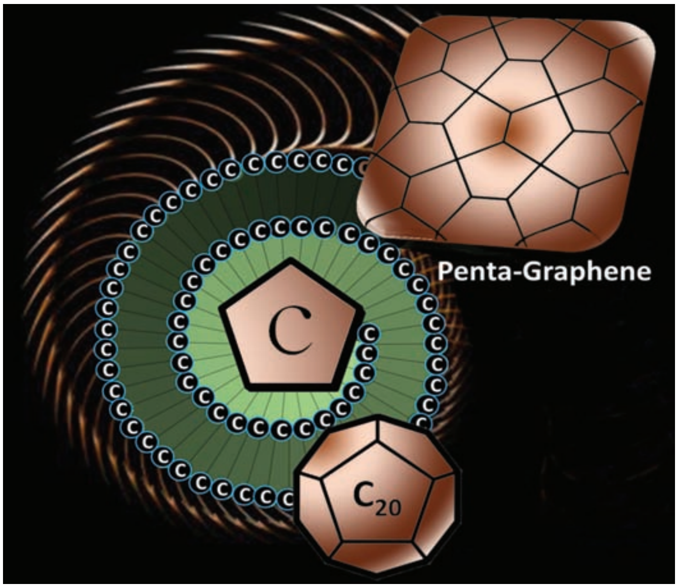
In This Issue

Converting solar energy into liquid fuel

Sunlight represents Earth's most abundant source of renewable energy, but efficient technologies to store and transport solar energy remain elusive. Although electricity from photovoltaic cells can readily split water into hydrogen and oxygen, this approach has limited applicability because most energy infrastructure is based primarily on liquid fuels. Seeking to bridge this gap, Joseph Torella et al. (pp. 2337–2342) devised an integrated bioelectrochemical system that uses the bacterium *Ralstonia eutropha* and hydrogen, liberated from water via solar energy, to convert carbon dioxide into biomass and the fuel alcohol isopropanol. Unlike previously reported applications that require precious metal catalysts, the authors' system runs on catalysts made of abundant Earth metals, generating equivalent solar-to-biomass yields that exceed the practical efficiencies of most terrestrial plants. The findings demonstrate that biotic and abiotic catalysts can be used to achieve challenging chemical energy-to-fuel transformations, offering a potential means to connect solar energy with a liquid fuel infrastructure, according to the authors. — T.J.

Simulated synthesis of a graphene alternative

Most carbon nanostructures contain hexagonal building blocks, sometimes interlocked with pentagons, which are typically deemed topological defects. Shunhong Zhang et al. (pp. 2372–2377) simulated the synthesis of a carbon structural variant composed entirely of pentagons fused in a pattern reminiscent of the paved streets of Cairo. The authors suggest that sheets of the predicted variant, named penta-graphene, can be chemically exfoliated from a previously reported tetragonal carbon variant called T12-carbon. Molecular dynamics simulations suggest that penta-graphene would be thermally stable, withstanding temperatures up to 1,000 K. Further, penta-graphene's ultrahigh mechanical strength, tied to an unusual property called negative Poisson's Ratio, would render it attractive for a range of technological applications. Importantly, penta-graphene carries a large intrinsic band gap, a characteristic that would enable penta-graphene–based semiconductors to be easily switched on and off; by contrast, the absence of a band gap in graphene has long proved an impediment to its widespread use in electronic devices. In addition, the authors demonstrate that penta-graphene sheets can not only be rolled into robust, stable, semiconducting nanotubes but also stacked into stable 3D structures with a band gap



Penta-graphene sheet composed entirely of pentagons.

larger than that of T12-carbon. Once synthesized, penta-graphene might find an array of uses in nanoscale electronic and mechanical devices, according to the authors. — P.N.

Strategy for heritability screening

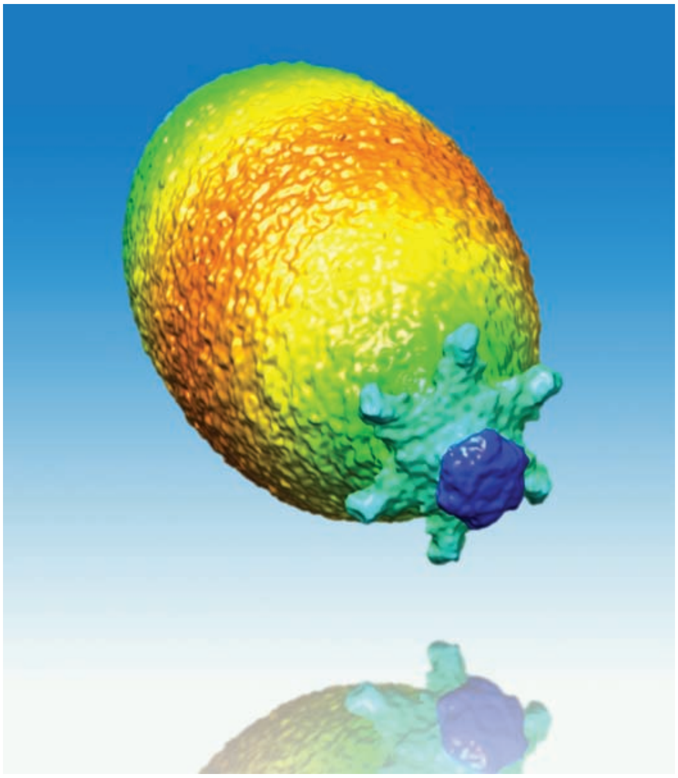
The possibilities for genetic analyses of differences between humans are expanding with the growing repositories of health information. However, identifying and prioritizing the most heritable phenotypes from these high-dimensional datasets have proven challenging. Tian Ge et al. (pp. 2479–2484) describe a rapid and accurate statistical method for assessing heritability called massively expedited genome-wide heritability analysis (MEGHA). The authors report that whereas existing methods require either computationally prohibitive genome analyses or elusive twin or pedigree data, MEGHA can be used to perform heritability-based prioritization of millions of phenotypes using information about genome-wide SNPs from unrelated individuals. In large-scale heritability analyses of brain imaging measurements, MEGHA facilitated heritability analyses of brain-wide structural phenotypes in significantly less computational time than existing methods. According to the authors, MEGHA is an accurate and rapid tool for high-dimensional heritability-based screening that could prove useful in areas ranging from neuroimaging genetics to analyses of the vast phenotype repositories in electronic health record systems and population-based biobanks. — A.G.

Self-regulating insulin molecule

Self-administered insulin can help regulate blood glucose levels in people with diabetes, but it can potentially endanger lives by inducing hypoglycemic shock. Attempts to use various chemically or genetically modified molecules to fine-tune the pharmacokinetics of insulin have not achieved self-regulating activity in vivo. Danny Hung-Chieh Chou et al. (pp. 2401–2406) describe soluble, circulating, glucose-sensing insulin derivatives with self-regulating activity. The authors demonstrate how the insulin derivatives, activated via a molecular switch that responds to blood glucose, can rapidly regulate blood sugar following a glucose challenge in a mouse model of diabetes. The authors compared the actions of insulin derivatives with standard insulin and a clinically used long-lasting insulin derivative. The findings reveal that the modified insulin restored normal blood glucose levels after a simulated meal more rapidly than standard insulin or the long-lasting insulin derivative. The authors found that the kinetics of the modified insulin in response to a glucose challenge were similar to those of insulin produced from a healthy pancreas. According to the authors, the insulin derivative represents a step toward the generation of autonomous therapy with improved blood glucose control. — A.G.

How a lemon-shaped virus infects hosts

Many viruses that infect single-celled microorganisms called archaea have shapes that resemble lemons, bottles, or droplets. How these viruses infect host cells remains largely unclear. Using biochemical experiments and an imaging technique called cryo-electron tomography, Chuan Hong et al. (pp. 2449–2454) studied a lemon-shaped archaeal virus called His1. Image analysis revealed that one end of the virus contains six tail spikes extending horizontally from a central hub, which is separated from the genome by a plug. Although His1 was extremely stable under various biochemical conditions, treatments such as boiling and exposure to certain detergents inactivated the virus, resulting in genome release and transformation of the lemon-shaped particle into an empty tube. The findings suggest that His1 likely uses the tail spikes to anchor to host cells and subsequently undergoes dramatic conformational changes to open the plug and eject genetic material through the hub and into host cells. Because tailed viruses that infect bacteria also use tail spikes to anchor to host cells and tube-like structures to eject their genomes, this mechanism may be used by different types of viruses to infect different hosts, according to the authors. — J.W.



The His1 virus uses a tail-like structure to infect hosts.