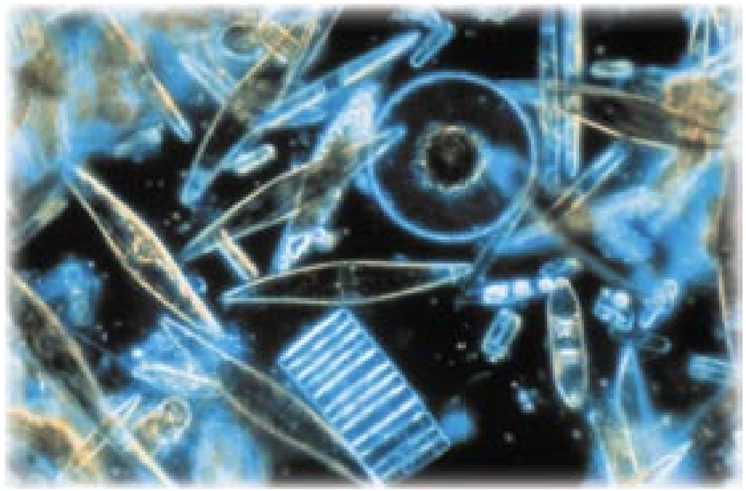
Nanotech gadgets to be built by algae?

Ancient, single-celled organisms that are lowly anchors in the marine food chain may soon be integral players in the lofty realm of nanotechnology, the science of the very small.

Nanotech materials and devices measure less than a hundred nanometers, a unit of measurement that is one billionth of a meter. By contrast, a human hair is about 20,000 nanometers thick.



A microscopic view of several marine diatom species reveals their silica exoskeletons, which have strikingly different shapes. Researchers hope to use the algae's shell-building process to manufacture nanotech materials. (Photograph by Neil Sullivan/University of Southern California, courtesy NOAA.)

According to scientists and market analysts, the world is on the cusp of a nanotechnology revolution: The teeny, tiny materials and devices are beginning to show up everywhere from clothing and sporting goods to computer electronics and medical equipment.

But a limitation to the pending revolution is the high expense and inefficiency of making materials and devices at the nanoscale, according to Gregory Rorrer, a chemical engineer at Oregon State University in Corvallis.

Rorrer believes a solution to the problem may lie in diatoms, single-celled marine life-forms that have been around since the age of the dinosaurs.

The algae are well known for their crucial role at the base of the marine food pyramid and for ridding the greenhouse gas carbon dioxide from the atmosphere. In addition, diatoms have a unique ability to pull silica from seawater and mill it into intricately-structured, rigid shells, Rorrer said.

The organisms create their shells by employing special proteins and subcellular organs to first assemble silica nanoparticles, which are composed of just a few hundred atoms. The proteins and subcellular organs then orchestrate the assembly of those nanoparticles into shells, Rorrer said.

"You've two levels of structure—these nanoparticles and then, what's way more interesting, is you can take these particles, and each one is like a little brick, and they are assembled into ornate microstructures," the chemical engineer said.

Last July Rorrer's lab at Oregon State University was awarded a four-year, 1.3-million-dollar (U.S.) grant from the National Science Foundation to develop a process that harnesses diatom shell-construction to create nanostructured materials. (The foundation also funds *National Geographic News*'s Pulse of the Planet news series, of which this story is a part.)

Products may include flexible computer screens, cheap and efficient solar cells, filtration devices, and drug delivery vehicles that can target, for example, a single cancer cell.

Nanomaterials

Rorrer's lab aims to incorporate elements such as silicon, germa-

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nium, titanium, and gallium into the diatoms' silica shells. At the nanoscale, these elements follow the laws of quantum mechanics instead of Newtonian physics, giving them unique and commercially desirable properties.

(Newtonian physics denotes well-known forces like gravity, while quantum mechanics describes laws of physics that apply at very small scales, such as those found in atoms.)

At the nanoscale, for example, the metal germanium glows blue when energy is applied to it. This has a host of applications in electronic and medical imaging technologies, Rorrer said.

The process to incorporate germanium nanoparticles in silica is "doable but difficult with existing technology," the scientist said.

The conventional process involves vaporizing a germanium crystal in a vacuum with a high-energy laser beam and coaxing the vaporized atoms to glom onto a silica surface.

"That has to be done at a high temperature [and] at a high vacuum and [with] all the equipment associated with the control of that," Rorrer said. "We do essentially the same thing by growing living organisms in a vat."

The trick for Rorrer and his Oregon State University colleague, Chih-hung Chang, is to add just enough dissolved metal to the vat to allow the diatoms to absorb it without dying.

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To date "the concept for germanium incorporation has been proven," Chang said. "We will work on incorporating other metals very soon."

Another advantage to using diatoms, Rorrer said, is that when the algae divide, they make a perfect copy of themselves, meaning "we can make a gazillion of these, and they are all the same."

Shapes

In addition to the ability of the diatoms to absorb these metals and create nanostructured materials, each diatom species makes shells with unique designs. And there are tens of thousands of diatom species.

Which means there are "tens of thousands of micro-templates," Rorrer said. "Some have holes, some ribs, some oval, some square—and all the microfabrication has been done by the organisms. We just put additional material on it."

In the future, the researchers hope they can use these diatoms to make intricate designs at the microscale that are currently not possible with existing technology.

To find the appropriate template, all a researcher would need is a searchable database of natural diatom designs. Genetic engineering may also one day make it possible to control diatom design.

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