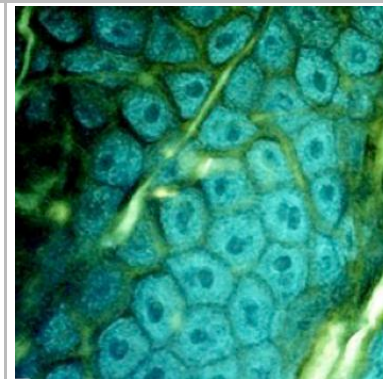
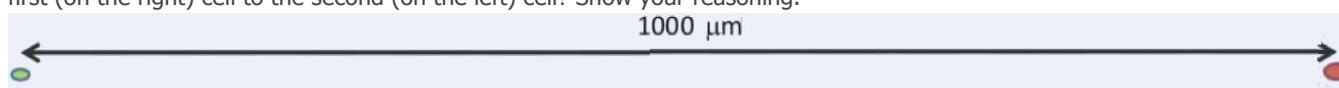


Relay cells

Cells in a multicellular organism often signal to each other by having specialized cells that emit signaling chemicals. Those signaling chemicals diffuse through the fluid medium in which the cells are imbedded. Consider two cells that communicate by diffusing a chemical that has a diffusion constant $D = 250 \mu\text{m}^2/\text{s}$. The cells are a few μm in diameter. (For the purposes of this problem, treat the situation as if it were simple diffusion in one dimension.)



A. Consider two cells that are a distance of 1 mm ($= 10^3 \mu\text{m}$) apart as shown below. About how long would it take for a signal to diffuse from the first (on the right) cell to the second (on the left) cell? Show your reasoning.



B. One way that organisms improve this time is by having *additional cells that relay the signal*; that is, instead of just having two cells 1 mm apart, there are an additional 9 signaling cells (in between the two end cells) 0.1 mm ($= 100 \mu\text{m}$) apart as shown below. As soon as one of the signaling cells detects the diffusing signal from the first cell, it immediately begins diffusing its own signal. When the third cell detects the diffusing signal from the second, it immediately begins diffusing its own signal, etc. Calculate how long it takes the signal to diffuse between cells 1 and 2; and between cells 2 and 3. Based on this information, how long it will take to get to the 10th cell, 1 mm away?



C. What happens if we have a 10 times the original distance (10 mm) and only two cells. How long will the chemical take to diffuse from one to the other? (Give your answer as a factor of the time it takes in part A, e.g., 10X, 100X, or whatever.) Explain your reasoning.

D. What happens if we have 10 times the original distance but now have 100 relay cells instead of 10, with the same 100 micron distance between cells? How long will the signal take to get from the first cell to the last? (Give your answer as a factor of the time it takes in part B, e.g., 10X, 100X, or whatever.) Explain your reasoning.