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NANOSCALE INFORMAL SCIENCE EDUCATION

Imaging with Quantum Dots

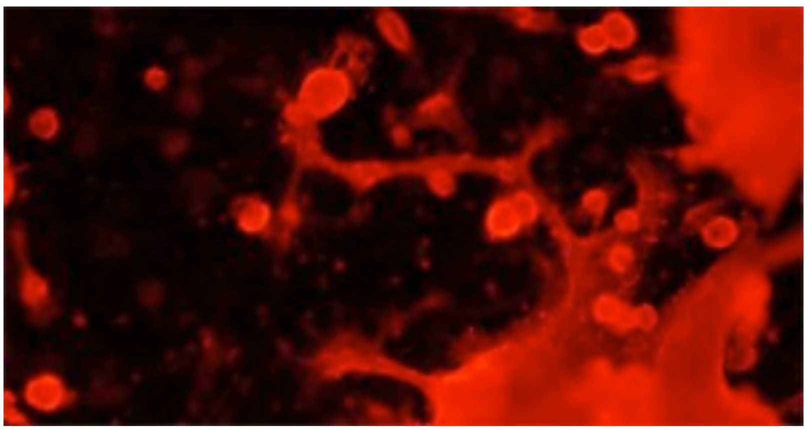
In medicine and biomedical research alike, understanding disease requires seeing the invisible. What pathogens are at work, and where are they lurking? Which tissue is diseased or damaged, and which tissue is healthy? How and where is the disease spreading? To answer such questions, or even to be able to understand how the body develops and functions when it's perfectly healthy, we have to be able to see things—viruses, genetic abnormalities, cellular changes—that can't easily be seen.

Until recently, researchers often visualized these tiny biological players by "tagging" them with organic dye molecules. These dye molecules absorb light of only a very specific wavelength and then reemit it at a different, yet specific, wavelength. When attached to their subject of interest and illuminated at their absorbing wavelength, their characteristic glow can be viewed through a special filter. Unfortunately, these organic dye molecules break down rapidly, quickly losing their ability to glow. Meanwhile, they are also often quite toxic, and so are of limited use for the study of living systems.

[Differently-sized quantum dots glow with different colors when exposed to ultraviolet light.]

But the future of biomedical imaging is glowing more brightly thanks to quantum dots. Quantum dots are semiconductor nanocrystals—very tiny bits of materials that are not quite metals, and not quite nonmetals. Imagine starting with a small chip of silicon, and then breaking it into smaller and smaller bits. When you have a piece that's only about 20 nanometers or so across, that's the type of material we are talking about.

The amazing (and amazingly useful) thing about quantum dots is their flexibility when it comes to both absorbing and emitting light. They can absorb light of all frequencies, above a certain threshold. The light they emit, however, depends on the dot's size. A smaller dot emits bluer light, a larger dot emits redder light. In this way, a single material such as silicon can be used to make a rainbow of differently-colored quantum dots, each of which can be chemically tailored to bind only to certain specific targets. It's like having an infinite variety of colored Post-Its® to paste directly onto cells, viruses, and other biological sites of interest.



[Glowing red quantum dots reveal cells infected with a respiratory virus.]

Biological systems being as complex as they are, the potential for numerous tags that can all be monitored at once is a great boon. The other advantage of quantum dots for biomedical imaging is a much longer lifetime. Cells can be tagged with a quantum dot and then visualized for several cell generations before they lose that special glow.

In light (ahem) of their advantages, quantum dots are being put to an ever-expanding number of research uses, such as watching the spread of a flu virus through lung tissue or singling out cancerous cells in mice. In the coming years, quantum dots are certain to speed research progress and thereby speed the arrival of cures and treatments. It's likely that quantum dots will eventually be put to use pinpointing disease sites and identifying pathogens in living humans.