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Rapid snapping in Venus flytraps

When triggered, the lobes of the Venus flytrap buckle and snap shut with a movement that lasts 100–300 milliseconds. Although many details about the trap, such as the triggering mechanism, have been described, its hydraulically driven nature and the elastic properties of its lobes remain unclear. Renate Sachse, Anna Westermeier, et al. (pp. 16035–16042) suggest that Venus flytrap snapping is driven by a simultaneous expansion of the lobe's outer surface and contraction of its inner surface—a process that requires the plant to be fully hydrated. Before snapping, the lobes likely accumulate internal hydrostatic pressure, priming the trap to instantaneously snap shut when triggered. The authors support the model using 3D digital image correlation, finite element modeling, and in vivo experiments and report that the mechanics of Venus flytrap snapping represent an elaborate and coordinated process in which multiple tissue layers swell and contract, liberating stored energy to close rapidly enough to trap prey. The findings add to a growing body of work that seeks a mechanistic understanding of Venus flytrap movement, according to the authors. — T.J.

Venus flytrap accelerates snapping and increases odds of capturing prey. Image credit: Plant Biomechanics Group Freiburg.

3D structure of water clusters

Water is fundamental to life on Earth, but the hydrogen bond networks that give condensed phases of water their crucial properties remain largely uncharacterized. How neutral water clusters evolve structurally and transition from just a few molecules into bulk liquid water remains unclear. Bingbing Zhang et al. (pp. 15423–15428) describe the structural progression of neutral water clusters from three to six molecules, captured using a hybrid instrument that combines infrared spectroscopy with a tunable vacuum ultraviolet free electron laser. The authors report that novel spectral signatures in the OH stretch band correspond to 3D hydrogen bonding networks, which appear as planar water tetramers transition to pentamer and hexamer clusters. In addition, the authors present model analysis of this 2D to 3D structural shift based on three different theoretical approaches. The findings suggest that the diverse nature of water's hydrogen bonding networks emerges early in the evolution of neutral water clusters and that size-selective infrared spectroscopy can be leveraged to characterize this life-sustaining process. — T.J.

Volcanic eruption's effects on Roman Republic

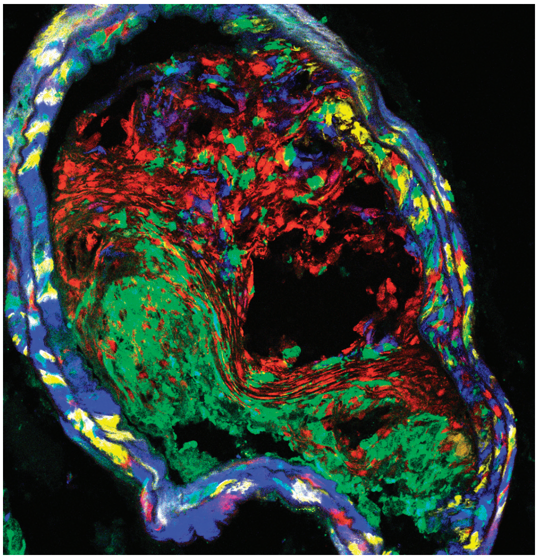
The years after the assassination of Julius Caesar in 44 BCE were among the coldest of the last 2,500 years, with inclement weather and widespread famine. Joseph McConnell et al. (pp. 15443–15449) report that a massive volcanic eruption in 43 BCE may have been responsible for the unusual atmospheric and climatic events that coincided with the fall of the Roman Republic and the Ptolemaic Kingdom, which subsequently led to the rise of the Roman Empire.

The authors obtained high-resolution measurements of volcanic fallout, including tephra, in six dated Arctic ice cores and found evidence of two high-latitude volcanic eruptions. The effects of the first eruption, in 45 BCE, appeared short-lived and limited in scale. In early 43 BCE, however, the second eruption produced fallout that lasted 2 years and coincided with temperature anomalies in tree ring and cave records. Geochemical analysis of the tephra identified particles unique to the Okmok volcano in Alaska. Earth system modeling of the eruption's effect on the ancient Mediterranean climate showed pronounced cooling, especially in summer and autumn, and markedly increased precipitation. Such climate conditions likely resulted in crop failures, famine, and disease, exacerbating social unrest and contributing to political realignments throughout the Mediterranean region, according to the authors. — T.H.D.

The 10-km-wide caldera on Alaska's Unmak Island formed during the 43 BCE Okmok II eruption. Image credit: Kerry Key (Columbia University, New York, NY).

How smooth muscle cells promote atherosclerosis

Current treatments for atherosclerosis target risk factors such as hypertension and diabetes, partly because the precise roles of the underlying cells driving atherosclerotic plaque formation remain unclear. Ying Wang et al. (pp. 15818–15826) combined mouse lineage-tracing experiments with analysis of data from banked human samples to uncover the key role in atherosclerosis of a proliferating group of vascular smooth muscle cells found near the necrotic core of plaques. The cells produce complement protein C3, which stimulates macrophages while driving the cells' own clonal expansion. Although the C3 protein identifies the cells as pathologic and flags them for clearance by resident macrophages, the cells escape immune surveillance likely because of signal-sensing defects in activated macrophages found in plaques. The authors found that activated macrophages express high levels of CD47—a molecular signature commonly used by cells to avoid phagocytosis—that might double as an appetite suppressor in macrophages. Building on that finding, the authors showed that tamping down CD47 restores the ability of activated macrophages to clear complement-coated target cells. Additionally,



Cross-section of advanced plaque from a diseased blood vessel showing clusters of smooth muscle cells (red, blue, and yellow) and infiltrating cells of nonsmooth muscle origin, such as macrophages (green).

mice treated with an anti-CD47 antibody exhibited reduced clonal expansion of vascular smooth muscle cells and lowered circulating C3 levels, compared with control mice, suggesting reduced vascular inflammation. According to the authors, the findings suggest that highly proliferative smooth muscle cells carrying stem cell markers drive atherosclerotic plaque formation and represent viable therapeutic targets, similar to cancer stem cells. — P.N.

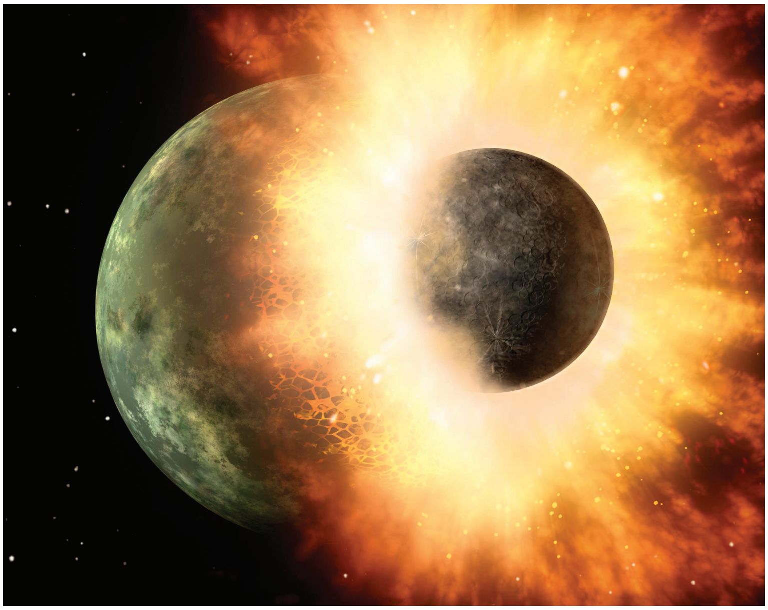
How long-tailed tits avoid incest

Many animal species avoid inbreeding, which can be detrimental to health, through mechanisms such as sex-biased dispersal, in which members of one sex leave their native site to breed. However, cooperative species with limited dispersal could encounter kin as potential mates, presenting a quandary. Amy Leedale et al. (pp. 15724–15730) examined how

Aegithalos caudatus.

long-tailed tits (*Aegithalos caudatus*), a species in which kin-directed cooperation is common and dispersal is constrained, avoid inbreeding when the birds pair off monogamously each spring. Analysis of 17 genetic markers and four fitness-related life history traits, including lifetime reproductive success and fraction of eggs hatched in a female's first clutch, revealed that inbreeding is harmful to the birds' fitness. Genetic relatedness analysis combined with mate choice models indicated that the birds avoid close kin while pairing. Long-tailed tits use learned vocal cues to preferentially aid kin, and the authors found that the tits' churr call, a short-range contact call akin to an individual signature, likely helps the birds avoid incest. Males and females within breeding pairs had more distinct churr calls than opposite-sex first-order kin within pairing range; the vocal distinction did not extend to second-order kin or nonkin. Similarities in learned vocal cues may stem from the close association of first-order kin—parents, offspring, and siblings—during rearing, when calls are learned; second-order kin and nonkin are usually reared apart. According to the authors, the study uncovers a potential mechanism by which long-tailed tits avoid incest. — P.N.

Angular momentum, Moon formation, and Earth rotation



Artist's depiction of a collision between two planetary bodies, similar to the one hypothesized to have formed the Moon. Image credit: NASA/JPL-Caltech.

Proposed scenarios for the Moon's formation typically involve a giant impact that would have left the Earth rotating much faster than its present rate. Several mechanisms for subsequent slowing of Earth's rotation have been proposed, including one that involves the postimpact Earth having high obliquity—the angle between the equatorial and orbital planes. ZhenLiang Tian and Jack Wisdom (pp. 15460–15464) analyzed the high-obliquity scenario in the context of a constraint that has not been previously fully explored. The component of the total angular momentum for the Earth–Moon system that is perpendicular to the Earth's orbital plane (L_z) is conserved throughout the system's history, except during intervals at which specific conditions are present. Therefore, the postimpact L_z should be within a few percent of its present-day value. The authors demonstrated that having a high postimpact obliquity always results in angular momentum much larger than the present-day value. This occurs regardless of the tidal parameters or tidal models used to model the system. The results suggest that the high obliquity scenario is incompatible with the present-day Earth–Moon system. However, a low obliquity scenario could be consistent with the L_z constraint, suggesting a plausible mechanism for how the fast-rotating postimpact Earth could have slowed to its present rotation rate, according to the authors. — B.D.