be viable in the outside world.

Furthermore, one can imagine enhanced growth rates, since the plants would need to expend considerably less of their vital resources on water transport.

Coal plant emissions and water supplies are matters of the utmost concern. In the American Southwest, for example, some 90% of water consumption goes to agriculture. Unfortunately, there seems to be no forum in which the necessary synergy might develop among energy companies, agribusinesses, and environmentalists.

Terry Goldman
(tgoldman@lanl.gov)
Los Alamos, New Mexico

I find PHYSICS TODAY a good source of information on physics in general. The Quick Study is usually interesting reading. However, the January 2008 Quick Study was an exception.

Granted, the topic of water transport to the tops of trees is a controversial one and the authors' description of the phenomenon, "life in a metastable state," pays little attention to the physical constraint of cavitation under high tension. The only reference given was from 1981, but new tools and techniques—for example, nuclear magnetic resonance imaging and pressure-probing techniques—have brought new insights on the topic in the past 27 years.

In a case like this, a warning to readers that scientists hold several different views on the topic and some reference to other perspectives would be welcome. In a more recent publication, Ulrich Zimmermann and coworkers provide access to more than 300 references on the subject.[1] They also give a well-documented description of a complex, multiforce, multistage, segmented xylem perspective on water ascent in trees.

I hope PHYSICS TODAY readers will eventually get a broader description than the "realm where water is transported in a metastable state," as the Quick Study authors call it.

Reference

1. U. Zimmermann, H. Schneider, L. H. Wegner, A. Haase, *New Phytol.* **162**, 575 (2004).

Jean Roy
(jeanroy_igp@videotron.ca)
Outremont, Quebec, Canada

Holbrook and Zwieniecki reply: Terry Goldman is correct in suggesting that providing plants with higher carbon dioxide concentrations can result in both water conservation and enhanced photosynthesis. Indeed, CO_2 fertilization is already used by many commercial growers. However, enclosed growing systems have huge energy costs associated with cooling and are thus unsuited for large-scale agricultural production.

On the planetary scale, we are currently conducting such an experiment, albeit in an uncontrolled fashion. Increased atmospheric CO_2 due to human activities such as fossil-fuel combustion and land clearing is estimated to have increased terrestrial photosynthetic output. However, at the same time, rising temperatures due to higher greenhouse gas concentrations increase the water demands placed on plants and are predicted to alter the frequency and intensity of precipitation events. Thus, although elevated CO_2 can improve the efficiency of photosynthesis, there appears to be no free lunch.

Jean Roy's letter suggests that our Quick Study on water transport in trees should "teach the controversy," so to speak. However, there is no scientific controversy regarding the cohesion-tension theory of water transport in plants. In the early 1990s, there was a short-term challenge to the theory due to discrepancies observed by Ulrich Zimmermann using a pressure probe. Subsequent refinements of that measurement technique by Zimmermann and others eliminated those concerns.[1] Since then no xylem water transport data have been found to be inconsistent with the cohesion-tension theory. Nor has any alternative mechanism been proposed that can explain the transport of water in plants. Publication of the reference Roy cites prompted 45 prominent plant biologists to protest.[2] The editor's response was that the paper by Zimmermann and coauthors should be perceived as representing the "views and opinions" of the authors and not as a review of the current state of knowledge appropriate for newcomers to the field.[3]

Finally, we stand by our citation of W. F. Pickard's 1981 work as an outstanding treatment of water transport in plants. That paper is particularly appropriate for the readers of PHYSICS TODAY because it assumes high literacy in the physical sciences rather than detailed knowledge of plant anatomy.

References

1. P. J. Melcher, F. C. Meinzer, D. E. Yount, G. Goldstein, U. Zimmermann, *J. Exp. Bot.* **49**, 1757 (1998).
2. G. Angeles et al., *New Phytol.* **163**, 451 (2004).
3. I. Woodward, *New Phytol.* **163**, 453 (2004).

N. Michele Holbrook
(holbrook@oeb.harvard.edu)
Maciej Zwieniecki
(mzwienie@oeb.harvard.edu)
Harvard University
Cambridge, Massachusetts

More light on the structure of nuclei

We agree with David Dean (PHYSICS TODAY, November 2007, page 48) that computational advances in solving many-body problems have led to important progress in understanding the structure of nuclei. However, we need to examine two of the five questions highlighted by the author, namely, the nature of the nuclear forces (beyond the well-understood long-range pion exchange) that bind nucleons in nuclei and the structure of neutron stars and dense cold nuclear matter. The answers to those two cannot be obtained within the mean-field approximation without probing the high-momentum component of the nuclear wavefunction. In the mean-field approximation and in the effective field theory approach, that component is hidden in the parameters of the effective interaction. At the same time, according to the most realistic calculations (see reference 1 and references therein), approximately 60% of the kinetic energy of nucleons in medium to heavy nuclei is due to the high-momentum component of the nuclear wavefunction.

In this respect we would like to mention recent significant progress in the investigation of the high-momentum nucleon–nucleon short-range correlations (SRC) that for years remained an elusive feature of the nuclei. The progress was made through the use of high-energy electrons at the Thomas Jefferson National Accelerator Facility and high-energy protons at Brookhaven National Laboratory.[2] Analyses of those data demonstrate that nucleons with momenta exceeding the Fermi momentum are present in medium and heavy nuclei with a probability of approximately 20–25%. The shape of the momentum distributions of the SRC does not depend on atomic number. Experiments also established that large nucleon momenta are balanced predominantly by one nearby nucleon with strong preference (by a factor of nine) for a proton momentum to be bal-