at Northwestern University, Illinois and California State University have constructed the first evolutionary tree describing a large family of gold nanoparticles, all of which have unique optical properties.

The researchers chose gold nanorods as the 'seed' material, or ancestor, of their family tree. They identified three main evolutionary pathways that the nanoparticle can follow, using growth solutions of slightly different concentration and pH. The three pathways produce particles shaped like peanuts, square cuboids or octahedrons, and different sizes can be isolated by interrupting each pathway at different stages of development.

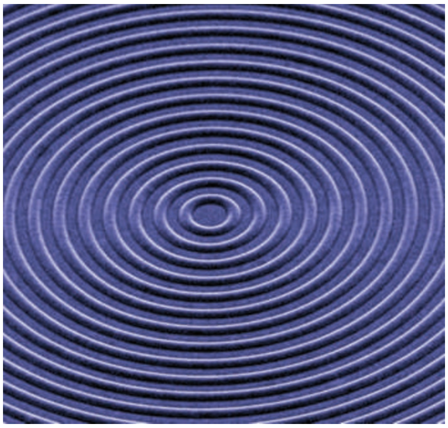
The researchers acquired even more types of nanoparticle by cross-breeding across evolutionary pathways. For example, by placing square cuboids in the growth solution for octahedrons, they produced elongated octahedrons.

This three-branch tree probably represents only a small portion of all the particles that can be produced from gold nanorods. By completing the family trees for this and other systems, researchers could more easily develop specific nanoparticles for applications such as biological labelling, sensing or drug delivery.

PLASMONIC DEVICES

Smooth operators

Science **325,** 594–597 (2009)



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David Norris and co-workers at the University of Minnesota have developed incredibly smooth metal films with various nanosize patterns on their surfaces. The films could be ideal components for new plasmonic devices.

Plasmonic devices work by manipulating surface plasmons — electromagnetic waves that appear when oscillating free electrons on a metal surface interact with light. The main technical challenge is to control the movement of surface plasmons, which is often erratic because metal surfaces have tiny random defects that get in the way.

Norris and co-workers etched patterns onto a very smooth silicon wafer, and coated the wafer with a thin layer of silver, gold or copper. Once the metals had set, they peeled them off to reveal patterned metal surfaces that were just as smooth as the silicon wafer templates. Using this method the researchers made ultrasmooth metal films with ordered grooves, ridges, pyramids, bumps or holes on their surfaces. They found that plasmons could travel long distances through the films without being scattered.

This simple new process could produce high-quality patterned metals for devices such as biological sensors and solar cells. Furthermore, the same technique can be used to produce metamaterials — films with a negative refractive index — for interesting optoelectronic applications.

SUPERHYDROPHOBIC SURFACES

Not so hot

J. Mater. Chem. **19,** 5602–5611 (2009)

Superhydrophobic surfaces that repel liquids have several applications in self-cleaning surfaces and protective clothing. These surfaces are known to perform well with cool water (around 25 °C) owing to their unique surface roughness, but whether they can repel hot liquids remains unexplored. Now, researchers at Hong Kong Polytechnic University and the University of Minnesota show that superhydrophobic surfaces cannot repel hot liquids effectively because the wettability of the surface changes when hot water comes in contact with them.

Yuyang Liu, John Xin and colleagues compared the repellent characteristics of a natural lotus leaf, an artificial leaf with similar micro- and nanostructures, and Teflon (a well-known hydrophobic coating manufactured by DuPont) by spraying them with water and measuring how much wetting occurred on the surfaces. All the surfaces repelled cool water (~25 °C) effectively, but not hot water (>55 °C). Further experiments indicated that surface roughness has an important role in repelling cool liquids, but the surface energy of a substrate is more important when dealing with hot water.

The lower surface tension of hot water also means that droplets can enter pores and fissures on rough surfaces more easily and displace the 'air cushion' that normally helps support cool water droplets. For this reason, it is suggested that to repel hot liquids surfaces should be designed to trap air.

The definitive versions of these Research Highlights first appeared on the *Nature Nanotechnology* website, along with other articles that will not appear in print. If citing these articles, please refer to the web version.

Top down Bottom up

Digging deeper

Fullerene molecules make small holes when they adsorb onto a silver substrate.

Renee Diehl's research project began small, but it didn't stay that way. Diehl, a professor of physics at Pennsylvania State University, was interested in how fullerene molecules bond to metal substrates. The project began with Diehl and three of his students, but grew to twelve people at seven different institutions by the time it was published (*Phys. Rev. Lett.* **103,** 056101; 2009). Researchers from the University of Liverpool helped with the experiments, and theorists from Finland, Germany and the US performed simulations. Initial calculations by Wolfgang Moritz from the University of Munich contradicted previous results, including those of Lin-Lin Wang from the University of Illinois, who then joined the collaboration, along with theorists from Duke University, the University of Florida and Lappeenranta University of Technology.

The team observed the adsorption of a fullerene monolayer on a silver surface using electron diffraction, and compared their data with the predictions of models to reveal the arrangement of carbon and silver atoms. The fullerene molecule is the most complex structure to have been analysed this way. Despite the relative strength of silver–silver bonds, the fullerene molecules dug small holes in the silver underneath their adsorption sites. This behaviour, which had not been previously observed, may have implications for interfaces in molecular electronics as well as biology.

The complexity of the project meant that it took some time to finish. "We have never taken so long to do a study like this" says Diehl. "It seemed to drag on forever because the analysis was so complicated. As problems become more complex, it is almost imperative to collaborate with others." Diehl considers the students, in particular, to have benefited. "I can see them grow" he says. "I think they are more likely to consider research careers as a result of these interactions."