An Exploration into the Ethics of Cloning Endangered Species

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Researchers are cloning endangered species, expanding the debate on human cloning to include both the value of evolution and the question of whether ethical issues affecting endangered species should be defined in terms of human medical benefit. In this paper, the author explores these questions and others with evolutionary biologist Kathryn Rodriguez-Clark, philosopher Holmes Rolston, III, and toxicologist Don Sparling. Whether or not we are ready to formulate ethics on the subject, if we do not enter into a serious dialogue now, then we allow the question of whether to clone any species—including our own—to be decided for us.

The possibility of cloning became real in 1997 when Dolly, the cloned ewe, entered the natural world. Global debate ensued, and President Clinton initiated a Congressional hearing that concluded with a ban on the use of human embryos in federally-funded medical research for five years. Even with the reality of Dolly, there remained important unresolved questions concerning cloning, and many scientists thought that they would never be faced with actually having to answer the difficult questions concerning the ethics of cloning.

Two of the research hurdles to cloning are explained below in Excursus 1. One involved the length of the telomere, the biological clock of chromosomes. If telomeres could not be returned to their length at the time of birth, clones could never be produced with a normal lifespan; they would be born at the biological age of their genetic twin. Another hurdle involved the donated chromosomes themselves. Early in the life of an embryo, its DNA differentiates to produce the different tissues that make up the future animal. If DNA cannot be returned to its original undifferentiated state, a new individual can never be produced. Great discoveries have been made during the last few years, and when the ban is reevaluated in 2002, cloning will be a reality and the debate will be historical.

Continued research on the cloning of animals was never banned. The November 2000 issue of *Scientific American* contained a paper presented by researchers at Advanced Cellular Technology (ACT) in Worcester, Massachusetts, describing their work in cloning endangered species, such as the guar, the Sumatran tiger and the giant panda. The ACT researchers also entertain the possibility of reincarnating the already-extinct African bongo antelope and support ongoing projects elsewhere to clone deceased domestic pets. The newest science of cloning involving somatic cell nuclear transfer is explained in detail in Excursus 2.

Dr. Betsy L. Dresser is one of three ACT researchers cloning endangered species. She holds the Virginia Kock endowed chair in endangered species conservation at the University of New Orleans and is vice-president of the Audubon Institute for Research of Endangered Species. The Institute outlines its position on the ethics of cloning endangered species on its website in a statement by CEO Ron Forman:
More animals will become extinct in our lifetime than at any other time in the history of mankind. If mankind is responsible for this extinction, then we also have the responsibility to act on behalf of these species. We at Audubon Institute are developing technology to freeze and stockpile reproductive material, using common, non-endangered animal surrogates to increase the birthrate for endangered species, until those species are threatened no more. This science is a major step towards eradicating extinction.

It is clear that ACT researchers uncovered an emotionally-charged deep pocket already established to conserve endangered species in order to fund their own research on cloning. As a consequence, questions concerning the ethics of cloning now include a myriad of totally separate issues that impact endangered species and are of utmost importance in shaping how we respond to our serious environmental problems of the 21st century.

The question of cloning is now before us, whether or not we are ready as a society to formulate ethics on the subject. If we do not examine the controversy now, we will become used to and accept the idea of cloning. Without ever entering into serious dialogue, we could allow the question of whether to clone any species, including our own, to be decided for us.

Because endangered species are being cloned, I am interested as a student of conservation biology in exploring these new areas now included in the cloning debate. I presented a set of questions to three scholars from different disciplines, to examine how their responses would differ from my own. Only by beginning such a dialogue can any of us understand how the decisions before us will impact the future of humankind and all life on earth.

I interviewed evolutionary biologist Kathryn M. Rodriguez-Clark, philosopher and environmental ethicist Holmes Rolston, III, and Don Sparling, a wildlife biologist and toxicologist. No ACT researcher responded to my requests for an interview.

The discussion that follows includes fascinating and thoughtful responses that were often diametrically opposed.

Question 1. Would you respond differently to a cloned individual of an endangered species than you would to one born in a wild population?

Holmes Rolston, III, answers, yes, the clone has a different historical genesis from the wild individual. The appropriate response to the clone is to be impressed with the human technicians, and the appropriate response to the wild animal is to be impressed with the animal.

I also answer, yes. I believe that evolution is a force included in the divine, and because a clone is produced by humans and does not originate from within evolution, it lies outside of our shared oneness with the universe. On the other hand, because a clone has life, I cannot deny that it has worth.

Don Sparling responds from a different perspective. He does not think that there would be any real difference between a cloned and a wild individual if the clone were taken from a wild individual. Clearly, if the clone had come from an individual that was part of a long line of captive bred individuals, differential selection could (and probably would) have occurred on that captive line compared to a wild line. Captive selection has been well documented. In the same way, a cloned animal is a chimera, not equivalent genetically to the original species, and most likely would not have the same fitness as a wild animal.

Question 2. Does a species have value outside of its natural ecosystem? If so, how is its value affected if it is extinct in wild nature and exists only in a zoo or preserve?

Don Sparling believes that most definitely a species has value outside of its natural ecosystem, although that value might be compromised. First, captive animals can serve as genetic reservoirs for the species at large. If conditions that led to the endangerment or extinction of a species in the wild can be corrected, captive individuals would be the only source for re-establishing the species. Captive programs are now sufficiently sophisticated to assure that the inbreeding coefficient can be kept at a manageable level. Second-
ary values for animals outside of their ecosystem include:

(a) As a possible surrogate for more endangered species. For example, during the 1980s Patuxent used Andean Condors as surrogates for testing medications and procedures before using them on the even rarer Californian condors.

(b) As a possible benefit for the human species in providing medicines, etc. A problem that can occur, however, is selection pressure due to captivity, which could select for more docile, easier-to-handle animals or more cultivable plants that may not be as wary as wild animals or resistant as wild plants.

Kathryn Rodriguez-Clark agrees that a species has value outside of its natural ecosystem, for educational purposes at least, and possibly economic ones. She uses African violets as an example, which are extinct in the wild.

Holmes Rolston, III, answers from a different perspective, noting that species have reduced value in zoos; they become museum pieces, not animals living on their own with their own defended integrity.

I, too, answer from this perspective. I believe that a species has less value outside of its natural ecosystem, but its value depends on why the species now exists outside of its natural ecosystem. As a representative individual of an extinct species, it has little value, since it only represents our failure to preserve it. I agree with Don Sparling, however, that a species in captivity has value both as a genetic reservoir and as a research subject for endangered species that have wild populations in protected ecosystems.

**Question 3. Should cloned endangered species be introduced into the wild to breed with remaining but still endangered populations?**

Kathryn Rodriguez-Clark makes the interesting observation that it depends on how the cloning is done. If eggs from another species are used, then probably cloned individuals should not be introduced into wild populations because of all the extra-species mitochondrial and cellular material introduced, which could have unforeseen impacts.

She further explains that most efforts at "cloning" do not produce a true clone but involve denucleating an egg of one individual that may be from a different species, and inserting into this egg the nucleus of the "target" species. Thus the result is a chimera, an individual that possesses the mitochondrial DNA and some cellular machinery of one species, and the nuclear genome of another species. Not much is known about how these two genomes interact, but since mtDNA is key for cellular respiration, it is likely they do interact in significant ways.

Don Sparling answers that if great care were taken in raising and selecting cloned individuals to avoid the problems discussed earlier, there should be no problem. From a population genetics perspective, the genotype and relevance of the clones are indistinguishable from that of the parent individuals. He adds:

> It is my belief that especially plants and probably non-human animals do not have any particular divine characteristics such as souls which would confound the ethical aspects of such decisions. However, the theological implications of such activities have not been sufficiently pondered.
Holmes Rolston, III, cautions, “Certainly not until we are sure whether the clone is normal in all respects in genes, morphology, behavior.”

I, however, am continuing to evaluate my position. Cloning endangered species should be considered neither as a strategy to avoid the extinction of a species, nor as a measure as important as preserving habitats and ecosystems. I also do not believe that cloning should be considered of equal value to reproduction through natural means, where the diversity of the genotype is protected. However, I believe that cloning may have a place where all other means of preserving a species fail.

**Question 4. What importance does the theory of evolution hold for you personally?**

We all agree that that evolution has a great importance for us personally, although our reasons may be different. Don Sparling responds:

I believe in the theory of evolution in the sense that natural environmental changes occur that can alter the composition of genomes and cause gradual change in species or the formation of new species out of pre-existing ones. That all of this occurs solely by random, stochastic events, and that out of this randomness has come the complexity of nature at the macro and micro-levels exceeds my credulity.

**Question 5. Should we clone only a few representative individuals of an endangered species, or should enough genetic diversity be preserved for evolution to continue in the species?**

I believe that as our scientific understanding of evolution expands, it precludes the notion that cloning is a vehicle for preserving evolution. Evolution arises from potentially adaptive mutations, and because these mutations are only a fraction of the total number of mutations occurring in an evolutionary dynamic genome, many genetically separate individuals are required to support continued evolution. Perhaps the number of individuals needed to preserve evolutionary viability is greater than 5000. Thus, regardless of other problems that this question suggests, the number the of genetically different individuals needed to even approach the successful preservation of evolution is much larger than our capacity to respond by cloning.

Don Sparling thinks that cloning only a few individuals would be like conducting a toxicity study on a statistically insufficient number of individuals: this action could be more detrimental than no action at all. It is an oxymoron to consider a few individuals representative of a species, for the species is the sum of its genetic variability. The less of that variability that is present in the cloned population, the less it represents the species. While one might be able to establish a “show-case” species, what would be produced from a few individuals would hardly suffice to represent the species as it once was.

Continuing, he says that deciding on how many animals or plants are necessary to be representative is much more open to argument, especially since we may not have any idea on how much genetic variability existed or needs to exist to be representative. If a measure of genetic diversity were available, would it be from a time when the species was healthy and robust or when it was severely decimated and consisting of only a fraction of its potential diversity? Would 50% of the potential diversity be adequate? 75%? 90%? From a practical aspect, we may have only a few individuals from which genetic material could be extracted. In that case, whether the
species was "restored" would be debatable, even if the progeny of the cloned individuals reached the hundreds or thousands. Evolution would occur in any case but the results of that evolution may or may not be the same as if the species had not become endangered or extinct.

Holmes Rolston, III, answers that it depends on whether the goal is to have museum pieces or animals with wild integrity. The number of individuals that must be cloned to provide that diversity depends on the species and the genetic pool required. Evolution from clones is not evolution by natural selection and, therefore, not evolution in the usual sense.

Kathryn Rodriguez-Clark does not think that cloning is ever likely to be a mode of "preserving" a species, except perhaps by generating enough interest and money to be put toward preserving wild habitat and supporting other in situ conservation efforts. Most captive-bred species are barely self-sustaining, much less capable of surviving re-introduction in the wild. However, there obviously are some notable exceptions, such as black-footed ferrets and whooping cranes, species that can be induced to breed readily in captivity. Rodriguez-Clark believes that genetic variation is obviously important, but so many other issues are normally far more important in determining the persistence of an endangered species, such as habitat loss, direct exploitation, lack of political will and institutional continuity, and even how "cute" and appealing it is to the public.

Question 6. Scientists involved in cloning research state that the knowledge we will gain will increase our understanding and treatment of human diseases. Should we define the ethical issues affecting endangered species in terms of human medical benefit?

Don Sparling explains that conserving biodiversity, which is part of what we are discussing, benefits all species. Human beings are a natural part of the environment because we are part of nature, although a unique part. So, yes, some of the benefit of being able to clone and maintain endangered species can be measured in terms of human health, although this in no way should be the primary value.

He makes a comment at the end of his interview that I think expands upon his answer here. The cloning of endangered species or any nonhuman species should not be equated with the cloning of human beings. Although we might allow the cloning of nonhumans (keep in mind that we do that all the time with plant cutting and shoots—and many endangered species are plants) only human beings are made in the image of God.

Holmes Rolston, III, disagrees. He believes it is doubtful that the knowledge gained from cloning endangered species will increase the understanding and treatment of human diseases. Neither does he believe that the ethical issues affecting endangered species should be defined in terms of human medical benefit.

Kathryn Rodriguez-Clark also disagrees. She answers that it seems simply false that we will increase our understanding and ability to treat human diseases through cloning endangered species. There are already plenty of studies of human monozygotic twins, who are natural clones, which have contributed immensely to the understanding of diseases. Cloning endangered species would, if anything, have the goal of preserving as many different genotypes as possible, whereas in a disease study context, the value would be in having many, many replicates of the same genotype, which is why highly inbred lines of mice are used. These goals are diametrically opposed.

I read the testimony of Dr. Michael West, president and CEO of ACT, who explained to Congress that cloning technology is an essential process in modern biomedical research to help us learn how to reprogram genes to develop different types of cells and create different proteins needed in the treatment of many diseases. I also read the debates of bioethicists supporting human cloning who focus their argument on the benefit to human reproduction, arguing that it is a
fundamental and a constitutionally guaran-
teed right. I do believe that medical research
should be allowed to proceed on animals, if
the knowledge it produces increases our
knowledge of life.

However, I believe we should not define
the ethical issues affecting endangered spe-
cies in terms of human medical benefit. Their
gene pool is from whence we came: we share
most of our genes with them. Where did hu-
man beings step out of the flow of history and
assume a different path? Drummond believes
that, by taking advantage of an open niche,
human beings became intelligent; but they as-
sumed additional responsibilities, not addi-
tional rights. Perhaps expanded human con-
sciousness enables the capability of deeper
fulfillment, but we must rethink the concept
of human rights in order to comprehend how
we fit into the whole of the cosmos. We have

the intelligence to work within the cosmos,
but not the right to have command over it.

Some may introduce here the argument that
because natural evolution produced humans,
all that we do is natural, that we have a right to
do it because we can. I want to expand on the
answer given by Holmes Rolston, III, to in-
clude his thoughts in Conserving Natural
Value. "We are not discriminating enough to
see that, though humans evolve out of nature
and its processes, we significantly evolve out
of it." Evolved out of nature, human culture
must remain in relative harmony with nature.
Although all deliberate human behavior is dif-
ferent from the process of spontaneous nature,
behavior that agrees with natural systems is
healthy for human beings, and behavior that

does not is not healthy.3 Defining human medi-
cal benefit in terms of the ethical issues affect-
ing endangered species places us outside of
relative harmony with nature and is not healthy.

Sparling foresees that if cloning became
acceptable it would become another tool in
the arsenal to maintain biodiversity and
species. As a result, it would become part of
organized programs that include habitat
restoration and sustainability. It would not
supplant these programs.

Question 7. If endangered species are
cloned, do you believe that momentum and
funding will be lost in efforts to conserve
them by other means, such as breeding
programs and protecting and restoring
their natural ecosystems and habitat?

Kathryn Rodriguez-Clark does not believe
momentum and funding will be lost. It would
probably raise public awareness and lead to a
rising tide that might raise all boats, which is
why I'm not against cloning altogether.

I think there are enough intelligent, well-
informed folks out there that if trends started
in that direction, there would be huge out-
cry. I do think it is important that the sci-
entists who are actually doing the cloning are
clear on this point, though, that cloning is
more along the lines of basic research and may
never have any applied use toward species
conservation. This de-
bate seems to me to be
quite similar to the de-
bate about "putting a
man on the moon." It
has not led to peopling
the moon, but it generated enormous support
for basic research in physics that has led to
all sorts of unexpected bonuses (like velcro,
for instance).

Don Sparling agrees that momentum and
funding will not be lost. Because of the diffi-
culty of cloning (and breeding) compared to
breeding extant populations, whenever pos-
sible the emphasis will be placed on breed-
ing. The value of cloning decreases dramati-
cally if there are already a sufficient number
of organisms to breed in captivity in safe pre-
serves. Also, there is not much value in sim-
ply cloning a species if there is no habitat avail-
able, unless one wishes to produce a show-
case species; but costs and problems would
keep that possibility down to a minimum.
Holmes Rolston, III, disagrees with them. He responds that a belief in ex situ conservation undermines in situ conservation.

I agree with him. I am deeply concerned that cloning endangered species will divert concern for species currently facing extinction. Species under stress have benefited because of the intense interest in breeding programs and the protection of ecosystems. This work is funded because we are concerned. If we convince ourselves that we can clone endangered species, to preserve them until we can figure out how to reestablish their ecosystems, we lose a great deal of the little time we have left.

Question 8. If endangered species are cloned, will it decrease the urgency to make our own environment sustainable, by leading us to believe that we can reconstruct it all later?

Don Sparling responds that he foresees that if cloning became acceptable it would become another tool in the arsenal to maintain biodiversity and species. As a result, it would become part of organized programs that include habitat restoration and sustainability. It would not supplant these programs.

Kathryn Rodriguez-Clark agrees. The idea that cloning endangered species will decrease the urgency to make our own environment sustainable by leading us to believe that we can reconstruct it all later is simply ridiculous.

Holmes Rolston, III, sees this from a different perspective. People pushy enough with their technology to clone endangered species think well of themselves and their technology. They are likely to believe in a technological fix for everything.

I agree with Holmes Rolston, III. I believe this is a major hazard of cloning endangered species, as it is human nature to put off until later changes that need to be made now and will lead us to postpone developing real solutions until we face a major crisis.

Question 9. Do you believe that an extinct ecosystem can be reestablished after it is destroyed by human development? Could it be made sustainable?

Holmes Rolston, III, believes that an ecosystem locally extinct might be restored, if there is another one elsewhere from which source material can be taken. Ecosystems globally extinct cannot be restored; nobody would know enough about what was there before to know how to restore it. If the ecosystem is otherwise intact, presumably a reintroduced species could survive, no matter whether cloned from individuals in zoos or restocked with wild individuals from other habitats. Yellowstone wolves came from Canada. They could have as well, under a perfect cloning scenario, have been cloned.

But in fact, Rolston continues, many species have all sorts of acquired behaviors they imprint from their parents, and just cloning an individual genetically does not reproduce the formative forces on the phenotype beyond the genotype.

I agree with everyone. An ecosystem is not just an area where species come together and live. There is a unique dynamic moving through every habitat and every ecosystem. It is a product of chance, of stochastic events, and timing. We have no way of knowing when or in what order species were originally introduced. An ecosystem is a product of its unique history and cannot be repeated. The only way to have the original ecosystem is to preserve it in its original totality.
**Question 10.** If you were faced with the decision today (and you are), would you support the cloning of endangered species? Please answer either Yes or No.

Kathryn Rodriguez-Clark responds, “Yes, but not as a ‘conservation technique,’ since it simply isn’t.”

Holmes Rolston, III, responds, “I’d have to see on a case by case basis. Presumably, no.”

Don Sparling responds, “Yes.”

And I respond, “No.”

**Excursus 1: Recently removed obstacles to the reality of cloning**

**A. Returning a differentiated cell to its original undifferentiated state**

Somatic cells donated by an adult contain a complete set of DNA. If they are, for example, skin cells, the genes that code for skin are activated and the remaining genes were turned off during fetal development. Early embryologists believed that DNA could never be returned to its original undifferentiated state, able to begin again, to differentiate a second time and grow a second complete animal. However, recent research has identified certain growth factor proteins in the cytoplasm of an egg that are capable of retroprogramming DNA, returning it to its original and undifferentiated state, enabling the cell to replay its growth.

**B. How old is a clone?**

A second problem, considered by some to be insurmountable during the 1997 Congressional hearings, centered around the length of the teleomere on the chromosomes from the somatic cell. Each strand of DNA ends in a sequence of genes called the teleomere, a biological “bookend” that holds the gene sequences in place. When chromosomes replicate, the two strands of the DNA double helix separate, and a group of enzymes known as DNA polymerases catalyze the synthesis of new strands. Each time the chromosome replicates, a tiny segment of the teleomere is lost, and when all segments of the teleomere have been lost, the cell dies. A telomere is a kind of molecular clock.

It was thought that clones would never have a normal life span, that they would be born with telomeres the same length as the somatic cell and begin life at the age of the donor. In April of 2000, Dr. Robert Lanza of ACT discovered that not only can telomeres be returned to their original length, but they can be made longer. He announced that not only could clones be produced with an anticipated normal lifespan, but that the longer telomeres could produce an exceptionally long lifespan. It would be possible, he announced, that cloned humans could live to 180 or perhaps 200 years.

To produce the long telomeres, Dr. Lanza allowed the somatic cells to continue to divide until 95% of their lifespan was used. The DNA from these aged cells was then inserted by nuclear transfer into the demucleated egg cell. He had conducted this research on calves, and the resulting cloned calf was not only normal, but had telomeres long enough to complete 91 cell divisions thirty more than 61 cell divisions expected during the normal lifespan of the animal.

**Excursus 2: The science of cloning by nuclear transfer**

Cloning by nuclear transfer begins with the donation of an ovum from one donor and a somatic cell from a separate donor. An ovum is the product of two meiotic divisions during which the chromosomes divide equally but the cytoplasm does not. Most of the cytoplasm contained in the primary oocyte remains in only one of the two cells produced by each division. The polar bodies, the other cells produced with each meiotic division, receive chromosomes but very little cytoplasm. Cytoplasm contains not only stored nutrients, but ribosomes, mitochondria, enzymes, and organelles (centers for protein assembly, energy production and respiration). The chromosomes in the polar bodies are sacrificed to assure that the ovum can best support an embryo.

An ovum is a sac within a sac. The innermost sac is the egg, which is covered by the
plasma membrane. The final polar body produced by the second meiotic division lies just above the plasma membrane but beneath an outer protective membrane, called the zona pellucida. After the ovum is harvested, it is matured in a culture dish. During cloning, the ovum is held by creating suction through a hollow pipette against the zona pellucida. Then, the ovum membranes are punctured by a thin needle through which the chromosomes and polar body are removed, leaving only cytoplasm and the membranes behind.

A somatic cell is harvested from a separate donor to supply the genetic material of the clone. Somatic cells are any cell other than a reproductive cell. Somatic cells are used to supply the chromosomes, because they divide by mitosis, which produces two cells each with a complete set of chromosomes and equal amounts of cytoplasm. The somatic cell is also matured in a culture dish. During nuclear transfer, the entire somatic cell is inserted into the cytoplasm of the ovum between the outer zona pellucida and the inner plasma membrane. Then, the cell is submitted to a tiny electric pulse of AC voltage that perforates the nuclear membrane of the somatic cell and the inner membrane of the egg. A second pulse, this time of DC voltage, fuses the membranes. These two tiny electric shocks mimic the process of natural fertilization. The sperm head, or acrosome, penetrates the zona pellucida and produces a burst of calcium ions, a biological DC electric shock, that causes the membranes of the two cells to fuse. A few hours later, during both natural fertilization and nuclear transfer, the ovum carrying the somatic cell nucleus begins to divide.

**Works cited:**


**Endnotes:**

1. Kathryn M. Rodriguez-Clark, Ph.D., Department of Ecology and Evolutionary Biology, Princeton University; contributing author in *Genetics and the Extinction of Species*, edited by Landweber and Dobson.

2. Holmes Rolston, III, Ph.D., Department of Philosophy, Colorado State University; in-
ternationally recognized speaker and author of several books, including *Genes, Genesis and God* and *Conserving Natural Value*.

3. Don Sparling, Ph.D., Toxicologist and Wildlife Biologist, USGS Patuxent Research Center, Laurel, Md.; deacon of the Roman Catholic Church and contributing author and co-editor of *Ecotoxicology of Amphibians and Reptiles*.


5. Rolston, p. 5.

Carol Drummond is a current Learner at The Union Institute, working toward her Ph.D. in conservation biology. She has designed her program to strengthen the bridge between science and philosophy and uses the current global decline and malformation of frogs as a barometer of our success in maturing our Earth Ethics. She has a B.A. in philosophy and an M.A. in environmental thought.

With twenty years' experience in surety, casualty and environmental claims, she has a clear understanding of the dynamics that take place in the global marketplace and the changes that must take place there if global society is to become sustainable.

Raised a Presbyterian and now a member of the Methodist Church, she explains that her work in conservation biology and environmental ethics has strengthened her spirituality and taken her beyond any denomination.

**Author's note:** I am truly grateful for the time and thought that Kathryn M. Rodriguez-Clark, Holmes Rolston, III, and Don Sparling put into their answers, exploring by dialogue these ethical issues that confront us.

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