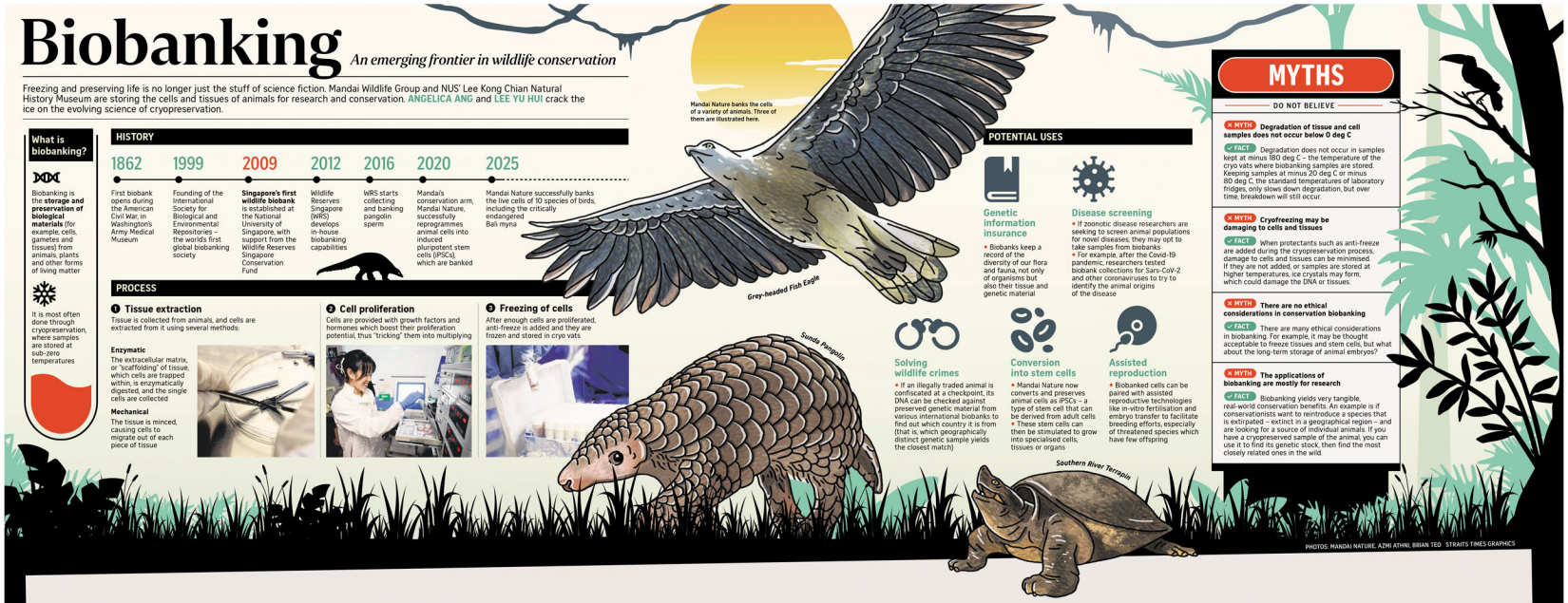
Source: *The Straits Times*, pA18 and A19
Date: 14 July 2025

Biobanking

An emerging frontier in wildlife conservation

Freezing and preserving life is no longer just the stuff of science fiction. Mandai Wildlife Group and NUS' Lee Kong Chian Natural History Museum are storing the cells and tissues of animals for research and conservation. ANGELICA ANG and LEE YU HUI crack the ice on the evolving science of cryopreservation.



What is biobanking?

Biobanking is the **storage and preservation of biological materials** (for example, cells, gametes and tissues) from animals, plants and other forms of living matter

It is most often done through cryopreservation, where samples are stored at sub-zero temperatures

HISTORY

1862 First biobank opens during the American Civil War, in Washington's Army Medical Museum

1999 Founding of the International Society for Biological and Environmental Repositories – the world's first global biobanking society

2009 **Singapore's first wildlife biobank** is established at the National University of Singapore with support from the Wildlife Reserves Singapore Conservation Fund

2012 Wildlife Reserves Singapore (WRS) develops in-house biobanking capabilities

2016 WRS starts collecting and banking pangolin sperm

2020 Mandai's conservation arm, Mandai Nature, successfully reprogrammes animal cells into induced pluripotent stem cells (iPSCs), which are banked

2025 Mandai Nature successfully banks the live cells of 10 species of birds, including the critically endangered Bali myna

PROCESS

1 Tissue extraction
Tissue is collected from animals, and cells are extracted from it using several methods:

Enzymatic
The extracellular matrix, or "scaffolding" of tissue, which cells are trapped within, is enzymatically digested, and the single cells are collected

Mechanical
The tissue is minced, causing cells to migrate out of each piece of tissue

2 Cell proliferation
Cells are provided with growth factors and hormones which boost their proliferation potential, thus "tricking" them into multiplying

3 Freezing of cells
After enough cells are proliferated, anti-freeze is added and they are frozen and stored in cryo vats

POTENTIAL USES

Genetic information insurance
- Biobanks keep a record of the diversity of our flora and fauna, not only of organisms but also their tissue and genetic material

Disease screening
- If zoonotic disease researchers are seeking to screen animal populations for novel diseases, they may opt to take samples from biobanks
- For example, after the Covid-19 pandemic, researchers tested biobank collections for Sars-CoV-2 and other coronaviruses to try to identify the animal origins of the disease

Solving wildlife crimes
- If an illegally traded animal is confiscated at a checkpoint, its DNA can be checked against preserved genetic material from various international biobanks to find out which country it is from (that is, which geographically distinct genetic sample yields the closest match)

Conversion into stem cells
- Mandai Nature now converts and preserves animal cells as iPSCs – a type of stem cell that can be derived from adult cells
- These stem cells can then be stimulated to grow into specialised cells, tissues or organs

Assisted reproduction
- Biobanked cells can be paired with assisted reproductive technologies like in-vitro fertilisation and embryo transfer to facilitate breeding efforts, especially of threatened species which have few offspring

MYTHS

DO NOT BELIEVE

MYTH **Degradation of tissue and cell samples does not occur below 0 deg C**

FACT Degradation does not occur in samples kept at minus 180 deg C – the temperature of the cryo vats where biobanking samples are stored. Keeping samples at minus 20 deg C or minus 80 deg C, the standard temperatures of laboratory fridges, only slows down degradation, but over time, breakdown will still occur.

MYTH **Cryofreezing may be damaging to cells and tissues**

FACT When protectants such as anti-freeze are added during the cryopreservation process, damage to cells and tissues can be minimised. If they are not added, or samples are stored at higher temperatures, ice crystals may form, which could damage the DNA or tissues.

MYTH **There are no ethical considerations in conservation biobanking**

FACT There are many ethical considerations in biobanking. For example, it may be thought acceptable to freeze tissues and stem cells, but what about the long-term storage of animal embryos?

MYTH **The applications of biobanking are mostly for research**

FACT Biobanking yields very tangible, real-world conservation benefits. An example is if conservationists want to reintroduce a species that is extirpated – extinct in a geographical region – and are looking for a source of individual animals. If you have a cryopreserved sample of the animal, you can use it to find its genetic stock, then find the most closely related ones in the wild.

PHOTOS: MANDAI NATURE, AZMI ATHNI, BRIAN TEO STRAITS TIMES GRAPHICS

Cryo-conservation

How animal cells in cold storage can help with wildlife protection in S'pore

Such repositories aid research into species, with the aim of saving them from extinction

Angelica Ang

Singapore is building a "Noah's Ark" of South-east Asian animals, and its collection – housed at two locations here – is slowly swelling with the region's mammals, birds, amphibians and reptiles.

These repositories of life at the NUS Lee Kong Chian Natural History Museum and Mandai Wildlife Reserve contain just traces of these animals.

Their cells and tissues, stored at sub-zero temperatures, can help researchers better understand these species, contributing to their conservation.

Special cooling technologies used by Mandai Wildlife Group, which manages Singapore's five wildlife parks, can even keep these cells alive.

When such cells are thawed, they can continue to grow and replicate.

This paves the way for novel applications of technology like in-vitro fertilisation. Far into the future, researchers could potentially use this to bring extinct animals back to life, although there are no plans to do so for now.

In January, Mandai Nature – the conservation arm of Mandai Wildlife Group – achieved a breakthrough: Researchers there successfully banked the live cells of 10 species of birds. These include the critically endangered Bali myna, and endangered lilac-crowned amazon and milky stork.

Previously, only live mammalian cells were effectively banked in the Republic's wildlife parks.

Dr Sonja Luz, chief executive of Mandai Nature, said this marks the latest addition to Singapore's conservation toolkit.

By shelving away the cells of threatened species, the odds of saving them in the future – should their natural population continue to dwindle – may significantly improve, she said.

Mandai Wildlife Group's vice-president of veterinary healthcare Xie Shangzhe (centre), Mandai Nature laboratory head Oz Pomp (left) and chief executive Sonja Luz oversee biobanking efforts at Mandai. ST PHOTO: AZMI ATHNI

THE PROMISE OF BIOBANKING

Biobanking is the storage and preservation of biological material from animals, plants and other forms of living matter. It is most often done through cryopreservation, where samples are kept frozen at sub-zero temperatures.

One of the earliest biobanks opened during the American Civil War in 1862, in Washington's Army Medical Museum.

Back then, the biobank – which mostly held the amputated limbs and diseased organs of humans – was used to expand the understanding of disease and war injuries, and develop measures to better care for American soldiers.

In the last few decades, there has been an exponential rise in the burden of chronic diseases.

Biobanking allowed researchers to keep records of the changes in genes and proteins affiliated with different conditions.

As biobanking technology became cheaper and more accessible, the scientific community started to recognise the potential for applying it outside of the medical realm.

Conservationists, in particular, started to take notice.

With a third of the planet's flora and fauna being threatened by extinction, these repositories serve as valuable homes for the tissue and genetic material of endangered species.

Singapore got its first conservation biobank in 2009.

The result of a collaboration between the National University of Singapore and Mandai Wildlife Group, then known as Wildlife Reserves Singapore, the biobank focused on storing dead cells and tissues for research.

Today, that biobank is helmed by the university's Lee Kong Chian Natural History Museum.

It houses approximately 33,400 samples from invertebrates like molluscs, and vertebrates such as mammals and birds. Currently, its samples span 3,283 species.

Mr Marcus Chua, the museum's mammal curator, said its mammalian specimens are mainly sourced from animal carcasses, such as roadkill.

Some faecal samples – including those of the critically endangered Raffles' banded langur, a type of primate – are also stored, said Mr Foo Maosheng, who oversees the museum's insect and cryogenic collections.

The samples are used mainly for research.

"If we're trying to find out what the Raffles' banded langurs are eating, for example, we can compare their faecal samples to the genetic material of different plants, to see which trees they feed on," said Mr Foo.

Mr Chua added: "Any kind of material stored in the cryogenic collection can be pulled out for research, rather than going out to the field to collect them again."

In February 2018, a group of other researchers from Singapore, Brazil and the US approached the museum for a loan of tissues of Singapore's two otter species – the smooth-coated otter and Asian small-clawed otter – in the hope of studying their genetic data.

Researchers can also use biobank data to solve wildlife crime.

For example, investigators looking to trace the origins of a wild animal trafficked into Singapore could cross-reference international databases to find out where it could have come from, given that sufficient countries maintain such databases.

GROWING CONSERVATION POTENTIAL

Singapore's biobanking initiative was further developed in 2012 when giant pandas Kai Kai and Jia Jia arrived in Singapore.

These bears do not breed well in captivity, so Mandai set up its own biobanking facility to store the semen of the male panda for artificial insemination.

During the process, which takes place in a laboratory, the team places banked sperm together with oocytes, or cells from the ovary.

Should the two successfully combine to yield a fertilised egg, it can then be transferred into the uterus or cervix of the female panda.

For cells to continue to be viable after they are thawed, they must be cryopreserved in a special way – by adding anti-freeze.

This prevents the formation of ice crystals during the freezing process, which would rip up the banked cells and render them unviable, said Dr Oz Pomp, lab head at Mandai Nature.

Following the success at preserving panda sperm, the Mandai team started collecting sperm samples from other animals, said Dr Luz.

"Over time, it became more clear that there are other opportunities to biobanking than just blood and gametes," she added.

The wildlife parks also offer Mandai's veterinary team access to rare and threatened species, from which valuable samples can be obtained.

Dr Luz said: "Zoos house many species that are on the brink of extinction. This has sparked discussions in the conservation community around how we can do what botanical gardens have been doing for hundreds of years – start banking genetic material."

With more wildlife species being pushed to the brink of extinction owing to habitat loss or poaching, the race is on to preserve their genetic data before they are gone forever, said Dr Luz.

"We have a lot of 'little too late' scenarios, where we're down to the last few individuals," she said.

By then, the organisms remaining in the wild may have limited genetic diversity, and may be less equipped to survive crises such as disease outbreaks.

"But if we started banking earlier, we would have a better chance to save some of these species, like the northern white rhino, Yangtze giant softshell turtle and saola," Dr Luz added.

For this to happen, biobanking must be done by zoological institutions with access to different animals. But not all of them may have the resources or capacity to start building such banks.

The process of extracting and banking cells is ethical, said Dr Luz, as long as the methodologies applied are non-invasive and appropriate, and no animal suffers.

Mandai has been experimenting with developing new ways of obtaining cells that can be easily replicated without specialised equipment, said Dr Xie Shangzhe, vice-president of veterinary healthcare at Mandai Wildlife Group.

For example, the research team found a way to obtain animal cells from subcutaneous fat found right under the skin.

This allows veterinarians to collect sterile cell samples with just a needle – an improvement from the past where samples were taken from animal skin, which is dirtier and more prone to contamination.

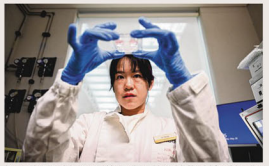
Once samples are contaminated, their integrity may be compromised, making it difficult to utilise them.

Mandai has also begun developing techniques to extract other types of cells from live animals, including non-mammalian species.

The team found success in growing fibroblasts, or cells that contribute to the formation of connective tissue, from fallen pin feathers, which are the developing feathers of birds.

Dr Xie said: "These breakthroughs by Mandai, they are simple things that scientists in other parts of the region can replicate easily.

"Things like getting feathers or fat – doing a few simple steps to get something that can be banked – I think this is what makes our work unique."



A researcher examining cultured frog cells at a biobank in Mandai. Special cooling technologies used by Mandai Wildlife Group can keep alive animal cells which, when thawed, can continue to grow and replicate. ST PHOTO: AZMI ATHNI

Animal cells and tissues stored at the NUS Lee Kong Chian Natural History Museum's biobank, which houses some 33,400 samples from invertebrates like molluscs, and vertebrates such as mammals and birds. ST PHOTO: BRIAN TEO

PROMISES AND PERILS

Now, inspired by stem-cell research developments in humans, conservationists are also looking into their potential to prevent animals from going extinct.

A group of cells known as induced pluripotent stem cells are especially powerful as they can be differentiated into a variety of cell types, such as sperm and eggs.

In 2020, Mandai's research team successfully reprogrammed extracted live skin cells from the North Bornean orang utan into induced pluripotent stem cells.

Most cells have a finite capability to proliferate, and stop multiplying after a few divisions, said Dr Pomp.

But induced pluripotent stem cells can proliferate forever, allowing conservationists to "make as much material as needed", added Dr Pomp, a stem-cell biologist who in October 2024 joined Mandai Nature to apply his skills to wildlife protection.

"It's just a matter of time until we can tailor this technology to other species as well."

THE FUTURE OF BANKED MATERIAL

How these banked samples are used needs to be more deeply considered, said the conservationists.

De-extinction, or the process of resurrecting a species that has died out, is one such example, said the museum's Mr Chua.

In April, Dallas-based biotech company Colossal Biosciences made news when it announced it had created three "dire wolf" pups, an extinct creature that roamed North America more than 10,000 years ago.

The firm had extracted and sequenced DNA from fossilised dire wolf remains, and then compared it against the genome of the modern grey wolf.

It then edited some of the wolf's genes so that it outwardly resembled its ancient counterpart.

But many researchers were sceptical of the claim.

Said Mr Chua: "At what point do you edit enough that it becomes a dire wolf? For now, it's a wolf hybrid, basically."

On July 9, the firm announced its next project: attempting to resurrect the extinct South Island giant moa, a 3.6m-tall flightless bird that once lived on the South Island of New Zealand, but vanished around 600 years ago.

De-extinction projects can be costly. Given that biodiversity loss is taking place at unprecedented rates, the decision to invest money in trying to de-extinct species, rather than save living ones, may also raise eyebrows, Mr Chua said.

Mandai's Dr Luz said: "For now, our aim is to collect, freeze and store as many samples as possible to create a safety net for some of the most threatened species of our region. Our goal is conservation, and nothing but that."

Singapore's biobanking efforts are not unlike saving for a rainy day.

Just like how the animals were led two by two onto Noah's Ark to assure their continued existence after a biblical flood, so, too, do the samples in Singapore's biobanks represent a lifeline for species on the brink of extinction.

Hopefully, it is one that would never need to be used.

angelicaang@sph.com.sg