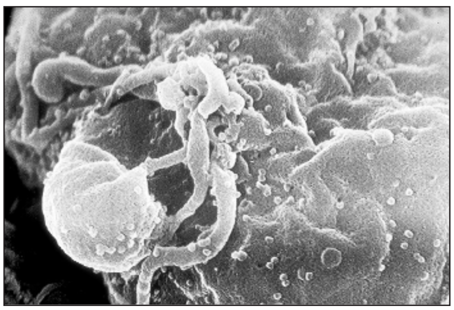
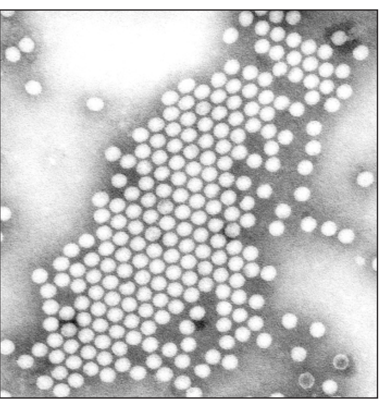
Letters to the Editor

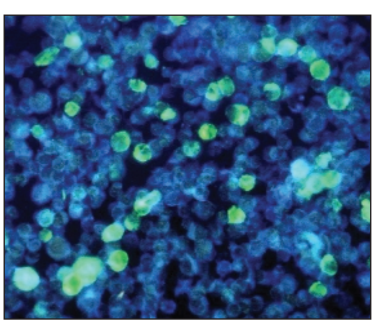
Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged 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.

Don't Forget About Viruses

THERE IS A GLARING OMISSION IN THE RECENT Tree of Life Special Issue (13 June, pp. 1691–1709). For too long, viruses have been overlooked by biologists attempting to frame the big picture of life's history. Earlier views maintained that viruses are not alive because of their lifestyle as obligate parasites, or that viruses are too changeable and inscrutable for inclusion in the tree of life. We argue that these views are no longer tenable. Viruses exhibit the same primary features common to all life forms (e.g., internal homeostatic controls promoting survival, structural organization based on heritable nucleic acids, reproduction, and so on). Furthermore, there are a legion of other obligate parasites that we do include in the tree (*E. coli* in our guts and mycorrhizal fungi, for example). Viral inscrutability is diminishing, and although the study of viral origins and evolution is in its infancy, the number of well-supported virus phylogenies is increasing, and, most importantly, there is a growing set of putative homologous genes linking various virus clades to nonvirus life forms, with more homologs likely to be discovered as genome sequencing efforts for diverse taxa continue. Integration of viruses into the tree of life is not just a viral birthright. It also promotes understanding of viral origins and their roles in emergent disease, in genome evolution through horizontal transfer of genes among hosts, and in the ecology of organismal evolution, as the diversification of viruses and their colonization of virtually all habitats and taxa on Earth have been significant in the creation, maintenance, and loss of biodiversity. Life is a clade, and, to be comprehensive, the tree of life must encompass all of the clade's diversity.







Counterclockwise top to bottom: scanning electron micrograph of HIV-1, photomicrograph of leukemia cells containing Epstein-Barr virus, and negative stain image of poliovirus.

CREDIT: CDC PUBLIC HEALTH IMAGE LIBRARY

DAVID P. MINDELL[1] AND LUIS P. VILLARREAL[2]

[1]Department of Ecology and Evolutionary Biology and Museum of Zoology, University of Michigan, Ann Arbor, MI 48109–1079, USA. [2]Department of Molecular Biology and Biochemistry, University of California at Irvine, Irvine, CA 92697, USA.

Developing World Science Strategies

IN HIS EDITORIAL "BRAZILIAN SCIENCE AT A crossroads" (11 July, p. 141), I. de Castro Moreira discusses the difficult problems facing Brazilian science and the enormous opportunities typical of science enterprises in developing countries. Persistent problems for these enterprises are inadequate funding, little capacity to use scientific information, poor management of human resources in science, and a demoralizing history of failure. The opportunities are brilliant researchers—an intellectual cream of the crop of the very best national achievers—and myriad intellectually stimulating problems too obvious and pressing to ignore. The main challenge is to find an intellectual framework that eliminates self-pity and instead blends the above problems and opportunities to produce science, technology, and innovation policies that can succeed.

To this end a "strategic decoupling policy option"—decoupling research from national poverty and handicaps—should be pursued. This option should target science and technology research questions of global interest and significance to boost the potential for endogenous research to find worldwide application. Major human resource opportunities may also be opened through strategic decoupling policies as information-hungry and well-resourced research and development communities go global in search of the best minds to tackle critical questions. Successful participation in a massive global R&D enterprise and concomitant relative funding security could contribute to successful efforts and a culture that is conducive to generation and use of scientific information. A successful national image could minimize self-pity among developing world scientists and breed new generations of scientists with greater self-esteem, self-confidence, and belief in their own ability to compete to win in science. Thus, major problems notwithstanding, Brazilian scientists must appreciate the significance (to developing countries) of their remarkable global achievements in energy, biotechnology, and genomics. In Jamaica, too, it is globally significant science achievements that will help to entrench science in the national culture.

ISHENKUMBA A. KAHWA

Department of Chemistry, University of the West Indies, Mona Campus, Kingston 7, Jamaica. E-mail: ishenkumba.kahwa@uwimona.edu.jm

Response

I AGREE WITH KAHWA'S COMMENTS WHEN HE points out some persistent problems and great opportunities facing science in developing countries. However, I disagree with him in two main points. Kahwa thinks that the main challenge is "to find an intellectual framework that eliminates self-pity" and increases scientists' self-esteem and self-confidence. In fact, this psychological factor is not a negligible one. But I do not think that it has great importance in the face of other more significant constraints. There are several social, economical, cultural, and political factors in Brazil that are behind our present problems, as I tried to expose briefly in my Editorial. Trying to elevate the self-esteem of individual scientists is no doubt a significant target, but I think it will be a consequence of a whole process, based not only on international acceptance but also on receiving respect, good working conditions, and valorization in their own country and having the possibility of contributing collectively for surpassing these problems.

I disagree partially with Kahwa's "strategic decoupling policy option," in which he proposes the decoupling of research efforts from national problems and handicaps. I think this strategy could be detrimental if employed without consideration of the local and global contexts. Of course, science is an international enterprise, and we cannot think about autonomous development, but it is also a socially conditioned activity and it would be risky to couple the whole scientific agenda of one developing country to the agenda of other developing ones. For instance, some of the remarkable achievements in science in Brazil emerged from facing important local problems, but with adequate resources and instruments, continued funding, and qualified scientific approaches. In some of these fields, such as energy, deep-water oil drilling, and biological and agricultural sciences, Brazil has a long-standing tradition. I do not think that there is a contradiction between making good science and facing local and important problems. Our challenge in fact is twofold: to participate in the international R&D entreprise and to tackle critical local problems. There are also internal political problems for using Kahwa's strategy: how, in a democratic country with such huge social problems, to entirely decouple research from local problems? The history of science and technology in many developed countries appears to show that they did not follow this strategy in full for achieving their success.

ILDEU DE CASTRO MOREIRA
Instituto de Fisica, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: icmoreira@uol.com.br

The Parasol Effect on Climate

BY BACKSCATTERING SOLAR RADIATION, aerosol particles and clouds exert a cooling (parasol) effect on climate, dampening Earth's warming by the greenhouse gases (GHG) (T. L. Anderson *et al.*, "Climate forcing by aerosols—a hazy picture," Perspectives, 16 May, p. 1103) (*1*). Based substantially on uncertain results from chemistry/climate models, Anderson *et al.* postulate large aerosol negative radiative forcing, including even the possibility of negative total (long wave minus short wave) radiative forcing, coinciding with the industrial (anthropocene) period and requiring large (≈ 3 W m^{-2}) positive internal climate forcing to produce the observed climate warming. Conversely, we present a method to quantify the parasol effect that does not require unproven major internal climate variability.

The change in the energy budget at the "top of the atmosphere" (TOA) during the anthropocene contains the following terms: (i) the global mean radiative forcing of 2.7 ± 0.3 W m^{-2} by GHG and tropospheric ozone (*1*), (ii) the increase in global average surface temperature since the latter half of the 19th century of 0.6 ± 0.2 K, causing an increase in outgoing long wave radiation (OLR), and (iii) the oceanic heat content, which increased on average by about 0.3 W m^{-2} between 1957 and 1994 (*2*). To estimate the change in OLR due to surface warming, we use the OLR sensitivity value (2 ± 0.3 W m^{-2} K^{-1}) obtained from global satellite data (*3*), which yields about 2 ± 0.3 W m^{-2} $K^{-1} \times (0.6 \pm 0.2)$ K, that is, about 1.2 ± 0.4 W m^{-2} leaves Earth. The OLR sensitivity is consistent with a positive water vapor feedback and a temperature-invariant relative humidity, which is supported by independent data. Water vapor concentrations increased by several percent per decade over many regions of the northern hemisphere (*1*). The assumption of constant relative humidity is becoming a "robust emerging constraint" (*4*).

Thus, out of 2.7 (± 0.3) W m^{-2} of GHG forcing, we can account for 1.5 ± 0.4 W m^{-2}. Because the atmosphere's heat capacity is small, 1.2 (± 0.5) W m^{-2} of solar radiation must have been reflected by aerosols and clouds, yielding an anthropogenic parasol effect of 45 ± 20%. We assumed that the preindustrial oceanic heat gain was zero and that internal climate variability averaged out over the anthropocene, contrary to the supposition of Anderson *et al*. Observational (*5*) and model studies (*6*) show that GHG warming is moderated by parasol effects on all continents.

We can also perform a similar analysis by comparing changes in Earth's heat budget (*7*) between the periods 1957–94 and 1861–1900. With a GHG forcing of 1.38 ± 0.14 W m^{-2}, a temperature rise of 0.33 ± 0.033 K, and change in the oceanic heat uptake of 0.15 W m^{-2}, we calculate similar values of 40 ± 10% for the parasol effect.

The anthropogenic parasol effect has been 45 ± 20%, probably mainly due to backscattering of solar radiation by aerosol and enhanced cloud brightness, but with smaller contributions from solar variability and land use (surface albedo) changes that seem to largely have cancelled each other out (*1*). Further, there does not appear to have been a long-term trend in volcanic activity (*1*). The effect is equal to 0.65 to 1.6% of the natural parasol effect of 107 W m^{-2} (*1*). The parasol effect increases with any TOA forcing by black carbon, which has been estimated at 0 (*8*), 0.5 (*9*), and 1 W m^{-2} (*10*).

PAUL J. CRUTZEN[1,2] AND V. RAMANATHAN[2]
[1]Max-Planck Institute for Chemistry, Post Office Box 30 60, 55020 Mainz, Germany. E-mail: crutzen@mpch-mainz.mpg.de. [2]Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, MC 0239-0221, La Jolla, CA 92093–0239, USA. E-mail: vram@fiji.ucsd.edu

References
1. J. T. Houghton *et al.*, Eds., *Climate Change 2001: The Scientific Basis, Contribution from Working Group 1, Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge Univ. Press, Cambridge, 2001).
2. S. Levitus *et al.*, *Science* **292**, 267 (2001).
3. A. Inamdar, V. Ramanathan, *J. Geophys. Res.* **103**, 32177 (1998).
4. M. R. Allen, W. J. Ingram, *Nature* **419**, 224 (2002).
5. M. L. Roderick, G. D. Farquhar, *Science*, **298**, 1410 (2002).
6. P. A. Stott, *Geophys. Res. Lett.* **30**, 1728, 10.1029/2003GL017324 (2003).
7. J. M. Gregory *et al.*, *J. Clim.* **15**, 3117 (2002).
8. J. E. Penner, C. C. Chang, K. Grant, *Clim. Dyn.* **14**, 839 (1998).
9. M. Z. Jacobson, *Nature* **409**, 695 (2000).
10. J. Hansen *et al.*, *Clim. Change* **52**, 435 (2002).

Response

CRUTZEN AND RAMANATHAN (CR) PROVIDE another inverse calculation of climate forcing by aerosols from observed temperature changes together with knowledge of nonaerosol forcings. Although CR's approach has the advantage of being shorter and perhaps conceptually simpler than others, it requires several assumptions and incorporates unquantified uncertainties such that its true uncertainty range must be substantially greater than claimed. In any event, CR's estimate of aerosol forcing (–1.2 ± 0.5 W m^{-2}) falls right in the middle of the six inverse calculations we cited.

CR do not acknowledge the inherent limitations to the inverse approach. Absent quantification of aerosol forcing (and of all exogenous forcings) in a manner that does not depend on the temperature record, it is not possible to evaluate performance of climate models by comparison with the temperature record or to use this temperature record to empirically estimate climate sensitivity. Thus, there is no escaping the need for the "forward" approach that evaluates aerosol forcing based on knowledge of anthropogenic aerosols and, importantly, their interactions with clouds.

The problem at present is that forward calculations of aerosol forcing admit the possibility of large negative values that are inconsistent with all of the inverse calculations. CR misread our paper on this central point. We did not "postulate" large negative radiative forcing by aerosols. Rather, we stated that present knowledge does not allow this possibility to be precluded. We did not deprecate either the forward or inverse approaches. Rather, we asserted that the disparity between these approaches requires resolution. This disparity can be resolved only by improved understanding and quantification of the relevant aerosol processes, properties, and geographical distribution; it cannot be resolved by models alone—whether they be aerosol chemical transport models or climate models.

THEODORE L. ANDERSON,[1] ROBERT J. CHARLSON,[1] STEPHEN E. SCHWARTZ,[2] RETO KNUTTI,[3] OLIVIER BOUCHER,[4] HENNING RODHE,[5] JOST HEINTZENBERG[6]

[1]Department of Atmospheric Sciences, University of Washington, Seattle, WA 98195, USA. E-mail: tadand@atmos.washington.edu. [2]Atmospheric Sciences Division, Brookhaven National Laboratory, Upton, NY 11973, USA. E-mail: ses@bnl.gov. [3]Department of Climate and Environmental Physics, Physics Institute, University of Bern, CH-3012 Bern, Switzerland. [4]Laboratoire d'Optique Atmosphérique, CNRS, Université des Sciences et Technologies de Lille, 59655 Villeneuve d'Ascq Cedex, France. [5]Department of Meteorology, Stockholm University, SE-10691 Stockholm, Sweden. [6]Institute for Tropospheric Research, D-04318 Leipzig, Germany.

The European Carbon Budget: A Gap

THERE IS A GAP IN THE EUROPEAN CARBON budget, as discovered by Janssens *et al*. in their recent Research Article "Europe's terrestrial biosphere absorbs 7 to 12% of European anthropogenic CO_2 emissions" (6 June, p. 1538). Seventy teragrams of carbon (C) absorbed by the biosphere per year is not recovered in terrestrial C stocks (corresponding to 7 g m^{-2} $year^{-1}$). Janssens *et al*. hypothesize that "missing fluxes" may account for the gap in the C budget (their fig. 1). In a search for this missing C, I reviewed drainage fluxes of dissolved C that bypass terrestrial C pools to enter the hydrosphere. Drainage exports 4 g m^{-2} $year^{-1}$ of dissolved organic C (0.4 to 19 g m^{-2} $year^{-1}$) (*1–9*) and 7 g m^{-2} $year^{-1}$ of dissolved inorganic C (0.6 to 21 g m^{-2} $year^{-1}$) (*10–18*) from soils to the ground water and springs. The resulting flux of 11 ± 8 g m^{-2} $year^{-1}$ of total dissolved C corresponds to riverine C export from European catchments of varying size (~15 g m^{-2} $year^{-1}$, 0.04 to 145,000 km^2) (*19*). Hence, drainage from soils decouples the exchange of C between the atmosphere and the biosphere over large distances. At a European scale, the drainage flux corresponds to 114 ± 83 Tg of C and therefore fills the gap in the C budget noted by Janssens *et al*.

JAN SIEMENS

Department of Soil Science, Institute of Ecology, Berlin University of Technology, Salzufer 12, 10587 Berlin, Germany. E-mail: jan.siemens@tu-berlin.de

References
1. R. Baeumler, W. Zech, *For. Ecol. Manage.* **108**, 231 (1998).
2. R. Baeumler, W. Zech, *For. Ecol. Manage.* **116**, 119 (1999).
3. K. R. Brye *et al.*, *J. Environ. Qual.* **30**, 58 (2001).
4. K. Kaiser, G. Guggenberger, W. Zech, *Acta Hydrochim. Hydrobiol.* **28**, 411 (2000).
5. B. Michalzik *et al.*, *Biogeochemistry* **52**, 173 (2001), and references therein.
6. R. G. Qualls, B. L. Haines, W. T. Swank, S. W. Tyler, *Soil Sci. Soc. Am. J.* **64**, 1068 (2000).
7. S. A. Quideau, J. G. Bockheim, *J. Environ. Qual.* **26**, 1167 (1997).
8. J. Siemens, M. Haas, M. Kaupenjohann, *Geoderma* **113**, 253 (2003).
9. S. Solinger, K. Kalbitz, E. Matzner, *Biogeochemistry* **55**, 327 (2001).
10. J. A. Andrews, W. H. Schlesinger, *Global Biogeochem. Cycles* **15**, 149 (2001).
11. M. B. David, G. F. Vance, J. S. Kahl, *Water Resour. Res.* **28**, 389 (1992).
12. J. J. C. Dawson, C. Bakewell, M. F. Billett, *Sci. Total Environ.* **265**, 153 (2001).
13. J. J. C. Dawson, M. F. Billet, C. Neal, S. Hill, *J. Hydrol.* **257**, 226 (2002).
14. J. B. Jones, P. J. Mulholland, *Ecosystems* **1**, 183 (1998).
15. M. Kaupenjohann, M. B. David, *Z. Pflanzenernähr. Bodenk.* **159**, 195 (1996).
16. G. W. Kling, G. W. Kipphut, M. C. Miller, *Science* **251**, 298 (1991).
17. R. L. Parfitt, H. J. Percival, R. A. Dahlgren, L. F. Hill, *Plant Soil* **191**, 279 (1997).
18. R. E. Stauffer, B. D. Wittchen, *J. Hydrol.* **138**, 559 (1992).
19. D. Hope, M. F. Billett, M. S. Cresser, *Environ. Pollut.* **84**, 301 (1994).

Response

CARBON FLUXES VIA RIVERS AND SEDIMENTAtion in aquatic ecosystems are currently a black box in most continental to global scale C-budget papers. In the study we did to reconstruct the C balance of the European biosphere, we did not directly include the flux reported by Siemens but assumed all C lost to have been respired within the continent. Hence, we welcome the current study. Furthermore, the combination of these results on soil C leaching with information on C export via European rivers (*1*) and heterotrophic activity in near-coastal zones (*2*) will allow us to further elaborate the European C budget. The only missing component in the aquatic part is now the sedimentation in European inland waters.

IVAN A. JANSSENS

Department of Biology, University of Antwerp, B-2610 Antwerp, Belgium.

References
1. W. Ludwig, J.-L. Probst, *Am. J. Sci.* **298**, 265 (1998).
2. M. Frankignoulle *et al.*, *Science* **282**, 434 (1998).

CORRECTIONS AND CLARIFICATIONS:

State of the Planet Series: Introduction: "The shape we're in" by H. J. Smith (14 Nov., p. 1171). In the third paragraph, Jeffrey Chow, the author of a upcoming Viewpoint in the series, is misidentified as Raymond J. Chow.