APPLIED PHYSICAL SCIENCES

Optimizing ionic conductivity in doped ceria

David Andersson et al. report calculations revealing how doped oxides with cubic fluorite structures become effective ionic conductors. Cubic fluorite structures, such as ceria (CeO$_2$), can become effective ionic conductors when doped with cations of lesser valence than the host cations. Doped ceria thus has potential as an electrolyte for environmentally friendly solid oxide fuel cells. Andersson et al. examined how different dopants affect ionic conductivity and found that oxygen-vacancy properties at the atomic level corresponded closely to macroscopic conductivity properties. The interactions between the dopants and the oxygen vacancies could be divided into repulsive elastic and attractive electronic parts, with the elastic part mediated by lattice deformations and the electronic part mediated by redistribution of the electronic structure. In the optimal electrolyte, these parts should balance, minimizing the strain on the crystal lattice. The ideal dopant was calculated to have an effective atomic number between 61 (Pm) and 62 (Sm). Unusual for dopants, combinations of Nd/Sm and Pr/Gd showed higher ionic conductivity than for each element separately. This finding offers a simple way to narrow the search for superior dopants and combinations of dopants in ceria for potential use as electrolytes. — P.D.

“Optimization of ionic conductivity in doped ceria” by David A. Andersson, Sergei I. Simak, Natalia V. Skorodumova, Igor A. Abrikosov, and Börje Johansson (see pages 3518–3521)

AGRICULTURAL SCIENCES

Transgenic high amylose wheat can improve gastrointestinal health

Ahmed Regina et al. have developed a transgenic wheat plant with high amylose content, which may be used to create fiber-rich food that may aid in nutritional and gastrointestinal health. To circumvent genetic manipulation hurdles posed by wheat’s hexaploid genome, Regina et al. used RNA interference to silence the expression of the two isoforms of starch-branching enzyme II (SBEIIa and SBEIIb). Transgenic wheat suppressing both SBEIIa and SBEIIb expression had greatly reduced levels of highly branched amylopectin, resulting in synthesis of starch that was >70% amylose and consequently more resistant to digestion in the small intestine. When the >70% amylose wheat was fed to rats, improved indices of large-bowel health were observed compared with feeding with standard wheat, including increased wet weight of digesta, lower bowel pH, and higher levels of short chain fatty acids. Adverse effects on growth or performance were not observed in the rats. The authors suggest that foods made from the high amylose wheat, with its high fiber content and low glycemic index, could provide a mechanism to deliver human health benefits. — N.Z.

“High amylose wheat generated by RNA interference improves indices of large-bowel health in rats” by Ahmed Regina, Anthony Bird, David Topping, Sarah Bowden, Judy Freeman, Tina Barsby, Behjat Kosar-Hashemi, Zhongyi Li, Sadequr Rahman, and Matthew Morell (see pages 3546–3551)
High-throughput identification of human microRNAs

Jordan Cummins et al. have developed a high-throughput method, miRAGE, to identify and analyze human microRNAs (miRNAs). miRNAs are small, ~22-bp noncoding RNAs that regulate gene expression by repressing mRNAs. Previous research using cloning and bioinformatic approaches has identified several hundred human miRNAs, but the total number of functional miRNAs is not known. Cummins et al. developed the miRAGE method by first isolating and tagging 18- to 26-bp RNA molecules from human colorectal cancer and normal colonic cells and then reverse transcribing them into cDNA. The authors analyzed >270,000 cDNAs and found nearly 70,000 matching known miRNA sequences. By evaluating the cDNAs in silico, 133 previously unidentified miRNAs were uncovered, 89 of which were confirmed by independent methods. The miRAGE technique was also utilized with a human colorectal cancer cell line in which the Dicer enzyme was disrupted; Dicer processes miRNA precursors into mature miRNAs. A depletion of mature miRNAs was observed, and this observation was used to validate several of the candidate miRNAs because it demonstrated Dicer’s requirement for miRNA biogenesis. — F.A.


Neuroprotective mechanism of antidepressant agent

Makoto Hara et al. report that a recently identified neuroprotective mechanism could explain how certain antidepressant drugs can slow the progression of disorders such as Parkinson’s and Alzheimer’s diseases. Monoamine oxidase (MAO) inhibitors, antidepressant drugs that increase levels of monoamine neurotransmitters by blocking their breakdown in the brain, have been used to slow the progression of neurodegenerative diseases like Parkinson’s. Studies have suggested that the neuroprotective effects of these drugs may be independent of MAO inhibition and may involve a mechanism blocking cell death via GAPDH signaling. Hara et al. examined the neuroprotective mechanism of the MAO inhibitor deprenyl and its derivative TCH346. Both agents were found to prevent the modification of GAPDH by nitric oxide, binding of GAPDH to Siah (an enzyme that carries a nuclear translocation signal), and translocation of GAPDH to the nucleus. The neuroprotective effect of the drugs and GAPDH involvement were confirmed in cultured cerebellar granule cells and in an animal model of Parkinson’s disease. The results support a role for GAPDH in cell death. Medications designed to prevent cell death via this mechanism may potentially be used to prevent certain neurodegenerative diseases. — M.M.

“Neuroprotection by pharmacologic blockade of the GAPDH death cascade” by Makoto R. Hara, Bobby Thomas, Matthew B. Cascio, Byoung-Il Bae, Lynda D. Hester, Valina L. Dawson, Ted M. Dawson, Akira Sawa, and Solomon H. Snyder (see pages 3887–3889)

Bile acid receptor induces antibacterial defense

Takeshi Inagaki et al. demonstrate that the farnesoid X receptor (FXR), a nuclear receptor for bile acids, regulates the body’s antibacterial defense system in the small intestine. Previous research has shown that obstruction of bile flow causes a proliferation of intestinal bacteria and can lead to systemic infection. Bile acids inhibit this proliferation, although the underlying mechanisms have not been well understood. Inagaki et al. found that FXR expression was highest in the ileum of the small intestine. Administration of a potent FXR agonist in mice lacking bile acid production caused an increase in the expression of an enteroprotection gene in the small intestine. In wild-type and FXR-knockout mice with bile duct ligation (BDL), which obstructs bile flow, the FXR agonist was administered for 2 days. The agonist increased the expression of genes regulated by FXR in the ileum of wild-type but not FXR-knockout mice. In BDL wild-type mice, the FXR agonist blocked an increase in bacteria in the ileum and cecum and in the mesenteric lymph node complex. Bacteria and edema were present in the junctions between epithelial cells in the small intestines of knockout animals that, unlike wild-type mice, were unresponsive to the FXR agonist. — F.A.

“Regulation of antibacterial defense in the small intestine by the nuclear bile acid receptor” by Takeshi Inagaki, Antonio Moschetta, Youn-Kyoung Lee, Li Peng, Guixiang Zhao, Michael Downes, Ruth T. Yu, John M. Shelton, James A. Richardson, Joyce J. Repa, David J. Mangelsdorf, and Steven A. Kliwer (see pages 3920–3925)