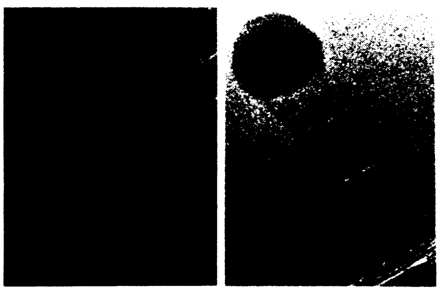
The liquid state of solid gold particles

Tiny particles of gold, made up of only a few thousand atoms, sometimes behave more like liquids than solids. New experimental evidence suggests that although such particles have a particular, orderly atomic structure at any given moment, they can easily shift from one atomic arrangement to another. Under these conditions, the particle appears to be in a "quasimolten" state, even though the material is at a temperature far below its normal melting point.

"It's both a solid and a liquid," says materials scientist Laurence D. Marks of Northwestern University in Evanston, Ill. "If you look at it for minutes to hours, it's a liquid. But if you look at it on the [much shorter] time scale, say, of a chemical reaction at the surface, it's a solid." Marks and P.M. Ajayan report their findings in the July 17 PHYSICAL REVIEW LETTERS.

The researchers used an intense electron beam to dislodge "ultrafine" gold particles attached to a magnesium oxide surface. Once free, the particles started rapidly and randomly changing their atomic structure. The experiments showed that whereas a large amount of energy was needed to initiate this behavior, only a small amount was required to sustain it.


Marks

A small gold particle, covered by a thin carbon coating, sits on a magnesium oxide substrate (left). The evenly spaced lines represent rows of gold atoms. Turning on the electron beam eliminates the carbon contamination and initiates the formation of a pillar beneath the gold particle. Eventually, the particle atop its pillar becomes so loosely attached to the substrate that its structure starts to fluctuate freely, even when the electron beam is faint. The particle's atomic arrangement shifts so many times in the 3 seconds it takes to produce an image that clearly defined rows of atoms are no longer visible (right). This behavior can last up to 40 minutes.

"We actually turned the beam off for 5 or 10 minutes, and when we turned the beam back on, it was still in the state," Marks says. That observation demonstrates that the particle's fluctuating behavior is a property of the particle itself rather than an electron-beam effect.

Marks and Ajayan also observed that tiny gold particles can sometimes induce the formation of a pillar of material beneath them. "Where the gold touches the magnesium oxide, it strains the material," Marks says. "As a consequence of that strain, some matter gets pulled out toward the particle."

Chemists often use fine particles as catalysts to speed up reactions. Usually, catalysis works by a lock-and-key mechanism in which the particle, having a certain surface structure, is the lock and the incoming molecule the key. "You really have to change how you think about a small particle," Marks says. "Your lock is actually changing in structure. It's varying its code all the time." *—I. Peterson*

Land plants' algal roots

Scientists know little about how plants evolved from their green algal ancestors. The problem is plain: Primitive plants, lacking hard parts, made poor fossils. But botanists probing living organisms have inserted a new piece into the plant-ancestry puzzle.

In the alga considered the best model organism for a land-plant ancestor, researchers at the University of Wisconsin-Madison have discovered a compound similar to lignin — an important structural element of wood and of cell walls in all vascular plants.

The finding provides a "chemical missing link" between land plants and the group of green algae that scientists believe gave rise to them about 400 million years ago, says Cornell University plant scientist Karl J. Niklas. Moreover, it suggests that lignin originated in algae and not, as previously thought, in early land plants, says study leader Charles F. Delwiche, who reports his group's results in the July 28 SCIENCE.

The new evidence also suggests that lignin's first function was not structural, since algae need not stand up in the water. Rather, the woody material probably acted initially as an antimicrobial agent, only later taking on a mechanical role, Delwiche says.

In addition, the Madison research team found a striking similarity between the distribution of the lignin-like chemical in the alga *Coleochaete* and in a species of hornwort, an early group of land plants related to mosses. This similarity indicates a closer-than-expected relationship between green algae and hornworts, Niklas says.

Delwiche's team began to suspect that something like lignin lurked in *Coleochaete* when they boiled the millimeter-wide organisms in strong acid and discovered, to their surprise, that much of the tissue remained intact. Using chemical and microscopic tests, they went on to confirm the identity of the durable debris. □

Cancer roadblock on cholesterol pathway

The road to cholesterol synthesis is paved with more than a dozen chemical precursors. Biochemists now report that blocking the production of one of these precursors yields an unexpected payoff: A protein involved in pancreatic and colon cancers can no longer prompt cellular changes associated with cancerous growth.

The finding, they say, establishes the first major link between cholesterol synthesis and cancer. It also suggests a new arsenal of anticancer drugs — possibly including a compound now marketed as a cholesterol-lowering agent — that target specific cholesterol precursors. On a more basic level, the discovery may help clarify the chemical changes and genetic mutations that trigger some genes, called oncogenes, to cause cancerous alterations in cells.

Researchers at the University of California, Berkeley, and the Lawrence Berkeley Laboratory inhibited the formation of mevalonate, a precursor to cholesterol and other compounds. Without mevalonate, the protein encoded by the *ras* oncogene cannot attach to cell membranes — a critical step in promoting pancreatic and colon cancers. Though the protein retains its ability to promote cancer, without membrane attachment it never gets the chance.

In unfertilized frog eggs, the group observed that human oncogenic ras — a rare, mutant relative of the normal ras protein found in cells — caused breakdown of the envelope surrounding the cell nucleus, indicating the protein induced cell division. But preinjecting the eggs with compactin or lovastatin — drugs that block the formation of mevalonate — prevented oncogenic ras from maturing and initiating envelope breakdown. Adding mevalonate to these eggs restored the ras protein's ability to cause envelope breakdown, the researchers report in the July 28 SCIENCE.

Because physicians already prescribe lovastatin to lower cholesterol in some patients (SN: 9/12/87, p.166), researchers are eager to know if the drug also lowers the incidence of cancers associated with the *ras* oncogene. But the California scientists and others emphasize that the anticancer potential of any such drug would hinge not on its cholesterol-lowering properties *per se* but on its ability to block precursors that assist oncogenic ras. In fact, note study coauthors Jasper Rine and William R. Schafer, better anticancer drugs might come from compounds that act on another cholesterol precursor, farnesyl pyrophosphate, which derives from mevalonate and serves to "glue" ras to cell membranes.

"Proteins such as ras are water-loving

molecules that have trouble attaching to the greasy cell membrane," Rine explains. "The protein requires a little dab of grease to attach." Upon detecting functional similarities between a yeast sex hormone and the yeast form of ras, the researchers hypothesized that farnesyl provides the missing dab of grease at the tail end of the ras protein.

Research reported by British investigators in the June 30 CELL confirms the location of farnesyl's attachment to ras. And a study by scientists at the La Jolla (Calif.) Cancer Research Foundation, to appear in an upcoming PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, chemically identifies farnesyl as the grease dab. Rine told SCIENCE NEWS his group plans to search for the enzyme that enables farnesyl to attach to ras. Once the enzyme is identified, he says, researchers might be able to develop drugs that inhibit it.

A more basic challenge, comments Nobel laureate Michael S. Brown, a cholesterol researcher at the University of Texas Southwestern Medical Center in Dallas, is to determine whether the link between cholesterol synthesis and the *ras* oncogene is "a mere evolutionary fact without deeper significance" or nature's way of activating oncogenes. *– R. Cowen*

Lethal look-alike unmasked, examined

A widespread protozoan infection called toxoplasmosis strikes humans and many other warm-blooded animals, including an estimated 40 percent of all cats. Though many of those infected live symptom-free, others suffer spontaneous abortion, severe illness and even death (SN: 2/13/88, p.102).

Now, a leading toxoplasmosis investigator reports data showing that another, long-unrecognized protozoan – able to parasitize many of the same hosts – has for decades masqueraded as a particularly virulent form of the more familiar *Toxoplasma gondii*.

Fourteen months ago, parasitologist Jitender P. Dubey identified and named *Neospora caninum*, isolated from the stored tissues of 10 dogs that had succumbed to a virulent toxoplasmosis-like disease. Working at the Agricultural Research Service in Beltsville, Md., he eventually grew *Neospora* in his lab. Last November, he showed it could induce severe toxoplasmosis-like disease in dogs. Says Dubey, "We now believe at least 4 percent of dogs are infected."

By infecting laboratory animals with *Neospora*, he has produced severe toxoplasmosis-like paralysis and death in cats, rats, mice and gerbils over the past year. Since February, Dubey has found the same *Neospora* in tissues from eight calves and one sheep. He described his ongoing work last week at the American Veterinary Medical Association meeting in Orlando, Fla.

Although *Neospora* can infect any tissue, Dubey says, "it is most commonly found in the brain and spinal cord," as is *Toxoplasma*. The two microbes look similar, except that *Neospora* cysts have a far thicker outer wall. *Neospora* also induces production of unique antibodies in its hosts – a finding Dubey and colleague David S. Lindsay employed in designing diagnostic assays. One such test permits researchers to identify *Neospora* in tissues that have been stored for decades. A newer test involves mixing a special dye with antibodies harvested from rabbits infected with a suspect microbe. If the dye fluoresces, *Neospora* is confirmed.

Most questions about this protozoan's life cycle, prevalence and susceptibility to treatment remain unanswered. "We also don't know whether it is infectious to people," Dubey notes. "But given its similarity to *Toxoplasma*" – which infects an estimated 35 percent of the U.S. population – "there is at least a potential for it." *Toxoplasma* can cause central nervous system ailments including paralysis, blindness and retardation.

In future studies, Dubey's group will focus on abortion rates in infected cattle. They also plan to investigate how *Neospora* spreads. Toxoplasmosis can result from eating the raw or undercooked flesh of infected animals, or even touching the mouth with hands or utensils that have touched such meat. Feces from cats – the only animals known to shed *Toxoplasma's* highly infective oocytes, or immature eggs – is another source of the infection. Dubey, who 20 years ago identified the essential role cats play in *Toxoplasma's* life cycle, says his experiments with *Neospora* have now virtually ruled out cats as its primary host. *– J. Raloff*

Clues to an ancient upside-down ocean

Picture an ice cream cake covered with a pool of hot fudge sauce. This is the way the ocean is organized, with buoyant warm water floating atop cold, denser layers. Scientists have considered such an arrangement a permanent feature of the ocean, but new evidence from the seafloor might turn this image on its head for certain times in the geologic past.

Researchers from the University of California, Santa Barbara, say their findings hint that 40 million years ago, warm, salt-rich water filled the deep ocean while cooler water covered the upper layers. "People have thought about the possibility of warm, saline deep water for years," says James P. Kennett. "These are the first data hinting that we may be onto something important."

Kennett and Lowell D. Stott found evidence for an upside-down ocean in sediment cores drilled from the Maud Rise near Antarctica. They measured the relative amounts of different oxygen isotopes locked within the calcium carbonate shells of tiny animals that fall to the seafloor after death. Oxygen isotope ratios indicate the water temperature during the animal's life.

Isotope ratios at two sites with different depths suggest the lower site was significantly warmer than the upper site at least as far back as the middle Eocene period, 46 million years ago. After many fluctuations, the ocean flipped to a more modern style around 28 million years ago, the researchers proposed last week at the meeting of the International Geological Congress in Washington, D.C.

From these data, Kennett and Stott infer that the entire ocean circulation ran backwards during the Eocene. Today, the bottom water forms at the poles, where air and ice cool the surface water and make it dense enough to sink. The cold bottom currents flow toward the equator.

The researchers say the deep water of the Eocene ocean formed not at the poles but primarily in the northern midlatitudes. During this period, a large ocean called the Tethys separated Eurasia from Africa and Arabia. With its high evaporation rates and scant precipitation, the shallow Tethys generated warm water so dense with salt that it sank to form the bottom layer, say Kennett and Stott. Ancient Antarctica, much warmer than today, spawned the cool water that filled in the upper layer of the ocean, according to their theory. The reverse circulation would have broken down when plate tectonics began pushing Africa and Arabia toward Eurasia, closing off the Tethys. Turning off the tap of warm water flowing to the poles would have helped cool Antarctica.

Kennett and Stott's interpretation may be flawed, argues Gerta Keller of Princeton (N.J.) University. She says investigators studying the same cores think the chemistry of the calcium carbonate from the Maud Rise may have changed over the eons – a finding that would limit the mineral's veracity as an indicator of past temperatures.

Many scientists are warming to the idea that bottom water once formed in the Tethys region. The question is whether this water was warmer or colder than the upper layers. Even if the Maud Rise isotope ratios represent true records, the case for an upside-down ocean will require more data from other sites.

– R. Monastersky