Cells can use dynamic patterns to pluck signals from noise

December 11 2014

Scientists have discovered a general principle for how cells could accurately transmit chemical signals despite high levels of noise in the system, they report in *Science* this week.

A cell's response to outside chemical signals depends on its physiological state, which can fluctuate considerably. Amounts of different kinds of proteins within individual cells varies by as much as 25 percent.

"Compared with an engineered components such as a transistor, that's a lot of noise," says Roy Wollman, a professor of chemistry and biochemistry at the University of California, San Diego. "This requires a different kind of problem solving."

Wollman and colleagues combined advanced microscopic imaging with information theory to determine how cells might encode information about the level of incoming chemical signals, given their variable states.

They studied three different chemical communication systems - molecules outside the cells that effect three different kinds of changes within, each on a different time scale. One signal releases calcium from internal stores to diffuse freely through the cytoplasm within minutes. Another changes the shape of a responding molecule over about an hour. A third moves a protein from the cytoplasm to the cell nucleus where it interacts with DNA over about 10 hours.

Wollman's team recorded responses to the three signals with a microscopy system that continuously measures changes in thousands of cells at a time. They monitored more than nine-hundred thousand cells responding to varying levels of each of the three chemical signals.

No single measure captured the cells' responses in a way that accurately preserved information about the concentration of the chemical signal outside the cell. Instead, a measure that captured the change of the cell's responses over time accurately recorded the level of the incoming signal. And information theoretical analysis concluded that the 'noise' of varying cellular states could be eliminated in this way.

"It shows how to build a communication system that can function in the presence of so much noise," Wollman said.

More information: "Accurate information transmission through dynamic biochemical signaling networks" *Science*, www.sciencemag.org/lookup/doi/ … 1126/science.1254933

Provided by University of California - San Diego