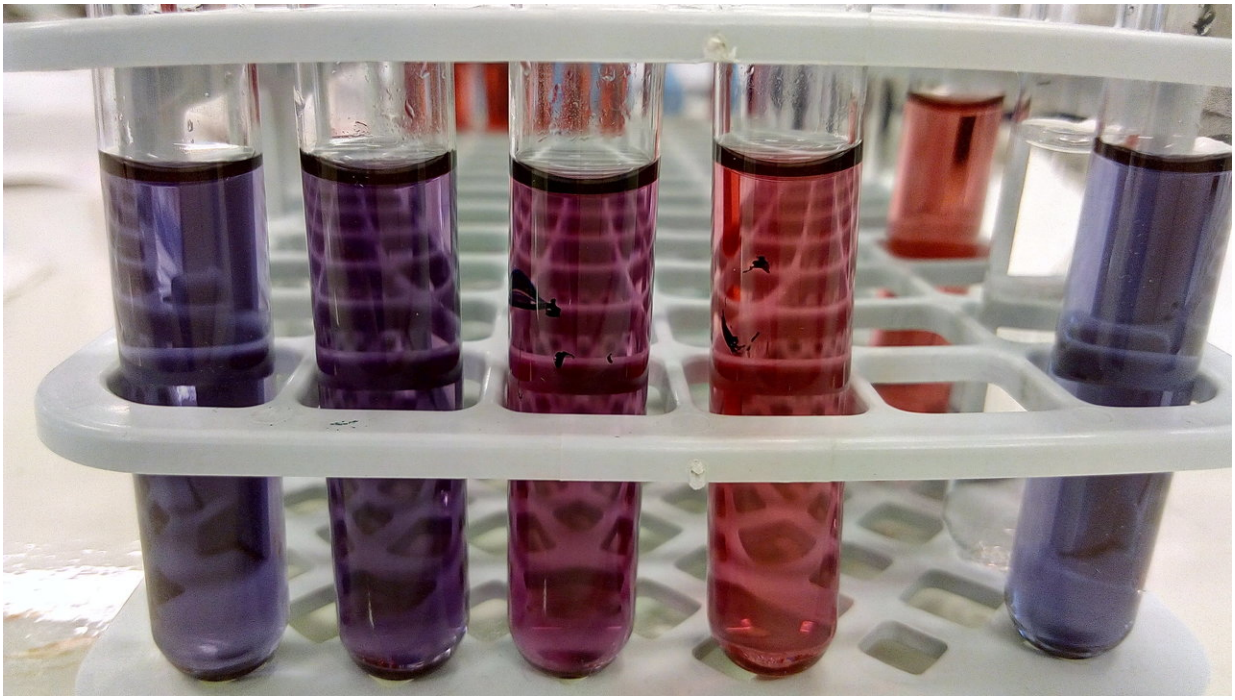
Why nanotechnology is more than just a buzzword

June 1 2018, by Upulie Divisekera



The colour of gold nanoparticles in suspension varies according to the size of the nanoparticles. Credit: Valeg96, CC BY

What does the word "nanotechnology" conjure up for you?

I've spent the best part of a week talking about the term "nanotechnology" and whether it's a real field, a real term or not.

In its simplest sense, nanotechnology means working with materials at the scale of one billionth of a metre. The prefix "nano" refers to one billionth: it's part of the scientific scale of measurement.

I use the term nanotechnology as a convenient catch-all term to describe my field of research. My research is into making nanoparticles that can be used as tiny capsules to deliver drugs to cells. I work with proteins and a range of gold nanoparticles to try and achieve this goal.

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Selling nanotechnology

Like many scientific and academic terms, nanotechnology (also known as "nano") is an overused, overhyped term in the mass media.

Cosmetic companies advertise products with "nanotechnology" – perhaps hoping to convey that tiny robots are repairing your skin. However, these products are more likely to just include liposomes – tiny, double-layered bubbles of lipid. They are nanoparticles, not quite the nano robots we would envision from science fiction.

The Tata Nano car in India, and Apple's iPod Nano music player also use the prefix "nano". It's become a convenient prefix, in the same way that "micro" and "smart" are overused and effectively meaningless marketing terms.

To complicate things further, nanotech and nanoscience are now popularly synonymous with "miniature robots that will turn the world into grey goo" or miniscule invisible threats to our health and environment.

It is true there is some concern around the potential environmental effects of improperly disposed nanomaterials. The toxicology of nanomaterials and regulatory issues around their use and disposal is an ongoing discussion.

But it is frustrating as a science communicator and scientist to see the term "nano" used in some of these ways – not for a lack of humour but because of the amount of effort required to counter these misconceptions is often disproportionate to the ease with which they are misused.

Does 'nano' mean nothing?

So does the term nanotechnology apply to everything, and therefore mean nothing? While nano is a buzzword in advertising and media, there is a more specific understanding of what it entails in science — or rather, engineering.

Nanotechnology is a wide field that covers research and inventions that make use of the quantum effects that happen at the nanoscale – that is, at the nanometre or billionth of a metre level.

Because of the size of the materials and particles at this level, the quantum effects become more pronounced at the nanoscale, and can be used to generate entirely new, thinner materials.

The term "quantum effects" here refers to the properties of the material that shape melting point, fluorescence, electrical conductivity and chemical reactivity.

For example, at the nanoscale, there are novel optical properties – that is, reactions between light and the material – that can be used for applications such as nanobarcoding.

Nanotechnology uses these properties to make new materials and devices — anything from soft electronics, plasmonic superlattices (ultrathin nanomaterials that interact with light), gold, silver and polymer nanoparticles, nanowires, and so on.

In truth, biomolecules and viruses are the original, all natural nanotech. Biomolecules such as DNA may store the genetic code of life, but the structure of DNA can be used to generate nanowires, and DNA can be used as a bridge between particles to connect them together.

Proteins can be used as scaffolds to make metallic structures known as metallo-organic frameworks that can be used as filters or for delivering therapies, to name just two applications.

We can also make materials from inorganic materials like gold and silver – there are now pens available that allow you to draw nanowire circuits.

Sunscreen has nanoparticles, and silver nanoparticles are used as anti-bacterial agents in many everyday items. Lithium batteries use nanotech for better storage: in fact, nanotech is critical for improving battery performance and capacity.

And nanotech is useful in miniaturising devices and improving their performance. We now have hand-held DNA sequencers that can be used in the field. We no longer have to send samples back to the lab and wait for the results – we can sequence DNA on site, thanks to the intelligent use of proteins in miniaturised devices.

Most nanotech research is interdisciplinary (combines different expertise), even transdisciplinary (operates across many fields of science). It requires that you delve into chemistry (inorganic and organic), electronics, analytical chemistry, surface chemistry, protein chemistry and structure, nucleic acid chemistry (both DNA and RNA),

lipids (fats), and many more techniques.

So, it's often easier to use the catch-all term "nanotechnology" when describing this kind of research involving many disciplines.

We use nanoscale properties of materials, creativity and inventiveness to create new tech, new materials, new structures, and perhaps in the future, new ways of being.

Think of it this way: if you want to shrink devices, you make the components of these devices smaller. Nanotechnology just uses nanometre size components to build these devices, using the quantum effects prominent at this scale.

Nanotechnology pulls together all of these features for useful applications.

Nano isn't all 'BS'

At the coal face, research is mostly intriguing ideas that require tedious optimisation; trying to manufacture tiny items from a bottom up process (that is, building at the nanoscale) rather than top down (refining existing materials).

In nanotechnology, we don't have to break large materials up into tiny pieces, we try to generate them from the bottom up using chemistry. This sort of work can be boring, but when it works for that first time, it's like magic.

So nanotech can, sometimes, like Elon Musk implied, be a "BS" catch-all term.

But it's also a field many scientists and engineers work in every day, and

that many universities acknowledge. It's a growing, burgeoning field full of exciting and intelligent new inventions.

In many ways, it's a truly serious attempt to cross both organic and inorganic together into devices that mimic the exquisite refinements of nature. It's difficult – and exhilarating.

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