ing it to the museum library, they stopped even that small resource.

More personally, I have for some years taken a certain ironic pleasure in using funds earned from speaking engagements where I talk about my work on gender and science to fund a small but fundamental project in basic biology. The time and emotional energy saved by not applying for grants has enabled me to develop a second field of scholarly expertise (feminist science studies). Not only that, I think it is a terrific example for my students, in this high-tech day and age, to see that the most essential tools of science are the brain, a little ingenuity, and a high level of devotion.

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One Man's "Torment..."

Arthur Taub (Letters, 9 Jan., p. 159) refers to acupuncture as "torment" and later describes it as "20-minute, painful needling." In the same manner, one might describe Taub's own practice of anesthesiology as a systematic drugging of the patient that infrequently results in death.

Little if any pain is associated with acupuncture. If acupuncture truly were experienced as "torment" or a "20-minute, painful needling," it wouldn't have the widespread use and interest that prompted the National Institutes of Health to study it in the first place.

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"Gaps" in the K-T Record

In their letter "Ancient sharks and rays,"(9 Jan., p. 161), J. Mark Erickson *et al.* state that, where they work in North Dakota, "the K-T [Cretaceous-Tertiary] boundary section is not complete because units of terrestrial Hell Creek and Ludlow Formations intervene...." They then state, in the next paragraph, that they sampled "nearshore marine facies on each side of the K-T boundary" and later say that "[s]ignificant species-level change in cartilaginous fish faunas occurred across the K-T boundary in the Williston Basin, and apparently globally...."

These remarks appear to be contradictory. Because one has Upper Cretaceous and Paleocene rocks superposed, one does not necessarily also have a K-T boundary section. The tick of the geological clock that we call the K-T boundary occurred whether or not we have rocks and fossils preserving the event. Probably no sections actually record the event, but several come close (tens of thousands of years) on one or both sides. The section studied by Erickson *et al.* is not one of those.

Data from a variety of sources [see references in (*1*)] suggest that the gap they study in the section through the K-T interval covers at least 1 million years—an extremely long time if one is attempting to examine species-level turnover.

Given this gap, I conclude that their data cannot be used to support the statement that "significant species-level change in cartilaginous fish faunas occurred across the K-T boundary in the Williston Basin, and apparently globally." As I have noted (*1*), because of this well-documented gap, it is not clear "whether the disappearances from the Western Interior [of elasmobranchs] are actually extinctions at the K/T boundary or whether the species survived elsewhere in marine environments into the earliest Paleocene." This also extends to statements

about global records of species-level changes.

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References

1. J. D. Archibald, *Dinosaur Extinction and the End of an Era: What the Fossils Say* (Columbia Univ. Press, New York, 1996).

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Human Genome Project: Data Quality

Steven E. Koonin's interdisciplinary perspective on the Human Genome Project (*Science*'s Compass, 2 Jan., p. 36) is intriguing, but I would like to comment on two key issues regarding data quality.

Koonin's proposal that quality monitoring be based on "gold standard" sequences does not meet the condition that the laboratory under review should be blind as to which of its sequences will be checked. Consequently, it is unlikely to yield representative results. A preferable procedure, which is already in use for sequencing centers funded by the National Institutes of Health (*1*), is to randomly select previously sequenced and submitted clones for resequencing by one or more competing laboratories, which would be motivated to find as many errors as possible.

The issue of setting cost-effective quality standards is more difficult, and Koonin is correct in observing that it is important to be quantitative. The Human Genome Project's target error rate of less than 1 in 10,000 at the per base level (*1*) is a pragmatic one, chosen because it is both attainable with current technology at a reasonable cost (currently about 50 cents per base pair) and adequate for essentially all known uses of the sequence. A higher error rate would tend to degrade our ability to use the sequence as a reference against which human genetic variation can be catalogued and would also tend to complicate gene-finding efforts.

Studying this issue using computer simulation, as Koonin proposes, is desirable in principle, but is impractical given our current limited knowledge. Biological features of unsuspected types likely exist even in well-studied sequences and cannot be modeled before they are discovered. Simulating the laboratory sequencing process, particularly those aspects that involve biological organisms (bacteria or humans), similarly appears beyond the state of the art.

The Human Genome Project has had a highly interdisciplinary character since its inception, and will continue to benefit from expert advice in order to meet the unprecedented challenges that still remain. Such input is most productive when biological and physical principles are effectively merged.

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References and Notes

1. Further comments on the full JASON study led by Koonin and reported on in his article may be found at http://bozeman.genome.washington.edu/ScienceLetter/JasonComments.html
2. "Report of NHGRI Workshop on DNA Sequence Validation" (National Human Genome Research Institute, 15 April 1996) (www.nhgri.nih.gov/HGP/Reports/dna_sequence_workshop.html).

Response: Green offers a number of thoughtful comments on the JASON report. I respond below to those contained in his letter:

1) The JASON study enumerates a number of nonexclusive quality-assessment strategies, including both competitive random resequencing and "gold standards." The report discusses the drawbacks of the latter that Green mentions, but still concludes that gold standards would be useful in that, be-