976



How is the rate saturating for such a small number of receptors?
The fraction of the surface covered by receptors is ≈ 0.1%!

Your guesses?

Tentative “solutions” of the “paradox”

The rapidity of the reaction in quiet media suggests that the initial contact may occur between small specific projecting elements on the host or on the virus. Such elements would have high thermal velocities (Brownian motions) relative to those of the larger bodies to which they are attached. During the time the virus and host are near each other in diffusing through the medium, such mobile elements would make many collisions; one collision in which the elements are properly oriented would lead to t’he steric fitting of the elements and the formation of a weak bond between virus and host. Such a tentative bond . . . holds the two bodies together long enough for some subsequent chain(s) of reactions to lead to more firm bonds between the two”.

Refs for the material discussed at the board

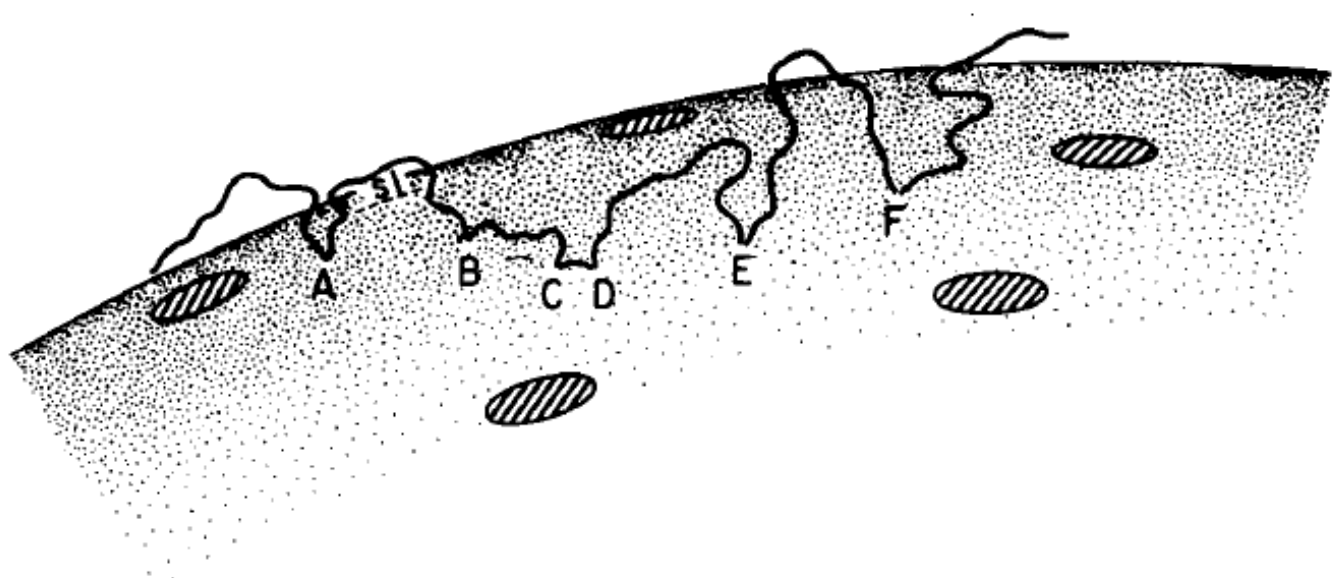
HC Berg & EM Purcell Biophys. Journ. 20:193, (1977).

R. Zwanzig PNAS 87:5856, (1990).

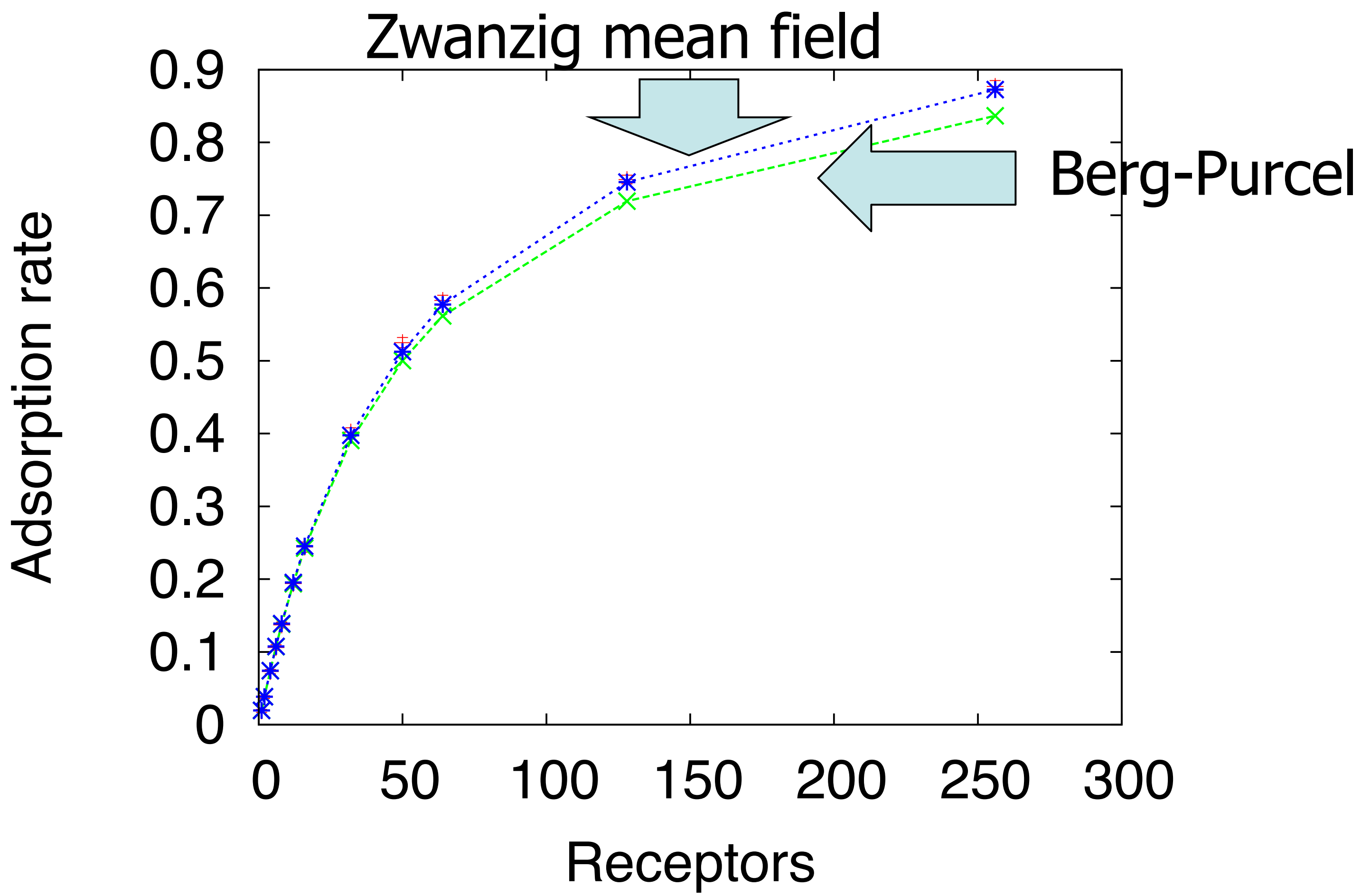
R. Zwanzig & E. Szabo Biophys. Journ. Biophys J. 60:671–678 (1991).

Qualitative message: hits of a diffusing particles onto the surface of a sphere are clustered and span a large area.

It is just the physics of diffusion!

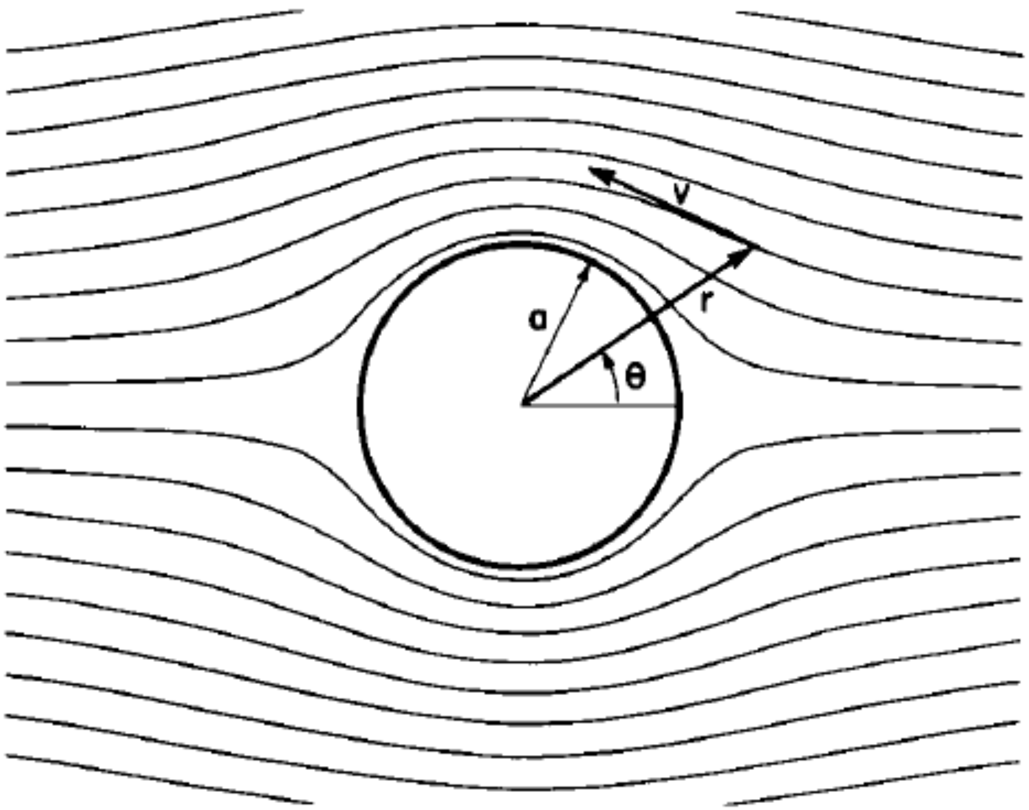


Comparison between the mean-field analytical prediction and numerical simulations



Bacteria live in a world without inertia

(E.M. Purcell Life at low Reynolds number, Am J Phys 1977)



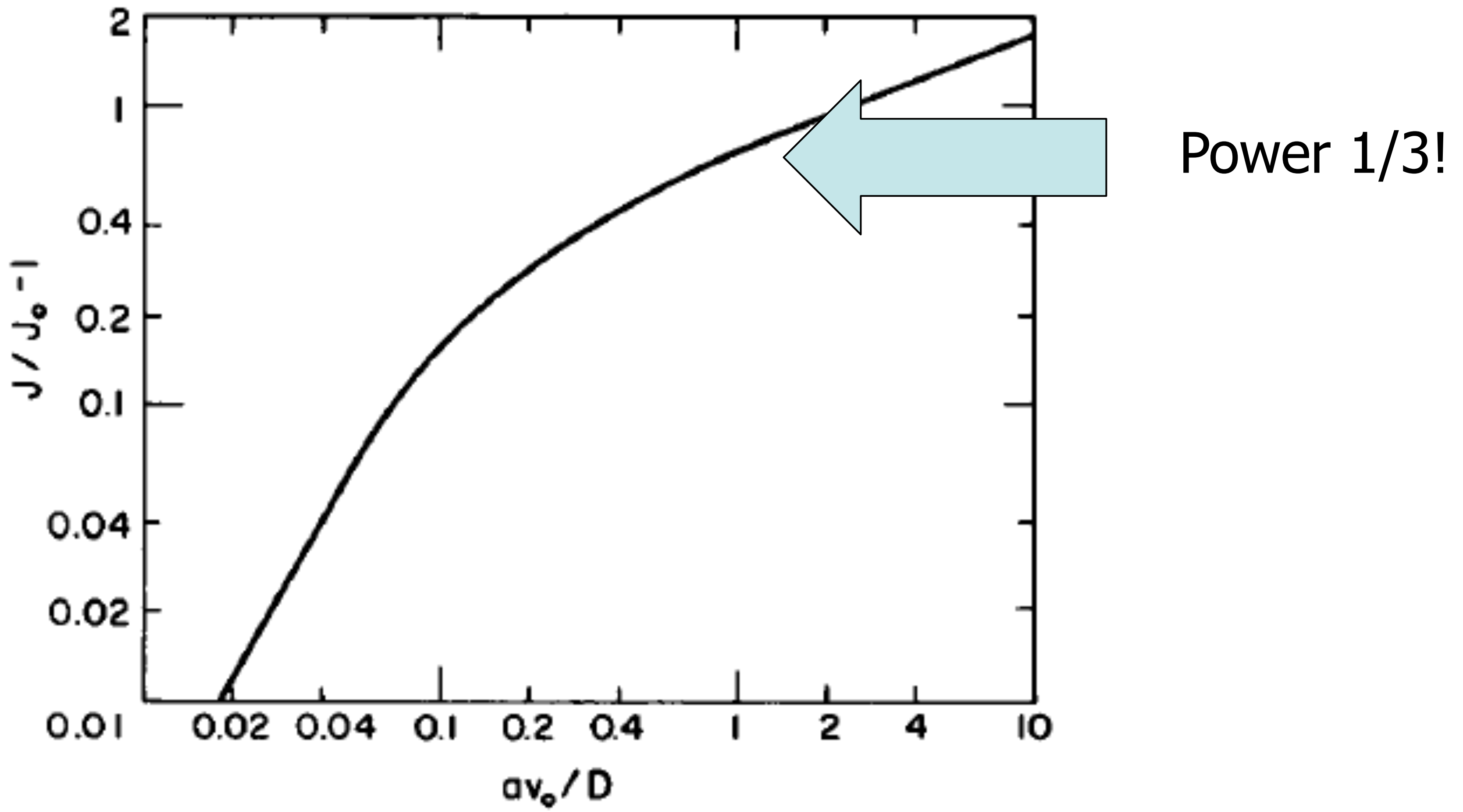
Reynolds number of bacteria moving in an aqueous solution is bound to be small (by the micron size and the velocity microns/s).

The flow around a moving sphere is a Stokes flow:

$$v_r = -v_0 \cos\theta (1 - 3a/2r + a^3/2r^3),$$

$$v_\theta = v_0 \sin\theta (1 - 3a/4r - a^3/4r^3).$$

Can the rate be increased by moving?



$$D\nabla^2 c - \mathbf{v}\cdot \operatorname{grad} c = 0,$$

And compute flux on the sphere

Not much!