Cell polarization and activation

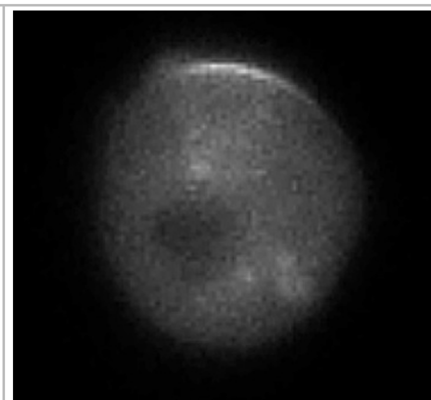
4.3.3.P3

Cells need to respond to chemical signals that they detect from their environment. One particularly important kind of signal is a directional one that helps the cell decide where something of importance to it is. This information is provided to the cell by a *chemical gradient* – there is more of the chemical on one side of the cell than on the other.

One way the cell changes itself so as to be able to respond to a chemical gradient is by changing the distribution of some of its internal proteins so as not to be uniform. Proteins get bound to the cell membrane, but only on one side of the cell with the chemical signal. This asymmetric arrangement of proteins on one side of the cell is called *cell polarization.* (This is in analogy to the asymmetric arrangement charges in an electrically polarized object, but cell polarization does not imply electrical polarization.)

An example of cell polarization is seen in the image on the right which shows a slime mold cell with the protein CRAC (cytosolic regulator of adenylyl cyclase) labeled and showing as bright regions. This “polarization” of crac allows cells to move in the direction of a chemical signal.

For slime mold cells, the chemical signal can change quickly, but even when the external chemical signal stops rapidly, the polarization of crac remains visible for about 20 seconds. Why does it take 20 seconds for polarization to end? One reason is that the molecules associated with the polarization might need to diffuse away. There are a number of possibilities. In each case, the diffusion constants are approximately known (and are typical for this type of biomolecule).



1. CRAC may remain stuck to the membrane but diffuse along the membrane and so distribute uniformly (D=0.03 $\mu m^2/s$; typical for membrane bound proteins).
2. The lipid molecules that gave the membrane stickiness may diffuse along the membrane surface (D=1 $\mu m^2/s$; typical for membrane lipids).
3. CRAC may be immediately released from the membrane, but take time to diffuse away from the membrane as they float around freely inside the cell (D=50 $\mu m^2/s$; typical for freely floating proteins).

How long does it take for each type of molecule to diffuse from the front to the center or sides of the cell? Does that calculation help you decide which of the three possibilities is more likely to have caused the gradual loss of polarization of crac over 20 seconds?