small peptide, modeling the inverse temperature transition of elastins (18). Although simulation seems to be ahead of experiment, the challenge of probing the dynamics of interfacial water is being taken up (19).

Most interestingly, this ab initio simulation (7) also provides first insights into how the electronic structure changes at the surface. Such modifications are of crucial importance in understanding chemical reactivity and heterogeneous catalysis at liquid interfaces (15). Recently, Knipping et al. reported that large anions accumulate at the water-air interface (20) due to their polarizability (21). However, it seems that a free volume effect interplaying with such a simple thing as ion size can also account for this enrichment without including polarizability in the computer simulations (22). This would connect the astonishing properties of interfacial water, via density modulations, to those of “stretched water” and thus offer a unified view. Even more salt is added to the soup given that the latest grazing incidence synchrotron x-ray reflectivity data of concentrated Na solutions, albeit at fairly low temperatures, apparently do not show such dramatic surface segregation effects (23). There is hope that first-principles simulations could help to settle these issues.

Apart from being a fascinating subject in its own right, the liquid-vacuum interface can serve as a well-defined model to study hydrophobic solvation (10, 24), vacuum being the ultimate hydrophobe. The feasibility study by Kuo and Mundy (7) demonstrates that such mesoscopic phenomena will soon be studied routinely, combining both realistic modeling and first-principles simulation. Thus, ab initio molecular dynamics (8) has a bright future.

References

Astronomy

Nuclear Fossils in Stardust

Larry R. Nittler

In 1952, Merrill reported in Science that the radioactive element technetium had been observed in a special class of giant stars (1). Because this element has no stable isotopes, Merrill proposed that these stars “somehow produce technetium as they go along.” This was direct evidence that elements are produced by nuclear reactions within stars, and it was only a few years later that a comprehensive theory of nucleosynthesis was laid out in largely modern form (2).

For decades, two lines of evidence have been used to test nucleosynthesis theories: chemical abundances measured spectroscopically in stars, and the bulk isotopic and elemental composition of the solar system. On page 649 of this issue, Savina and co-workers (3) report evidence for now-extinct technetium in microscopic grains of silicon carbide (SiC) extracted from a meteorite. These grains of circumstellar dust predate the solar system and provide a new and powerful way to investigate stellar evolution and nucleosynthesis with a level of detail and precision almost unheard of in nuclear astrophysics.

Since they were discovered in the late 1980s, stardust grains in meteorites have provided astrophysical information complementary to that obtained by astronomical observations (4, 5). These rare and tiny (less than a few micrometers) grains of minerals such as SiC, graphite, and Al₂O₃ have isotopic compositions that establish their formation in stellar outflows and ejecta. They survived conditions in the interstellar medium and early solar system and became trapped in asteroids, pieces of which now fall to Earth as meteorites. Each individual grain is essentially a condensed piece of a single star, and each contains a record of a wide array of astrophysical processes.

The best studied type of presolar stardust in meteorites is SiC (see the figure). More than 90% of presolar SiC grains (known as the “mainstream”) are believed to have originated in asymptotic giant branch (AGB) stars, one of the last evolutionary stages of stars with mass up to a
A Pattern of Precision

Paul W. Sternberg

The amazing precision with which different cell types find their correct locations in developing tissues has fascinated biologists for decades. Models of cell fate patterning during development emphasize the contrast between spatial gradients of developmental signals that act at long range and cell-to-cell signaling events that act locally. Development of the vulva in the nematode Caenorhabditis elegans provides an elegant model system for examining the patterning of cell fate in an animal. There is strong evidence that two different intercellular signals contribute to the relatively simple induction of cell fate among vulval precursor cells (VPCs): a long-range spatial gradient of epidermal growth factor (EGF) mediated by the EGF receptor (1, 2) and a cell-to-cell lateral signal mediated by the Notch-like receptor LIN-12 (3–5). It is well established that the combined action of the EGF receptor and LIN-12 receptor signaling pathways generate the pattern of VPCs in the developing vulva (6); however, the molecular details of this cooperative effect have remained elusive. On page 663 of this issue, Yoo et al. (7) provide the missing molecular connection. They report that VPCs activated by a low level of EGF are blocked from adopting a particular cell fate by a LIN-12 lateral signal from a neighboring cell.

The C. elegans vulva is formed from the descendants of six multipotent VPCs that adopt one of three cell fates (1°, 2°, 3°). A single primary (1°) VPC is flanked by two secondary (2°) VPCs that are morphologically indistinguishable but generate distinctly different sets of progeny cells that form the vulval epidermis; descendants of three tertiary (3°) VPCs do not form the vulva itself but fuse with the epidermal syncytium. Evidence suggests that VPCs adopt different cell fates depending on their distance from a graded EGF signal secreted by an anchor cell (see the figure). If a VPC is close to the anchor cell it will become a 1° cell; if a VPC is at an intermediate distance from the anchor cell it will become a 2° cell; a more distant VPC remains a 3° cell (1). Thus, VPCs respond to the EGF signal in a dose-dependent manner: A strong EGF signal specifies a 1° fate, an intermediate signal specifies a 2° fate, and low or no signal specifies a 3° fate (2). On the other hand, a VPC can become a 2° cell even if it does not express EGF receptors (4, 5) because LIN-12 signaling by a neighboring cell can induce a 2° cell fate (3, 6). A strong EGF signal, however, overrides the LIN-12 effect (6, 8), suggesting that the level of signaling is crucial to the ultimate fate of VPCs.

The vulval cells of C. elegans are dis-