

- Moritz, C. (1992). Molecular systematics. *Austral. Biol.* 5: 40–47.
- Pääbo, S., Wayne, R., and Thomas, R. (1992). On the use of museum collections for molecular genetic studies. *Ancient DNA Newsl.* 1: 4–5.
- Patterson, C. (Ed.) (1987). "Molecules and Morphology in Evolution: Conflict or Compromise?" Cambridge Univ. Press, Cambridge.
- White, T. J., Arnheim, N., and Erlich, H. A. (1989). The polymerase chain reaction. *Trends Genet.* 5: 185–189.

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Reply: Molecular Extracts from Museum Specimens Can—and Should—Be Saved

To the Editor:

The Whitfield and Cameron (1994) letter on use of museum specimens in molecular-systematic research focuses on a timely issue, and it should serve to stimulate continued discussion of this important topic. DNA and other molecular extracts (including isolated proteins) taken from traditionally preserved museum specimens are valuable research materials that are normally acquired through partial or complete destruction of the original specimen. Because the source of these materials (i.e., the original specimen) is unique and nonrenewable, it is imperative that every molecular extract obtained through destructive sampling receive maximal usage by the research community. In this spirit, Whitfield and Cameron (1994) suggest appropriately stringent criteria for granting of specimen loans when destructive sampling is planned (see also Pääbo *et al.*, 1992).

It is unfortunate, however, that Whitfield and Cameron consider it impractical for recipients of such loans to deposit molecular extracts into permanent museum collections upon completion of research projects. They argue that because most museums are not equipped to curate molecular samples, the loanee should be required to return only information about the extract (e.g., GenBank accession numbers, extraction protocols, literature citations, etc.), rather than the actual extract itself. This misconception (that there are few museums willing and able to curate molecular extracts) is widespread among molecular biologists and has resulted in loss of countless molecular extracts, either because of neglect or poor curation on the part of individual research scientists (Dessauer and Hafner, 1984). Unfortunately, Whitfield and Cameron's em-

phasis on preservation of *data*, rather than preservation of *molecular extracts*, will only perpetuate this wasteful practice.

Any policy, formal or informal, that allows molecular extracts to be tucked away (and eventually forgotten) in laboratories scattered across the nation is wasteful of this precious resource and should be viewed as unacceptable by the research community. This was the overarching conclusion of a workshop panel (sponsored by the Association of Systematics Collections and funded by the National Science Foundation) convened a decade ago to formulate a national policy on tissue collection management (Dessauer and Hafner, 1984). A major recommendation of that panel was establishment of a national network of collections to serve as long-term repositories for native tissues *and tissue extracts*.

This important goal—a national network of repositories for molecular samples—is well on its way to realization. The upcoming second edition of the book *Molecular Systematics* (Hillis and Moritz, 1990) will include a directory of such collections worldwide. Several of these collections are quite large, and many are willing to serve as repositories for molecular extracts taken from museum specimens, even if the original specimen came from a different institution. For example, the Collection of Genetics Resources at Louisiana State University (LSU) now contains tissues and extracts representing approximately 40,000 specimens. Importantly, the source specimens (vouchers) for many of these tissue samples are maintained in traditional museum collections at other institutions. The staff of the LSU tissue collection (a full-time Ph.D. curator, half-time collection manager, half-time graduate curatorial assistant, and several student workers) is willing and able to curate DNA (and other) extracts donated for long-term preservation. Because this collection, and others, is willing to serve as "at-large" repositories, there is no longer any excuse for valuable DNA extracts to accumulate in lab freezers across the nation, only to be discarded as the research directions of the individual investigator change.

In the context of research museums, I believe that Whitfield and Cameron's (1994) emphasis on molecular-systematic data (e.g., published papers and DNA sequences), rather than the DNA extract itself, is misguided. It has never been the responsibility of museums to serve as repositories for research data based on their specimens, and I see little advantage in expanding the museum's role in this direction. Research museums curate *specimens* and parts thereof (which include—or should include—DNA and other tissue extracts), not data or publications based on those specimens. This distinction between data (which vary in quality and are subject to many kinds of error) and sources of data (i.e., specimens) is fundamental and worth preserving. As the needs for databases emerge,

these will develop on their own outside the museum sphere (e.g., GenBank for DNA sequences), and properly designed databases will be cross-referenced with museum voucher specimens. Because museums curate specimens, not publications, it strikes me as backward (not to mention wasteful) to encourage a scientist to send reprints of a molecular publication to the museum while permitting the scientist to discard the molecular extract(s) upon which the study was based.

I certainly appreciate and support Whitfield and Cameron's desire to maintain the important linkage between biological specimens and data generated from those specimens, but I would remind them that such a mechanism already exists in the form of the "specimens examined" section of a research publication, which lists specimens by museum voucher number. Unfortunately, the excitement and rapid pace of research in molecular biology have caused many scientists (as well as editors of molecular-oriented journals) to lose sight of the importance of voucher specimens as the ultimate source for data verification. In short, I believe that molecular data that lack this essential documentation should not be published.

For whatever reason, the research community seems to be largely unaware of the existence of museum repositories for their molecular samples; perhaps this letter—and the list of collections that will appear in the next edition of the Hillis and Moritz (1990) book—will help spread the word. Given the existence of ready and willing repositories for molecular samples, Whitfield, Cameron, and other concerned scientists can now take a firmer policy stance on the issue of molecular extracts taken from museum specimens. In that spirit, I recommend that the following policy be adopted by all museums that permit destructive sampling of their specimens: *DNA and other molecular samples extracted from museum specimens must be returned to the museum or, if the museum is unable to store the extracts, they must be deposited in another molecular collection with appropriate cross-references to the original voucher specimen.* I would argue that appropriate repositories are already in place, and I offer the LSU collection as one example. This is the loan policy under which our collections operate, and I understand that more and more curators are awakening to the realization that molecular extracts are bona fide components of the original specimen and, as such, should be returned to the museum (or an alternate repository) for long-term preservation.

ACKNOWLEDGMENTS

I acknowledge the seminal contributions of Herbert C. Dessauer to formulation of policies designed to conserve molecular research resources. My ideas have benefited from discussions with J. V. Remsen, Jr., Frederick H. Sheldon, Francis X. Villablanca, Robert M. Zink, and many others. The opinions expressed, however, are my own.

REFERENCES

- Dessauer, H. C., and Hafner, M. S. (1984). "Collections of Frozen Tissues: Value, Management, Field and Laboratory Procedures, and Directory of Existing Collections," Assoc. Syst. Coll., Lawrence, Kansas.
- Hillis, D. M., and Moritz, C. (Eds.) (1990). "Molecular Systematics," Sinauer Associates, Sunderland, Massachusetts.
- Pääbo, S., Wayne, R., and Thomas, R. (1992). On the use of museum collections for molecular genetic studies. *Ancient DNA Newslet.* 1: 4–5.
- Whitfield, J. B., and Cameron, S. A. (1994). Museum policies concerning specimen loans for molecular systematic research. *Mol. Phylogenet. Evol.* 3.

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Authors' Response to Hafner

To the Editor:

Dr. Hafner has pointed out the importance of long-term tissue and extract storage repositories in documenting molecular systematic research and has provided additional valuable information on locations of such repositories. We do not wish to counter his arguments for the value of long-term preservation of molecular extracts; indeed, we feel strongly that vouchering molecular research projects by deposition of extracts will become increasingly important in the future and should be encouraged, perhaps, as he suggests, required. We thank him for responding to our suggestions and for offering additional useful recommendations.

We wish to clarify, however, our position (requirement 1 under "What should museums require back?") that a museum's loan policy should include submission of the unused remains of specimens used for DNA research and that the place of deposition of the molecular extracts should also be provided (requirement 2). Dr. Hafner appears to have missed these points in suggesting that we would allow scientists to discard the molecular extracts.

We also wish to comment on several of his assertions about the roles of museums in documenting research, and on how these roles influence loan policies. Specifically:

1. Museums *are* in fact often required to document the publications that have resulted from loans of their specimens. Not only is such documentation often required for obtaining NSF or other grant funding for collection support, but it is often also required by the institutions to which the museums may be attached.