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'Scientists do have Eureka moments'

Long before nanotechnology became a buzzword, Dr **Anita Goel** had become fascinated by things tiny – the proteins that inch their way along the DNA, reading and copying the genes inside every cell. By her own admission the Massachusetts-born daughter of an Indian-American doctor held almost an equal interest in physics and mathematics as well as in medicine and biology.

"I wanted to combine physics and medicine in a hardcore scientific way," the 37-year-old said of her childhood ambition. Today, in many ways the Harvard/MIT trained physicist and physician, has seemingly been able to achieve her ambition, which, in turn, has opened new vistas and exciting possibilities in biophysics and nanobiotechnology.

Dr Goel, at 34, was featured as the world's top 35 science and technology innovators by MIT's prestigious *Technology Review Magazine*. She received the Global Indus Technovator Award from MIT that recognizes the contributions of the top 10 leaders working at the forefront of science, technology and entrepreneurship. She is also an entrepreneur. Founder, chairman and CEO of Nanobiosym, that she founded in 2004 to develop technologies that integrate advances in physics, biomedicine and nanotechnology, she has received several rounds of federal funding awards for her research and recently won a $2 million contract from the US Defense Threat Reduction Agency.

This year she also signed a deal with the government of Himachal Pradesh to develop a state-of-the-art nano-biotechnology park in the district of Solan. The total outlay for the venture, which has support from the Indian government as well, is likely to exceed $500 million and will be dedicated to research, development, manufacturing and distribution of nanotechnology-based and other biotechnology innovations in the areas of medical diagnostics, life sciences, and nanomedical health care. Excerpts from an interview with Senior Editor **Suman Guha Mozumder**.

I believe that you fell in love with things small and tiny at a young age, much before nanotechnology became a well-known subject among academics. What really inspired you to begin the journey?

It actually goes back to my childhood in a rural town in Mississippi where my dad was the local town surgeon and where I had lived from the age of three. I was interested in physics and mathematics on the one hand and biology and medicine on the other.

My dad being a doctor exposed me to medicine early in life. It so happened that as I went deeper into physics and math on the one hand and biology and medicine on the other, I noticed that they were seemingly orthogonal pursuits, at least to the Western mindset. At an early age, I was exposed to Eastern philosophy like the Bhagvad Gita and the Vedas. The ancient concepts embodied there made a deep impression on me; they suggested an underlying unity in nature. The philosophical belief that there must an underlying unity in nature led me to want to combine physics and medicine in a hardcore scientific way.

Thus began my quest. When I went to Stanford and majored in physics, it was just becoming possible with rigorous concepts and new tools emerging from physics to use light to manipulate matter and probe the physics of DNA molecules at the level of single molecules.

Was that nanotechnology?

That field was not really called nanotechnology. It was an interesting way in which physics was shedding light on biology. So the passion for me was the way physics and biomedicine could come together. And it so happens that one of the places where physics and medicine meet is at the nanoscale.

One thing led to another and then, of course, I came to Harvard/MIT for my MD/PhD program. There I found myself going back and forth between the world of physics with my PhD in the Harvard physics department and medicine with the HST joint program between MIT and the Harvard Medical School.

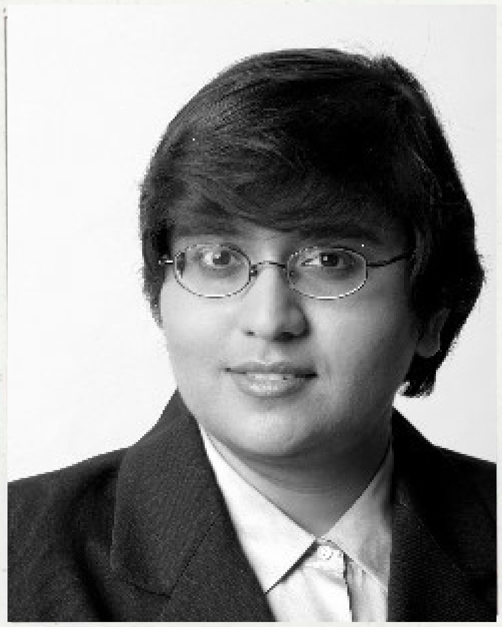
There was this constant tension between these two worlds because they really did not communicate with each other. It just so happened that my work at the intersection of physics and biology began to be increasingly identified as part of this emerging field of nanotechnology, a highly interdisciplinary area. Nanotechnology, in my mind, is the ability to control and probe matter, energy and other systems on increasingly finer scales, not just the nanoscale, but even beyond. The physics of living matter on these tiny scales fascinates me.

I am curious to know the place where you grew up, what kind of influence did it have on you?

It was the rural south of the early 1970s. We were the only Indian family in this tiny town, where black and white people lived on different sides of the railroad. There was lots of green and nature around. We had chickens, rabbits, and peacocks in our backyard. My parents sent us to an all-white racially segregated school and a Southern Baptist Church to learn the local culture. The small rural town did not yet know what to do with Indian people. There was simply not enough critical mass at that time. In any case, it was an interesting adventure...and helps to build character.

***MIT Tech Review* said you had an epiphany of sorts about using nanoscale platforms for rapid portable biodetection.**

That's perhaps just a way of speaking. But often we as scientists do have flashes of insight or Eureka moments when we make nonlinear jumps in our thinking. I have seen this in my own life on multiple occasions. I will be deeply immersed in a problem, tossing it over in my mind. Then, often when I least expect it, the solution to the problem will just come in a flash. This phenomenon in itself is fascinating and worthy of scientific investigation.



The Business Interview
Dr Anita Goel

When I was at Stanford, the word nanotechnology was just being coined and was starting to get some traction. It was not a very popular word in the beginning, just a buzzword. As scientists we did whatever we did, working on tiny length scales and one day the popular press began calling that 'nanotechnology.' Soon afterwards, the large organized effort and lobby in the United States began pushing for accelerating investments into nanotechnology innovation. In the late 1990s, President Clinton established the first National Nanoinitiative which triggered a wave of popular press and excitement about nanotechnology.

You said there was not much traction about nano during those early days. So what then gave you the confidence that this area had potential and someday be so successful?

There were probably two things. First, there was a deep passion of sorts and an inner drive that went back to my childhood days when I thought about bringing physics and medicine together. This may sound idealistic, but the passion to understand how nature works, the way life works, the way living systems work drives me. If you look at our physics of the 20th century, it deals primarily with inanimate, inert matter and does not really come to terms with life and living systems. Likewise, when you look at biology and modern medicine, it seems to be practiced mostly at the level of molecular biology or biochemistry. There is very little understanding on the role of physics in physiological processes. If we can understand gravity, we can understand quantum mechanics; we should be able to understand life at some level. So, this became a part of my personal quest.

You just mentioned life and understanding of life. Do you think this marriage between physics and medicine can lead us to better understand what life is after all?

Yes. Biology is forcing physics to expand its language in order to reconcile with life and living systems. Living systems are by definition open systems that actively exchange matter, energy, and information with their environment. Traditionally, physics has dealt with closed systems where the interaction with the environment was treated as a perturbation. So I believe the language of physics will have to be evolved. I believe there are real game-changing opportunities when these two fields meet.

I believe your company Nanobiosym is bringing a hand-held device for portable real-time disease diagnosis using nanotechnology.

Yes. Through support from the Department of Defense and some private investors, we have successfully demonstrated proof-of-concept and have begun prototyping for commercial applications.

What is going to be its impact and potential?

I would envision the impact of this technology to be similar to the cell phone industry. We saw a paradigm shift when computing and communications devices became portable. Likewise, I believe that we will see a similar paradigm shift in health care when the ability to detect and diagnose a disease is taken out of pathological labs and put into the hands of doctors, healthcare workers and patients themselves, in homes and in rural areas with minimum overhead infrastructure and personnel training.

Cellular technology has made an impact not only on developed world economies like the United States and western Europe, but also on emerging economies. I was amazed to see that in India for example, farmers and rickshaw-*wallahs* use mobile phones and the growth rate of cell phones in emerging economies has rapidly surpassed many more developed markets.

By lowering the infrastructure that is necessary to diagnose diseases, lowering the manpower and cost and time needed to diagnose disease, it will become increasingly possible to bring first rate health care to some of the most remote areas of the world.

Does the technology have other potential applications?

It enables many commercial markets. We have looked at the life sciences tools market, the bio defense market where we are already working with the US military and perhaps, by far, our largest market is the clinical diagnostic market. We envision our portable biosensor chip could be employed for water-testing, blood-testing, organ transplant testing, forensic applications, avian flu, et cetera. A lot of unexpected performance advantages stem from our working at the nanoscale.

I do not know if the analogy is correct but do you think it is going to revolutionize things the way discovery of Pentium chips changed the world?

In our business model we certainly get a lot of inspiration from that. For example, in the Intel model, they initially make the chips and supply them to a lot of different players. So the initial part of our strategy is to be really good at our chips and integrate them with a bunch of companies' existing product lines and then eventually get into some of end user markets.

Any interest from India in this technology?

The government there has expressed interest in our manufacturing and doing some of the clinical tests in India. My interest in India also stems from the humanitarian impact that our technology could have on remote villages. It also turns out that there is a huge global market. So we see a humanitarian aspect as well as a large commercial scope.

India is a very interesting place because you have the juxtaposition of many different socio-economic sectors and have the unique opportunity to make a big humanitarian impact at the same time as you build a very huge emerging market.

Professor Henry Baltes of Zurich ETH once predicted that you and your work would fundamentally be carving out the landscape of this field of nanobiophysics in years to come. What do you think of that?

That is a tough question (*Laughs*) I am honored that he felt that way, but I still see myself as a passionate scientist and an entrepreneur who would like to leave the world a better place. Isn't there a saying in the Bhagvad Gita that says something about worldly praise and fame being merely transient phenomena.