FOCUS QUESTIONS

- What are some of the major anthropogenic (human caused) threats to the Earth's biodiversity and why?
- What are the differences between *in-situ* and *ex-situ* conservation efforts and what are some examples of each strategy?
- What role does genetic diversity play in the ability of a population to survive in a rapidly changing environment?
- What is captive breeding and what role does it play in the conservation of endangered and threatened species?
- Why is it important to help a species avoid unnaturally small populations?

OVERVIEW

"é restaurar o hábitat para mostrar que, sim, é possível para fazer a espécie mais resiliente a eventuais novas doenças que possam ocorrer no futuro."

"We want to show that restoring the habitat is possible, making the species more resilient to any new diseases that may occur in the future." Luis Paulo Ferraz, Executive Director, Associação Mico-Leão-Dourado (Golden Lion Tamarin Association)

In ***One Golden Chance*** we learn about a global and decades-long effort to save the golden lion tamarin from almost certain extinction in the wild. We meet zoologists, conservation biologists, and a virologist who are working together to maintain a wild and self-sustaining population of tamarins, an iconic species of the Brazilian Atlantic forest ecosystem.

KEY CONCEPTS

- Threatened and Endangered Species: The International Union for the Conservation of Nature (IUCN) lists more than 44,000 species threatened with extinction. Habitat loss and destruction and agriculture are the major threats for more than 85% of these species. The IUCN also lists disease as a major factor contributing to the endangerment of species and the overall loss of biodiversity.
- Genetic diversity: When the numbers of individuals of a species reaches low levels genetic drift can begin to erode the genetic diversity in the population. Low genetic diversity can increase the susceptibility of a population to disease.
- Extinction vortex: When a population shrinks it can become susceptible to extinction through genetic drift and inbreeding. These two processes can reduce the overall fitness of the population and lead to a downward spiral of further population declines. This *extinction vortex* was affecting the golden lion tamarin population in the 1960s as the population plummeted to below 200 individuals.
- Captive breeding: Breeding animals in a controlled environment, like zoos or conservation facilities, can protect species from extinction, enhance their health, and potentially lead to reintroduction to the wild. The captive breeding program we learn about in ***One Golden Chance*** also involved selectively breeding captive golden lion tamarins to maintain their genetic diversity.
- Insurance population: A major emphasis of captive breeding programs is to maintain a breeding group of endangered plants or animals in captivity to ensure that the species will not go extinct, even if it disappears in the wild. Dozens of insurance populations of golden lion tamarins are maintained at zoos and conservation facilities around the world.
- Restoration ecology: Centuries of unsustainable human activities have degraded the Earth's terrestrial, freshwater, and marine ecosystems. Some terrestrial areas that used to contain expansive, continuous habitat have been reduced to a few islands of vegetation that cannot support many species or protect vulnerable ones. Restoration ecology is focused on reversing this degradation by restoring natural

habitats and processes, including providing connectivity between habitats so individuals can move from one breeding population to another thereby increasing genetic diversity.

- Conservation biology: The practice of conservation biology recognizes the intrinsic value of the Earth's natural diversity of organisms. Conservation biology works to understand how the natural world operates, how humans affect nature, and how we can use collective scientific and cultural knowledge to conserve Earth's biological diversity.
- *In-situ* and *ex-situ* conservation: *In-situ* conservation mainly focuses on protecting a species in its natural habitat whereas *ex-situ* conservation focuses on off-site captive conservation. The golden lion tamarin captive breeding program exemplifies a successful and hopeful integrative conservation approach, combining *ex-situ* breeding and vaccination management with *in-situ* reintroduction and habitat preservation.

BACKGROUND

The golden lion tamarin (*Leontopithecus rosalia*; heretofore tamarin) is a small, arboreal primate endemic to Brazil's Atlantic Forest and is characterized by its vibrant golden-orange fur and lion-like mane. This species has faced significant conservation challenges over the past century. By the 1960s primatologists that had been tracking the tamarin population reported that fewer than 200 individuals remained in the wild. When a population shrinks to such small numbers it can become susceptible to extinction through genetic drift and inbreeding. These two processes can reduce the overall fitness of the population and lead to further population declines, a downward spiral called an *extinction vortex*. The primary driver of this decline was extensive deforestation for agriculture, logging of forest products, and urban development, leading to severe habitat fragmentation and the loss of 98% of original tamarin habitat. The fragmentation and massive habitat loss isolated small tamarin populations, limiting genetic diversity and increasing vulnerability to environmental changes. Significant numbers of tamarins were also captured by poachers and sold to zoos and the pet trade.

The imperiled status of the tamarin prompted conservation biologists to launch a global captive breeding program at zoos around the world. The first such program was initiated in 1972 by research zoologist, Dr. Devra Kleiman, at the National Zoological Park in Washington, D.C. The primary objectives were to increase captive birth rates, maintain genetic diversity, and reintroduce individuals into their native habitats in Brazil. To enhance reproductive success, researchers implemented dietary modifications, notably increasing protein intake, which led to improved birth rates in captivity. By the early 1980s, the captive population had grown sufficiently to support reintroduction initiatives. The program emphasized genetic management to ensure a diverse and robust captive population, involving nearly 150 zoos worldwide.

In the ***One Golden Chance*** film we learn about how successful the captive breeding and reintroduction program was: by 2014 over 3,700 individuals were living in protected areas in Brazil, an increase of over 1,800% since the 1960s. However, beginning in 2016 yellow fever had entered the tamarin population and began reversing the success of the conservation efforts. Between 2016 and 2018 the yellow fever epidemic had reduced the population by 32%. Fortunately, Dr. Marcos da Silve Freire was able to repurpose the yellow fever vaccine he had developed for humans so that it could be used on the tamarins.

The golden lion tamarin captive breeding and vaccination program highlighted in the ***One Golden Chance*** film exemplifies a successful and hopeful integrative conservation approach. The approach has combined *ex-situ* breeding and vaccination management with *in-situ* reintroduction and habitat preservation as ecologists and land managers like reintroduction biologist Andreia Fonseca Martins restore connectivity between habitats so individuals can move from one breeding population to another thereby increasing genetic diversity.

BIODIVERSITY THREATS

The major threats to the Earth's biodiversity can be grouped into seven categories that spell the easily recalled acronym H.I.P.P.O.: **H**abitat destruction and fragmentation, **I**ntroduced species, **P**ollution, **P**opulation growth, and **O**verharvesting. Many species are threatened by a combination of these factors, but habitat loss is the greatest threat to biodiversity. In ***One Golden Chance*** we learn that habitat destruction and fragmentation due to human population growth can drive a species to or near extinction and disease can complicate conservation efforts to restore species populations.

DISCUSSION QUESTIONS

- [Before showing the film] Have students brainstorm why it is important to help a species avoid unnaturally small populations.
- [Before showing the film] Explain to students that the extinction of species is a natural evolutionary process. Have students discuss the reasons for conserving species of animals and plants that are currently threatened with extinction.
- In the film we learn that the golden lion tamarin population had been reduced to fewer than 200 individuals in the wild. Provide students with the wild population data presented in the film (see below) and have them recreate the time series graph of the population dynamics. Have students compare their graphs to the logistic population growth model and discuss whether or not they think the wild population of golden lion tamarins is following this model and why. The data are: 1977: 200, 1992: 562, 2001: 1,000, 2005: 1,600, 2014: 3,700, 2018: 2,500, 2022: 4,800.
- Ask students to explain how a vaccine originally designed for humans is also able to work in a completely different species: golden lion tamarins.
- Provide students with the definition for the extinction vortex and have them discuss why the wild golden lion tamarin population may have been experiencing an extinction vortex by the 1960s.
- Provide students with the definitions for *in-situ* and *ex-situ* conservation and have them outline how the golden lion tamarin conservation approach is a combination of both efforts.

Curriculum Connections

NGSS

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS4.D: Biodiversity and Humans

HS-LS3 Heredity: Inheritance and Variation of Traits

- LS3.A: Inheritance of Traits

HS-LS4 Biological Evolution: Unity and Diversity

- LS4.B: Natural Selection
- LS4.C: Adaptation

ETS1.B: Developing Possible Solutions

AP Biology (2021)

Enduring Understandings

- Evolution (EVO)
    - EVO-1: Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
- Energetics (ENE)
    - ENE-4: Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.

- Information Storage and Transmission (IST)
    - IST-1: Heritable information provides for continuity of life.
- Systems Interactions (SYI)
    - SYI-3: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

IB Biology (First Exam May 2025)

A. Unity and Diversity: Common ancestry has given living organisms many shared features while evolution has resulted in the rich biodiversity of life on Earth.

- A2.3 Viruses
- A3.1 Diversity of organisms
- A4.2 Conservation of biodiversity

B. Form and Function: Adaptations are forms that correspond to function. These adaptations persist from generation to generation because they increase the chances of survival.

- B4.1 Adaptation to environment
- B4.2 Ecological niches

C. Interaction and Interdependence: Systems are based on interactions, interdependence and integration of components. Systems result in emergence of new properties at each level of biological organization.

- C3.2 Defence against disease
- C4.1 Populations and communities

D. Continuity and Change: Living things have mechanisms for maintaining equilibrium and for bringing about transformation. Environmental change is a driver of evolution by natural selection.

- D3.2 Inheritance
- D3.3 Homeostasis
- D4.1 Natural selection
- D4.2 Stability and change

REFERENCES

Dietz, J. M., Mickelberg, J., Traylor-Holzer, K., Martins, A. F., Souza, M. N., & Hankerson, S. J. (2024). Golden lion tamarin metapopulation dynamics five years after heavy losses to yellow fever. *American Journal of Primatology*, 86(7), e23635.

Kierulff, M. C. M., Ruiz-Miranda, C. R., De Oliveira, P. P., Beck, B. B., Martins, A., Dietz, J. M., ... & Baker, A. J. (2012). The Golden lion tamarin *Leontopithecus rosalia*: A conservation success story. *International Zoo Yearbook*, *46*(1), 36-45.

Moraes, A. M., Ruiz-Miranda, C. R., Galetti Jr, P. M., Niebuhr, B. B., Alexandre, B. R., Muylaert, R. L., ... & Ribeiro, M. C. (2018). Landscape resistance influences effective dispersal of endangered golden lion tamarins within the Atlantic Forest. *Biological Conservation*, *224*, 178-187.

Wright, Jennifer. (2019). “Going Wild with Golden Lion Tamarins.” Smithsonian Institution Archives. Accessed on 24 March 2025, https://siarchives.si.edu/blog/going-wild-golden-lion-tamarins?utm_source=chatgpt.com

CREDIT

Written by Paul K. Strode, Ph.D., Fairview High School, Boulder, Colorado