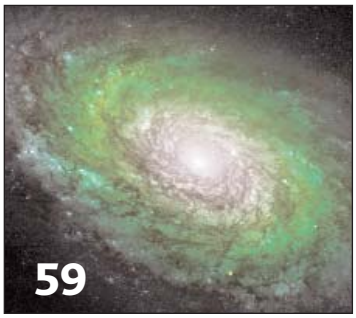
THIS WEEK IN Science

edited by Stella Hurtley and Phil Szuromi

A Winter's Trail

Before migrating into North America, early humans first moved into Arctic Siberia and adapted to its harsh environment. The few oldest sites have been dated to at most about 15,000 years ago or so, which was after the major Northern Hemisphere ice sheets had begun to recede. **Pitulko *et al.*** (p. 52; see the cover and the news story by **Stone**) now report a series of radiocarbon ages and artifacts found in a terrace along the Yana River (just south of its mouth into the Arctic Ocean, in central Siberia) that date to 27,000 radiocarbon years ago (about 30,000 calendar years). Artifacts include an ivory foreshaft from the horn of a rhinoceros, two others made from mammoth tusk, and several hundred stone points and flakes.

A Home in the Milky Way



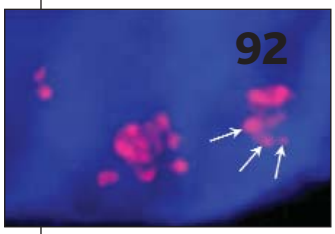
What fraction of stars in our Galaxy might play host to planets that can support multicellular life? **Lineweaver *et al.*** (p. 59; see the news story by **Irion**) calculate the probable extent of hospitable space for complex life in the Galaxy, called the Galactic habitable zone (GHZ). Their criteria include distance from deadly supernovae, enough heavy elements to form terrestrial planets, and enough time for life to evolve. Based on these criteria, the GHZ is an annular region between 7 to 9 kiloparsecs from the Galactic center and contains about 10% of the Milky Way stars with ages between 4 to 8 billion years old.

Now You See Them

Self-assembly of small molecules can create objects with a wide variety of morphologies on the nanometer-to-micrometer scale. **Yan *et al.*** (p. 65) have used hyperbranched polymers that have both hydrophilic and hydrophobic domains to create hollow tubes that are millimeters in width and centimeters long. The tubes form when the polymer is stirred into acetone. Electron microscopy analysis of the tube walls indicates that alternating lamellae form in which the hydrophobic domains are amorphous and the hydrophilic ones are ordered. These tubes are robust and can likely be tailored by derivatizing the side walls.

Mix and Fix Damaged DNA

Double-stand breaks (DSBs) in DNA can lead to tumorigenic chromosomal translocations, but it is not clear how the broken ends find each other. Are the different sites in the DNA in contact before the breakage occurs ("contact-first" model) or are the two different broken ends mobile in the nucleus ("breakage-first" model)? By exposing cells to α particles, **Aten *et al.*** (p. 92) generated linear tracks of DSBs through cell nuclei. DSB-containing chromosomes were mobile within the nucleus, as predicted by the "breakage-first" model. In some cells, the broken ends formed large clusters, which brought many DSBs in close proximity with one another for potential repair.



Extending the Range of Fuel Cell Electrolytes

Some of the operational limitations of hydrogen fuel cells, such as maximum operating temperatures near 100°C and fuel leakage, are imposed by polymer electrolyte membranes. Solid acids can transport protons at high temperatures without water, but systems based on sulfate or selenate ions are prone to reduction by hydrogen itself. **Boysen *et al.*** (p. 68; see news story by **Service**) now show that fuel cells that incorporate a phosphate-based solid acid, CsH_2PO_4, can be run for extended periods of time (more than 100 hours) with either hydrogen or methanol as fuel without significant loss of performance. Operation at 250°C was maintained by adding water vapor to avoid decomposition to $CsPO_3$.

Fire in the Whole World

Fires account for a significant part of the interannual variability of the atmospheric concentrations of many important trace gases like CO_2 and CH_4, but the relative contribution of emissions from different global regions is very uncertain. In a study using satellite and atmospheric data, biogeochemical modeling, and an inverse analysis of atmospheric CO anomalies, **van der Werf *et al.*** (p. 73) analyzed how fires across different regions contributed to global trace gas variability between 1998 and 2001. Unusually high fire emissions from Southeast Asia accounted for most of the global signals. Contributions from Central America, northern boreal regions, and South America that were underestimated previously were also important sources.

Breaking Down the Stride

The energetic costs of running and the underlying physiological mechanisms have been studied for decades. However, relating the energetics to underlying mechanics has relied on "black-box" approaches. In an experimental study of guinea fowl, **Marsh *et al.*** (p. 80; see the Perspective by **Heglund**) used blood flow to the muscles as a measure of how the energy is distributed. Contrary to previous predictions, the energy used by muscles that swing the upper limbs was not negligible—it was about a third of the amount used by the lower limbs that transmit force to the ground.

MicroRNA Management

Micro (mi)RNAs are small noncoding RNA genes found in most eukaryotic genomes and are involved in the posttranscriptional regulation of gene expression. The miRNAs are transcribed in the cell nucleus where they are processed into pre-miRNAs. Further processing occurs in the cytoplasm, where the pre-miRNAs are cleaved into their final ~22-nucleotide-long form. **Lund *et al.*** (p. 95) investigated the transport of pre-miRNAs from the nucleus and into the cytoplasm. Pre-miRNAs are exported through the RanGTP-binding export receptor Exportin-5, which is also involved in the export of other small, structured RNAs. The pre-miRNAs bind directly to Exportin-5, which plays a critical role in

CREDITS: (TOP TO BOTTOM) LINEWEAVER *ET AL.*; ATEN *ET AL.*

the biogenesis of miRNAs. **Chen *et al.*** (p. 83) analyzed the function of a set of mice miRNAs that are specifically expressed in hematopoietic cells. Their expression patterns mirror cell lineage changes, and overexpression of miR-181, whose expression in bone marrow correlates with the B-lymphoid lineage, causes the production of a preponderance of B-lineage cells both in tissue culture and in mice.

Repressing Early Neuronal Cell Fates

As the mammalian brain develops, newly formed neurons become organized into layers in the cortex. The earliest born neurons form the deepest layers, with later-born neurons forming progressively more superficial layers. How do neuronal progenitors produce different types of offspring as developmental time progresses? **Hanashima *et al.*** (p. 56; see the Perspective by **Levitt**) now show that the potential for an early cell fate is not really bypassed with time, but persists and is repressed by continuous expression of a regulatory factor. For example, Cajal-Retzius neurons are produced early, and their absence in later-born neuronal cell layers is caused by suppression of the Cajal-Retzius differentiation pathway by the transcription factor Foxg1.

Chloroplast Maltose Transporter Identified

Carbon that is assimilated during daytime photosynthesis is temporarily stored in the plant chloroplast as starch. In the dark, breakdown of the starch provides a steady supply of carbon to the plant. Much of the starch breakdown product is transported from the chloroplast to the cytoplasm as the disaccharide maltose. **Niittylä *et al.*** (p. 87) have now identified in *Arabidopsis* the maltose transporter that resides in the chloroplast membrane.

Membranes from Cut Carbon Nanotube Arrays

Carbon nanotubes can be synthesized with a narrow range of inner diameters. **Hinds *et al.*** (p. 62) show that the range is narrow enough to create membranes. They spin-coated a thin film of polystyrene onto an array of nanotubes. This polymer tends to wet the surface of the carbon nanotubes, and this formed a matrix around a nanotube array. The polymer-nanotube composite was then treated with a water plasma, which cut open the nanotubes and created a membrane whose pores had openings a few nanometers in diameter. Plasma cutting left exposed carboxylic groups on the nanotube tips that were then functionalized with biomolecules to create even smaller channel openings. Ceramic membranes with well-defined channels tend to be brittle, but the polystyrene matrix of these composite membranes lends robustness and flexibility.

Regulating Recombination, or Not...

An early step in meiosis is to bring together matching pairs of chromosomes to allow for interchromosomal recombination. The process of chromosomal pairing seems to be separable from the subsequent process of recombination, whereby segments of DNA are exchanged between the chromosomes. **Pawlowski *et al.*** (p. 89; see the Perspective by **Martinez-Perez and Moore**) have identified a mutation in maize that disrupts homologous chromosomal pairing but still allows DNA exchange to proceed. In the *phs1* mutant, nonhomologous chromosomes nevertheless attach to one another and exchange DNA. Thus, recombination depends on close apposition of chromosomes but is seemingly oblivious to the overall homology of the paired partners.

Chaperoning the Chaperones

In eukaryotes, Hsp70 molecular chaperones are involved in protein biogenesis, cellular responses to stress, and apoptosis. These proteins bind unfolded proteins in an adenosine triphosphate (ATP)–dependent manner. This step requires an intrinsic ATPase activity that is modulated by co-chaperones. **Steel *et al.*** (p. 98) present evidence that two distinct Hsp70s specifically interact to coordinate their reaction cycles, resulting in a dramatic increase in overall activity. The results suggest a general model for the coordinated regulation of Hsp70s within multivalent chaperone complexes.

CREDIT: NIITTYLÄ *ET AL.*