In this issue . . .

Chemical hints of ayahuasca use in pre-Columbian shamanic rituals

Contents of ritual bundle: leather bag, snuff tablets, camelid-bone spatulas, headband, snuff tube, fox-snout pouch, and plant pieces on strings. Scale bars are 10 cm.

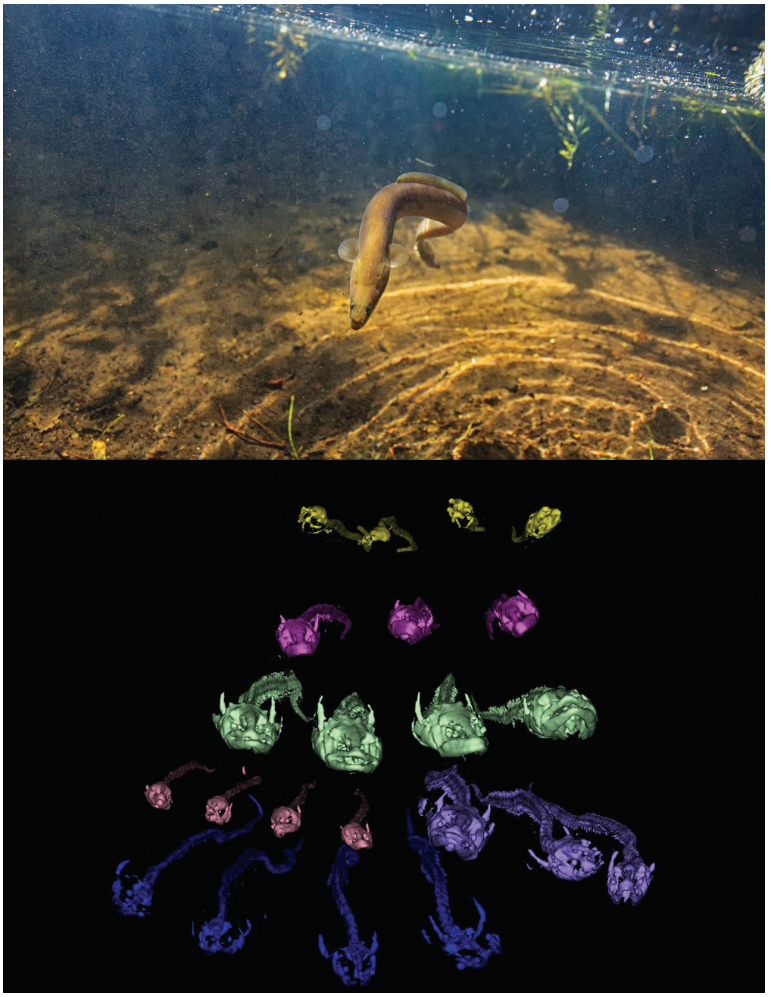
Archaeological studies have found evidence of ritual consumption of psychoactive plants among native cultures in South America. However, the evidence is fragmentary, preventing researchers from piecing together a coherent picture of hallucinogen use in ancient South America. Melanie Miller et al. (pp. 11207–11212) analyzed the chemical makeup of artifacts in a 1,000-year-old ritual bundle recovered from a rock shelter in southwestern Bolivia's Lípez highlands. Unearthed from layers of rubble, the bundle contained a large leather bag with a pair of wooden snuffing tablets, a snuffing tube, a pair of llama-bone spatulas, a textile headband, fragments of dried plant stems held together by wool and fiber strings, and a pouch stitched from three fox snouts. Radiocarbon dating traced the bundle to 905–1170 CE. Using liquid chromatography tandem mass spectrometry, the authors analyzed the plant stems and fox-snout pouch and detected at least five psychoactive compounds—cocaine, benzoylecgonine, harmine, bufotenine, and dimethyltryptamine—whose source plants are foreign to the Lípez highlands. The presence of cocaine suggests that the pouch held coca leaves, and the bufotenine signature hints that vilca or cebil (*Anadenanthera colubrina*) seeds were carried in the pouch, ground on the snuffing tablets, and inhaled using the snuffing tube. The cooccurrence of harmine, found in yage (*Banisteriopsis caapi*), and dimethyltryptamine, found in vilca and chacruna (*Psychotria viridis*), suggests that multiple plants may have been used to make ayahuasca, which can induce hallucinogenic trips; the plants may have been consumed as a composite snuff or brewed into a potent beverage. The finding hints at ayahuasca consumption during shamanic rituals as old as 1,000 years. Despite the lack of human remains at the site, the findings raise the possibility that in pre-Columbian times shamans acquired psychoactive plants directly or through trading networks and used them in rituals to induce altered states of consciousness in hopes of communing with deities and deceased ancestors, according to the authors. — P.N.

Chromosome number abnormalities predict lethal prostate cancer

One hallmark of cancer is an abnormal number of chromosomes, known as aneuploidy. However, how aneuploidy influences cancer progression, or whether chromosome gains or losses can inform treatment decisions, remains unclear. Konrad Stopsack et al. (pp. 11390–11395) developed a method to estimate chromosome arm gains and losses by comparing DNA copy-number data with whole-transcriptome data from tumor samples from 333 patients with prostate cancer. The authors applied an algorithm for predicting aneuploidy to transcriptome data for two independent cohorts of 404 men with prostate cancer. The patients were followed prospectively for a median of 15 years to assess long-term outcomes of metastases and prostate cancer-specific death. The 23% of patients whose tumors had five or more predicted chromosome arm alterations at the time of diagnosis had 5.3 times higher odds of lethal cancer during follow-up, compared with those who had no predicted aneuploidy. Even among high-risk patients, the degree of tumor aneuploidy predicted future lethal disease. According to the authors, the findings suggest that aneuploidy plays a key role in driving aggressive disease in prostate cancer. Moreover, the extent of aneuploidy could be used clinically as a tool to inform risk stratification and treatment. — J.W.

Body reorganization in migrating anguillid eels

The European eel (*Anguilla anguilla*), a critically endangered species, embarks on a 6,000-km-long transoceanic journey to reproduce once in its lifespan. Adults spawn in the open ocean, and the larvae are transported to inland and coastal waters, where the eels grow and mature into adults. With the onset of puberty, the eels change in appearance from pale yellow to gleaming silver—a process termed silvering—before returning to spawn in the ocean. On the return trip, the eels undergo drastic changes: they stop feeding, shrink their guts, break down their skeletons, and build up their gonads. Marko Freese, Larissa Yokota Rizzo, et al. (pp. 11339–11344) used hormone treatments to artificially mature the eels in the laboratory and monitored the breakdown of the eels' skeletons and resulting redistribution of minerals during maturation. Using analytical and imaging techniques, the authors found that the eels' average bone mass and mineral content declined with the onset of silvering, potentially compromising mechanical support offered by the vertebrae while sparing the function of the notochord. Bone loss was more pronounced in females than males. The proportion of phosphorus and calcium in soft tissues versus bone increased as maturation progressed, indicating that the eels use their bones and muscles as energy and mineral reserves for locomotion and spawning. Moreover, the authors detected the transfer of an array of metals—cadmium, copper, manganese, and mercury—from bones and soft tissues to the ovaries of gravid silver eels. The latter finding suggests that the metals, known to generate toxic free radicals, might hamper the eels' reproductive success, raising the specter of potential anthropogenic impacts on the eels' freshwater habitats. According to the authors, the findings provide a window into the molecular processes underlying dramatic body reorganization in a species of conservation concern. — P.N.



***Top*: Yellow-stage European eel. *Bottom*: Frontal view on computed tomography scans of eels in different maturation stages displaying successive loss of bone.**

Carbon capture and utilization for chemicals

Carbon capture and utilization (CCU) technologies capture CO_2 from industrial sources or ambient air and use the captured CO_2 as a carbon source for value-added products such as chemicals. To evaluate the potential impact of CCU technologies on chemical industry greenhouse gas (GHG) emissions, Arne Kätelhön et al. (pp. 11187–11194) developed a bottom-up model of global production of 20 major bulk chemicals, which are collectively responsible for more than three-quarters of the industry's GHG emissions. According to the model, production of these chemicals in 2030 using CCU technologies would substantially increase mass flows compared with conventional technologies, due to the large amounts of CO_2 used and wastewater produced. CCU-based production would also require at least 18.1 PWh of electricity, corresponding to more than half of the projected global electricity production in 2030. Thus, achieving substantial GHG emissions reductions from CCU technologies would require a massive expansion of low-carbon electricity generation. In the scenario with the lowest GHG emissions, conventional production would be replaced by CCU, including technologies that are currently in early stages of research and development, with all electricity inputs supplied by wind power. According to the authors, in such a scenario, annual GHG emissions would decrease by 3.5 Gt CO_2-eq, potentially rendering the chemical industry nearly carbon-neutral and independent of fossil resources. — B.D.

Potential biomarker for suicidal thoughts in PTSD

Posttraumatic stress disorder (PTSD) is an important risk factor for suicidal ideation and attempts, as well as death by suicide. Because little is known about the

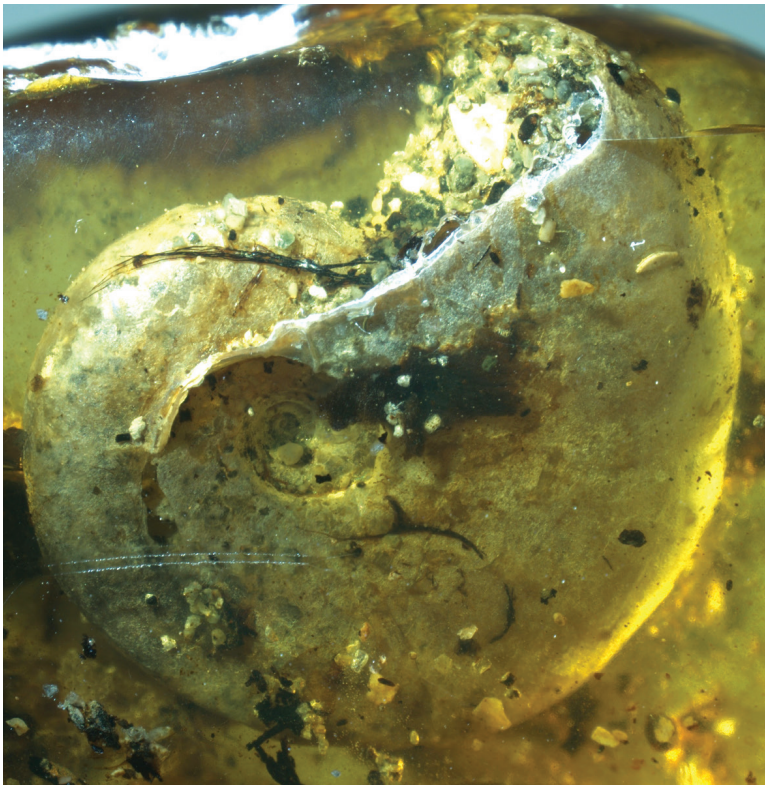
biology underlying suicide in PTSD, there are limited pharmacologic options to treat PTSD patients at high risk of suicide. Margaret Davis et al. (pp. 11490–11495) report that the metabotropic glutamatergic receptor 5 (mGluR5) might serve as a potential biomarker for intervention and suicide risk management in PTSD. Using positron emission tomography (PET), the authors quantified mGluR5 density in five brain regions in 29 individuals with PTSD, 29 participants with major depressive disorder (MDD), and 29 healthy controls. The authors found that mGluR5 availability in individuals with PTSD was significantly higher in all five brain regions, compared with healthy controls, as well as in three brain regions, compared with individuals with MDD. In particular, mGluR5 upregulation in all five brain regions was associated with self-reported suicidal ideation on the day of the brain scan in individuals with PTSD, but not in individuals with MDD. Moreover, higher mGluR5 availability was associated with mood disturbances in the PTSD group, but lower mGluR5 availability was associated with mood disturbances in the MDD group. According to the authors, the findings suggest that downregulating mGluR5 might decrease suicidal ideation and related symptoms in individuals with PTSD. — J.W.

Reporter gene for central nervous system

While gene therapy strategies have begun to proliferate, techniques to monitor and assess their efficacy, particularly within the central nervous system (CNS), have not kept pace. One approach would be to leverage positron emission tomography (PET) reporter gene systems, a functional imaging technique that uses emissions from radiopharmaceutical tracers to visualize cellular-level physiological processes. Tom Haywood et al. (pp. 11402–11407) describe a PET reporter gene system for the CNS that exploits the gene for the enzyme pyruvate kinase M2 (PKM2) and its associated radiotracer [^{18}F]DASA-23. The system uses adeno-associated virus (AAV9), a well-established gene delivery mechanism, and stereotactic injection to precisely situate the imaging payload in the brain. Using cell cultures, the authors demonstrate that PKM2 protein levels can be successfully increased in HeLa cells via transfection with a plasmid and that [^{18}F]DASA-23 accumulation correlates with the concentration of the transfected plasmid. The authors also present in vivo results demonstrating that mice injected with PKM2 gene-carrying AAV9 exhibit increased levels of PKM2 protein expression in the brain 2 months after the procedure. The findings suggest that PKM2 combined with [^{18}F]DASA-23 potentially represents a reporter gene for noninvasive PET imaging of gene expression in the CNS, according to the authors. — T.J.

Ammonite preserved in amber

Because the source of amber is fossilized tree resin, the inclusion of aquatic and marine animals in amber is exceptionally rare. Tingting Yu, Richard Kelly, Lin Mu, et al. (pp. 11345–11350) describe the terrestrial and marine animal assemblage present in a specimen of Burmese amber recovered from Myanmar. Prominent in the amber is a marine ammonite shell, identified by its shell structure as a juvenile from the Late Albian or Early Cenomanian age of the Cretaceous Period. Accompanying the ammonite are marine gastropods and terrestrial mites, spiders, other insect orders, and millipedes. Several lines of evidence suggest that the ammonite and the gastropods were dead before becoming engulfed in resin.



Ammonite in Burmese amber.

No soft tissue was preserved in the marine species, which displayed signs of abrasion, and the ammonite contained coarse sand in its shell. Taken together, the evidence suggests that the amber formed on a beach with resin-producing trees near enough to the water to capture both terrestrial insects on the tree and remains of marine organisms transported into the resin, which was later preserved and fossilized. Previously discovered Burmese amber samples lacked ammonites. Hence, the authors suggest, the presence of a rare specimen in amber warrants exploration of the possibly exceptional circumstances of its fossilization. — P.G.