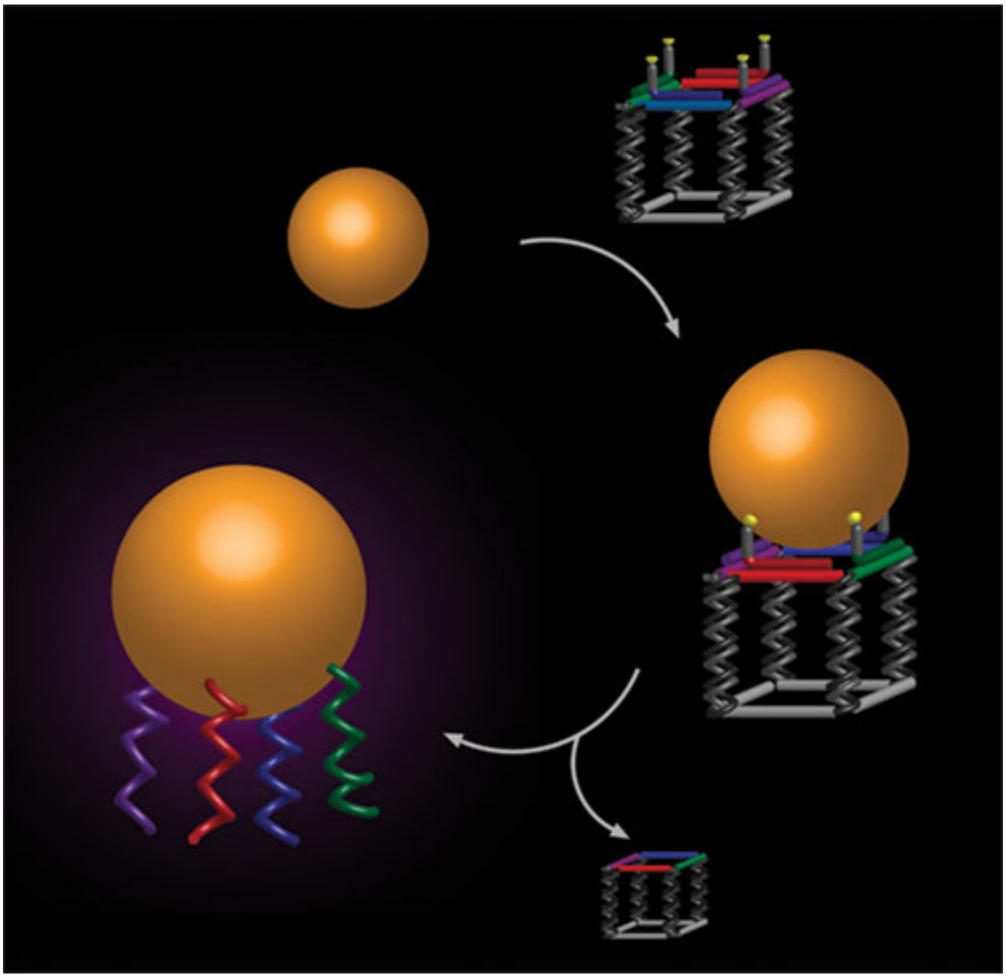
Using DNA as a printing press to create nanostructures

May/June 2016
BIOCHEMISTRY
TIM LOUGHEED



Molecular patterns are transferred to gold particles via a DNA-derived template. Photo Credit:

Tom Edwardson

Just as hydrocarbons ranked as perhaps the most influential family of complex molecules in the 20th century, DNA may well be on its way to claiming that title for the 21st. Since it was first characterized in the 1950s, this intricate double helix biopolymer has opened up new frontiers in the study of life on earth, including an unprecedented understanding of how our own bodies grow and develop.

But over the past few decades, chemists have employed the powerful binding characteristics of DNA for another purpose: as scaffolding for all manner of novel structures that could be used to create nanoscale devices. In the years to come, these devices may analyze proteins, direct enzyme activity or capture light. Hanadi Sleiman, who holds the Canada Research Chair in DNA Nanoscience at McGill University, has prepared her own elegant examples of such structures. Sleiman is quick to add, however, that so far their practical value has generally remained limited by how expensive and time-consuming they are to produce.

For just that reason, Sleiman and graduate student Tom Edwardson have been exploring a way to convert the role of DNA from that of an essential scaffold to something more akin to a printing press. The DNA molecule would serve as a template, transferring its rich information content to gold nanoparticles that interact with it. "These particles will be just as smart as the DNA scaffold because they got the pattern from the DNA," she says.

Sleiman is referring to the information content that is transferred from the DNA to the gold nanoparticle, an innovative process that promises to transform this type of manufacturing. In the rapidly growing field of nanostructure assembly, gold has become prized for the unique optical, electronic and chemical properties that it can yield at extremely small scales. These effects are enhanced when nanoparticles are brought together in clusters or crystal assemblies, which might be made up of millions of nanoparticles. Corralling all these loose pieces is a major logistical challenge, along with ensuring they move into the appropriate arrangement to carry out their intended function.

In a *Nature Chemistry* paper published earlier this year, Sleiman describes how she and her colleagues created site-specific addressability, which she dubs "sticky patches," on a three-dimensional DNA structure, such as a cube, triangular or pentameric prism. When a gold particle interacts with these DNA prisms, the pattern DNA strand with sticky patches is "printed" on it. The DNA prism can then be reused. The resulting gold particles are very different from their symmetrical predecessors. They can assemble together autonomously into well-defined structures like a "cat's paw" without needing external help from a DNA scaffold. "As a result of conducting electrons being confined in a gold nanoparticle, there are new properties that occur," Sleiman says. "Even more interesting are properties that come from coupling two or three particles together."

Above all, Sleiman adds, once the hard work of designing the template is complete, large numbers of these intricate nanostructures could be readily manufactured. "You can imagine a factory where the DNA itself is the stamp, continuously transferring a pattern to different gold particles," she says. "The same structure could be used to make thousands and thousands of gold particles."

 Connect with us