LETTERS

edited by Jennifer Sills

Standing the Test of Time Variations

IN HIS NEWS FOCUS STORY "RENEWABLES TEST IQ OF THE GRID" (10 APRIL, P. 172), D. Charles describes the widely held belief that large-scale use of renewables will become viable with a smart electric grid and short-term energy storage devices (such as pumped storage and batteries). However, the problems of integrating renewables with the electricity grid in a low-carbon world are much larger. Renewables are a time-varying source of energy that does not automatically match the demand-side time variations. Electricity demand varies daily, over a 3-day weather-related cycle, weekly, and seasonally. The seasonal variation in electric demand in much of the country is greater than a factor of 2, with seasonal mismatches between renewable production and demand.

In a low-carbon world, the major energy options (nuclear, fossil fuels with carbon-dioxide sequestration, and renewables) have high capital costs and low operating costs. These high–capital-cost systems for electricity generation operate most economically when they are at full load all the time. For renewables, this is the maximum output given solar or wind conditions. To optimize their operation and to meet the storage needs of renewables requires systems that can store large amounts of energy and can do so on a daily to seasonal basis. The only existing such technologies are large hydroelectric dams—but there is not enough water storage capacity to meet the need.

Hydroelectric dam. Dams such as this one can store large amounts of energy on a flexible schedule, but they have insufficient water storage capacity globally to be our sole renewable energy source.

There is limited ongoing work on several new technologies. For example, in nuclear-hydrogen peak electricity systems, the nuclear reactor operates at steady state on a continuous basis (*1*). At times of low electricity demand, steam and electricity from the reactor are converted to hydrogen and oxygen by a solid-oxide high-temperature electrolyzer. At times of peak electricity demand, the reactor sends electricity to the grid and the electrolyzer is operated in reverse on hydrogen and oxygen from storage as a high-temperature fuel cell to produce electricity. Large-scale seasonal hydrogen storage is economical with use of current underground natural gas storage technologies. Eliminating greenhouse gas emissions from electricity production and large-scale use of renewables is not possible until we develop multiple, seasonal, energy storage systems with fast response capability to address mismatches between electricity production and demand.

CHARLES FORSBERG* AND MUJID KAZIMI

Department of Nuclear Science and Technology, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.

*To whom correspondence should be addressed. E-mail: cforsber@mit.edu

Reference

1. C. W. Forsberg, M. S. Kazimi, 4th OECD-NEA Information Exchange Meeting on the Nuclear Production of Hydrogen, 14 to 16 April 2009, Oakbrook, IL; http://mit.edu/canes/pdfs/nes-10.pdf.

Heliophysics Missions Show Promise

A RECENT NEWS OF THE WEEK STORY ("REPORT puts NASA's solar program under a cloud," A. Lawler, 13 March, p. 1415) noted that a report from the National Research Council (NRC) ("A performance assessment of NASA's heliophysics program") was critical of the performance of NASA's Heliophysics Division with respect to the 2003 Decadal Survey for Solar and Space Physics. NASA's heliophysics program has a record of remarkable success with its recent space flight programs. These have, in general, been well-managed, cost-effective, and scientifically exciting efforts. They have returned far more than the minimum science goals, and they continue to constitute a "Great Observatory" of the Sun-Earth system.

It is unfortunate that the mainstays of heliophysics space mission funding lines (the Solar Terrestrial Probe and Explorer lines) were hugely reduced in the Fiscal Year (FY) 2005 budgets of NASA (*1*). More than half the budgetary authority for the Solar Terrestrial Probe and Explorer mission lines was removed. With such evisceration and consequent programmatic uncertainty, it is not surprising that it is difficult for the Heliophysics Division to maintain and manage its space flight program.

The NRC review gave a low grade to the "Geospace Network" program. However, the Radiation Belt Storm Probes part of Geospace Network is already approaching its critical design review and is well on its way to a 2012 launch. Also, the mentioned Magnetospheric Multiscale program was subjected to an extended (nearly 5-year) initial study phase before beginning in earnest. It was reassigned to three different NASA administrators and five different associate administrators before being allowed to hit its stride. This is the "disastrous" result to which one of us (D.N.B.) was referring in his quote to Lawler.

Similarly, a very creative part of the heliophysics program, a modified Solar Probe mission, has been included in NASA's budget. NASA should be commended for accelerating scientifically rewarding programs,

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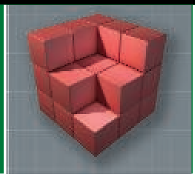

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and not punished—as the NRC performance review seems to do—for advancing one of the most important missions in solar and heliospheric physics.

It is clear that all of NASA (and other components of the U.S. space program as well) is witnessing large cost growths in flight missions. As Lawler points out, this has specifically been true of several recent solar and space physics missions. NASA must bring the best management techniques to bear (*2*) to help rein in mission cost growth. Heliophysics is clearly not alone in seeing cost overruns in its programs. However, based on its history and track record, heliophysics may have the best chance of turning this trend around to the great benefit of all.

DANIEL N. BAKER[1]* AND THOMAS H. ZURBUCHEN[2]

[1]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303, USA. [2]College of Engineering Entrepreneurial Program, University of Michigan, Ann Arbor, MI 48109–2143, USA.

*To whom correspondence should be addressed. E-mail: daniel.baker@lasp.colorado.edu

References and Notes

1. D. N. Baker, "Exploration Without Explorers?", *Space News*, 24 April 2006, p. 19.
2. National Research Council, *Assessment of Mission Size Trade-Offs for NASA's Earth and Space Science Missions* (National Academy Press, Washington, DC, 2000).
3. The authors are chair and vice-chair, respectively, of the NRC Committee on Solar and Space Physics, but they make their comments here as individuals.

How the Gray Wolf Got Its Color

THE REPORT "MOLECULAR AND EVOLUTIONARY history of melanism in North American gray wolves" (T. M. Anderson *et al.*, 6 March, p. 1339) suggests that the K^B gene for black coat color was introgressed from dogs (*Canis lupus familiaris*) into North American gray wolves (*C. lupus*). However, the authors fail to consider an alternative hypothesis: The K^B gene may have originated in the historic black wolves of eastern North America (*C. niger*, *C. rufus*, and *C. lycaon*).

The potential for gray wolf and eastern wolf introgressive hybridization (*1*) provides a mechanism to move an eastern wolf–derived variant into *C. lupus* during the Wisconsin glaciation (11,000 to 18,000 years ago). The only evidence for the K^B gene in coyotes is in the range of the eastern wolf where hybridization between the two species (*C. lycaon* x *latrans*) has occurred (*2*) and not in more western geographies where gray wolves, dogs, and coyotes overlap. These coyote samples, however, were excluded from the analysis of the most recent common ancestor. If the selection hypothesis for black coat color in forested habitats is true, the prevalence of black pelage in the original timber wolves of the eastern temperate forests of Canada and the United States makes the inclusion of eastern wolf specimens critical for assessing the three possible evolutionary histories proposed by Anderson *et al*. We suggest that a more complete examination of black canids from eastern North America be conducted before conclusions of introgressive hybridization from dogs to gray wolves are drawn.

LINDA Y. RUTLEDGE,[1]* PAUL J. WILSON,[2,3] CHRISTOPHER J. KYLE,[3] TYLER J. WHEELDON,[4] BRENT R. PATTERSON,[4] BRADLEY N. WHITE[5]

[1]Department of Environmental and Life Sciences, Trent University, Peterborough, ON K9J 7B8, Canada. [2]Department of Biology, Trent University, Peterborough, ON K9J 7B8, Canada. [3]Department of Forensic Science, Trent University, Peterborough, ON K9J 7B8, Canada. [4]Ontario Ministry of Natural Resources, Wildlife Research and Development Section, c/o Trent University, Peterborough, ON K9J 7B8, Canada. [5]Department of Biology, Natural Resources DNA Profiling and Forensic Centre, Trent University, Peterborough, ON K9J 7B8, Canada.

*To whom correspondence should be addressed. E-mail: lrutledge@nrdpfc.ca

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2. C. J. Kyle *et al.*, *Conserv. Genet.* **7**, 273 (2006).

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 3 months or issues of general interest. They can be submitted through the Web (www.submit2science.org) or by regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Response

WE APPRECIATE AND ENDORSE THE IDEA THAT additional molecular and phenotypic information on natural canid populations will add to our understanding of gene flow and evolutionary histories of domestic dogs and their wild relatives. However, this information could only expand upon, rather than revise, our primary conclusion that the K^B allele has been introduced into wolves from dogs.

Several lines of independent evidence indicate that K^B is "older" in dogs than in Arctic wolves and their descendants in Yellowstone National Park. Extended haplotypes associated with K^B are much shorter in dogs than in wolves, more point mutations have accumulated in dog K^B than in wolf K^B chromosomes, and the worldwide distribution patterns for K^B are much broader in dogs than in wolves. Had the k^y to K^B mutation originated in North American eastern wolves, as Rutledge and colleagues speculate, it is difficult to envision how it could have spread so widely among dog breeds around the world. Thus, even if K^B was introduced from eastern to western wolves during the Wisconsin glaciation, K^B in eastern wolves would still have been acquired originally from American (in this case, Native American) dogs.

GREGORY S. BARSH,[1]* TOVI M. ANDERSON,[1] BRIDGETT M. VONHOLDT,[2] SOPHIE I. CANDILLE,[1] MARCO MUSIANI,[3] DANIEL R. STAHLER,[2] JENNIFER A. LEONARD,[4] BADRI PADHUKASAHASRAM,[5] ETTORE RANDI,[6] CARLOS D. BUSTAMANTE,[5] ELAINE A. OSTRANDER,[7] HUA TANG,[1] ROBERT K. WAYNE[2]

[1]Department of Genetics, Stanford University, Stanford, CA 94305, USA. [2]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, CA 91302, USA. [3]Faculty of Environmental Design, University of Calgary, Calgary, AB T2N 1N4, Canada. [4]Department of Evolutionary Biology, Uppsala University, 75236 Uppsala, Sweden. [5]Department of Biological Statistics and Computational Biology, Cornell University, Ithaca, NY 14853, USA. [6]Instituto Nazionale per la Fauna Selvatica (INFS), 40064 Ozzano Emilia (BO), Italy. [7]National Human Genome Research Institute, Bethesda, MD 20892, USA.

*To whom correspondence should be addressed. E-mail: gbarsh@stanford.edu