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Popular Article

Veterinary Biobanking: Role in Animal Health and Livestock Genetic Conservation

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Abstract

Biobanking has become an essential part of modern biomedical and veterinary sciences, offering well-organized collections of biological materials and related data that support diagnostics, therapies development, and biodiversity preservation. Although originally centered on human medicine, biobanking is now expanding to veterinary science due to its important role in monitoring animal diseases, advancing comparative oncology, improving livestock breeding, conserving wildlife and advancing comparative oncology studies. Veterinary applications extend from zoonotic disease tracking to precision breeding programs and initiatives aligned with the 'One Health' approach. Despite these advances, challenges remain, including ethical issues, lack of representation of certain species, limited resources, and concerns about sustainability. Unequal infrastructure and standards across regions also limit progress, particularly in developing countries. Future progress is expected through the integration of multi-omics, artificial intelligence, advanced data systems, and eco-friendly practices that reduce environmental impact. Together, these developments highlight the potential of veterinary biobanking to transform animal health research, support conservation, and strengthen connections with human healthcare.

Keywords: Biobank, Veterinary biobank, DNA Biobank, Dog Aging Project, One Health

Introduction

The term 'biobank' first appeared in scientific literature in 1996, initially referring to human-based repositories for genetic and epidemiological research. A 'biobank' is now



formally defined as a structured storage of biological materials and associated data, organized for scientific or therapeutic use (Hewitt and Watson, 2013). This definition emphasizes equal importance of clinical, demographic and genetic information linked to physical (collected biological) specimen. With passing time, the concept has expanded to include facilities that follow standardized protocols for collecting, preserving, distributing, and storing samples along with their contextual data reflecting the increasing complexity of biomedical research. With advancements in genetics and bioinformatics, the role of biobanks has expanded further. Technologies such as high-throughput sequencing, precision medicine, and host–pathogen interaction studies rely on high-quality, well-preserved samples.

While human biobanks have developed steadily over time, veterinary biobanking has gained significant attention only in recent years. Veterinary biobanking has evolved to support comparative research, diagnostics, and animal health. These biobanks collect samples such as blood, tissues, genomic materials (DNA), micro-organisms from livestock, pets and wildlife animals for long-term storage for scientific applications. Emerging and re-emerging zoonotic diseases have made veterinary biobanks even more critical, since nearly 75% of newly emerging viral diseases in humans originated from animals. This underlines their importance in advancing the One Health approach. In veterinary science, biobanks provide resources for infectious disease surveillance, livestock breeding, biodiversity conservation, and comparative oncology, strengthening both animal and human health. Looking forward, veterinary biobanking is expected to extend its applicability horizon through the integration of multi-omics study, artificial intelligence, digital platforms, and environmentally sustainable green practices. These innovations will strengthen research quality, reduce environmental impact, and enhance the role of veterinary biobanks in precision medicine, biodiversity protection, and global One Health initiatives.

Type of biobanking

- a) **Organoid biobanks:** Organoids are three-dimensional cultures made from tumor or stem cells that preserve the properties of their original tissue. Tumor-microenvironment investigations, drug screening, and customized oncology are all aided by organoid biobanks.
- b) **Tissue-based biobanks:** These stores frozen or formalin-fixed paraffin-embedded (FFPE) tissues, which are essential for histology and molecular research. Frozen tissues better preserve proteins and nucleic acids for use in subsequent processes.
- c) **Cell biobanks:** These biobanks offer robust, verified, and ethically procured cell lines for use in regenerative medicine, disease modeling, and drug development research.



RIKEN Bioresource Center Cell Bank, Coriell Stem Cell Biobank, DSMZ Human and Animal Cell Lines Bank, American Type Culture Collection (ATCC), and European Collection of Authenticated Cell Cultures (ECACC) are a few examples.

- d) **Genomic material biobanks:** Genomic material (genomic DNA), after extraction from a variety of nucleated sources, including fresh and formalin-fixed tissues, mucosal swabs, whole blood and other bodily fluids, can be preserved for longer period.

Biobanking in Veterinary Medicine and wildlife conservation

Infectious disease surveillance

Veterinary biobanks have been found useful in **tracking zoonotic pathogens**, enabling pathogen identification, epidemiological studies, and the development of preventive measures. The importance was further highlighted during the COVID-19 pandemic, when animal biobanks contributed to **One Health surveillance** of reservoir and intermediate hosts. Human biobanks have shown parallel importance, exemplified by the **Vilnius Santaros Klinikos (VSK) Biobank** (Lithuania), which collected 87254 COVID-19-related specimens from patients, healthcare workers, and recovering donors. These resources not only facilitated research into SARS CoV-2 biology, vaccine response, and viral variants, but also provided the ultra-low temperature infrastructure required for vaccine distribution. Together, veterinary and human biobanks can form **complementary infrastructures** to strengthen global research networks, improve epidemic preparedness, and enhance cross-species translational research under **One Health framework**.

Comparative oncology and translational medicine

Veterinary biobanks contribute significantly to cancer research by enabling comparative oncology studies that bridge veterinary and human medicine. Companion animals such as dogs and cats spontaneously develop cancers including osteosarcoma, lymphoma, and mammary tumors that closely resemble human malignancies in terms of genetics, biology, and clinical progression. By preserving tumor tissues, blood samples, and genetic material from affected animals, veterinary biobanks provide critical resources for studying cancer pathogenesis, identifying biomarkers, and evaluating novel therapeutic approaches. This not only improves veterinary care but also accelerates the discovery of innovative cancer treatments for humans.

Recent advances in precision medicine illustrate the growing role of veterinary biobanks in translational cancer research. Targeted therapy guided by DNA sequencing has led to major improvements in aggressive cancers such as triple-negative breast cancer, as seen



in the case of Chelsey Pickthorn, a cancer survivor who benefited from precision oncology interventions. Her dogs participated in a collaborative project between Weill Cornell and the Cornell Veterinary Biobank, designed to extend precision medicine approaches to both humans and companion animals. This initiative expanded beyond DNA-based studies to metabolic profiling, focusing particularly on lymphoma. By examining blood samples from dogs with and without lymphoma, researchers aim to identify conserved metabolic indicators across species. The Cornell Veterinary Biobank, which provides high-quality, ISO-accredited samples, plays a central role in enabling such metabolomic and genomic research. These integrative approaches demonstrate the potential of comparative oncology to improve cancer diagnosis and therapy in both veterinary and human medicine.

Beyond oncology, veterinary biobanks also support ageing research. Companion dogs which share human environments, healthcare systems, and age-associated disorders considered as more relevant models for ageing studies. The Dog Aging Project (DAP), launched in 2014, exemplifies this approach by combining clinical data, genomic and metabolomic analyses, and biological samples from older dogs. Central to this initiative is the TRIAD clinical trial, which evaluates the anti-ageing properties of rapamycin. Supported by the National Institute on Aging and the Cornell Veterinary Biobank, the DAP represents a large-scale, open-science model for advancing geroscience, community engagement, and translational ageing research.

Veterinary biobanks also enhance translational research across species in alignment with the One Health framework. For example, canine biobanks have enabled the development of single nucleotide polymorphism (SNP) arrays for identifying human disease-linked genetic variations, while resources such as the Munich MIDY-PIG Biobank (Germany) use porcine data to study diabetes. Similarly, the Swiss Canine Cancer Registry expands cross-species datasets for comparative genomics, precision medicine, and the development of novel diagnostics and therapeutics. Collectively, these examples demonstrate that veterinary biobanks are indispensable for comparative oncology and translational medicine, serving as platforms that bridge fundamental science with clinical application to benefit both animal and human health.

Livestock breeding and genetic resource conservation

Biobanking supports livestock breeding programs by preserving genetic material from high-performing or disease-resistant animals. Frozen semen, embryos, and genomic materials are stored to facilitate selective breeding and genetic improvement. In addition, biobanks play a vital role in conserving rare and indigenous breeds, which face increasing threats from



industrial farming practices, genetic homogenization, and climate change. By integrating advanced reproductive technologies with long-term preservation methods, biobanks provide a foundation for both genetic progress and biodiversity conservation in animal breeding.

The gene banks were first established with the advent of reproductive techniques such as artificial insemination and initially focused on storing semen and embryos. Gradually, their role broadened to support more sophisticated applications, most notably the rapid implementation of genomic selection. This approach of whole genome sequencing (WGS) and genome-wide SNP markers identification, to predict the genetic merit of breeding individuals has revolutionized cattle breeding. Bulls with extensive performance records, such as milk yield data, provided the basis for predictive models and availability of DNA and semen samples from biobanks and made it possible to correlate these records with genomic information. The widespread adoption of genomic selection would likely have taken decades without these biobanked resources. Furthermore, biobanks are indispensable for the conservation of genetic diversity in production animals, addressing the well-documented decline in livestock variation. By the year 2012 the USDA ‘National Animal Germplasm Program’ had collected gametes and tissue samples animals and distributed for diverse applications such as quantitative trait loci (QTL) mapping, genetic distance studies, cryobiology research, generating experimental research lines, reduction of inbreeding, and re-introduction of genotypic combinations lost in current production populations. These examples underscore the shift in perception from viewing gene banks as repositories of last resort to recognizing them as dynamic resources for both research and industry.

Wildlife conservation and biodiversity

Veterinary biobanking is an essential tool in wildlife conservation, enabling the preservation of genetic material and supporting biodiversity restoration. Systematic collection and cryo-storage of biomaterials from diverse wild species have been conducted to safeguard genetic diversity and enhance both *ex situ* and *in situ* management programs. Cryopreserved biomaterials offer wide-ranging opportunities, from understanding the biology of understudied species to facilitating conservation breeding, genomic research, and veterinary care. Early wildlife biobanking efforts primarily focused on germinal materials such as spermatozoa and embryos. Recent approaches emphasize the potential of non-germinal cells, thereby expanding the scope of conservation strategies.

Several initiatives illustrate the global scope of wildlife biobanking. The Frozen Ark Project, launched in 1996, aims to catalogue and conserve the genetic material of threatened animal species, ideally in the form of living cells, including somatic cells. It represents an



internationally connected, systematically catalogued repository supported by a membership network of zoos, aquaria, museums, and universities across the United Kingdom, United States, Australia, India, and other nations. In India, the ‘Laboratory for the Conservation of Endangered Species’ (LaCONES), established at ‘Centre for cellular and molecular biology’ laboratory exemplifies a national effort in this field. By integrating assisted reproductive technologies with biobanking, LaCONES has achieved notable successes, including the births of Spotty, a spotted deer fawn, and Blacky, a blackbuck calf, through artificial insemination. Additional contributions include conservation programs for the Kashmir Hangul Deer, Nicobar Blue-Rock Pigeon, Mousedeer, and the Chhattisgarh Buffalo.

On a global level, the ‘Frozen Zoo’ at the San Diego Zoo Wildlife Alliance demonstrates the long-term value of cryopreservation. Cells from a male przewalski’s horse cryopreserved in 1980 enabled the birth of a foal named Kurt in 2020, followed by another successful clone in 2023. These births restored lost genetic diversity within the managed population, showcasing how cryobiology and advanced reproductive technologies can be integrated to support species recovery. All these reports highlighted the transformative role of wildlife biobanking in biodiversity preservation. By securing genetic reservoirs, facilitating assisted reproduction, and expanding beyond germline storage to include somatic cells, veterinary biobanks strengthen species resilience, support ecological restoration, and create future opportunities for genomics, veterinary medicine, and One Health initiatives in the face of climate change and anthropogenic pressures.

Conclusion

Veterinary biobanking has grown into an important resource for science, supporting disease research, conservation, and the improvement of animal and human health. Beyond being simple storage centers, biobanks now act as advanced platforms that connect biological samples with digital data, helping researchers study diseases, develop diagnostics, and improve therapies. They also play a central role in protecting biodiversity, strengthening livestock breeding, and preparing for future health emergencies under the One Health approach. The approaches like combining biobanking with multi-omics study and integration of biobanking with artificial intelligence (AI) and automation in Laboratory Information Management Systems (LIMS) will help in reshaping veterinary healthcare research. However, veterinary biobanks still face challenges such as high costs, uneven infrastructure, gaps in species coverage, and concerns about ethics, data security, and environmental impact. Addressing these issues requires global collaboration, strong governance, and the adoption of innovative approaches like multiomics, artificial intelligence, and green biobanking practices.



By combining scientific progress with sustainability and ethical responsibility, veterinary biobanking can continue to expand its role as a powerful tool for advancing research, conserving biodiversity, and improving both animal and human well-being.

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