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The Frozen Zoo

Wildlife gene banks provide a tool for studying species and monitoring conservation efforts.

By Oliver Ryder

In the course of their work, field biologists, veterinarians, and zoo scientists often collect biological specimens in order to assist ongoing studies on the biology and health of species. If, in doing so, they make additional efforts to bank specimens for future studies, they provide future scientists—who may have access to technologies undreamed of by their forbears—with opportunities to gain insights that may contribute to conservation efforts for declining species. With the declines in biological diversity that have been well known for the better part of a century, these biobanking efforts have rather quietly been underway for over thirty-five years at the institution where I work. The Frozen Zoo at the San Diego Zoo's Institute for Conservation Research now encompasses gametes, embryos and cell cultures from over 9,000 animals, comprising more than 1,000 species.

The frozen cultures of viable cells may be thawed, grown and divided into more cells, which can be frozen again. Although not an infinitely expendable resource, it provides the opportunity to conduct studies now, while still keeping supplies for the future.

Hundreds of scientific studies have used samples from the Frozen Zoo. New species have been identified after their distinctiveness was revealed by genetic studies of biobank

samples. Studies of species and individual identity, for wildlife management and forensic applications, have been undertaken and have expanded the database of DNA profiles and barcodes. Infertile animals have been identified from genetic testing, parentage relationships identified and incorporated into species management programs; and now, whole genome sequencing and studies of the repertoire of expressed genes—the "transcriptome"—are being studied using samples banked over the last four decades. From most of the small population management programs of zoos, questions have arisen that are answerable by genetic testing, if appropriate samples are available. The Frozen Zoo has played a crucial role in all these activities.

Opportunities for the future

Before Dolly, the sheep cloned by Dr. Ian Wilmut's team in 1996, most scientists—myself included—considered that the differentiated adult cells of the body could not be reprogrammed and proceed again through or guide the mammalian development. It was a surprise again when Dr. Shinya Yamanaka's team demonstrated that cultured fibroblast (skin) cells could be reprogrammed by transiently activating as few as four genes introduced into these cells. If the techniques for producing induced pluripotent stem cells (iPS, cells capable of becoming any cell type in the body) could be adapted to provide similar results with fibroblasts from many other species, the Frozen Zoo potentially represents the source of the largest and most diverse collection of stem cells anywhere.

After more than a year of dedicated work, Dr. Inbar Ben-Nun, in Professor Jeanne Loring's group at The Scripps Research Institute, and a team from U.C. San Diego and the San Diego Zoo Institute for Conservation Research announced the production of iPS from two endangered species, the drill and the northern white rhinoceros. The drill is a large African monkey with a declining population in U.S. zoos and endangered in its habitats in Cameroon because of habitat loss and illegal poaching. The northern white rhinoceros is the most endangered form of rhinoceros. Studies of skull characteristics and genetics analyses resulted recently in this African rhinoceros being named a separate species, distinct from its southern relatives.

These studies demonstrate the potential for stem cells to be used in veterinary medicine and for treating illnesses. The question also arises of the potential for applying new approaches in assisted reproductive technologies. These might include producing sperm and eggs in tissue culture flasks, the production of embryos, and down the road, northern white rhino babies. But it is a long road to travel. Time is running out for the northern white rhino, and although it may be one of the last tools remaining, technology may not be sufficient to prevent its extinction.

Impacts of induced pluripotency

It is altogether reasonable that we pause and consider what we might do, for what reason, and for whose benefit.

The use of DNA banks to produce living animals, restore to life extinct species, and provide novel life forms is entrenched in popular musings. The broadly reported effort to clone a mammoth seems to be known by people of all ages.

Given the limitations of our times and our global society in addressing the declines in biological diversity and loss of species, should we strive to produce a living animal that went extinct ten thousand years ago? Could it play a role today as it did in its native ecosystem?

If the motivation for developing advances in assisted reproductive technologies were to be based on preventing ongoing losses of biological diversity and reducing the risk of extinction of species that have undergone dramatic recent declines because of human activities, the investments and benefits would reflect a different set of values.

The way to sustain and conserve species is in natural habitats. However, without invoking additional and alternative strategies, losses of biological diversity will surely be large, for many species continue to disappear from their habitats.

The controversies that arise around the discussions of conservation strategies and methods stand in a different realm from the efforts of museums, zoos, and research institutes to prospectively bank biological samples that can assist conservation assessments, monitoring and management. Efforts devoted to banking cells desperately need to be expanded by and for the global community.

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