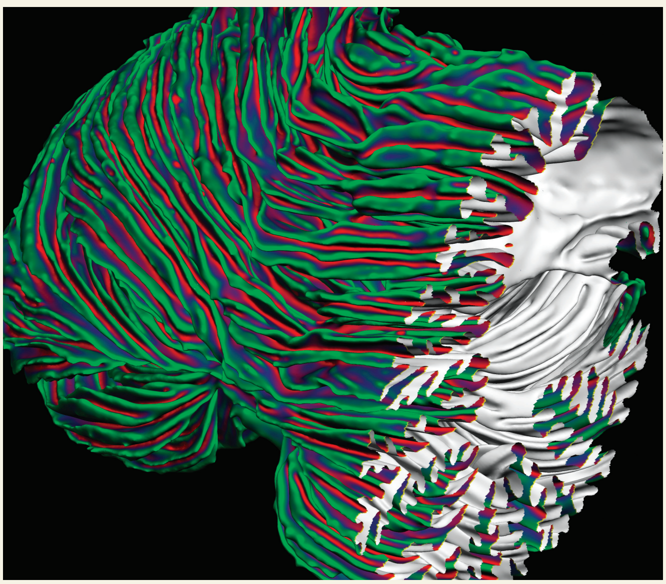
In this issue . . .

Human cerebellum and neocortex

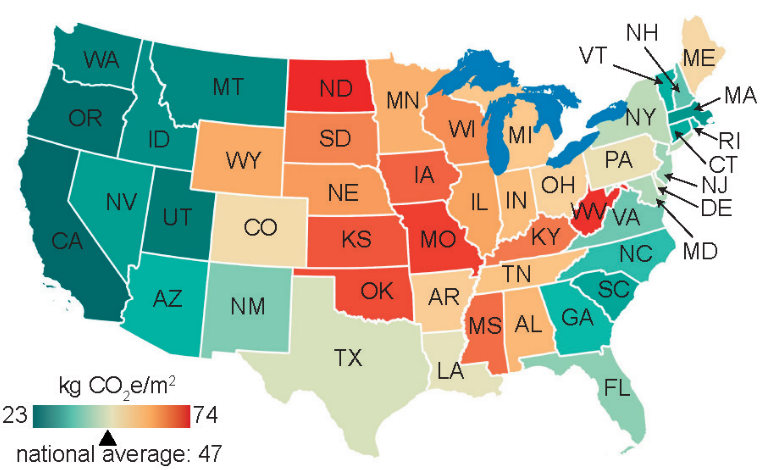


The folded cerebellar surface (Purkinje cell layer) cut through the right hemisphere (inside is white).

The coexpansion of the brain's neocortex and cerebellum is a defining feature of human evolution. Much smaller than the cerebrum, the human cerebellar cortex contains so many small and tightly packed folds that computationally reconstructing its surface at the level of all individual folds is challenging. Using ultrahigh magnetic fields, Martin Sereno et al. (pp. 19538–19543) generated multicontrast, high-resolution MRI scans of preserved postmortem human cerebellum specimens and reconstructed, unfolded, and flattened the cerebellar cortex at the individual fold level. Based on the reconstruction, the authors estimate that the surface area of the cerebellar cortex is 1,590 square centimeters, an area that is approximately 78% the size of the neocortex and substantially larger than thought. In addition, the authors show that the same approach applied to the brain of a macaque monkey reveals that the cerebellum in this primate species is only one-third the size of its neocortex. In addition to providing a quantitative map of the human cerebellar cortex resolved to individual folds, the study suggests that the cerebellum influences uniquely human cognitive abilities and behaviors, according to the authors. — T.J.

Carbon footprints of US residents

Around one-fifth of greenhouse gas (GHG) emissions in the United States results from residential energy use. However, it is unclear which states harbor the most carbon-intensive and energy-intensive housing stocks. Using 2015 tax assessor records of approximately 93 million homes in the contiguous United States, Benjamin Goldstein et al. (pp. 19122–19130) reviewed information relevant to estimating energy consumption—including building age, size, location, and construction year—and housing type, such as whether the building was a single-family home or an apartment complex. GHG emissions per unit floor space were highest in central states and lowest in western states. Low-income residents emitted approximately 25% less GHGs for energy use than high-income residents, primarily because they live in smaller homes. High-emissions neighborhoods were primarily high-income neighborhoods. Such effects were magnified in affluent neighborhoods, where GHG emissions were up to 15 times higher than

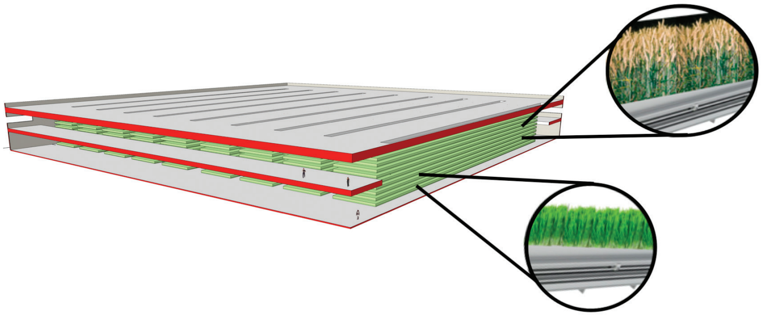


US household GHG intensity in 2015. Household GHG intensity represented by kilograms CO_2-equivalents per square meter by state.

nearby less affluent neighborhoods. Furthermore, the authors predict that residential neighborhoods will be unable to achieve the Paris Agreement target of cutting 80% of GHG emissions by 2050 by relying solely on a transition to low-carbon electricity production. The findings suggest that reduced floor spaces and communities with increased density are necessary to create low-carbon neighborhoods, according to the authors. — M.S.

Wheat yield and vertical farming

Wheat accounts for approximately 20% of the calories and proteins in the typical human diet. However, wheat yields are variable and typically depend on several factors, including soil quality and weather. To determine whether vertical farming is a viable option for increasing wheat production and meeting global food demand, Senthold Asseng et al. (pp. 19131–19135) simulated wheat growth using two crop simulation models on a hectare of land in a 10-layer indoor vertical facility under optimized artificial light, temperature, and carbon dioxide levels. The simulated yields revealed that vertical farming could produce at least 700 +/- 40 t/ha and up to 1,940 +/- 230 t/ha of grain per year, which is 220–600 times the current world average annual wheat yield. Compared with traditional farming methods in outdoor fields, indoor vertical farming requires less land area, water, herbicides, and pesticides and results in less nutrient loss to the environment. The findings suggest that indoor vertical farming may help offset disruptions to food production systems, according to the authors. — M.S.



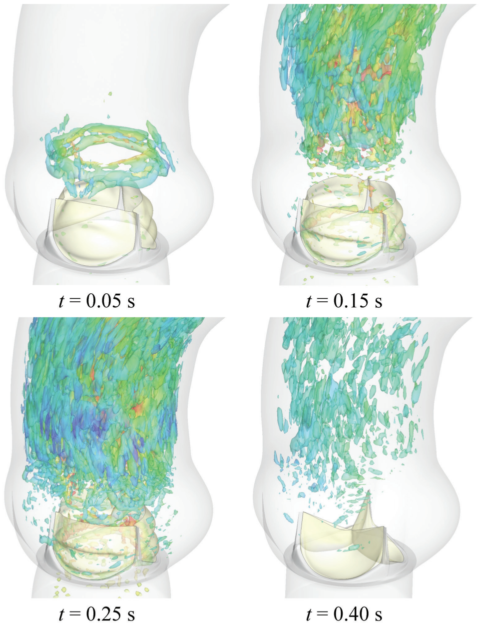
Section perspective of a 1 ha vertical wheat farm growing 10 layers of wheat from seeds to harvest.

Predicting opiate-induced brain state transitions

Addiction to opioids is associated with changes to brain plasticity, and researchers have hypothesized that long-term changes to neural connectivity may explain why individuals with a history of chronic drug exposure have high opiate abuse liability. Julia Brynildsen et al. (pp. 19556–19565) investigated the network-level effects of chronic opiate exposure on mouse brains by analyzing the expression of the *c-Fos* gene, a widely used neuronal activity marker, the expression of which is correlated with drug-induced behavioral changes. Network analysis of FOS expression in 19 brain regions in mice that were morphine-naïve, morphine-dependent, or underwent 4 weeks of withdrawal from chronic morphine exposure revealed that chronic morphine exposure altered FOS correlation network connectivity, with a persistent reduction in connectivity strength following opiate dependence. The authors examined correlated gene expression patterns across 19,616 genes within the brain regions and found that basal gene coexpression patterns were predictive of changes in FOS correlation networks following chronic opioid exposure, with significant involvement of genetic pathways tied to synaptic transmission. Based on axonal connectivity, regions of the hippocampus, striatum, and midbrain were particularly influential in driving transitions between opiate-naïve and opiate-dependent brain activity states. The results uncover links between gene expression and neural connectivity changes in response to opioids, potentially aiding the development of therapeutic interventions, according to the authors. — S.R.

Tissue thickness and heart valve replacement

Aortic heart valve diseases, such as calcification, are typically treated by replacement with a bioprosthetic heart valve that restores valve function. Recently, percutaneous bioprosthetic heart valve replacement, a minimally invasive treatment that involves catheter-based deployment, has become popular. Such designs require thin, flexible biological tissues that



Blood flow vortices generated near a bioprosthetic aortic valve implant (leaflet thickness of 0.193 mm) at multiple timepoints during a typical cardiac cycle.

can fit into delivery catheters, but the impact of using such tissues is unclear. Emily Johnson et al. (pp. 19007–19016) used high-fidelity computational methods to model and simulate four bioprosthetic aortic heart valve implants and evaluated the impact of using thin tissues on bioprosthetic heart valve function. The authors found that thin tissues induced significant leaflet flutter, a phenomenon that generated irregular, oscillatory valve behavior and may accelerate leaflet deterioration and reduce valve durability. The flutter motion also induced disturbed blood flow patterns that can lead to an increased risk of blood damage and thrombosis. According to the authors, thinner, more flexible tissues can have a potentially serious impact on bioprosthetic heart valve function due to the adverse effects of leaflet flutter on valve structural integrity and on blood flow throughout the cardiac cycle. — S.R.

REM sleep and feeding behavior

Rapid eye movement (REM) sleep is associated with an increase in the activity of neural networks in the lateral hypothalamus, a brain region that plays a critical role in feeding. However, the physiological functions of such neural activity are unclear. Lukas Oesch et al. (pp. 19590–19598) used calcium imaging and optogenetic silencing to record and inhibit the activity of neurons in the lateral hypothalamus of freely behaving mice. The authors focused on vesicular γ-aminobutyric acid (GABA) and glycine transporter-expressing (LHvgat) neurons, which release the inhibitory signaling molecules GABA and glycine. Calcium imaging experiments showed that the activity patterns of LHvgat neurons during feeding were highly similar to those during REM sleep, but not during non-REM sleep. Moreover, optogenetic silencing of LHvgat neurons during REM sleep, but not during wakefulness, resulted in a decrease in food consumption in later feeding sessions. Taken together, the results suggest that the activity of LHvgat neurons during REM sleep is necessary to maintain normal activation of feeding-related LHvgat neurons and normal food intake during subsequent wakefulness. According to the authors, the activity pattern that signals feeding during wakefulness might be strengthened during REM sleep, which may play an important role in stabilizing feeding behavior and its underlying neuronal circuits. — J.W.