Physical scientists will apply laws of physics in cancer fight

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Instead of killing cancer cells, researchers at Arizona State University will use the laws of physics to figure out how to control them. And, rather than treating cancer as a disease and seeking a cure, ASU scientists will view cancer cells as physical objects and study them the way a physicist would, using simple variables like temperature, pressure and force.

That fresh approach is behind a new research center at Arizona State University - one of 12 Physical Sciences-Oncology Centers receiving some of $22.7 million in funding this fiscal year from the National Institutes of Health's National Cancer Institute. Each center will bring a non-traditional approach to cancer research with the goal of developing new methods of arresting tumor growth and metastasis.

In addition to ASU, other institutions receiving funding include: Johns Hopkins University, Massachusetts Institute of Technology, Memorial Sloan-Kettering Cancer Center, Northwestern University, Princeton University, H. Lee Moffitt Cancer Center and Research Institute, Cornell University, Scripps Research Institute, University of California-Berkeley, University of Southern California and University of Texas Health Science Center.

The new Center for Convergence of Physical Science and Cancer Biology at ASU will receive about $1.7 million in funding for each of the first two years of a five-year proposal. Part of the plan is the establishment of a "cancer forum," hosted by the BEYOND Center for

Fundamental Concepts in Science at ASU.

"What is new about this initiative is that it is going to be tackling the root causes of cancer on a conceptual level," says Paul Davies, a theoretical physicist, cosmologist and astrobiologist who is leading the ASU cancer initiative. "We want physical scientists to think about why cancer exists in the first place. What is its role in the great biological scheme of things as life has evolved over the last several hundred million years? Within the human body, how does cancer behave as a physical object?"

Davies is experienced at asking these types of big questions. As director of the BEYOND Center in ASU's College of Liberal Arts and Sciences, Davies' work has focused on applying the laws of physics to the early universe, from the first split second. He is noted for his work on the theory of quantum fields in curved spacetime, the thermodynamics of black holes, the arrow of time, the nature of the laws of physics and the emergence of life in the universe.

"My interests have been very broad. I started out working on fundamental physics and cosmology and about 15 years ago became interested in astrobiology, which is the study of origin and distribution of life in the universe," Davies says.

"When I first began thinking about the problem of cancer, it occurred to me that physicists can do some pretty fancy things. If we can build the Large Hadron Collider to find the Higgs Boson amid one trillion proton collisions, maybe we can find clever ways of locating and zapping individual cancer cells in the human body. So I began to get excited about the prospect of just throwing the full panoply of toys that physicists use at the problem of diagnosing and killing cancer cells.

"Then, I came to realize that 'think big and zap the problem' was probably not the best way to go. A more subtle approach to really understand cancer cells is to regard them as physical objects rather than as enemies to be destroyed. Cancer is a fascinating manifestation of an endlessly fascinating subject, namely life," Davies says.

"Cancer cells are, after all, physical objects," he notes. "Instead of thinking 'oh let's throw all these chemicals at them and see if we can kill them,' let's think of them as physical objects in the body or in isolation and study them in that way as a physicist would - we look at the forces that act upon them, look at their mechanical properties, their electrical properties, how they cluster, how they act as communities."

Surgeon John E. Niederhuber, director of the National Cancer Institute, says: "By bringing a fresh set of eyes to the study of cancer, these new centers have great potential to advance, and sometimes challenge, accepted theories about cancer and its supportive microenvironment."

Other collaborators on the ASU team include Stuart Lindsay, a Regents' Professor of physics and chemistry and director of the Center for Single Molecule Biophysics at the Biodesign Institute; Deidre Meldrum, dean of the Ira A. Fulton Schools of Engineering and director of the Center for Ecogenomics at the Biodesign Institute; Timothy Newman, professor of physics and director of the Center for Biological Physics; Robert Ros, associate professor of physics; Peiming Zhang, an associate research professor in the Biodesign Institute; Roger Johnson, a research scientist and laboratory manager; and Pauline Davies, a professor of practice in the Hugh Downs School of Human Communication.

"We are also collaborating with the Fred Hutchinson Cancer Research Center, which will provide the cell lines for us, and the Mayo Clinic, which will provide tissue samples," Davies says.

"And, we will be looking at the mechanical properties of the cells. We have state-of-the-art equipment to examine individual cells in suspension in three dimensions. The problem when you look at a cell usually is that it's a slide, it has been squashed flat and stuck to a surface, it's a two-dimensional picture. We can examine cells in a three-dimensional suspension, we can examine them from all sides," says Davies. "So we can look at normal cells, cancer cells at various stages of progression, and we have an atomic force microscope that can be used to prod the cells and see how their mechanical properties change as the cancer progresses.

"It's well known that cancer cells get more squishy. The reason they get bent out of shape is because of the squishiness, they become less elastic. Nobody really knows what the reason for that is or whether this is something just to do with the membrane of the cell or the cytoskeleton - little tubes inside the cells that pull like ropes. We want to know what's going on in these cells. Why they are getting squishy? How does that effect the survival chances of the cancer cell?"

Taking that a step further, Davies asks: "Then, can we approach the problem of cancer by controlling the mechanical environment in some way instead of thinking about switching on genes and chemical pathways? Maybe we just need to control the physical environment. We've got simple variables like temperature and pressure and force and electric potential, these are the tools of the trade for physicists. Let's bring those to bear on cancer."

The center at ASU will be a think tank that hosts several workshops each year on topics related to the intersection of physical science and cancer. "The goal of the workshops is to serve as a catalyst to establish new lines of inquiry, both theoretical and experimental," Davies says. "We are aiming for that big conceptual breakthrough that would transform the subject, as opposed to the slow incremental progress that's been made so far using traditional approaches."

The center will also create a Web site to serve as a window on the research program and to host research papers, podcasts, webcasts and news items, Davies notes.

"The traditional approach to cancer is it is a disease to be cured. We are taking the approach that it is part of life's intrinsic exuberance that we wish to control," Davies says. "We don't have to cure cancer. All we have to do is to find ways of preventing it from taking over and destroying the body of the host."

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