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**David Todd** [00:00:03] Hi. Good afternoon.

**David Todd** [00:00:04] I am David Todd and I have the privilege of being on the line with Dr. Jim Derr. And with his permission, we plan on recording this interview for research and educational work on behalf of the Conservation History Association of Texas, a non-profit here in the state, and for a book and a website for Texas A&M University Press, and, finally, for long-term storage at an archive at the Briscoe Center for American History, which is at the University of Texas at Austin.

**David Todd** [00:00:37] And I wanted to stress that he would have all rights to use the recording as he sees fit. It is his to use.

**David Todd** [00:00:45] And I want to make sure that's okay with you.

**Jim Derr** [00:00:51] Yes, sir. I'm perfectly happy with that.

**David Todd** [00:00:53] Okay, well, great. Well, well, let's get started, then.

**David Todd** [00:00:57] It is Friday, February 17th, 2023. It's about almost 1:20 Central Time. As I said, my name is David Todd, and I am representing the Conservation History Association of Texas. And I'm here in Austin. And we are conducting a remote audio interview with Dr. Jim Derr, who is based in the College Station area.

**David Todd** [00:01:23] Dr. Derr is a professor in the Department of Veterinary Pathology at the College of Veterinary Medicine and Biomedical Sciences at Texas A&M University in College Station. He has taught biomedical and mammalian genetics for many years and has supervised the studies of over 100 graduate and post-grad students in the field.

**David Todd** [00:01:46] Much of his research has helped our understanding of the genetics of the American bison, furthering its recovery from a series of population declines and bottlenecks that it has passed through over the past 150 years. So in that way, he's ensured, helped ensure, its genetic diversity and responded to some issues of cattle introgression.

**David Todd** [00:02:10] That's just a brief introduction, but I hope we'll learn more in just a moment. We'll be talking about Dr. Derr's life and career so far, and especially focus on his work with the American bison.

**David Todd** [00:02:24] So for that, I wanted to thank him.

**Jim Derr** [00:02:27] Yeah, no problem. Happy to be here.

**David Todd** [00:02:29] Well, I appreciate it. So, we'd like to start these interviews by just asking about your childhood and early years and if there might have been people or events in your life that might have influenced your interest in animals and even bison in particular.

**Jim Derr** [00:02:49] Well, I was born in and grew up, was raised, went to school in northern Oklahoma, in north central Oklahoma, at a place called Enid, Oklahoma, and went to school, went through high school there. Probably the biggest industry in that part of Oklahoma is farming and oil production, oil and gas production.

**Jim Derr** [00:03:13] And I grew up, like a lot of like a lot of kids did then. And, you know, hunting and fishing were my passions, I would say. Playing football, too, but it was really mainly hunting and fishing. That was my passion and that's what I liked to do. And, and so growing up there, kind of in a rural community, and my dad did quite a bit of farming, my grandparents had farmed, and so I was pretty familiar with livestock and wildlife.

**Jim Derr** [00:03:46] And, you know, being in Oklahoma, there were a few bison around, too. So, I was familiar with what bison were, and what they looked like, and what had happened to them in the past. And so, I was always interested in that species.

**David Todd** [00:04:01] And then, as you moved on and, you know, in grade school and then later attending Cameron and Sul Ross State and Texas A&M, were there any teachers or classmates who might have helped encourage that earlier interest in in wildlife?

**Jim Derr** [00:04:22] I went through Cameron University in London, Oklahoma, as an undergraduate student, and I majored in biology. And honestly, when I went to school there, because I was interested in hunting and fishing and the outdoors, I really thought I'd get a degree in biology and that I would become, you know, a game warden maybe, or a wildlife manager of some sort.

**Jim Derr** [00:04:44] And I'm not sure what year it was, probably my junior year, the department head called me into his office one day, and his name's Mickey Cooper, and he said, Wichita Mountains Wildlife Refuge, which was a U.S. Federal refuge right north of Lawton, Oklahoma, in the Wichita Mountains, had contacted him and had some work that needed to be done with some bison at the refuge, and he asked me if I'd be interested, me and a couple of other students.

**Jim Derr** [00:05:22] And we were. You know, we were biology students, and an opportunity to get our hands on some bison sounded fun.

**Jim Derr** [00:05:29] And so we went up there and we worked with the people with Wichita Mountains Wildlife Refuge.

**Jim Derr** [00:05:33] That was really the first time I ever seriously thought much about bison and actually was up close to them and, you know, was able to get my hands on them.

**Jim Derr** [00:05:46] And I remember it was, it was somewhat of a life-changing kind of thing, because it was the first time I'd ever been around a very large wildlife species like that. I mean, I was hunting, you know, quail and ducks. And when I was a hunter, I was certainly not a big game hunter when I was young. And it was fun and I enjoyed doing it.

**Jim Derr** [00:06:12] And I remember talking to the department head of biology, you know, the next week when we came back and telling him how much fun it was. And he actually gave me a book after that. It was Zane Gray's "The Thundering Herd". And he told me I ought to read that book because, you know, it has some good insight into bison and bison history.

**Jim Derr** [00:06:32] So that kind of got me started thinking about bison. I never really thought at that time I'd get the opportunity to do research with bison, but it kind of left a soft spot in my heart for that species after that encounter.

**David Todd** [00:06:50] So this sounds like pretty formal, although it was out in the field, exposure to bison. Was there any sort of kind of informal side to getting interested in wildlife and maybe even bison - something you might have read - sort of general literature, or movies that you might have seen, or TV shows that you might have caught on the boob tube?

**Jim Derr** [00:07:19] Well, I will tell you that one book that had a major impact on me when I was probably junior high was an aunt of mine gave me a copy of Teddy Roosevelt's chronicle of his safari adventures in the early 1900s in Africa. And it's called, "African Game Trails". And so, I read that book, and I never, ever thought that I would ever get to go to Africa or see wildlife in Africa.

**Jim Derr** [00:07:53] But, just the descriptions that Teddy Roosevelt wrote about the animals and the adventures that he had, I could vicariously, as a junior high kid, you know, live the life that an ex-president got to live in Africa. And it really instilled a love for me in these species, whether they're North American species or African species, but wildlife species in general.

**Jim Derr** [00:08:19] And, you know, somewhere along in my undergraduate career, I decided I don't really want to be a game warden because you have to work whenever there's hunting days. And I started thinking more and more about research, and maybe I could figure out a way to get an advanced degree and start doing some research and maybe some research with wildlife that would be meaningful.

**David Todd** [00:08:51] Well, and so you went to graduate school at Sul Ross and Texas A&M, is that right?

**Jim Derr** [00:09:01] That's correct. When I finished at Cameron University, I had a bachelor's degree. And we had taken a field trip there, a mammalogy class, and we'd stopped at Sul Ross University in Alpine, Texas, and we had met a biology professor there. He was doing field work with wildlife and I liked him and apparently he liked me. And so, he invited me to come back and work on a master's degree with him.

**Jim Derr** [00:09:28] So I did. I went out to Alpine and I spent two years working on a master's degree project I had. It involved wood rats, and I learned a little bit about how research works and, and the mentality of doing research with wildlife, maybe some of the realities. But anyway, I learned about it and I learned that I liked it.

**Jim Derr** [00:09:55] And, he knew some people at Texas A&M University. And he, he hooked me up with those guys, and I came to Texas A&M University and applied for a position at the university to work on a Ph.D. And I decided that that Ph.D. needed to be with wildlife, but I wanted, I wanted to focus on genetics. And so I ended up getting the Ph.D. at Texas A&M University in genetics.

**David Todd** [00:10:30] Well, it seems like that has been a really interesting window onto wildlife behavior and conservation.

**David Todd** [00:10:44] One of the animals I guess you've really focused on has been the bison. And I thought we might just jump into this and ask you to help us understand the origins of the herd that's now at Caprock Canyon State Park and what we know about it and how it's been understood and protected over the years.

**David Todd** [00:11:13] I gather the starting point for this was when a fellow named Wolfgang Frey believed that the herd that was at the JA Ranch might have some sort of link to the old Charles Goodnight bison herd from the latter part of the 19th century.

**David Todd** [00:11:39] Is that a place to start on this story, or how would you begin?

**Jim Derr** [00:11:44] Yeah, most certainly. That is a wonderful story. I think probably most Texans don't know that story very well. And, you know, I think it's important that that story be told and people know what happened out there in the panhandle of Texas with that bison herd.

**Jim Derr** [00:12:06] So back in the 1870s, we all know what happened to bison at that time when professional hunters were moving through and killing most of the bison, killing them basically for their hides or their tongues, leaving the meat in the field. And hundreds of bison, thousands of bison, then eventually millions of bison were killed across the plains. And Texas was no different. People came, shot bison in Texas.

**Jim Derr** [00:12:38] And Charles Goodnight had a ranch. He was manager of the JA Ranch. And the hunters had come through and shot most, if not all, of the adult bison. And they didn't shoot the, the calves, especially the really little calves that were not weaned.

**Jim Derr** [00:12:57] And the story goes, Charles Goodnight's wife Mary was, could hear those unweaned calves out there crying, and convinced Charles Goodnight to go and catch them. And she said she'd bottle-raise them, and take care of them.

**Jim Derr** [00:13:15] And so there's, there's actually photographs of Charles Goodnight having four or five or six calves all roped together behind him while he's riding the horse. These calves are following him. And he takes them back to her and she, she bottle-feeds them and keeps them alive until they can eat on their own.

**Jim Derr** [00:13:36] And then Charles Goodnight starts his own herd of bison. And about that time, there were people who were talking about producing hybrids between bison and cattle, beef cattle, to produce a better, hardier beef animal, that was as tough as bison, didn't need as high quality a feed, was resistant to many of the, for example, parasites that occur in, in North America. They didn't have calving problems, stuff like that, that they had with their cattle.

**Jim Derr** [00:14:18] So, Charles Goodnight, and Charles Jones in Kansas and a few other people started doing experiments to cross bison and cattle, and they were successful at producing hybrids. And there's even quite a few pictures of Charles Goodnight with his hybrid, bison/cattle hybrids. And he even published a paper in 1914 in the Journal of Heredity about how to produce - "My Experience with Cattle/Bison Hybrids, or Cattalos".

**Jim Derr** [00:14:51] And that herd stayed after Charles Goodnight died: that herd stayed on the JA Ranch. And it stayed there for well over 100 years. And until, like you mentioned, Wolfgang Frey, a conservation biologist, pointed out to Texas Parks and Wildlife that this might be an important heritage herd for the state of Texas, because it was probably the only representative herd of bison that existed in Texas before the big population crash in the 1800s.

**Jim Derr** [00:15:32] And so, Texas Parks and Wildlife got interested in them. And then in 1997, the animals at the JA Ranch were captured by Texas Parks and Wildlife and moved to Caprock Canyons State Park, outside of the Quitaque, Texas, to establish the Texas State Bison herd that exists there today.

**David Todd** [00:16:10] You know, I was interested, and I think I may have learned this from you, actually, when we spoke earlier, that the overhunting that happened in the 1870s and thereabouts was just one of the problems that had really winnowed the population of bison, that there were other problems with, with disease, and as you mentioned just a moment ago, with interbreeding with, with cattle. Can you talk about some of those factors that made these bison at the JA, and later at the Caprock Canyon State Park, so, so very valuable?

**Jim Derr** [00:16:56] Well, when we look back over the history, nobody knows how many bison existed before Columbus came to the New World, obviously. And nobody even has a really good idea how many bison existed in North America in the 1700s, or even early 1800s. But, from reports like from the Lewis and Clark expedition and others at the time, there clearly, across North America, were millions of bison. Some estimates say as high as 60 million bison, and others suggest maybe 30 million bison, but lots and lots of bison.

**Jim Derr** [00:17:35] But, when the hunters came through and they started shooting them, they, they killed millions of animals. There's no question about that.

**Jim Derr** [00:17:43] But, there have been historians go back and look, and look at the number of hides that were sold per year to major buyers that were buying and kept good records, or the number of tongues or whatever that was sold from individual bison. And yes, there's evidence of millions of bison - somewhere, maybe, in the neighborhood of upwards to 10 million bison over that time period from the late 1860s to the early 1880s. But not 30 million, certainly not 60 million bison. There's no evidence that that many bison were actually shot by hunters. Yeah, there were millions of bison shot by hunters, but 30 million bison, that's a lot of bullets.

**Jim Derr** [00:18:31] But, it has been pretty clearly documented that bison at the time, and still today, are more or less naive to a number of different bovine diseases that were introduced with cattle when cattle were brought to the New World.

**Jim Derr** [00:18:51] And these diseases include a viral disease called malignant catarrhal fever, or MCF. MCF is absolutely a deadly viral disease for bison. It can kill cattle. But, most of the time when cattle get MCF, they don't die. But, most of the time when bison get it, they do die.

**Jim Derr** [00:19:15] And other diseases that were probably introduced early on by bringing livestock to the New World included things like brucellosis, which we still have a problem with today. It's a bacterial infection in bison. Basically, it's not treatable. There are some vaccines for brucella, but no vaccines for brucella, or brucellosis, have been developed

specifically for bison, and so we only have the cattle vaccine to use and it doesn't work very well in bison.

**Jim Derr** [00:19:53] So, bison were exposed to bullets from hunters, and they were also exposed to pathogens that were brought with the cattle. And, you know, those, those two factors, combined with habitat loss, and, you know, most likely the restriction of movement by barbed wire fences were brought in at that time and restricted their movement.

**Jim Derr** [00:20:16] So the combination of all those things probably led to the demise of bison down to something less than a thousand animals by around 1880, early 1880s.

**David Todd** [00:20:36] That's, that's so dramatic. I mean, just less than 1%, certainly, way less.

**Jim Derr** [00:20:44] It's estimated that 99.99% of the bison that existed in North America were killed.

**David Todd** [00:21:02] And then tell me a little bit more about the, this interbreeding. I think that's so interesting the project of trying to develop a cattalo herd that would have, you know, some of the better traits of cattle and the aspects of bison that appealed to livestock raisers.

**Jim Derr** [00:21:27] Yeah. The guys who were really involved in that mainly were Charles Goodnight, who we've already talked about some, and another contemporary bison person, cattle person, by the name of Charles Jones in Kansas. And there were others. There were a couple of guys in Montana. There was a guy in South Dakota. There was a guy in Alberta, Canada. They were all cattlemen. All these guys were cattlemen.

**Jim Derr** [00:21:54] And they all had heard because there was, you know, trade magazines, newspaper articles, scientific reports about using bison/cattle hybrids to produce a better breed of beef cattle.

**Jim Derr** [00:22:10] And, you know, even back then, people had a good understanding of hybrid vigor, so that when you cross two varieties together, the hybrid that you get can sometimes outperform either of the two parents. And so that's what they thought would happen when they crossed bison and cattle - you would get the good characteristics of bison and the good characteristics of cattle and produce a better beef animal.

**Jim Derr** [00:22:41] Even Charles Jones made an argument to Teddy Roosevelt at one time to depopulate all of the bison in Yellowstone National Park and replace them with cattalo, because Charles Jones felt like they were better animals than the native bison. Thank goodness he wasn't allowed to do that. But he tried.

**Jim Derr** [00:23:04] And, the fact of the matter is, by the early 1900s, Charles Goodnight, even Charles Jones, had given up on this effort to try to produce a better beef animal by crossing bison and cattle, because they realized that the animals they were producing were not superior to either bison or beef cattle. They didn't produce more meat, or better meat, or cheaper meat, or be healthier. This just simply wasn't true.

**Jim Derr** [00:23:37] Probably the reason that it didn't work with bison and cattle is because those two species are two genetically different for hybrid vigor to actually happen. So, most of the time, if you cross two species, they have to be really, really closely related to each other.

**Jim Derr** [00:23:57] We do it all the time still in the cattle industry. We cross Brahman cattle with black Angus cattle, for example, and these are two different species of cattle. But we produce hybrids and that's what we use for a lot of the meat production in the US. That works fine.

**Jim Derr** [00:24:21] But bison and cattle don't because they're simply genetically too distinct from each other.

**David Todd** [00:24:26] I see. So, cattalo is a far cry from Brangus.

**Jim Derr** [00:24:33] Yes. So, Bos indicus and Bos taurus, which is European cattle like Hereford or Angus, those two species are much closer to each other than bison are to any cattle breed, much closer genetically and evolutionarily.

**David Todd** [00:25:02] Well. So, this has left, I guess, as I understand it, that some of the bison that are roaming the plains, may be not entirely, purely bison. Is that right? Is there's some, what you call, "introgression", that may be at play in the bison that are remaining?

**Jim Derr** [00:25:26] Yeah, unfortunately, unfortunately, we are left with the legacy of what those guys did 140 years ago, even today. And my research program here at Texas A&M University investigated, started investigating bison and then kind of stumbled on some cattle genes in bison in the late 1990s. We did stumble on them by accident.

**Jim Derr** [00:25:55] And, we found that there was a particular kind of organelle in a cell that, and it's known in all mammals, it's got DNA in it. It's called mitochondria. And we found mitochondrial DNA in normal-looking bison. But that mitochondrial DNA originated from domestic cattle.

**Jim Derr** [00:26:19] And we, you know, and we found that out in the 1990s. And we didn't know the extent of cattle genes in bison, but we knew there were some. And so, we started testing quite a few bison over the years for those cattle genes. And we found those cattle mitochondrial genes in most bison herds.

**Jim Derr** [00:26:42] But, there were a few places we didn't find them. And we didn't find them in Yellowstone National Park and we didn't find them in some other national parks, like Wind Cave National Park, for example. And we had a few markers in the nuclear genome, where chromosomes are, that were, that would distinguish bison and cattle. And even with those markers, we couldn't find any hybridization in Yellowstone or Wind Cave.

**Jim Derr** [00:27:10] So at the time, now 25 years ago, we felt fairly confident that most bison had some cattle genes, very few, but some. But there were a few herds that didn't, that didn't seem to have any cattle gene introgression.

**Jim Derr** [00:27:27] But unfortunately, technology gets better. DNA sequencing for genomes gets cheaper and better. And the price point got to the level that we can afford to sequence bison genomes and do enough of them - you know, 30, 40, 50 animals - where we could sequence the bison genome and then compare it directly to the cattle genome, which was well-known and well-established.

**Jim Derr** [00:27:56] And unfortunately, what we found was that all bison that we've tested, from all of the lineages that survive through the bottleneck, have limited or low levels of cattle genes in them.

**Jim Derr** [00:28:16] So even the bison in Yellowstone, Wind Cave, Teddy Roosevelt, National Bison Range, Wichita Mountains in Oklahoma that I talked about a little earlier, they all have evidence of domestic cattle genes in them.

**Jim Derr** [00:28:30] So, as a matter of fact, I'm, I'm pretty comfortable now in saying that there aren't any bison that exist today that don't have a few cattle genes that got into them, into their lineage, less than about 200 years ago.

**Jim Derr** [00:28:49] So, you know, it is what it is. There's a small amount of cattle genes there. These animals are still bison. They're, you know, 99 or more percent bison. But there's a small amount of cattle genes that are found in every single bison.

**David Todd** [00:29:06] And do you think that that most of the introgression is from the deliberate work in hybridizing cattle and bison, or more maybe sort of informal efforts where, you know, the species interbred on their own?

**Jim Derr** [00:29:23] I think the majority of what we're seeing was purposefully caused by people like Charles Goodnight and Charles Jones, purposefully done.

**Jim Derr** [00:29:34] There are a few cases of bison that have spontaneously produced offspring with cattle. Matter of fact, there's, there's one cattle herd in West Texas today that two years ago had one female bison, and that was in a black Angus herd. And she got pregnant and had a calf and that calf is a first-generation hybrid.

**Jim Derr** [00:30:00] But there are other examples like Wichita Mountains Wildlife Refuge for pretty close to 100 years now, bison and longhorn cattle have shared the same pastures for 100 years. And to my knowledge, there's never been a documented hybrid between those two species.

**Jim Derr** [00:30:20] So I think the two species probably don't like to hybridize. And if they have, if they have members of their own species to breed with, then I don't think it happens very often.

**Jim Derr** [00:30:34] But I think if you put them in a situation where they don't have anything else to breed with, it can happen.

**David Todd** [00:30:42] And do you think, do these crossbred traits, is that a problem for their, for the species, the bison's long-term integrity and survival?

**Jim Derr** [00:31:05] You know, that's a really good question. And look, we can break it down to mitochondrial DNA, or nuclear DNA where the chromosomes are. I would say from mitochondrial DNA, we have clear evidence that if a bison, an otherwise normal bison, has cattle mitochondrial DNA, then those animals, because mitochondria is where most of the energy is produced in a cell, and those animals simply don't convert food to energy as efficiently as bison who have true bison mitochondrial DNA.

**Jim Derr** [00:31:42] And as a matter of fact, most often those animals are smaller. They wean smaller, and when they are adults, they're smaller. And that means that they're probably not converting energy as efficiently as they would if they had the correct mitochondrial DNA. So, that's not good. So, there's no advantage to a bison having cattle mitochondrial DNA. As a matter of fact, there's only disadvantages.

**Jim Derr** [00:32:08] On the nuclear side, though, the argument for the chromosomes line where most of our genes are, the story is quite different. Because, you know, we know that mammals have about 20 or 25,000 genes. And when we look at bison genomes, we sequence a genome and we look at an individual bison and we compare it to cattle, oftentimes we see pieces of cattle chromosomes all through their genome. And that includes all kinds of different genes.

**Jim Derr** [00:32:40] So it's really important which genes from cattle are found in an individual bison as to whether that has a detrimental impact on that bison or not. So the bottom line is, from the nuclear side, it's not a matter of how much cattle genetics are there, it's what cattle genetics are there. And that's, that's on an individual bison evaluation, because different bison will have different cattle genes.

**Jim Derr** [00:33:16] So, you know, there's a lot of research to be done to see if there are genes that are cattle genes that are segregating in bison herds that are detrimental to those animals.

**Jim Derr** [00:33:28] Or I guess, on the other side of the coin, are there cattle genes in bison that confer some benefit to those animals, maybe give them resistance to some disease or disorder, or maybe make them more fertile or whatever the trait might be? At this point, we don't know.

**David Todd** [00:33:52] Well, this is really interesting. Thanks for walking us through this cross-breeding issue. And, I guess, the other genetic aspect I was curious you could help us with is the inbreeding that I gather has been an issue for some bison herds, including the one at Caprock Canyon State Park. I think you had done a population viability analysis a number of years ago and it had brought up a lot of concern for you. And I was wondering if you could talk a little bit about that.

**Jim Derr** [00:34:31] Sure. I'm happy to talk about that.

**Jim Derr** [00:34:34] So in 1997, when Texas Parks and Wildlife took over the bison herd from the JA Ranch, they brought those animals to Caprock Canyon State Park. They had people to take care of those bison. They had people to feed them. They kept them in a fairly small 100-or-so-acre enclosure. And they had excellent nutrition. They had excellent veterinary care. They had a really nice pasture to live in. It was a healthy place for them.

**Jim Derr** [00:35:09] And they started that population in 1997. And the first year, they didn't have any calves or very, very few calves that made it - that were born and survived. And the implication was then, well, maybe it's just because we moved them and they're in a different environment. Next year, things will be better. But then the next year, in 1999, they weren't any better. Again, very, very few, if any, calves were born alive, and the ones that did, died soon.

**Jim Derr** [00:35:43] Something was going on. And then in 2000, the same thing. And then in 2001, pretty much the same thing.

**Jim Derr** [00:35:51] And the problem, the problem was, when we went and looked at the genetics of these animals, these animals, because they had been kept on the JA herd for over 100 years, males had been removed by various means, sometimes hunting, sometimes by castrating the bull calves. But the males had been removed so that not very many males were doing the breeding.

**Jim Derr** [00:36:17] And the population was really small. It may have been 100 at some times, but it may have been 25 at some times. So, the population fluctuated quite a bit, but it was always really small.

**Jim Derr** [00:36:28] And with a few number of males producing offspring per generation, what happened was they started to suffer from inbreeding. And, as a matter of fact, by the time Texas Parks and Wildlife took over this herd, this herd was in full-blown inbreeding depression.

**Jim Derr** [00:36:48] And when we went and we fertility tested all of the bulls at Caprock Canyon State Park, I think in 2001, none of the bulls passed fertility tests. So, the problem was they were not producing sperm cells that would meet the requirements for fertility in a domestic animal. So, we knew there was a problem.

**Jim Derr** [00:37:15] Then, as a geneticist, I started looking at this herd and saying, "Well, at least from 1997 to 2001 or 2002, they've only recruited a handful of calves into this herd." And so, a graduate student and I did a quick calculation of the average age of the bison in this herd. And most of the time, if you're replacing the animals that die with newborns in a population, the average age of a population will remain fairly constant.

**Jim Derr** [00:37:50] What we saw at this herd, in the early 2000s, was this herd was increasing in age, the average age of this herd, and it was going to reach a point, if it kept going the way it was going, and it looked like without intervention, it would, this herd would fall into what biologists call an "extinction vortex".

**Jim Derr** [00:38:15] And that's where you don't produce enough offspring to replace the animals that are dying. And the average age of the herd increases every year to the point that the majority of the animals in the herd are too old to reproduce. And that is what we call an extinction vortex.

**Jim Derr** [00:38:37] And that means that population, without some kind of drastic intervention, that population is going to become extinct. So, we realized in about 2002, 2003, that was where this population was.

**Jim Derr** [00:38:55] We all knew it was a very valuable population because it was the last remnant herd from Texas of bison. We also realized with some modeling, and with some research that we had done, that this herd had a very high probability of going extinct by about 2040.

**Jim Derr** [00:39:17] So, we had to do something. So, the idea was, looking back at the history, in 1902, Charles Goodnight had sold three bulls to help reestablish Yellowstone National Park. And so I thought, "Well, man, wouldn't it be great if in 2002, 100 years later, we bring three bulls from Yellowstone National Park to try to do something about this inbreeding problem here in Caprock Canyon State Park. Man, that'd be great." That would be a wonderful

hundred-year kind of story where that herd was used to rescue bison at Yellowstone National Park, and then the bison in Yellowstone 100 years later could rescue Charles Goodnight's old herd.

**Jim Derr** [00:40:05] The problem was that the bison in Yellowstone National Park have that bacterial disease brucella, and there simply was no way we could take bison out of Yellowstone and bring them to this Texas herd, because it just simply wasn't going to happen.

**Jim Derr** [00:40:23] So we searched around for the next best option. And there is a herd in New Mexico. It's owned by Ted Turner. It was a herd that was on the Vermejo Park Ranch. It's called the Castle Rock Herd. And that herd was moved to that ranch sometime in the 1930s, 1940s. The majority of those animals did come from Yellowstone National Park. That was, we knew because we had done some genetic testing in that herd, that was a very genetically healthy herd. They did, it was a Yellowstone lineage herd. And they did not have infectious diseases like brucellosis.

**Jim Derr** [00:41:07] And so we approached Mr. Turner. And he agreed to provide three bull calves for Texas Parks and Wildlife to put in this herd at Caprock Canyon State Park.

**Jim Derr** [00:41:23] So we got the bulls. They were young bulls. We kept them in quarantine for a year because we were, you know, cautious that we didn't want to, we didn't want to introduce them to this herd too quickly. We wanted to make sure they were healthy, and we wanted to make sure that everything worked out right.

**Jim Derr** [00:41:42] And then in the second year, we just exposed one of the bulls to the cows at Caprock Canyon State Park to see what would happen as an experiment.

**Jim Derr** [00:41:54] And that one bull I believe produced, I can't remember exactly, I think it was 13 calves that next year. That was the most calves that had ever been born in that herd, and this was in 2005. That was the most that had ever been born in that herd in one year since that herd was established in 1997.

**Jim Derr** [00:42:15] We knew for a fact that this was going to work. And, and the fact of the matter is, it did work and it worked very well.

**Jim Derr** [00:42:26] So we used one of those other bulls the next year and he produced 15 or 16 calves that were put in the herd. Then a couple of years later, we went back to the Vermejo Park Ranch and got a couple more bulls and brought them and used them as breeders.

**Jim Derr** [00:42:43] And now, when we look at this herd at Caprock Canyon State Park: it started with 37 or so animals. Now that herd has over 300 animals. Genetically, it is much healthier than it was 25 years ago. That herd is completely self-sustaining. We eliminated that extinction vortex. We turned around the problems with inbreeding, and that is a genetically healthy herd.

**Jim Derr** [00:43:17] And it still represents the last remaining herd of that great herd that occurred, you know, in the early 1800s that extended all the way down into Texas. It is the last, it is the most southern part, of that bison herd that lived in Texas and all through the plains in the 1800s and before that.

**Jim Derr** [00:43:44] So, in my view, it's a success story. We took a herd that was going to become extinct. We knew that it was valuable, and we figured out a way to use genetic technology to pick a herd that was free of diseases and had the right genetics to bring back into that herd.

**Jim Derr** [00:44:05] So, it worked. And you can go there today and you can see these bison today and they're extremely healthy and they're doing very well. And every spring there's a ton of calves in that herd now.

**David Todd** [00:44:21] That's, that's remarkable. What a great success.

**David Todd** [00:44:26] So, something I wanted to follow up with you about. It sounds like one of the important ways to keep a bison herd genetically healthy is to make sure that there isn't this introgression and there's not problems with inbreeding. And, you know, you can bring in these animals that maybe have, have the right genetics to try to give sort of robust genetics to the herd. But I've heard that there's also some folks that do culling, to try to weed out animals that maybe don't have the right genetic mix. Is that, is that something that you're familiar with, and, you know, so how is that best done?

**Jim Derr** [00:45:18] Well, there are you know, there are thousands of people across the U.S., Canada and Mexico that raise bison, you know, raise bison commercially. And, matter of fact, the vast majority of the bison in North America today are owned by private individuals. And most of those herds, the vast majority of them, are fairly small, probably less than a couple of hundred bison.

**Jim Derr** [00:45:43] And, you know, there's all kinds of different people who have different strategies in how they manage and raise their bison. And I would say almost all of them have some kind of selection criteria for how they choose to cull animals out of their herds.

**Jim Derr** [00:46:00] Because let's face it, if you're selling meat, that's how you're, you know, that's how you're supporting that herd and hopefully making money from that herd. You got to cull, and you've got to decide who you're going to get rid of from that herd.

**Jim Derr** [00:46:16] And so different people have different selection strategies. I would say, in my experience with most bison producers, however, most bison producers don't raise their bison like a lot of cattle producers would, where there's a lot of selection. And selection is for behavior. Selection is for growth factors, selection for size, selection for meat tenderness, lipid profiles - so a lot of different kinds of selection pressure that's put on dairy and beef cattle.

**Jim Derr** [00:46:54] But I would say, in general, the vast majority of the people who raise bison are interested in raising bison, but they're not interested in a lot of, putting a lot of selection pressure on particular traits.

**Jim Derr** [00:47:08] And I think part of that is because virtually everybody who raises bison in the U.S. and Canada and Mexico could be raising cattle, if they wanted to. But they've chosen to raise bison and they've chosen to raise bison for a lot of different reasons. But, one of those reasons always is because they love that species, and they like the heritage of that species, and they like what bison represent as an iconic species in North America.

**Jim Derr** [00:47:40] And so, in my experience, the mentality of the bison producers is generally different than the mentality of the cattle, particularly beef producers, in that the

bison people are not that interested generally in selection. They're more interested in, you know, like the Bison Association says, "letting bison be bison".

**David Todd** [00:48:11] This is maybe returning to something that we talked about earlier, this hybridizing introgression issue, but maybe this is a good time to discuss it. And that is, that I've, I've read some about the difficulties of protecting animals that may not be 100% made up of the genes that are true to their named species. And I'm thinking about red wolves and Guadalupe bass that have hybridized from time to time with coyotes in the red wolf's case and smallmouth bass in the Guadalupe bass' situation.

**David Todd** [00:48:55] And I gather the concern is whether the Endangered Species Act protects those animals that are slightly hybridized or maybe powerfully hybridized. And I was wondering if you've thought much about that, and might be able to sort of offer, well, you know, what's the value in protecting an animal that may not be 100% the animal that it's named for, but, you know, it somehow had some drift there.

**Jim Derr** [00:49:30] Yes, the Endangered Species Act, in the way that it was originally written and the way it's been interpreted a lot, tried, did its best, to try to exclude hybrids between two species. And primarily, it's my view, at least, primarily people who were initially involved in the Endangered Species Act were really talking about early-generation hybrids. So hybrids between two species and these animals were not clearly one of the other parent species, but they were actually true hybrids first, second, third generation hybrids where you could look at them and tell they're hybrids.

**Jim Derr** [00:50:16] And there's lots and lots of examples of that. As we, as we know, we're learning even more with genomic technologies, hybridization is not an unusual event. As a matter of fact, hybridization between distinct species is actually pretty darn common. It happens a lot, sometimes it's man-mitigated, like most of the bison hybridization was. Sometimes it's not. You know, sometimes it just happens. And fish are notorious for that, much more even than mammals are.

**Jim Derr** [00:50:49] So, first of all, I think that a species like bison, when you can sequence its genome, and clearly see how much cattle introgression is there, and document one half of 1% of the genome or 1% of the genome, or however much it is in that individual bison actually came from another species, but that hybridization event happened 20 or 30 or 40 generations ago, maybe 150 years ago or longer.

**Jim Derr** [00:51:22] Then, for the most part, that species is still an intact species. That species still fulfills an ecological niche that it should. And, in the end, they look like bison and they act like bison, and they fulfill the ecological role of that species that has historically been filled.

**Jim Derr** [00:51:45] And so, honestly, for the most part, with the bison we're talking about, and the hybridization we're talking about here, I don't think that it's a big issue that would involve protection or threatened status for North American bison.

**Jim Derr** [00:52:02] I don't think they need to be uplisted in regarding the Endangered Species Act. I just don't think it's necessary because I think bison are thriving. I think they do extremely well. We have well over 500,000 bison in North America now.

**Jim Derr** [00:52:20] And if you want to, you going to have a bison burger for lunch and you know, there's nothing wrong with doing that.

**Jim Derr** [00:52:26] So, as far as I'm concerned, the hybridization events that happened well over 100 years ago with bison really don't have any significant status for their taxonomic position or their legal status as a legitimate species.

**David Todd** [00:52:47] Okay, okay. Thank you. Thank you.

**David Todd** [00:52:52] So, one of the things that I think is really interesting that I think you've managed to accomplish in your lab with your team of students is identifying the gene markers for albinism in bison, and just generally mapping and sequencing, annotating the bison genome. And I was hoping that you could tell us about how that work came to be and how you figured this out.

**Jim Derr** [00:53:27] You know, kind of the holy grail for genetics and geneticists is to be able to sequence genomes, so that you can sequence every gene in the genome. And I got my Ph.D. 30 years ago, and the same year that I got my Ph.D., the Human Genome Project started, or at least close.

**Jim Derr** [00:53:51] And, the Human Genome Project took 12 years to complete. It cost something more than three billion dollars. And the genome sequence that we actually had when it was completed in 2002 was not very complete and there was a lot of gaps in it and there was a lot of mistakes in it. And we had spent three billion dollars doing it. At that time, it was the largest science experiment ever in the world. But, you know, it was expensive. And it took about 600 Ph.D.-level people to pull it off over a 12-year period.

**Jim Derr** [00:54:36] Then five years later, six years later, a consortium of people, including some people here at Texas A&M, put together funding to sequence the cattle genome. And at that time, it cost fifty million dollars to sequence the cattle genome. And they did it. And they reported that sequence of the cattle genome in 2006 or 2007.

**Jim Derr** [00:55:00] Well, there's no way that I'm going to get fifty million dollars to sequence the bison genome. It's just not going to happen for that species, or almost any other species, other than a really important livestock species or humans.

**Jim Derr** [00:55:17] Well, fast forward to about three years ago, when the price of sequencing the genome got down to about $1,000. And it didn't take years to do it. It took a few weeks, maybe a month, and you could have a genome for a thousand dollars in a month, that was a high-quality genome. And so I was able to get the money to sequence some bison genomes. The price continued to fall and the quality of the genomes continued to get better.

**Jim Derr** [00:55:53] So that today, in February of 2023, we can sequence mammalian genomes for less than $500. And we can do it in as little as a week, sometimes quicker than that.

**Jim Derr** [00:56:12] And so, it gives us the opportunity to really do some cool things and really be able to ask questions of species like, like North American bison, which don't have a huge economic impact, but have a huge, I guess, emotional impact because it is the U.S. National mammal. And we can start asking questions about bison that we could never ask before.

**Jim Derr** [00:56:39] So, now we have these tools. We can sequence these genomes. The bottom line is we have sequenced the genome of bison. We've compared it directly gene-by-gene to cattle. We know exactly where the genes are, for the most part, in bison. We know where a lot of the variation is in those genes. And the bottom line is now, no gene in bison can hide from us, because we can identify any gene and determine the variation of that gene in any gene in bison that we want.

**Jim Derr** [00:57:20] And so, when we got ready to publish this new annotated gene sequence for bison, I had a meeting with a couple of students and we decided, "You know what? We're going to publish this annotated sequence, this assembled sequence. It's all put together with the genes in order. We need to figure out a proof-of-concept experiment to do this. And we need to prove that we can use this to find a genetic trait in bison that's of value."

**Jim Derr** [00:57:52] And, but let's face it, most bison look the same. They're big, they're hairy, they're brown.

**Jim Derr** [00:57:59] And so we were talking about various disease-related genes or fertility-related genes, but you can't actually look at a bison and see those. One of the students said, "What about an albino bison? That - everybody can see that because they're clear. We clearly know that's a different bison and we even know how it's inherited as a recessive trait.".

**Jim Derr** [00:58:26] So we went and sequenced an albino bison. And I'm talking about true albino bison - individuals with no melanin and red eyes and white fur.

**Jim Derr** [00:58:38] And sure enough, we used our annotated sequence and we found the mutation that caused this that caused bison to be albinos. And we know what gene it's in. We know where the mutation is. We know the nucleotide change. We know that it causes a loss-of-function mutation in that enzyme. And that enzyme works in a biochemical pathway to produce melanin, which puts color in your skin and your hair and your eyes. And it stops that pathway because this enzyme doesn't work. It's a loss-of-function mutation. And the enzyme is then incapable of catalyzing that biochemical reaction.

**Jim Derr** [00:59:20] So that's that. Those animals can't produce melanin. They don't produce color.

**Jim Derr** [00:59:25] And we devised the test so that we can test for animals that are carriers of that mutation. So, they have normal color patterns, but they have one copy of the gene that's for albinism. And we tested hundreds of bison from different populations, different federal herds.

**Jim Derr** [00:59:44] And we've not found a heterozygote yet. We've not found a carrier yet unless it is a parent of a albino animal. That's the only heterozygote carriers we've found.

**Jim Derr** [00:59:56] So, so true albinism in North American bison is extremely rare. Native Americans have said forever that one in a million bison are albinos. And honestly, I'm beginning to think that they're probably about right.

**David Todd** [01:00:16] Wow. What a story. That's, that's impressive to see, you know, over the course of your career, so much technological change and advances in understanding.

**David Todd** [01:00:30] I'm curious, you know, with all the changes you've already seen, what do you see as you look forward for the bison and for the, you know, genetic understanding and protection of the animal?

**Jim Derr** [01:00:46] Well, as a geneticist, I guess maybe, you know, I like technology, and I think technology can be used to learn things that you can't learn in other ways. And I think, with some of the tools that we have developed, particularly these genomic tools that will allow us some insight into genetically how bison are different from cattle, and different from other species, so that we can use that information about how they're genetically different to their advantage.

**Jim Derr** [01:01:24] For example, there's not a single commercially available vaccine that I know of, that exists today, that was made specifically for bison. So, the vaccines we use, whether it's for, most of them are for infectious bacterial or viral diseases - the vaccines that we use for bison were all made for cattle. And we know that the bison immune system is quite different than it is in some ways in cattle.

**Jim Derr** [01:01:57] So, I think we can use this information to learn more about the immune system of bison, why bison are susceptible to certain diseases that cattle are not susceptible to, and bison are resistant to certain disorders and diseases and parasites that cattle are very susceptible to.

**Jim Derr** [01:02:16] So, I'm looking forward to using this kind of technology to understand more about the bison immune system, to use that to help bison, to use that as a tool where we can produce better resources, so that bison can even do better and maybe be healthier. And, you know, we all want bison to be around forever.

**David Todd** [01:02:45] Yeah. Inspiring animal. Just, you know, magnificent, charismatic. And it's, it's very cool that there's some of these genetic tools that may help, you know, with its resistance to parasites and bacteria and viruses and so on.

**David Todd** [01:03:01] Well as you as you look in the future, is there anything that we may have skipped in peppering you with questions, something that that maybe you'd like to address, either what's happened so far, or what might happen in the future?

**Jim Derr** [01:03:24] You know, I have students, when I teach a class, I have students that ask me questions about bison and why we should use this kind of technology, genetic technology, genotyping technology, genomics technology with bison. And I have producers that ask me those questions, you know. Why do you spend so much time and effort using these advanced technologies in bison? We can just let them be bison and they'll be okay.

**Jim Derr** [01:03:55] And, you know, to some degree, I agree with that. But I'd like to give an example of a study we did a few years ago, that the only way to get the information that we were able to develop was by the use of genetic technology. And I'm going to tell you a story, David, and you're not going to forget this story because it is, I think, an amazing use of technology to learn something that you couldn't learn any other way.

**Jim Derr** [01:04:26] So briefly, we went to Wind Cave National Park in 1999 and sampled genetic samples from the entire herd at one of their roundups, as part of a study we were doing with the National Park Service. And I fell in love with Wind Cave National Park. It's right, right next to Mount Rushmore. It's in the Black Hills. It's a beautiful place, wonderful

people there. And so, every year for ten years, I would either go back or I would send a student where they would collect samples for me.

**Jim Derr** [01:04:57] We got DNA samples from all the calves, because they would round them up every year. But we didn't have any money, so we just banked those DNA samples. And then, after about ten years, around 2010, we got a little bit of money and we parentage-tested all those calves. And so, we knew every calf for ten years and who their parents were.

**Jim Derr** [01:05:21] And so we started asking a bunch of questions and, you know, how old are the bulls that are producing cows? How, does a cow produce a calf every year or every other year? How old is the cow, how old can the cows get and can still produce calves? Which age of bulls produces the most calves. So, all those kinds of questions.

**Jim Derr** [01:05:44] But, the one thing that jumped out at us was that there were some year and a half old bull calves that produced about ten per cent of the calves in the herd. Year and a half old! These are little guys. And then there are two and a half year old bull calves that produced, I don't know, five, six, seven per cent every year. So that somewhere around 15, 18% of the calves that were born every year, the fathers, the sires, of those calves were one or two years old.

**Jim Derr** [01:06:19] But then, the three year old bull calves almost never produce calves. And then it would step up to four year olds would produce about 15%, and the five year olds would produce more, and the six year olds would produce more. The seven year old bulls were the ones, were the major breeders. And then after seven, it dropped off. And then by the time the bulls were 12, 14 years old, they quit producing calves.

**Jim Derr** [01:06:43] So, but the question remained. Why don't three year old bull calves produce offspring? I mean, what happened? They didn't forget, you know. Something's going on in this herd.

**Jim Derr** [01:06:59] So I had a graduate student at the time. Her name was Natalie Halbert, and she was the one who had collected this data. And she said, "I think I know what's going on", because she had been in a lot of bison herds and she had observed these animals. She said, "I think those first one and two year old bull calves are living in the matriarchal groups and they're protected by their moms and their aunts, and so forth. But by the time they're three years old, they push them out. They push those three year old bull calves out of those matriarchal groups and don't let them back in."

**Jim Derr** [01:07:35] She said, "I think that these one and two year old bull cows are breeding with their female relatives."

**Jim Derr** [01:07:42] And so I said, "Can we test that?"

**Jim Derr** [01:07:44] She said, "Yeah, we can, because we have a pedigree here. We know who's related to who, because we know every parent, and we know every aunt and every uncle and every cousin in these herds because we had a full pedigree of ten years."

**Jim Derr** [01:07:58] So, we tested. The one and two year old bull calves - what cows they were breeding with to produce the caves they were producing. And overwhelmingly they were breeding with their first and second degree relatives.

**Jim Derr** [01:08:14] But, by the time they're three years old, those big cows push them out of the herd and they don't get the opportunity to breed with their relatives anymore.

**Jim Derr** [01:08:21] So, what that told us was a normal bison herd, probably from antiquity had about 15% of the breeding in the herd was inbreeding in the herd. And about 85% was not inbreeding in a herd.

**Jim Derr** [01:08:42] So, that has serious implications for how genetic diversity is preserved in a herd over time. That changes the calculation that you have to make when you look at genetic diversity over time. And without the use of genetic technology to genotype these animals, no one, I don't think anyone, would have predicted what we found - that those one and two year old bull calves were breeding their relatives. But you have three year old bull cows virtually never produced any offspring.

**Jim Derr** [01:09:15] So I like to tell people that story because it's a use of biotechnology. It's a use of this kind of genetic technology to learn something about a bison herd that you couldn't learn any other way.

**David Todd** [01:09:30] That is fascinating. It's a real head scratcher.

**David Todd** [01:09:33] So, I'm curious if, if the 85% that were not breeding with their first or second degree relatives, were they breeding outside of their sort of immediate clan or family because they were so mobile? And that's what kept the genetic diversity of the bison population as a whole? Or, or is 15% inbreeding not a big deal?

**Jim Derr** [01:10:08] I think, 15% inbreeding is a big deal, because inbreeding in a herd, sometimes inbreeding is a good thing. From a human standpoint, inbreeding is always a bad thing, okay, because we're an outbred species. But in a lot of herds, a lot of populations, inbreeding can be a good thing, because inbreeding will, over time, put together gene combinations that don't happen without inbreeding. For example, all breeds of cattle, all breeds of dogs, all breeds of cats, all varieties of corn, wheat, rice, oats, whatever: all of those things were developed because of inbreeding. And we used inbreeding to develop all those breeds or varieties - agriculture did.

**Jim Derr** [01:11:00] And they did it over time and they did it over time in order to fix positive traits in the Labrador retrievers that we have, or black Angus cattle.

**Jim Derr** [01:11:12] So a little bit of inbreeding can actually be beneficial, because it puts gene combinations together in animals in the herd that wouldn't normally be put together.

**Jim Derr** [01:11:23] You don't want to get too much inbreeding in a herd because it can cause too many problems, but a little bit not necessarily a bad deal.

**Jim Derr** [01:11:31] So I think, I think these bison herds knew what they were doing because they've been doing it for a very long time. And I think, in fact, it's probably not detrimental. It's probably a benefit in the long term to these herds.

**Jim Derr** [01:11:49] And what I do know for a fact is that the more males that contribute offspring, every generation, in a population, the better things are, because you have more males contributing more genes to a population. And as a matter of fact, there are even some large private herds now that leave their bull calves in the herd until they're three years old,

before they cull those bull calves out of the herd, just so they get the opportunity to have those animals put their genes back into that herd before they're culled out.

**Jim Derr** [01:12:27] What that does for them is that it ensures that they have more males breeding every year in the herd, and it increases their genetic diversity and helps preserve it.

**David Todd** [01:12:45] Well, I'm writing furiously because this is just all so, so valuable. But I know that your time is precious. You probably have students at the door, so I don't want to take too much of your time. But I did want to leave just, you know, an open-ended question here. Is there anything that you might like to address that we haven't talked about so far?

**Jim Derr** [01:13:17] Well, I would just like to, to point out the fact that bison are one of the most unique species on this planet. And, you know, I have people ask me pretty darn often because I used to do a lot of work with cattle and other livestock species. And they asked me, you know, "Why do you work with bison? What's the, what's the allure to work with this animal, to put so much time and effort into these genetic resources and bison?".

**Jim Derr** [01:13:48] And I'll submit this to you, David. There's no other species on the planet that has the kind of interest that bison do. So, let's look at it this way: bison in the national parks - Yellowstone National Park, Teddy Roosevelt, National Bison Range. Bison in national parks are an iconic wildlife species for North America. You can show a kid anywhere in the world a picture of a North American bison, and he's going to think about primarily the American West. So, it's an iconic wildlife species.

**Jim Derr** [01:14:23] However, if you go to the National Bison Association meeting, you know, they have meetings with a thousand producers coming to their meetings. A lot, have a lot of members, a high membership, a lot of people producing bison. Ted Turner's got more than anybody else, but there's a lot of people that have a lot of bison. And they, they're raising them, number one, because they love bison. But number two, they raise them for meat, and they raise them for fiber, and they raise them for profit. So that bison are also, they're wildlife species, but they're also a production species.

**Jim Derr** [01:15:00] So there's not a lot of species that can say they're wildlife in some cases and their production in other cases, a commercial species.

**Jim Derr** [01:15:09] But there's a third component to the bison, and that's what really makes them unique, because if you talk to Native Americans, particularly people that are members of the Lakota Sioux tribe or other tribes, they're going to tell you, they're going to explain to you how important a spiritual animal bison are to them, particularly like we talked about a while back with white bison, with albino bison. They, they have very, very strong beliefs that bison are a spiritual animal, that their lives are intertwined with the lives of bison.

**Jim Derr** [01:15:48] And so, I've learned over the years in conversations with Native Americans, this, this is serious business to them. And it doesn't matter what your religion is, whether you're Christian or Muslim or whatever, there are certain things you hold very dear in your heart. And bison are one of those things that Native Americans do, and it's a serious business.

**Jim Derr** [01:16:14] So I submit to you, David, how many species on this planet can you think of that are an iconic wildlife species, an important production species, and a spiritual symbol to a large group of people?

**David Todd** [01:16:31] Few. Maybe none.

**Jim Derr** [01:16:35] Maybe one.

**David Todd** [01:16:37] Maybe none. I don't know. I just love that they circulated around the U.S. on the nickel. So many people had this intimate connection with them, even if they never seen them in the live place.

**David Todd** [01:16:57] Yeah. Well, thank you so much. You really shared and taught us a lot. I appreciate it. I hope that our paths cross in the future. I will keep an eye out for your continuing research. It's just been so exciting to hear about it one-on-one like this has been a real treat, and I appreciate it.

**Jim Derr** [01:17:18] Thank you, David. Thank you very much for the opportunity. And, you know, I'm in the education business, so I hope that what we've done is educate people a little bit into genetics and bison and this species and why so many people love them.

**David Todd** [01:17:33] Yeah. And your life as well and career which has contributed much of this, so thank you.

**Jim Derr** [01:17:40] Thank you.

**David Todd** [01:17:41] All right. You have a good day. Thank you so much.

**Jim Derr** [01:17:43] Yes, sir.

**David Todd** [01:17:44] Bye now.