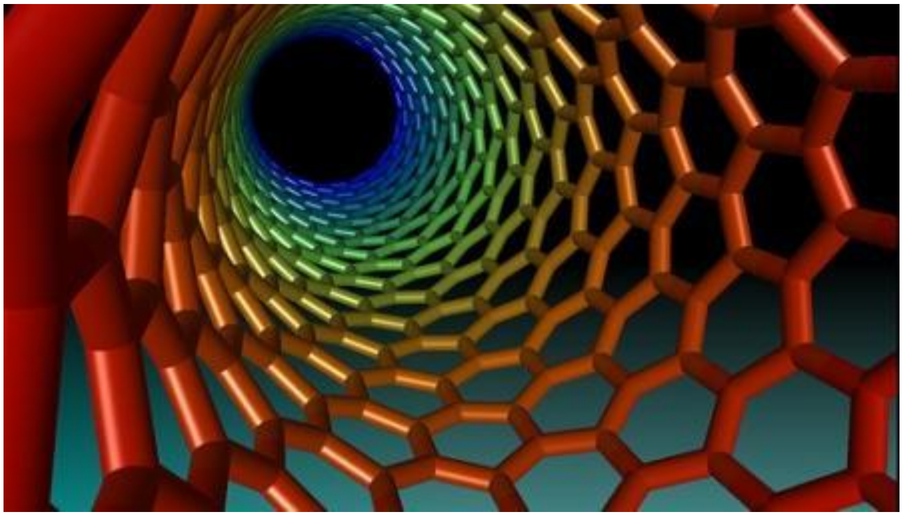
The Smallest Revolution: 5 Recent Breakthroughs in Nanomedicine

By Julian Taub | September 30, 2011 | 1



Nanotechnology is a cutting-edge advancement within science and engineering. It is not a single field but an intense collaboration between disciplines to manipulate materials on the atomic and molecular level. When this technology is applied to medicine, the results are especially exciting, and can better our lives in drastic new ways. Its inventive and interdisciplinary nature constantly surprises me, as do the men and women behind these projects. Each breakthrough in nanotechology solves a problem that many thought could not be overcome. Here are five innovations in nanomedicine in the past year and the faces behind them:

Lung Cancer Early Screening:

We constantly come across depictions of lung cancer in anti-smoking ads. In addition to the gruesome nature of these images, there's another reason to be afraid: until now, lung cancer has been almost impossible to detect in its early stages. Thousands of people go about their daily lives unaware that tumors are forming inside of them.

The lung cancer screening test, designed by pathologist Dr. Michael Wang and biomedical engineer Dr. Li-Qun Gu at the University of Missouri, relies on a simple yet efficient design. The principle behind it is that when cancer starts forming in the lungs, it distorts the sequence on a molecule called microRNA. If the scientist can find the irregularities in the microRNA, he can discover if the patient has cancer. To do this, he takes a sample of microRNA (which is easily extracted from a sample of blood plasma), and runs it through a nanopore, a hole in a protein-based membrane that is so small it lets only one molecule pass through at a time. Running a current through the pore, a machine picks up on the signals given off by the base pairs of the RNA as each one interacts chemically with the protein hole and can detect any abnormalities in the sequence. The test is so straightforward to perform that patients can be diagnosed and begin therapy during their first visit.

Dr. Wang is a professor at the University of Missouri in clinical molecular genetic pathology. He also works at the Ellis Cancer Center in Columbus MO. Dr. Gu works in biomedical engineering at Dalton Cardiovascular Center. He was inspired by the way ions move across cell membranes and has worked to make similar structures that perform important tasks.

Gold Nanoparticle Flu Test:

Most flu tests today are either time-consuming or incredibly inaccurate. The most accurate technique is called PCR, where a sample is taken, stored for a few days, its RNA is replicated, and then two weeks later, the results arrive. At that point it could be too late to halt an epidemic.

However, with the gold nanoparticle test, the results can be found out immediately, and the patient can be treated right away without spreading it to more people. Created by a team at the University of Georgia headed by Ralph A. Tripp, the test takes advantage of gold nanoparticle's ability to scatter light in drastically different ways, depending on its geometry. The scientists attached the nanoparticles to antibodies that bind specifically to the flu virus. When the particles surround the virus, their geometry changes and they disperse light differently, making it clear that the virus is present. All the doctor has to do is take a fluid sample and mix it with a gold nanoparticle filled solution. If the virus is present, the solution will scatter light in a measureable pattern. Not only is the test quick, it's inexpensive as well. The gold used is in such a minute amount that it costs 100th of a cent to take the test.

Besides for determining influenza, the test works for a whole host of other diseases as well. Scientists can attach any antibody necessary to the nanoparticles. Each type of antibody has special receptors that bind only to a certain type of virus. The test can even tell if there is salmonella in your chicken.

Dr. Tripp, the research group leader behind this breakthrough, is a Georgia Alliance Eminent Scholar. He has worked with state-of-the-art solutions to infectious diseases, such as RNA silencing and trying to create a vaccine for the avian flu. He strives to understand how cells respond to infection to learn how to better fight disease.

Sandia Cancer Hunters:

All over the world people suffer from tumors. Sometimes they can be removed surgically, but many times the affected cell is in an inaccessible area. Chemotherapy is another option, but radiation isn't picky about what it kills. Oncology needs a version of "going for the jugular" in their arsenal.

That weapon might just have been invented. The protocell, engineered by Jeff Brinker and his team at Sandia National Labs in New Mexico, is a contraption to carry nanoparticles filled with toxins and RNA silencers to a cancer cell. It's a capsule of porous silicon dioxide (think: quartz) encased in a double layer of lipids. Once it approaches the cancer cell, the protocell's proteins latch onto the tumor's receptors, allowing the cell to engulf it. It lets it enter and float around in a bubble of the tumor's own cell barrier, called an endosome. To release the death blow, the fusogenic peptides, a type of protein attached to the protocell's outer coating, create holes in the endosome that bring hydrogen ions into the bubble. The pH of the bubble increases, releasing the cell toxins and breaking the endosome. The toxins now go about poisoning the tumor and halting protein production. Some toxins have nucleotides attached to them, allowing them to be picked up by transport RNA and brought to the nucleus, where they can destroy the tumor's DNA.

Protocells target cancerous cells; they have at least a 99% affinity to bond with the overgrowth of receptors that occur on the cell membrane of tumors. It is highly specialized and economical as well; only one protocell is necessary to silence a tumor. They are remarkably stable in body fluid, won't leak nanoparticles onto healthy tissue, and are simple to prepare. Scientists only need to soak the protocell in a solution containing whatever nanoparticles and other toxins that they want to use.

This remarkable invention has an equally remarkable man behind it. Dr. Brinker is one of those scientists who you think only exists in sci-fi movies. Neither of his parents went to college, and his chemistry set inspired him to pursue a science career. As a novice working at Sandia, he solved a scientific problem concerning aerosol-gels, was elevated to the expert of his field, and then wrote the textbook on the subject. He was at the forefront of molecular self-assembly, creating a new technique that made porous nanostructures, like the one used in the protocell. He also created biosensors made out of cells imbedded into nanostructures that change colors when exposed to toxic material.

Cell Feedback:

To put a new drug on the market pharmaceutical companies usually spend about twelve years and over $300 million in the process. They go through various stages of testing, from cell cultures, to animal testing and eventually human trials. However, there has been one crucial step of testing that they have not been able to perform: testing the cell's response to the drug from the inside.

Professor Karen Martinez, with her team at the University of Copenhagen, has made a breakthrough in biosensors. They inserted semiconductor nanowires into a cell without interfering with its internal processes or killing it. Human liver cells and rat neurons were placed on a bed of indium-arsenide nanowires, and were still able to function, living for several days. The researchers then measured processes inside the cell in real-time, including internal response to stimuli and cell membrane potential. They could also transport drugs along the wire into the cell and test the reaction from the inside.

The ability to enter electronics into a cell without disturbing its behavior opens up a new field of drug testing. Now researchers can test drugs on an individual neuron and receive feedback on the interaction. This technique can be used with any new drug and can help explain its side effects. It can also help improve existing drugs by obtaining detailed feedback on its effects inside the cell. This breakthrough has put Copenhagen on the map in the nanotechnology world.

Martinez came to the University of Copenhagen after conducting research in Switzerland, where she studied protein receptors to make more affective drugs. Along with teaching courses in bionanotechnology, she sits on the board of directors for a company called inXell, a company that she founded with two other collaborators on the cell-nanowire project. inXell will become the business end of this breakthrough, working to create microchips that possess the feedback nanotechnology to test new drugs on cells.

Spinal Cord Repair:

Accidents occur every year that leave individuals paralyzed and wheelchair-bound for life. When a spine is injured, a cyst can form, blocking the nervous tissue from regenerating. The nerves below the break are then cut off from the rest of the nervous system and atrophy. One of the most famous examples is the late actor Christopher Reeve. Many see stem cells as the solution to spine rehabilitation, but two researchers in Milan have utilized another approach.

Fabrizio Gelain and Angelo Vescovi constructed nanotubes filled with self-assembling peptides to act as support for the damaged area and mimic the structure of the spine. They tested the procedure on rats and inserted the nanotubes into their broken spines where cysts where forming. After six months, they observed that the cysts were replaced by newly formed cells that included neurons, blood vessels, and bone cells. There were also neurons inside the nanotubes where the peptides originally were. Once the area recovered, the tubes would biodegrade and be eaten by microorganisms.

Tests on the rats' motor skills showed that their legs and back motor movements improved and they didn't have to drag their back legs around anymore. They also responded better to electrophysical stimuli than a control group of rats that were not given nanotubes.

Gelain is the vice-director of the Center of Nanoscience and Tissue Engineering in Milan. His work centers on developing nanomaterials to repair nerve tissue in victims of spinal cord injuries and strokes. He was a visiting professor at MIT and is an editor at the journals PLoS One and Frontiers in nanotechnology.

Vescovi, on the other hand, is one of the leading stem cell researchers in Italy and is interested in the regulation of cell growth. His focus is on neural stem cells in the brain and how to use them to treat disorders. He is the director of the Italian Consortium of Stem Cell Research and worked as the stem cell consultant for the Pontifical Academy of Life at the Vatican.

These innovations I've mentioned are just the beginning of how nanotechnology can change our quality of life. Its combined fields are so vast that different disciplines are intertwining and making unpredictable discoveries all the time. Searching nanotechnology online, more often than not I learn about a new breakthrough each day. The question then becomes: What does this all mean? Where is nanotechnology taking us? I don't think anyone knows at this point, but I'm sure looking forward to the journey.

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