



Benefit-Cost Analysis and the Environment

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As many of us know, giving individual scientists their own RO1 grants provides them with the opportunity and incentive needed for them to explore their own creative ideas with the perseverance required for new discoveries. Let us as scientists thank Vice President Gore for communicating with us and reminding us of our obligations in helping to create and harness the power of "distributed intelligence" that can be used to improve our lives.

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Nesting Dinosaur

The idea that dinosaurs might brood their eggs ("Another nesting dino," *Random Samples*, 10 May, p. 819) is not unexpect-

ed. Among their living reptilian cousins, the snakes and lizards, well over 100 species are known to brood eggs or maintain a nest, and more than 10 species engage in communal nesting, including the green iguanas of Panama. Maintaining and guarding nests with eggs is particularly well known in such reptiles as crocodylians, king cobras, and pythons, the latter becoming endothermic during brooding. However, the conclusion drawn from these dinosaur nesting finds—that oviraptorids are engaged in avian-style brooding behavior—stretches far beyond the evidence (accordingly, a crocodile, turtle, or python, preserved similarly, would be exhibiting "avian brooding behavior"). Perhaps "the strain of egg-laying" would have resulted in the fossil python's untimely death, as it was with *Oviraptor*. Hirsch *et al.* (1) showed that the addition of the shell to dinosaur eggs and bird eggs is fundamentally different. This is illustrated by an Upper Jurassic dinosaur egg, which had a pathological multiple shell, typical of modern pathological reptilian eggs (commonly seen in marine turtles), but dramatically different from those of birds. Pathological reverse peristalsis in the avian oviduct produces an "ovum in ovo," as opposed to a double-shelled reptilian pathology, thus degrading the dinosaur-bird connection.

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1. K. F. Hirsch, K. L. Stadtman, W. E. Miller, J. H. Madsen Jr., *Science* **243**, 1711 (1989).

Benefit-Cost Analysis and the Environment

In their Policy Forum of 12 April (p. 221), Kenneth J. Arrow *et al.* argue that benefit-cost analysis should play a role in determining environmental, health, and safety regulation—a conclusion with which we agree. But we disagree with their proposed method for discounting future costs and benefits. "Ideally," they write, "the same range of discount rates should be used in all regulatory analyses." It seems to us, though, that there is a big difference between short-term health and safety regu-

Carl von Linné: 18th century botanist, researcher; physician, professor, lecturer and a resident of the Swedish university city of Uppsala (pronounced OOP-SA-LA). A consummate classifier, Linné systematized the plant, animal and mineral kingdoms as well as drew up a treatise on the diseases known in his day.

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lations and long-term environmental problems. Arrow *et al.* suggest that the discount rate should be based on "how individuals trade off current for future consumption." This is a reasonable approach for problems that can be addressed during the life span of an individual. But it is inappropriate for environmental problems that span multiple human generations.

The problem of global warming provides a good example. The time scale for global warming is so long that the assumption of any fixed discount rate could lead one to overlook potentially large economic damages caused by climate change in the distant future. Cline (1) and others, including ourselves (2), have argued for a zero pure rate of time preference for such problems, mandated by the need to ensure intergenerational equity. Humans living several generations in the future have the same right to a hospitable environment as do those of us alive right now. Future costs and benefits should be discounted to present value, but only in such a way as to offset economic and population growth. The preference of individuals for current instead of future consumption has no bearing on this type of intergenerational environmental problem.

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1. W. R. Cline, *The Economics of Global Warming* (Institute for International Economics, Washington, DC, 1992).
2. P. A. Schultz and J. F. Kasting, in preparation.

Response: We conclude that benefit-cost analysis can provide important information to decision-makers for both short-term and long-term problems, provided that its strengths and limitations are recognized. While the tool identifies the approach with the greatest net economic benefits, decision-makers should consider a range of issues in addressing long-term problems characterized by low probability and potentially high-consequence events, such as global climate change. Other potentially important factors include risk aversion and the distribution of costs and benefits over time and across countries.

The appropriate discount rate depends on the rate at which individuals are willing to trade off present for future consumption. Discount rates can change with the time

horizon to reflect the judgment and behavior of individuals. We disagree with Kasting and Schultz, who propose to set the discount rate for long-term problems "only in such a way as to offset economic and population growth." Economic theory suggests that the discount rate should be the sum of the pure rate of time preference, which is normally positive, and a wealth effect. If, as seems likely, wealth increases, the wealth effect would account for the falling valuation of additional consumption as individual incomes increase. Even if the pure rate of time preference is assumed to be zero, typical estimates of the wealth effect alone would imply a discount rate greater than the growth of real per capita income. Thus, it is difficult to justify a zero discount rate.

The choice of a discount rate can have profound effects on the relative ranking of different policies in terms of their net benefits. To minimize the potential for bias, policy analysts should choose a discount rate based on sound economics. Selecting an outcome and then trying to justify the implied discount rate lead to unproductive debate that draws attention from the important issues.

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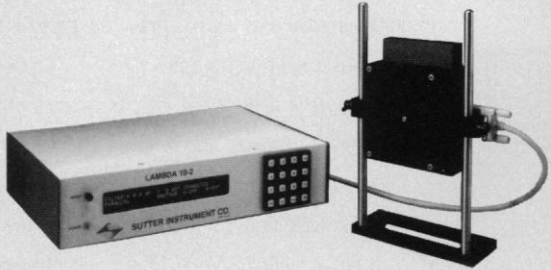
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Loco Cow Logo

The News & Comment article "Mad cow disease: Scant data cause widespread concern" by Claire O'Brien (29 Mar., p. 1798) was illustrated with a color picture resembling abstract art, but carrying the caption "Mad cow brain. Brain tissue from cow with BSE [bovine spongiform encephalopathy] shows fibrils and spongy lesions." To my neuropathologist's eye, this seemed strange, indeed.

After a journey through the literature, I

came to appreciate that this illustration is the apparent endproduct of a 7-year metamorphosis that includes cropping, coloring, turning, flipping, and re-captioning a figure within a paper by James Hope *et al.* in 1988 (1). The caption of the original black and white image read, "Electron micrograph of negatively-stained fibrils from the spinal cord (C1/C2 segments) of a BSE-affected cow." This makes sense; no "spongy lesions" here. An intermediate version of the illustration can be found in a News & Comment article "Mad cow disease: Uncertainty rules," by Jeremy Cherfas (28 Sept. 1990, p. 1493).

It would appear that this illustration has obtained "logo" status for BSE.

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Corrections and Clarifications

In the Research News article "Mammal diversity takes a 20-million-year leap backwards" by

Kim Peterson (24 May, p. 1102), the legend for the accompanying map contained two errors. The colors indicating "zhelestids" and ungulates were reversed, and the South American fossils, which are solely ungulates, were incorrectly represented as "zhelestids" and ungulates.

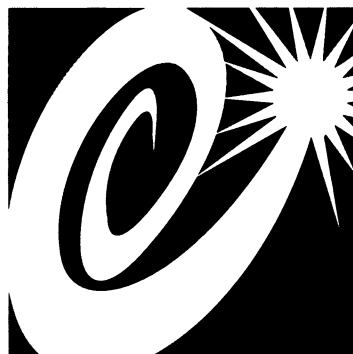
In the report "Lead and helium isotope evidence from oceanic basalts for a common deep source of mantle plumes" by B. B. Hanan and D. W. Graham (17 May, p. 991), on pages 993 (middle column, last paragraph) and 994 (middle column, third line), the word "carbon" appeared instead of the symbol "C," which stands for "common component." *Science* regrets the error, which occurred during proofreading.

Letters to the Editor

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