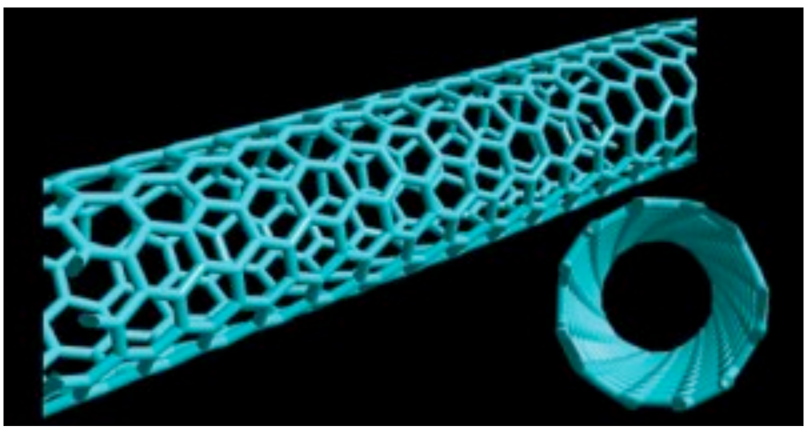
A Cure for Cancer?

"You've got cancer." There are few medical diagnoses more terrifying. Although many cancers are treatable, the most widely used therapies—surgery, chemotherapy, and radiation—have a number of highly unpleasant side effects. But technologies currently in development strongly suggest that the day is not too far off when "the big C" will no longer be so big a deal.

Traditional chemotherapy and radiation therapies are the medical equivalent of saturation bombing. Healthy cells are killed along with the cancerous ones. The trick to an effective cancer cure is finding a way to target only cancerous cells. That's where nanotechnology comes in.

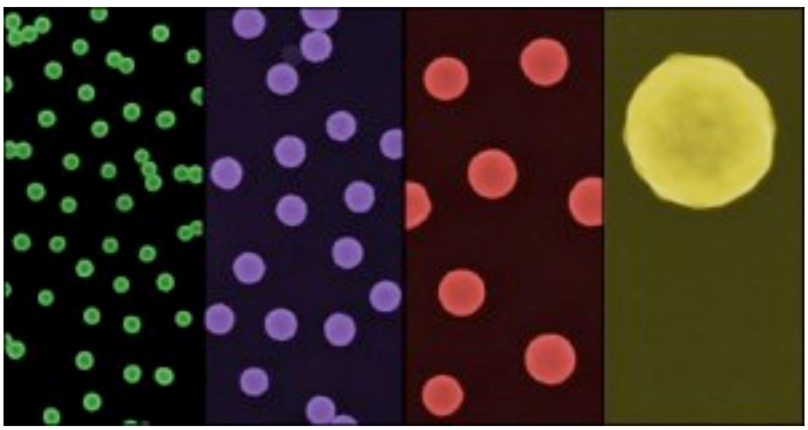


[A carbon nanotube is a hollow tube consisting of repeating hexagonal arrangements of carbon atoms.]

Several varieties of nanostructures are demonstrating extraordinary power to selectively destroy cancerous cells. Nanostructures like carbon nanotubes and gold nanoshells both show promise not only in treating cancer, but also in allowing early, precise, and noninvasive detection of cancer. Carbon nanotubes are rolled-up sheets of carbon atoms, forming hollow tubes only about one nanometer wide. Gold nanoshells are tiny spheres (in this case, of silica) coated with a thin layer of gold.

What's the trick to getting nanotubes and nanoshells to stick only to cancerous cells? Researchers have experimented with using both folate (a B vitamin) and antibodies. Rapidly dividing cancer cells have an unusually high number of receptors for folate, and nanostructures coated in folate can pass with relative ease into cancerous cells. Antibodies promise even greater selectivity; for example, a nanostructure can be coated with antibodies that bind to proteins found only on the surface of melanoma cells.

Once the nanotubes are stuck to the cancerous targets, they are poised to kill in one of two ways. Their hollow interiors can carry anticancer drugs, or they can be zapped with infrared radiation, the same relatively harmless form of radiation that causes sunlight to feel warm and that turns on your TV remotely. Bathed in infrared light, which passes easily through body tissue, the carbon nanotubes heat up dramatically and destroy the attached cancerous cells.



[Gold nanoshells appear in this series of photographs, magnified 15,000X, 20,000X, 30,000X, and 95,000X respectively.]

Gold nanoshells also show great promise in targeting tumors, even without the help of folate or antibodies to guide them. Thanks to their small size—twenty times smaller than a human blood cell—nanoshells injected into the bloodstream tend to congregate in cancerous tumors. Why? Tumors grow so rapidly and erratically that they tend to have “leaky” blood vessels with small holes that let gold nanoshells pass into the cancerous tissue. Apply some infrared radiation from the outside and the nanoshells cook the tumor to death while leaving healthy tissue unharmed.

The fact that nanostructures can be designed to collect at tumor sites makes them very promising for cancer detection, as well. Nanotubes and nanoshells are both good conductors; when they collect around cancerous cells, they can act as beacons to make even tiny tumors visible during scans.

So far, the great promise shown by nanostructures in treating cancer has been limited to Petri dishes and mice. Human trials are likely to begin in the next few years, a prospect that thrills some people even as it makes others nervous.

Despite glimmers of a cancer cure on the horizon, the nanostructure picture isn't entirely rosy. The ease with which nanostructures can enter cells leaves open the as yet largely unexplored question of what else they might do once inside. Fish exposed to nanostructures called buckyballs developed severe brain damage in one study, and another showed that mice inhaling carbon nanotubes developed lesions in their lungs. Any medical use of nanostructures will require plenty of research to confirm that they can be administered safely.