APRIL 2, 2013

In This Issue

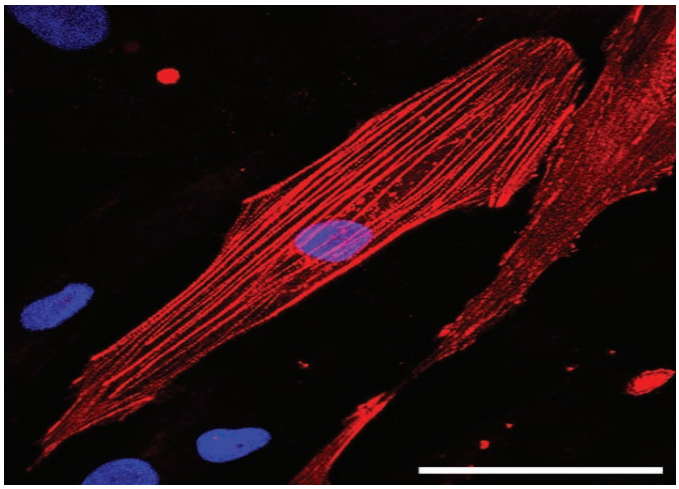
Radiocarbon analysis of arsenic-contaminated aquifers in Bangladesh

More than 100 million people in Southeast Asia are chronically exposed to arsenic-contaminated groundwater, which causes skin lesions and increases the risk of certain cancers. Recent studies suggest that bacterial respiration of organic carbon releases naturally occurring arsenic from sediment into groundwater, but the source of this organic carbon remains unclear. Brian Mailloux et al. (pp. 5331–5335) isolated microbial DNA from several depth intervals in arsenic-contaminated aquifers in Bangladesh and analyzed the DNA's radiocarbon signature, which reflects whether the organic carbon used by the microbes comes primarily from younger, surface-derived sources that are transported by groundwater into the aquifers, or older, sediment-derived sources. The authors found that the DNA samples were consistently younger than the sediment, suggesting that the microbes preferentially use surface-derived carbon. However, the authors also found that this surface-derived carbon has flowed from the surface into the aquifer over hundreds to thousands of years—a rate that is approximately 100 times slower than that of groundwater flow. The results suggest that recent human activities, such as intensive groundwater pumping, have not yet affected the release of arsenic into the groundwater at this site, but could do so in the future, according to the authors. The findings may aid the understanding of the causes of arsenic contamination in the region and the development of potential mitigation strategies, the authors suggest. — N.Z.

Aquifer at the study site in Bangladesh.

Reprogramming skin cells into heart muscle-like cells

Researchers have identified genes capable of reprogramming adult fibroblast cells into skeletal and smooth muscle cells, but successful reprogramming of fibroblasts into heart muscle cells largely remains a challenge. Young-Jae Nam et al. (pp. 5588–5593) previously reported that a combination of genes involved in cardiac development can be used to convert fibroblasts from mouse skin and heart into functional cardiac-like muscle cells. Extending their findings, the authors explored the ability of a mix of human heart-forming genes and muscle-specific microRNA molecules—tidbits of RNA that can control gene expression—to turn fibroblasts derived from newborn human foreskin and adult human heart into heart muscle cells. The authors report that the heart-forming genes and the microRNAs triggered the expression of heart-specific molecular markers in the human fibroblasts, suppressed the expression of nonmuscle-related genes, and endowed the cells with structures reminiscent of sarcomeres, the building blocks of muscle cells, after 4–11 weeks of growth in laboratory dishes. Some of the reprogrammed cells, the authors found, spontaneously contracted under the proper experimental conditions. According to the authors, human fibroblasts can be directly reprogrammed into cardiac-like muscle cells using a mix of heart-forming genes and microRNAs, raising the possibility of therapeutic reprogramming as an approach for treating heart muscle damage. — P.N.



Immunostaining for cardiac marker alpha-actinin (red) 4 weeks after insertion of reprogramming factors into human foreskin fibroblasts.

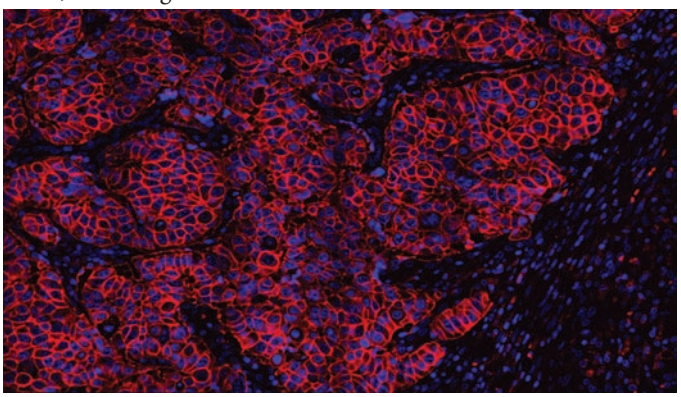
Insufficient sleep increases food intake and can lead to weight gain

Insufficient sleep is associated with the risk of weight gain and obesity, yet little is known about how it contributes to the risk. Rachel Markwald et al. (pp. 5695–5700) quantified the effects of 5 days of insufficient sleep, the equivalent of a work week, on the total daily energy expenditure and energy intake of 16 adults. The authors found that average daily energy expenditure increased by about 5% when participants were allowed to sleep for up to 5 hours compared to when they were allowed to sleep for up to 9 hours. The participants' food intake also increased during insufficient sleep, leading to weight gain. Participants overate despite changes in levels of the

hormones leptin and ghrelin, and peptide YY that signals excess food intake. During insufficient sleep, participants ate a comparatively smaller breakfast but consumed more calories as after-dinner snacks rich in carbohydrates, protein, and fiber; when the participants shifted from sleep loss to adequate sleep they reduced their caloric intake, especially from fats and carbohydrates, and lost weight. Unlike male participants, female participants maintained their weight during adequate sleep, but showed reduced dietary restraint and weight gain when they had insufficient sleep. The study demonstrates mechanisms by which insufficient sleep may contribute to weight gain, according to the authors. — S.R.

Improved biomarker expression analysis for breast cancer diagnosis

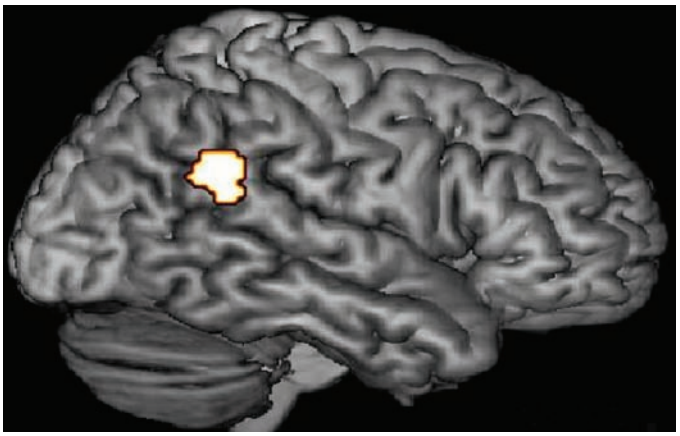
The human epidermal growth factor receptor 2 (HER2) is a valuable biomarker for breast cancer prognosis. HER2 expression levels are typically assessed by staining tissue samples using anti-HER2 antibodies, but this technique, known as immunohistochemistry (IHC), is time consuming and fails to accurately quantify biomarker expression levels. Ata Tuna Ciftlik et al. (pp. 5363–5368) developed a microfluidic device that improves the speed and accuracy of IHC analysis. To fabricate the device, the authors etched a network of microfluidic channels onto a silicon wafer, bonded the wafer to a piece of glass, and clamped the silicon/glass structure to a microscope slide, forming a thin chamber that enabled the breast tissue section on the slide to be uniformly exposed to the IHC reagents. After optimizing the staining conditions using HER2-positive human breast cancer tissue sections, the authors tested the device with 76 invasive breast carcinomas with varying HER2 status. Compared with conventional IHC, which produced ambiguous results for 27 of the samples, the microfluidic device produced only 3 ambiguous results and correctly assigned the HER2 status for all other samples. Furthermore, the microfluidic analysis required less than 5 minutes, compared with 1 hour for conventional IHC. The findings could lead to an improved method for breast cancer diagnoses, according to the authors. — N.Z.



Breast cancer tissue with cell membranes showing the HER2 biomarker in red.

Unraveling moral judgments through neural analysis

Determining whether someone was hurt deliberately or accidentally requires the capacity to gauge personal intent, a function of the human brain's right temporo-parietal junction (RTPJ) and other regions. Jorie Koster-Hale et al. (pp. 5648–5653) used a method of fMRI data analysis known as multivoxel pattern analysis (MVPA) to explore how the RTPJ mediates moral judgment in high-functioning adults with autism spectrum disorders and so-called neurotypical people. Previous studies have shown that RTPJ disruption impairs moral judgment, and that judgments by people with autism account less for personal intent than do judgments by neurotypical people. The authors performed a series of fMRI experiments to assess changes in neural activity when 16 adults on the autism spectrum and 14–23 neurotypical participants read about someone accidentally, deliberately, or not injuring another person. The authors report that MVPA can distinguish the neural responses to intentional versus accidental harm in neurotypical adults, but that adults with autism spectrum disorders responded similarly to each account. Further study revealed that the neural patterns observed in the RTPJ of each individual can be used to predict that person's moral judgments about the scenario. According to the authors, the findings demonstrate that representations of other people's intent are encoded in patterns of brain activity, and that such representations are clinically relevant. — A.G.



Neural correlates of moral judgment.

Electricity from heat on a chip

Thermophotovoltaic (TPV) generators use heat-generated photons to produce electricity. TPVs are quiet, portable, have no moving parts, and can use any fuel that creates sufficient heat. However, because energy is lost at every conversion step, TPVs suffer from poor efficiency. Until now, researchers had not demonstrated small-scale TPV devices, but Walker Chan et al. (pp. 5309–5314) built and tested a prototype TPV device that uses propane combustion to generate electrical power. The so-called microTPV (μTPV) burns propane inside a tiny combustor channel, which heats the combustor until it glows. A photonic crystal on the surface of the combustor shapes the spectrum of the radiant energy. The thermal radiation lands on specialized infrared photovoltaic cells, where the photons energize the material's electrons, generating electricity. The authors note that while considerable barriers remain to achieving its full potential, their μTPV produced 344mW of power over a 1-cm^2 area with an efficiency of 2.5%. Computer models calculated that an optimized μTPV could match the efficiency of heat engines and vastly surpass the power density of chemical batteries. According to the authors, such small-scale TPV devices may someday compete with batteries, portable fuel cells, and other technologies in applications that may include battlefield electronics and spacecraft. — J.M.