EMERGING TECHNOLOGIES AND THEIR IMPACT
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Advances in biotechnology have put bioweapons within the reach of terrorists and offer governments new opportunities for violence and repression.

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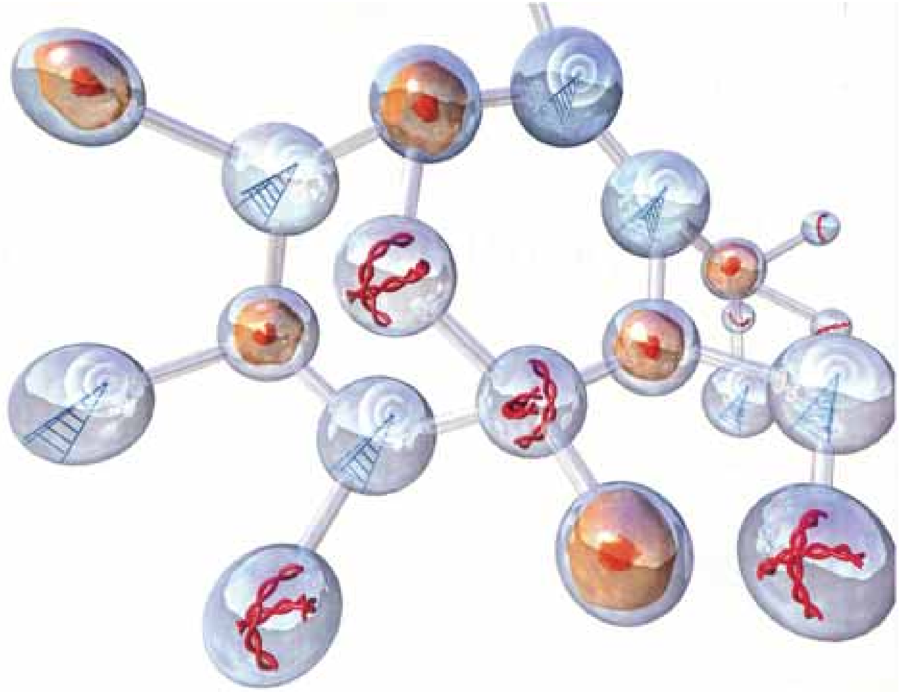


TechnologyReview

10 Emerging Technologies

EACH YEAR, *Technology Review* identifies 10 technologies that are worth keeping an eye on. This year's list spans a broad range of disciplines, from life sciences to nanotechnology to the Internet, but the technologies have one thing in common: they will soon have a significant impact on business, medicine, or culture. *Nanomedicine* and *nanobiomechanics* both illustrate nanotechnology's increasing contribution to the understanding and treatment of diseases. In biology, *epigenetics* is part of an exploding effort to understand the ways that chemical compounds can influence DNA, while *comparative interactomics* is a compelling example of how researchers are beginning to visualize the body's remarkable complexity. *Diffusion tensor imaging* is the most recent in a series of astonishing breakthroughs in imaging the brain. Meanwhile, *cognitive radio*, *pervasive wireless*, and *universal authentication* reflect the continuing struggle to keep the digital world accessible and secure. There is also controversy on the list: *nuclear reprogramming* describes the contentious hunt for an "ethical stem cell." Finally, some of the technologies, such as *stretchable silicon*, are just cool.

BRYAN CHRISTIE DESIGN

MOLECULAR BIOLOGY

Nanobiomechanics

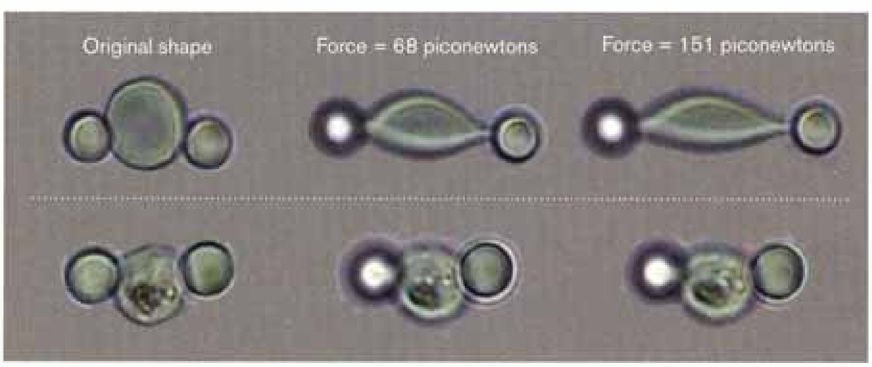
Measuring the tiny forces acting on cells, Subra Suresh believes, could produce fresh understanding of diseases.

MOST PEOPLE DON'T THINK OF THE human body as a machine, but Subra Suresh does. A materials scientist at MIT, Suresh measures the minute mechanical forces acting on our cells.

Medical researchers have long known that diseases can cause–or be caused by–physical changes in individual cells. For instance, invading parasites can distort or degrade blood cells, and heart failure can occur as muscle cells lose their ability to contract in the wake of a heart attack. Knowing the effect of forces as small as a piconewton–a trillionth of a newton–on a cell gives researchers a much finer view of the ways in which diseased cells differ from healthy ones.

Suresh spent much of his career making nanoscale measurements of materials such as the thin films used in microelectronic components. But since 2003, Suresh's laboratory has spent more and more time applying nanomeasurement techniques to living cells. He's now among a pioneering group of materials scientists who work closely with microbiologists and medical researchers to learn more about how our cells react to tiny forces and how their physical form is affected by disease. "We bring to the table expertise in measuring the strength of materials at the smallest of scales," says Suresh.

One of Suresh's recent studies measured mechanical differences between healthy red blood cells and cells infected with malaria parasites. Suresh and his collaborators knew that infected blood cells become more rigid, losing the ability to reduce their width from eight micrometers down to two or three micrometers, which they need to do to slip through capillaries. Rigid cells, on the other hand, can clog capillaries and cause cerebral hemorrhages. Though others had tried to determine exactly how rigid malarial cells become, Suresh's instruments were able to bring greater accuracy to the measurements. Using optical tweezers, which employ intensely focused laser light to exert a tiny force on objects attached to cells, Suresh and his collaborators showed that red blood cells infected with malaria become 10 times stiffer than healthy cells–three to four times stiffer than was previously estimated.



OPTICAL TWEEZERS stretch a healthy red blood cell (top row), increasing the applied force slowly, by a matter of piconewtons. A cell in a late stage of malarial infection is stretched in a similar fashion (bottom row). The experiment illustrates how the infected cell becomes rigid, which prevents it from traveling easily through blood capillaries and helps cause the symptoms of malaria.

OTHER PLAYERS

Nanobiomechanics

Researcher	Project
Eduard Arzt *Max Planck Institute, Stuttgart, Germany*	Structure and mobility of pancreatic cancer cells
Peter David and **Geneviève Milon** *Pasteur Institute, Paris, France*	Parasite-host interaction; mechanics of the spleen
Ju Li *Ohio State University*	Models of internal cellular structures
C. T. Lim and **Kevin Tan** *National University of Singapore*	Red-blood-cell mechanics

Eduard Arzt, director of materials research at the Max Planck Institute in Stuttgart, Germany, says that Suresh's work is important because cell flexibility is a vital characteristic not only of malarial cells but also of metastasizing cancer cells. "Many of the mechanical concepts we've been using for a long time, like strength and elasticity, are also very important in biology," says Arzt.

Arzt and Suresh both caution that it's too early to say that understanding the mechanics of human cells will lead to more effective treatments. But what excites them and others in the field is the ability to measure the properties of cells with unprecedented precision. That excitement seems to be spreading: in October, Suresh helped inaugurate the Global Enterprise for Micro-Mechanics and Molecular Medicine, an international consortium that will use nanomeasurement tools to tackle major health problems, including malaria, sickle-cell anemia, cancer of the liver and pancreas, and cardiovascular disease. Suresh serves as the organization's founding director.

"We know mechanics plays a role in disease," says Suresh. "We hope it can be used to figure out treatments." If it can, the tiny field of nanomeasurement could have a huge impact on the future of medicine. **MICHAEL FITZGERALD**