Kurt Benirschke (1924-) [1]

By: Love, Karen Keywords: Frozen Zoo [2]

Kurt Benirschke studied cells, placentas, and endangered species in Germany and the US during the twentieth century. Benirschke was professor at the University of California in San Diego, California, and a director of the research department at the San Diego Zoo in San Diego, California. He also helped form the research department of the San Diego Zoo and its sister organization [3], the Center for Reproduction of Endangered Species. Benirschke contributed to the field of embryology [4] through his work on human and animal reproduction, including work on human placentas and birth defects [5], through work on the structure of chromosomes, and through work on the reproduction and conservation of endangered species.

Kurt Benirschke was born 26 May 1924 in Glückstadt, Germany, to Marie Luebcke and Fritz Benirschke. In 1948, he received his medical degree from the University of Hamburg [6] in Hamburg, Germany. He studied English in London, England, before moving to the United States in 1949 in search of work as a physician. Prior to accepting an internship in 1950 at the Holy Name Hospital in Teaneck, New Jersey, he delivered German newspapers with his cousin to receive an income. Benirschke met Marion Elizabeth Waldhausen, a nurse, in Teaneck. They married and had three children, Rolf Joachim, Stephen Kurt, and Ingrid Marie. Though Benirschke encouraged Rolf to pursue medical studies, Rolf played professional football. Stephen became an orthopedic surgeon, while Ingrid Marie became a marketer.

In 1955, Benirschke became a pathology resident at Harvard Medical School [7] in Boston, Massachusetts. There he began to study diseases affecting the placenta [8] during pregnancy [9]. He then worked at the Boston Lying-In Hospital [10] (which became the Brigham and Women's Hospital in 1983) in Boston, Massachusetts. While there, Benirschke conducted research and published articles related to childbirth, obstetric pathology, and the development of the placenta [8] in pregnancies of twins. In 1958, Benirschke investigated the role of maternal Coxsackie Virus B, Type Three, which caused infant myocarditis and meningoencephalitis, a disease that affects cardiac development in newborns. Benirschke studied two cases in which each newborn contracted the virus from its mother. Benirschke determined that one of the infants had contracted the virus while in the womb [11]. That result led Benirschke to conclude that the virus could be passed from a pregnant woman to her fetus [12].

In 1960, Benirschke became chair of the department of pathology at Dartmouth Medical School in Hanover, New Hampshire. During his time at Dartmouth, Benirschke researched primates and genetic chimerism. Chimerism is a state in which an individual contains two or more complete sets of genetic material. Chimerism can occur naturally in fraternal twins or it can be artificially generated in laboratory organisms or tissues. In 1962, Benirschke published a paper detailing the role of chimerism in the mechanism for marrow production, the process by which red and white blood cells are produced. He discussed marrow chimerism in three adult marmosets, two male *Callithrix jacchus* [13] and one female *Leontocebus rosalia* [14]. He described how before fraternal marmoset twins were born, their bone marrows mixed with each other.

In the late 1960s and 1970s, Benirschke published several textbooks that influenced generations of researchers and students. For the first, Benirschke and Shirley Driscoll co-authored a book on diseases in the placenta [8] titled *Pathology of the Human Placenta*. In the following decades, the book went through multiple editions. The second textbook was the *Atlas of Mammalian Chromosomes*. Benirschke collaborated with colleague Tao-Chiuh Hsu to create the atlas, which described chromosomes for greater than 400 mammalian species across multiple volumes. They published updated volumes from 1971 until 1977. In the early 1970s, Benirschke mentored Geoff Altshuler at Dartmouth College Medical School, where Altshuler completed his residency. They remained lifelong friends until Altshuler died in 2014.

After a decade at Dartmouth, Benirschke relocated to San Diego, California, to help create the medical campus for the University of California in San Diego. At the university, he assisted with autopsies, established a genetics laboratory, and chaired the department of pathology. Benirschke continued to study obstetric pathology, chimerism, twinning, and comparative cytogenetics, the study of the similarities and differences in the genetics of humans [15] and of other animals at the cellular level.

His 1973 co-authored work, "Man and *Pan paniscus*: A Karyologic Comparison," is an example of the study of human karyotypes, the number and appearance of chromosomes in the cells of an organism, through the examination of, and comparison to, the karyotypes of the bonobo ape *Pan paniscus* [16]. For the study, Benirschke acquired lymphocytes, a type of white blood cell, from a female and a male bonobo. Benirschke colored the cells with specific dyes to examine the structure and number of the chromosomes. He did the same with cells from female and male humans [15] to compare the structures with the samples from the bonobos. Benirschke noted differences in the number of chromosomes and the appearance of the

chromosomes between the two species.

In 1975, Benirschke helped convince the Zoological Society of San Diego to establish a research department, called the Center for Reproduction of Endangered Species (CRES). He was a leader and a contributing member of the CRES until his appointment to the San Diego Zoo's Board of Trustees in 1987. In the late 1970s and early 1980s, Benirschke argued for the creation of a collection of frozen cells from over 600 mammals, a collection called the Frozen Zoo. The San Diego Zoo began to build its Frozen Zoo around that time, and it eventually contained the cell lines of a number of endangered and threatened mammalian species. In 1984, Benirschke discussed the zoo in his work "The Frozen Zoo Concept," in which he said that zoos have an obligation to participate in conservation research because biologic material from exotic species is difficult to obtain for scientists. He reaffirmed that conclusion in 1987 in "Why Do Research in Zoological Gardens," This paper discussed widespread biodiversity loss as a result of humans [15] and the roles that zoological institutions can perform in conservation research. Also in 1984, some of Benirschke's former students and colleagues contributed to a book, *One Medicine: A Tribute to Kurt Benirschke*, in honor of his sixtieth birthday.

Though Benirschke researched the reproduction of rare and endangered species, he also continued to publish articles about human reproductive pathologies. In his 1990 work, "The Placenta in Twin Gestation," he examined placentas from multiple child births, mostly cases with twins and triplets. Benirschke identified each umbilical cord [17] with clips to record birth order, performed preliminary examinations on placentas, and also photographed the placentas for later reference. Through these studies, Benirschke identified traits of the placenta [8] that signaled the presence of birth defects [5] in twins, such as cerebral palsy, a condition that affects human development and future mobility. Benirschke argued that the study of the placenta [8] was important partly in case patients sued medical institutions because of birth complications. In addition, Benirschke's research on placentas in twinning and his work with the patients of the Boston Lying-In Hospital [10] suggested that the survival of twins before and during birth depended on the form and function of placenta [8].

In "DNA Banks for Endangered Animal Species," published in 2000, Benirschke and his colleagues argued that extensive collections of frozen cells have research potential in many fields. The cells can be stored indefinitely and could later be used for *in vitro* [18] fertilization [19] and the preservation of species. For example, researchers used frozen cells in conservation efforts for the California condor (*Gymnogyps californianus* [20]). Benirschke encouraged other scientists to contribute genetic materials to these collections.

Benirschke authored twenty-six books and hundreds of scientific articles, and he became a Fellow of the American Academy of Arts and Sciences in 1994, the year he retired. Between time spent working on sports cars and tasting German wines, he served as the president of the board of trustees for the San Diego Zoo from 1997 to 2000.

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