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Bad Ethics, Good Ethics and the Genetic Engineering of Animals in Agriculture

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ABSTRACT: Genetic engineers have been remiss in addressing ethical and social issues emerging from this powerful new technology, a technology whose implications for agriculture are profound. As a consequence of this failure, society has been uneasy about genetic engineering of animals and has had difficulty distinguishing between genuine and spurious ethical issues the technology occasions. Many of the most prominent concerns do not require a serious response. On the other hand, concerns about a variety of possible risks arising from genetic engineering of animals require careful consideration and dialogue with the public. Such concerns are an admixture of ethics and prudence. A purely ethical challenge, however, hitherto not addressed, is represented by problems of animal welfare that arise out of genetically engineering agricultural animals. A principle of "conservation of welfare" is suggested as a plausible moral rule to guide such genetic engineering.

Key Words: Animal Welfare, Ethics, Genetic Engineering

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Introduction

The advent of biotechnology has provided society with what could become the most powerful technological tool ever possessed by humanity. The public response to biotechnology, however, has not been overwhelmingly positive, and a good many social and ethical concerns must be addressed before it will be acceptable to society in general.

Primarily because 20th-century science has tended to distance itself from ethical issues, these issues have been defined for the public by others, sometimes in inaccurate ways. Three very different sorts of issues must be examined and addressed regarding genetic engineering of animals: the claim that it is intrinsically wrong; the claim that it is dangerous to society and nature; and the claim that it is likely to produce a good deal of suffering for animals. Each of these claims will be examined in the context of animal agriculture.

The Denial of Ethics in Science

Genetic engineering is perhaps the most powerful technology ever devised by humans. Although still in its infancy, its potential for affecting health, the environment, the food supply, and the very nature of humans and animals is clear. Whereas scientists generally greet these prospects with unbridled enthusiasm and excitement, the general public is far more guarded and equivocal in its response. In this presentation, I discuss some fundamental issues that must be dealt with in order to both bridge this gulf and ensure the orderly development of one aspect of this technology of direct concern to animal science, the genetic engineering of animals.

In a recent book (Rollin, 1995), I articulated what I call a "Gresham's law for ethics." Gresham's law, it will be recalled, asserts that bad money will drive good money out of circulation. In other words, if people are faced with the option of paying a debt with either of two currencies of the same face value, they will pay with the one possessing the least intrinsic value. A parallel phenomenon occurs in ethics: given a new situation for which no consensus understanding of the moral problems involved exists and given that the situation naturally demands articulation and discussion of such issues, the most shrill and dramatic articulations of these problems will tend to seize the center stage. We in the United States have seen this occur in a variety of newly emerging social issues, such as the use of animals in research, concern with the environment, the advent of women's issues and radical feminism, issues of diversity, issues regarding homosexuality. In the absence of ethically informed

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expertise to counter and moderate the distortions inherent in such formulations, they tend to dominate the social mind and drive the legitimate ethical concerns out of its awareness.

This is, of course, what has occurred *vis à vis* genetic engineering in general, and the genetic engineering of animals in particular. Center stage has been occupied by lurid sound bites calculated to frighten and titillate: "Genetic engineering is playing God"; "Genetic engineering is against nature"; "Genetic engineering does not show proper respect for the gift of life"; "Genetic engineering breaches species barriers and violates species integrity." As empty of content and undefended as these assertions may be, they fill the ethical lacuna in social thought and become entrenched and difficult to counter, and they essentially define the universe of moral discourse for the society.

Much of the blame for this unfortunate state of affairs in the arena of genetic engineering must be laid at the feet of the research community. Part of the problem arises from its insularity and distance from the general public. Even more of the problem comes from scientists' disavowal, in theory and practice, of responsibility for the ethical and social issues raised by new developments in science and technology.

As I have demonstrated (Rollin, 1989), 20th-century science has deliberately distanced itself from social ethical issues in both theory and practice. Nascent scientists are taught that science is value-free, that, in the words of one biology textbook (Keeton and Gould, 1986), "science cannot make value judgements"; that ethical judgments fall within the purview of at worst politicians and at best society in general, but not within the activities of the scientific community. This doctrine, which is a major part of what I have called the ideology or common sense of science, is historically based in a laudable caveat: not to admit into science meaningless, unverifiable assertions of the sort about "life force" or "absolute space" that pervaded 19th-century science. But however laudable its intentions, the results have generated problems, as we shall see.

In practice, scientists follow this ideology and rarely discuss ethical issues occasioned by their activities in courses, journals, conferences, or other forums. As a result, they end up taking indefensible ethical positions without realizing that they are doing so—witness James Wyngaarden's remark that "genetic engineering should not be hampered by ethical considerations" (Michigan State News, 1989), or the numerous versions of the claim that animal use in science is not an ethical issue, it is strictly a scientific question.

In theory and practice, scientists' adherence to this ignoring of ethics runs afoul of ordinary common sense and public sensibilities; regulating research on human and animal subjects and genetic engineering provide instructive cases in point. In addition, the way is paved for opportunists to define the issues in a manner to which it is difficult to respond and from which it is difficult to recover.

What must be indelibly marked by agricultural scientists is that science was not, is not, and can never be value-free, or even ethics-free. When massive amounts of public money are funneled into AIDS research rather than into curing baldness, or when the study of the relationship between race and intelligence is socially disallowed, the *subject matter* studied by science is determined by social ethical values. When biomedical research is performed on rats rather than on unwanted children, and the control of pain in these rats is socially mandated, the *method of science* is determined by social ethical values. And when the degree of statistical reliability demanded in science fluctuates when one is testing the efficacy of a new human drug vs when one is testing a new survey instrument, one again sees the influence of ethics. Experimental design, acceptable sample sizes, and acceptable confidence intervals will vary greatly across different types of research because of moral concerns, even when similar sorts of questions are being asked. Thus the very logic of science is modulated by social ethical concerns.

Similarly, genetic engineering of animals raises significant social ethical concerns that the agricultural science community must address, else these issues will be erroneously defined by others. I have already mentioned such spurious issues, but it is worthwhile to briefly indicate why they are illegitimate.

The Spurious Ethical Issues Raised by Genetic Engineering

The average person, indeed sometimes even the average scientist, will inevitably raise the issues of "playing God" when asked about the ethical issues occasioned by genetic engineering of animals. I would argue that neither this nor any variation of this represents a genuine ethical issue. To be sure, the creation of new forms of life may be offensive or even immoral to certain theological traditions, but that does not mean that such activity represents an ethical problem in secular society not ruled by that tradition. If "playing God" in this area is intrinsically wrong, it is hard to see why damming rivers, eradicating smallpox, and building cities is not also wrong. As a matter of fact, there are numerous theologians from a variety of traditions who do not see genetic engineering as inherently wrong.

One can similarly dismiss, at least on a rational level, the claim of various religious leaders that "the gift of life from God, in all of its forms and species, should not be regarded solely as if they were a chemical product subject to genetic alteration and patentable for economic benefit" (Crawford, 1987). Such a dictum contains no argument or even clear statement of what is allegedly problematic; until these are forthcoming, the position cannot be taken seriously. The same is true of Jeremy Rifkin's claim that genetic engineering "desacralizes nature" (Rifkin, 1985).

One can similarly dismiss Rifkin's and others' jeremiads about the intrinsic wrongness of "violating species integrity" or "crossing species barriers" (Rifkin, 1985). In actual fact, we know that species are not the fixed, immutable rigid building blocks of nature that Aristotle and the Bible believed them to be, but "snapshots" of a dynamic natural process. Species evolve; why then is it intrinsically wrong for humans to participate deliberately in that evolution, especially when we have been doing it since *we* evolved, unwittingly by serving as a selection pressure on other organisms and contrivedly by domestication and by cultivation, preferential propagation, and the whole panoply of artificial selection? Indeed, it is estimated that 70% of grasses and 40% of flowering plants were "created" through human artifice, and vast numbers of animals have been drastically modified (witness the dog).

Theology and environmental philosophy probably provide the unseen skeleton underlying the objection about species integrity. In the case of environmental philosophy, which is a dominant mode of thought in contemporary society, much is made out of the point that species should not be allowed to vanish as a result of human activity. It is a psychologically small step, albeit a conceptually vast one, to move to the view that species ought not *change* at human hands, a position for which no adequate defense exists.

There is another concern sometimes voiced by those who allege the intrinsic wrongness of genetic engineering of animals. Theological types, in particular, object to the "mixing of human and animal traits" (Crawford, 1987). Presumably, this means the insertion of human genetic material into animals, or the insertion of animal genetic material into humans. The former has occurred; as we shall discuss later, the human growth hormone gene was inserted into animals in order to create meatier, leaner animals. To my knowledge, the latter has not been attempted.

What, precisely, is intrinsically wrong with such an admixture? We have certainly inserted animal parts into the human body to treat disease, pig heart valves and pig skin for example, and we routinely use animal products for medical purposes. Suppose that an animal were found that contained genes for preventing cancer (sharks, allegedly, are tumor-free). Suppose, further, that this gene produced no untoward effects in humans; indeed, its only effect was to confer immunity against neoplastic disease. Why would such gene transfer be wrong in and of itself? Similarly, if the case were reversed, and the gene were transferred in the other direction, from humans to animals to instill disease-resistance, it is difficult to see why this would be morally problematic. To be sure, when the human growth hormone gene was transferred to animals, it caused animal disease and suffering, and thus such transfer was wrong because of its *effects*. But one has still not shown that *in and of itself* such transfer is wrong.

Issues of Risk in Genetic Engineering of Animals

The above sorts of objections, claiming that genetic engineering of animals is intrinsically wrong, have fueled the gap in social thought about genetic engineering of animals in the absence of forthright articulation of genuine concerns by the scientific community. We have argued that none of these claims of intrinsic wrongness represent legitimate concerns. Nonetheless, there are genuine issues of risk to humans and to the environment growing out of genetic engineering of animals that must be addressed and managed for the technology to be socially acceptable. The issues discussed above can be resolved if the biotechnology community undertakes such serious and genuine dialogue with the general public on all aspects of this technology, which I believe it must do to survive.

It is vital that discussion of such risks and their management not be restricted to "experts" but rather involve the general public, perhaps through local community review. The general public does not trust experts to articulate risks, to assess their likelihood, or to manage them: they have lived through too many Chernobyls, too many Challengers, too many killer bee escapes. In agriculture, the public has seen the unexpected consequences of DDT, the unanticipated contamination of ground water from herbicides, pesticides, and fertilizers, and the unexpected spillage of millions of gallons of hog manure in North Carolina during the summer of 1995, despite assurances from experts that it could not happen. And indeed, the public has a point—scientists tend to get cavalier about risks in their area; ask any university biosafety officer. Scientists furthermore tend to minimize the danger of unanticipated consequences of new technology or believe that they can fix them with further new technology, whereas members of the general public fear the unknown and tend to believe that technological fixes generate new and unanticipated consequences. Failure to involve the public in such risk-management discussion is very likely to result in rejection of genetic engineering. This has already occurred with bST and with Campbell's genetically engineered tomato. *Jurassic Park* should provide a parable for genetic engineers.

Potential dangers emerging from genetic engineering of animals obviously stem from the rapidity with which such activity can introduce wholesale change in organisms. Traditional "genetic engineering" was done by selective breeding over long periods of time, allowing ample opportunity to observe the untoward effects of narrow selection of isolated characteristics. With the techniques currently available, however, scientists are doing their selection "in the fast lane," and thus we may not detect the problematic aspects of what we are doing until after the organism has been widely disseminated.

Another way to put the same point is that with traditional breeding, there is an *enforced waiting period* necessarily associated with attempts to incorporate traits into organisms. In the animal arena, especially, one can significantly change animals from the parent stock, but it will take many generations to do so, during which time one has ample opportunity to detect problems with the genome one is creating, or with its phenotypic expression. To be sure, as occurred with the breeding of many pure-bred dogs, one may choose to disregard the untoward effects. But the point is, one could see the problems developing if one cared to do so. With genetic engineering, however, one can insert the desired gene in one effort, and the problems that emerge may be totally unexpected.

There are many instances of this, in fact, even in traditional breeding. One famous example of this concerns corn, and grows out of the phenomenon known as *pleiotropy*, which means that one gene and its products controls or codes for more than a single trait. In this case, breeders were interested in a gene that controlled male sterility in corn, so that one could produce hybrid seeds without detasselling the corn by hand, which is very labor-intensive. So the gene was introduced to provide genetic detasselling. Unfortunately, the gene also was responsible for increased susceptibility to Southern Corn Blight, a fact of which no one was aware. The corn was widely adopted, and in one year a large part of the corn crop was devastated by the disease.

Similarly, when wheat was bred for resistance to a disease called blast, that characteristic was looked at in isolation, and was encoded into the organism. The back-up gene for general resistance, however, was ignored. As a result, the new organism was very susceptible to all sorts of viruses which, in one generation, mutated sufficiently to devastate the crop.

What we have then, *vis à vis* the danger associated with genetic engineering, is what philosophers call an *a fortiori* situation. If such unanticipated consequences can and do occur with traditional breeding, where one of necessity proceeds slowly, how much the more so does the danger of unanticipated consequences loom when one is creating transgenic animals? When one inserts a sequence of DNA (a gene) into an organism, one cannot anticipate pleiotropic activities, where the gene affects other traits one has not anticipated. By the same token, one may have overlooked the need for more than one gene to get the desired result phenotypically. Any of these factors can produce a variety of conditions deleterious to the organism. The way to control this risk, then, whether one is doing traditional breeding or transgenic shortcuts, is to do a great deal of small-scale testing before one releases or depends on the new organism.

The second type of danger resulting from fast-lane genetic engineering of animals can be illustrated by reference to food animals. Here the isolated characteristic being engineered into the organism may have unsuspected harmful consequences to humans who consume the resultant animal. The deep issue here is that one can of course genetically engineer traits in animals without a full understanding of the mechanisms involved in phenotypic expression of the traits, with resulting disaster. Ideally, though this is probably not possible either in breeding or creating transgenics, one can mitigate this sort of danger by being extremely cautious in one's engineering until one has at least a reasonable grasp of the physiological mechanisms affected by insertion of a given gene.

A third general kind of risk growing out of genetic engineering replicates and amplifies problems already inherent in selection by breeding, namely the narrowing of a gene pool, the tendency toward creation of genetic uniformity, the emergence of harmful recessives, the loss of hybrid vigor, and, of course, the greater susceptibility of organisms to devastation by pathogens, as has been shown to be the case in crops.

So, once again, we encounter a problem that already exists in traditional breeding. As we find the traits we consider desirable, we try to incorporate these traits into the organisms we raise, be they plant or animal. We continue to refine and propagate these animals and plants until a particular genome dominates our agriculture. In other words, we put all our eggs in one basket. The number of strains of chicken in production of eggs and broilers, for example, has decreased precipitously since the rise of large corporate domination of the industry during the last 40 years. What this means in practical terms is that the industry stands and falls by what it considers the few superior genomes it has developed. If circumstances change, or if a new pathogen is encountered, wholesale devastation of the population will of necessity occur and has occurred, for example by Newcastle's disease or influenza. Loss of genetic diversity means loss of potential for adaptation to new circumstances.

The way in which genetic engineering can accelerate this tendency is clear. Suppose a "superior" animal is created transgenically with great rapidity. Those who utilize this animal gain a clear competitive edge, be it because of increased disease resistance, greater efficiency in feed conversion, greater productivity, or whatever. In order to compete, other farmers replace their stock with this animal, because old strains are viewed as obsolete. The entire branch of agriculture tends toward a monoculture, with the extant gene pool severely limited. Over a period of time, however, untoward consequences of the new genome emerge, be it disease susceptibility, reproductive problems, stress susceptibility, or some other problem. A potentially disastrous situation forms because the best sort of response to the crisis has been lost with the loss of genetic diversity. Alternatively, social or economic circumstances may change so as to require change in agricultural practices or locale such that the extant genome does not fit well with the new circumstances. Once again, the presence of a limited gene pool militates against the sort of quick, reasonable, and efficacious response that a diverse gene pool would provide. In the end then, genetic engineering of animals runs the risk of accelerating the tendency that is already established in at least certain portions of animal agriculture (the chicken and egg industry, for example).

A fourth set of risks arises from the fact that in certain cases, when one changes animals, one can thereby alter the pathogens to which they are host. This can potentially occur in two ways. First, in genetically engineering for resistance to a given pathogen in an animal, one unwittingly could create an environment in the animal favorable to a natural mutation of that pathogenic microbe to which the modified animal would not be resistant. These new organisms then could be infectious to these other animals, or to humans. (Society already has witnessed such untoward consequences as a result of its indiscriminate use of antibiotics in medicine and agriculture. Widespread use of these drugs killed off susceptible bacteria, and in essence served to select for bacteria that were resistant to them.)

One possible example of this sort of reaction has recently been discussed regarding the so-called SCID mouse developed as a model for AIDS (Lusso et al., 1990). These animals are genetically engineered to possess a human immune system and are then infected with the AIDS virus. Some researchers suggest that, in such a mouse, the AIDS virus could become more virulent and infectious by interacting with native mouse viruses, thereby taking on new characteristics such as, for example, becoming transmissible by contact with the airborne virus. It is for similar reasons that the National Institutes of Health, which has developed a different mouse model for AIDS, took extraordinary precautions to ensure that the experimental mice could not accidentally escape.

Even if one were to genetically alter an animal without specifically changing its immune system, one might inadvertently alter the pathogens to which it is host indirectly by changing the microenvironment where they live. This, in turn, could result in these pathogens becoming dangerous to humans or other animals. Thus, for example, in altering agricultural animals such as cattle by genetic engineering, one runs the risk of affecting the pathogenicity of the microorganisms that inhabit the organism in unknown and unpredictable ways. The more precipitous the change, the more difficult it is to estimate the effects of the pathogens.

A fifth set of risks is ecological, associated with the possibility of radically altering an animal and then having it escape into an uncontrolled environment. Although this might seem to be a minimal danger when dealing with intensively maintained and strictly confined swine, chickens, or laboratory animals, it could pose a real problem with extensively managed and loosely confined sheep or cattle, as well as with rodents, or rabbits that may escape despite ordinary precautions, and, most obviously, with fish. Experience teaches us that the dangers of releasing animals into a new environment cannot be estimated, even with species whose characteristics are well known. Witness the uncontrollable proliferation of rabbits and cats released in Australia and the mongoose in Hawaii, as well as our inability to deal with the accidental release of killer bees, or imported snails in our waterways. Ignorance of what could happen with newly engineered creatures is even more certain.

A sixth set of risks is also environmental. By now we are all familiar with the threat to global and regional ecosystems posed by agricultural expansion in Third World countries. Slash-and-burn techniques deployed to provide grazing land for cattle has led to desertification in some areas (Africa) and dramatic loss of species in others (South America). What effect would genetic engineering have on these pernicious pursuits? The answer is not clear. It could be argued in favor of genetic engineering that our ability to genetically adapt animals and plants to indigenous conditions would halt such practices while allowing for economic growth. However, it is equally plausible to suggest that such technology could augment plunder of the environment by foisting animals on all sorts of hitherto undisturbed areas with unimaginable consequences. Once again, it is difficult to foresee such risks.

A seventh set of risks derives from potential military applications of such technology. It is not difficult to imagine the sorts of weapons that could be created using animals as carriers to infect populations with human pathogens.

Finally, the patenting of genetically engineered animals poses socio-economic risks. For example, many farmer groups anticipate that small family farmers might be forced to acquire expensive patented animals in order to compete with large corporations and could well be forced out of business. This, in turn, might strengthen the ever-increasing tendency of large agribusiness to monopolize the food supply. We have ample evidence from bST and elsewhere that the public will reject anything that endangers family farms. The extrapolation of these technologies to Third World cultures, where adequate regulation is unlikely and socio-cultural disruption can threaten the social fabric and way of life, represents another risk in this category.

Issues of Animal Welfare

Responding to the above concerns is just as much a matter of prudence as self-interest for those engaged in genetic engineering, because they are themselves put at risk by many of the dangers enumerated, and because any catastrophic outcomes will likely result in severe restrictions of their activities and in massive public rejection of the technology. A purely moral challenge lies in the issue of the welfare of the animals to be engineered. Because human benefits can and will likely exact a cost in animals suffering, and there is no benefit to humans militating in favor of controlling that suffering, the task of protecting such animals will be formidable. On the other hand, as I have discussed elsewhere, social concern for animal welfare has never been higher in the United States and abroad (Rollin, 1995).

In agriculture, attempts to engineer animals have been largely based on increasing animal efficiency and productivity. Based on the history and the development of confinement systems in industrialized agriculture, it is clear that if the pain, suffering, and disease of the animal does not interfere with the economic productivity, the condition is ignored. (Hence the existence of the so-called "production diseases" endemic to confinement agriculture.) Most important, there are no legal or regulatory constraints on what can be done to animals in pursuit of increasing agricultural productivity, either in agricultural research or in industry. Given the absence of such constraints and the historical willingness of industrialized agriculture to sacrifice animal welfare for productivity, the moral problem inherent in genetically engineering animals for production agriculture is obvious.

Most of the attempts that have thus far been made to genetically engineer farm animals have generated serious welfare problems. For example, attempts to increase the growth rate and efficiency of pigs and sheep by insertion of modified genes to control growth, while achieving that result, have engendered significant suffering (Pursel, 1989). The desired results were to increase growth rates and weight gain in farm animals, reduce carcass fat, and increase feed efficiency. Although certain of these goals were achieved (in pigs, rate of gain increased by 15%, feed efficiency by 18%, and carcass fat was reduced by 80%), unanticipated effects, with significantly negative impact on the animals' well-being, also occurred. Life-shortening pathogenic changes in pigs including kidney and liver problems were noted in many of the animals. The animals also exhibited a wide variety of diseases and symptoms, including lethargy, lameness, uncoordinated gait, bulging eyes, thickening skin, gastric ulcers, severe synovitis, degenerative joint disease, heart disease of various kinds, nephritis, and pneumonia. Sexual behavior was anomalous; females were anestrous and boars lacked libido. Other problems included tendencies toward diabetes and compromised immune function. The sheep fared better for the first 6 mo but then became unhealthy.

There are certain lessons to be learned from these experiments. In the first place, although similar experiments had been done earlier in mice, mice did not show many of the undesirable side effects. Thus it is difficult to extrapolate in a linear way from species to species when it comes to genetic engineering, even when, on the surface, the same sort of genetic manipulation is being attempted.

Second, as we mentioned, it is impossible to effect simple one-to-one correspondence between gene transfer and the appearance of desired phenotypic traits. Genes may have multiple effects, and traits may be under the control of multiple genes. The relevance of this point to welfare is obvious and analogous to a point we made earlier about risk: one should be extremely circumspect in one's engineering until one has a good grasp of the physiological mechanisms affected by a gene or set of genes. A good example of the welfare pitfalls is provided by recent attempts to genetically engineer mice to produce greater amounts of interleukin 4, in order to study certain aspects of the immune system (Lewis et al., 1993). This, in fact, surprisingly resulted in these animals experiencing osteoporosis, a disease resulting in bone fragility, clearly a welfare problem.

Another example is provided by a recent attempt to produce cattle genetically engineered for double muscling (G. Niswender, personal communication). Though the calf was born showing no apparent problems, within a month it was unable to stand up on its own, for reasons that are not yet clear. To the researchers' credit, the calf was immediately euthanatized. Yet another bizarre instance of totally unanticipated welfare problems can be found in the situation where leglessness and cranio-facial malformations resulted from the insertion of an apparently totally unrelated gene into mice (McNeish, 1988).

Thus welfare issues arise both in research on genetically engineered agricultural animals and, more drastically, in potential commercial production. The research animal issues can best be handled with judicious use of anesthesia, analgesia, and, above all, early end points for euthanasia if there is any suffering. The issues associated with mass production of suffering genetically engineered animals must be dealt with in a different way. For this reason, I have proposed the "Principle of Conservation of Welfare" to guide the agricultural industry (Rollin, 1995). This principle states that *genetically engineered animals should be no worse off than the parent stock would be if they were not so engineered, and ideally should be better off*. Genetically engineering disease resistance (e.g., for Marek's disease in chickens) is a good example of the latter case.

Implications

Agricultural scientists cannot ignore the pressing socio-ethical concerns about genetic engineering of animals. By meeting the issues head on, they can first of all separate good ethical coin from bad and avoid the pernicious consequences of our "Gresham's law for ethics." Second, they can listen to and enter into dialogue with the public, engage their concerns about risk, and thereby bridge the gulf of fear and ignorance distancing ordinary people from this new technology. Finally, they can help ensure that the unfortunate tendencies in modern agriculture to place emphasis on productivity and efficiency above animal well-being can be checked in this new technology so as to ascertain that it is "animal friendly" and beneficial to animals as well as people.

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