Nature still sets standard for nanoscience revolution

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(PhysOrg.com) -- By striving for control and perfection in everything from computer chips to commercial jets, scientists and engineers actually exclude a fundamental force that allows nature to outperform even their best efforts.

Although it may appear to defy logic, imperfections and the seemingly randomness among even the lowly bacteria help keep nature a couple of steps ahead, according to Oak Ridge National Laboratory's Peter Cummings and Mike Simpson, co-authors of a paper published in *ACS Nano*.

"Contrarian investing is one strategy for winning in the stock market," Cummings said, "but it may also be a fundamental feature of all natural processes and holds the key to many diverse phenomena, including the ability of the human immunodeficiency virus to withstand modern medicines."

In their paper, Cummings and Simpson outline a theory that maintains that in any given population, an imperfect minority - the "noise" - is beneficial to the whole. Less perfection is actually good.

"That is the lesson of nature, where a humble bacterial cell outperforms our best computer chips by a factor of 100 million, and it does this in part by being less than perfect," Simpson said.

If we think of a computer chip as a lot of on-off switches, modern technology has become pretty good at making the switches perfect. When we turn them on, they are on. But life works differently, as it has the element of chance, where like the flip of a coin, the outcome can't be predicted, just the likelihood - a 50 percent chance of heads - can be known. In contrast to the computer chip, the bacterial cell has imperfect chance-ridden switches, and through these imperfections, the bacteria can do things the computer chip cannot.

"Instead of trying to make perfect decisions based on imperfect information, the cell plays the odds with an important twist: it hedges its bets," Simpson said. "Sure, most of the cells will place bets on the likely winner, but an important few will put their money on the long shot."

These few contrarian bets can have consequences that belie their rarity. For example, the AIDS virus has one of these chancy switches in which most of the infected cells are made to produce new virus that can make them infect other cells. But just a few of the infected cells flip the switch the other way and the virus enters a dormant state.

"Like ticking bombs, these dormant infections can become active sometime later, and it is these contrarian events that are the main factor preventing the eradication of AIDS," Simpson said.

From the point of view of the virus, it is this imperfect switch that allows it to deal with the threat of therapy.

Circling back to the computer chip, Cummings noted that they get faster and more powerful mostly by getting smaller. They have gotten so small now that they are entering the world of nanotechnology, where things become less perfect and more affected by chance.

"But our technology has fought against this chance using a brute force approach that consumes a lot of power," Cummings said.

In fact, one of the factors limiting the building of more powerful computers is the grid-busting amount of energy they require. Yet residing atop the cabinets of these supercomputers, basking in the heat generated in the fight to defeat the element of chance, the lowly bacteria show us another way.

More information: The paper is titled "Fluctuations and Correlations in Physical and Biological Nanosystems: The Tale is in the Tails."

Provided by Oak Ridge National Laboratory

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