Readers applaud Robert Irion's article on the contributions of small telescopes to modern astronomy: "Small telescopes can (and do!) yield big science." Two letters say that preserving DNA from endangered species is not enough—we also need "conservation genetics research" and "improved ways of sampling and preserving DNA." Ryder agrees, but says that we should take first things first because "research is only possible if the samples are available" and that we will soon have the technical tools "to overcome many of the problems of degradation that have taken place" in DNA samples. Sir Arthur C. Clarke reminds us that his proposal for a "network of communications satellites in geosynchronous orbit...was not made in a work of science fiction," but rather in a technical paper.

Small Telescopes, Big Results

I am writing in praise of the News Focus article "Astronomers overcome 'aperture envy'" by Robert Irion (7 Jul., p. 32) in which an important point is made, courageously, in the face of "big" astronomy's new conventional wisdom favoring large telescopes: Small telescopes can (and do!) yield big science. Without the armada of well-equipped, small-aperture telescopes slowly sprouting up across the globe, the progress of discovery in astronomy and astrophysics would be severely stunted.

The value of Irion's piece can best be summarized by his quote of John Huchra's observation on the move toward larger instruments: "This trend hurts students the most." As an undergraduate at the University of Arizona, the only reason I was able to observe with a research-quality telescope at all was the availability of small instruments at Kitt Peak. (This was before the recent policy of "selling out" those telescopes to private consortia.) Graduate students usually don't get time on 8- to-10-meter telescopes. If they do, it is only by riding the coattails of their advisors' observing time and academic reputations.

John C. Barentine
Department of Physics, Colorado State University, Fort Collins, CO 80523–1875, USA. E-mail: jcb@lamar.colostate.edu

Although we enjoyed Irion's excellent article describing the many contributions of small telescopes, we were struck by the comments of National Optical Astronomy Observatories director Sidney Wolff, who stated that "forefront questions...require...more powerful instruments and multi-institutional collaborations." The article itself contradicts this view and describes a number of small telescopes and small collaborations that are making exciting contributions to "forefront" research. These include (i) measuring changes in the expansion rate of the universe; (ii) finding the optical counterparts to gamma-ray bursts; (iii) making precise observations of sun-like stars to understand solar influences on climate change; (iv) making the first direct detection of extrasolar planets, which led to the first determination of their physical properties; (v) understanding stellar interiors through asteroseismology; (vi) conducting the first deep all-sky survey in the near infra-red; and (vii) discovering near-Earth asteroids.

Thus, small telescopes are, in fact, making big contributions to science. It's clear to us that small telescopes still have a bright future.

Frank Fekel
Gregory W. Henry
Center of Excellence in Information Systems, Tennessee State University, 330 10th Avenue North, Nashville, TN 37203–3401, USA. E-mail: henry@schwab.tsuniv.edu

Shakespearian Views on Choosing Associates

In the item "Fat and happy" (Random Samples, 14 Jul., p. 241), James Watson is quoted on the merits of hiring thin people.

This forms an interesting contrast to the words William Shakespeare put into the mouth of Julius Caesar (*Julius Caesar*, Act 1, Sc. 2): "Let me have men about me that are fat, sleek-headed men, and such as sleep o' nights: yon Cassius has a lean and hungry look; he thinks too much: such men are dangerous."

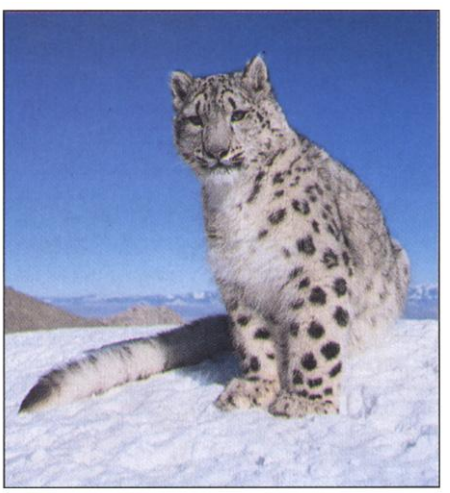
Tom Davidson
2482 Kiowa Creek Drive, Brighton, CO 80601, USA. E-mail: tadchem@earthlink.net

Preservation of DNA From Endangered Species

In their Policy Forum entitled "Ecology: DNA banks for endangered animal species" (14 Apr., p. 275), O. A. Ryder, A. McLaren, S. Brenner, Y.-P. Zhang, and K. Benirschke make it clear that now is the time for greater coordination and cooperation in the collection of DNA and other samples from endangered species (*1*). However, active conservation of these endangered species can also benefit from laboratory research to inform conservation management and policy (e.g., *2, 3, 4*). The examples Ryder *et al.* provide clearly show the importance of this research, but the Policy Forum does not address how the need for such research will be met.

Some portion of the collected DNA, tissues, and cell lines, equivalent to the human genome diversity cell line collection, plus an archive of tissues for physiological and DNA expression studies (*5*), must be made available to all interested researchers. "Soft" funding of collections means that changes in political climate, personnel, and funding availability are probable; to ensure stability, the collection must be funded at a base level with long-term funding to ensure continuity of expertise, support, and equitable availability at reasonable cost to conservation researchers.

Equally important, conservation biologists, managers, and policy-makers need access to technology and expertise in genetics research. Few researchers in conservation



The endangered snow leopard *Uncia uncia*.

CREDIT: GERARD LACZ/ANIMALS ANIMALS

(and even fewer managers or conservation organizations) have access to the type of genomics technology or the expertise that serves the Human Genome Project. Genomics research for conservation biology, like collection and preservation of genetic samples, must be organized and brought up to the standards of scientific excellence demanded in human biomedical research.

The need for conservation genetics research is as urgent as the need for collection of genetic resources. These two parts of the conservation genetics equation cannot be treated independently. Formation of an endowed international collection and conservation genetics research organization would provide the necessary permanence and availability of a collection, and would also create the link between collection, research, and conservation that will make the

best, most efficient use of such resources, with a goal to link the sample collections and research directly to conservation action.

Phillip A. Morin
Max Planck Institute for Evolutionary Anthropology, Inselstrasse 22, D-04103 Leipzig, Germany. E-mail: morin@eva.mpg.de

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Ryder *et al.* (*1*) present an important and timely reminder for the need to begin storing DNA samples of endangered species for future research. However, we do not believe that "[t]he technical aspects of saving DNA are straightforward" or that there is evidence in support of the statement that "purified DNA may be preserved for hundreds to thousands of years at room temperature, provided it is kept dry, for example, in a closed vial of inert gas."

What we do know is that the DNA in fossil remains of organisms is heavily damaged after even a few hundred years (*2*). It is also quite clear that DNA preservation is a function of the temperature and the environment of storage (*3, 4, 5*). Thus, although low relative humidity and temperature, as well as minimal exposure to oxygen, help preservation, DNA damage is extensive and irreversible. High-energy particles (radiation, cosmic rays, etc.), oxidation, and hydrolysis reactions with bound water molecules take their toll over time.

So how can we preserve the DNA of endangered species? By looking at the protective measures used by some organisms, we can generate ideas for effective preservation. Some nematodes, bacteria, and plants survive extreme desiccation by packaging their vital biochemical machinery with massive amounts of solutes, such as the nonreducing sugar trehalose (*6*). In addition, the best preserved forms of life are the "survival capsules" such as seeds, pollen, and bacterial cysts (*7*), which employ concentric protective layers of biopolymers. Thus purified, high molecular weight DNA is not a good candidate for preservation; better would be a natural biological package, such as a seed.

At present, some banks use liquid nitrogen for storage of frozen specimens (*8*), but others simply store dried leaves, which are poor sources of genomic size DNA. We feel that DNA banks should investigate improved ways of sampling and preserving DNA. The procedure needs to ensure that damage during storage is minimal and (preferably) repairable, for a bank with poorly preserved DNA will be of little use a hundred years from now.

Hendrik N. Poinar
Max Planck Institute for Evolutionary Anthropology, Inselstrasse 22, D-04103 Leipzig, Germany

Geoffrey Eglinton
Hanse Wissenschaftskolleg, Lehmkuhlenbusch 4, D-27753 Delmenhorst, Germany. E-mail: geglinton@www.h-w-k.uni-bremen.de

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Response

Morin makes some excellent points in his letter regarding the need for research on the genetics of endangered species. However, research is only possible if the samples are available. Morin believes that establishment

of collections and the provision of technological infrastructure for analysis cannot be separated and proposes setting up a Conservation Genetics Institute. Our present objectives as stated in the Policy Forum are less ambitious: We want only to discover which (if any) of the described and evaluated species listed as endangered in the International Conservation Union (IUCN) Red Book [used as the basis for the Wildlife Conservation and Monitoring Centre (WCMC) Web site we referenced] represent securely stored DNA or tissue samples. The purpose of our suggestion was to draw attention to the urgent need to save genetic resources, an action that serves and facilitates all the other activities.

We agree with Poinar and Eglinton that more focused research on the long term storage of DNA would be useful. We feel, however, that we should not wait to establish DNA collections. Although preservation of DNA in frozen source tissues may provide the best means of reducing the rate of degradation, all freezers break down and the cost of a "fail-safe" system of freezers will be very large compared to the storage of DNA at room temperature. Even before a hundred years is up, it will likely be possible to sequence genomic DNA rapidly and, if sufficient amounts of DNA have been saved, to overcome many of the problems of degradation that have taken place in that relatively short interval. The immediate requirement is to obtain cells and DNA from threatened and endangered species and preserve it as best we can until it can be sequenced.

We also wish to clarify that the International Biodiversity Observation Year (IBOY) 2001-2002 is an initiative of DIVERSITAS, the international program of biodiversity science, co-sponsored by the International Union of Biological Sciences (IUBS), the United Nations Educational, Social and Cultural Organization (UNESCO), the International Council for Science (ICSU), the Scientific Committee on Problems of the Environment (SCOPE), the International Geosphere Biosphere Program (IGBP), and the International Union of Microbiological Sciences (IUMS). Further information on the IBOY can be found at http://www.nrel.colostate.edu/IBOY.

Oliver A. Ryder
Anne McLaren
Ya-Ping Zhang
Sydney Brenner
Kurt Benirschke
Center for Reproduction of Endangered Species, Zoological Society of San Diego, Post Office Box 120551, San Diego, CA 92112–0551, USA. E-mail: oryder@ucsd.edu

Stranger than Science Fiction

Thank you for the reference to me in "Plan 9 from EuroSpace" (Random Samples, 7 Jul., p. 41). I was intrigued by the European Space Agency's recent announcement that they are scouring through science fiction in search of new space propulsion technologies. It is further proof that science fiction is now being taken very seriously by scientists.

My proposal for a network of communications satellites in geosynchronous orbit, however, was not made in a work of science fiction. It was in a technical paper entitled "Extra Terrestrial Relays" written in the summer of 1945, and printed in the British journal *Wireless World* in October of that year.

This paper is now on display at various exhibitions and aerospace museums, including the Smithsonian. It is also found in my collection of technical papers, *Ascent to Orbit* (Wiley, New York, 1984).

Sir Arthur C. Clarke
"Leslie's House," 25, Barnes Place, Colombo 7, Sri Lanka