

Nonhuman Animal Emotions and Human Morals in Animal Research

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Abstract

It has been found that, in at least some species, nonhuman animals experience a range of emotions. As more evidence and knowledge accumulates about animal emotions and the public has more access to information through the internet and media, people are becoming more morally concerned with the treatment of animals in situations such as zoos, sports, and research facilities. In this paper, I argue that due to the recent advancements in the analyzation of animal emotions, it can be concluded that animals are sentient. Therefore, current researchers should be more considerate of the suffering of laboratory animals in testing, and we should move towards eliminating animal testing altogether. In order to support this claim, I analyze and synthesize my research findings on the topics of animal emotions, morals and ethics, and animal research that I have gathered from various scholarly articles. From my research, I have concluded that the United States' government must tighten restrictions and set more specific standards for animal research in legislation and agencies, researchers, scholars, and students must be re-sensitized to the notion that nonhuman animals are in fact sentient beings and that it is morally wrong to knowingly inflict pain onto another sentient being, and the United States must start familiarizing itself with the idea of reduction, refinement, and replacement of animals used in research whether this is done through the government or researchers themselves.

Keywords: animal emotions, sentience, suffering, psychology, animal testing, animal research, ethics, morals

BACKGROUND

Charles Darwin is the scientist who is often credited with being the first to pay serious attention to the study of animal emotions (Bekoff, 2000). Darwin's books, *On the Origin of Species* (1859), *The Descent of Man and Selection in Relation to Sex* (1871), and *The Expression of the Emotions in Man and Animals* (1872) argue that animals are sentient and that there is continuity between humans and nonhuman animals in their emotional lives (Bekoff, 2000, Dawkins, 2006). Darwin believed that animals express a variety of emotions in different ways and, "like any man, [animals] manifestly feel pleasure and pain, happiness and misery," that may only be different in degree, rather than in kind, compared to humans (Dawkins, 2006, Bekoff, 2000).

Since Darwin, it has still been argued that at least some nonhuman animals have basic emotional systems inborn in their brains (fear, play, and panic, for example) that serve as adaptive functions, and that these are also the "building blocks" of all other emotional reactions (Mendl et al., 2010). Researchers have gathered a magnitude of evidence that support this argument, and may even go as far to claim that some nonhuman animals have *deep* and *complex* emotional lives (Bekoff, 2000). Nonhuman animals, such as elephants, whales, chimpanzees, dogs, rats, buffalo, elk, geese, and gorillas, have been observed feeling a range of emotions such as play, love, grief, and embarrassment, and it must be made clear that even if one species experiences these emotions differently from another, it does not mean that they don't experience them at all (Bekoff, 2000). Because of this accumulating knowledge of animals' ability to feel emotions such as pain and the public's growing access to information, more and more people are becoming morally concerned with how animals are treated in situations such as zoos, sports, and research facilities.

Animal research has been around for decades, and more specifically, vivisection on animals dates back to at least the ancient Greeks and Romans (Evans, 2014). The first modern movement against vivisection began in the 19th century in the United Kingdom and the United States (Evans, 2014). The British humanitarian, Henry S. Salt (1851- 1939) believed that the practice of vivisection was “revolting to the human conscience” as he explained in his book *Animals’ Rights Considered in Relation to Social Progress* (1894) (Evans, 2014). During this century in the United Kingdom, animal welfare organizations formed and made efforts for legislation against animal cruelty to be made, and in 1849 the Cruelty to Animals Act was passed and later amended in 1876 to restrict the use of animals in research (Evans, 2014). Animal welfarists also fought vivisection in the United States, and although various groups pushed to outlaw the practice, they were unsuccessful (Evans, 2014).

Animal research in the United States has since grown to test a variety of products for human use. Throughout the first half of the 20th century, some household products contained toxic substances and acids that injured, sickened, and even killed Americans (Evans, 2014). The public became angry with the lack of safety of their products and pressured Congress to strengthen regulations, and thus the Food, Drug, and Cosmetic Act (FDCA) was passed in 1938 and required animal testing (Evans, 2014). Animal testing expanded from initially testing on rats for a time period of less than a month, to a multitude of animal species that required testing for at least 12 to 18 months (Evans, 2014).

As of 2012, 100 million animals were estimated to being used in research facilities in the United States (Goodman et al., 2012). The total number of animals tested in USDA-registered facilities in the United States in 2012 was reported to be 937,580 which excludes mice, rats, and birds because they are not covered under the Animal Welfare Act due to their large numbers in animal research (Evans, 2014).

Those who favor animal research look to the same interspecies similarities and the benefits to human health in order to justify the suffering of the nonhuman test animals (Goodman et al., 2012).

Those who oppose animal testing believe that animals' abilities to feel emotions, such as suffering, and the biological, emotional, moral, and cognitive similarities between humans and nonhuman animals make the practice unethical (Dawkins, 2006, Goodman et al., 2012). The amount of people who oppose animal research and testing continues to rise (Goodman et al., 2012).

EMOTIONS

What are emotions?

In the scientific community, there is still a debate over what emotion is (de Vere & Kuczaj, 2016). It has been broadly referred to as a "psychological phenomena," or something that is an "inner feeling state" induced by a positive or negative situation (Bekoff, 2000, Dixon, 2001, Dawkins, 2008).

What we do know is that there is believed to be a mental component to emotions, but it is not necessary to be able to reflect on the experience or emotion that was felt, and emotions involve some bodily response or sensation whether these are behavioral or physiological (de Vere & Kuczaj, 2016, Dixon, 2001, Dawkins, 2006). These emotion-related sensations are different from physical feelings such as an itch or a stomach ache (Dixon, 2001). These responses can be behavioral, bodily, and/or neural (Mendl et al., 2010).

What emotions do animals feel?

It is believed that, in at least some species of nonhuman animals, there are basic emotional systems inborn in the brain that serve as adaptive functions, and that these are also the “building blocks” of all other emotional reactions (Mendl et al., 2010). These “building blocks” are known as primary emotions (Bekoff, 2000). Moreover, there is also sufficient evidence that has been acquired in the scientific community to conclude that at least some species of nonhuman animals experience a variety and range of emotions (Bekoff, 2000). Animals, such as elephants, chimpanzees, geese, elk, dogs, whales, gorillas, and buffalo, have been observed feeling a range of positive and negative emotions such as play, love, embarrassment, grief, stress, fear, depression, anxiety, and helplessness (Bekoff, 2000, de Vere & Kuczaj, 2016, Rollin, 2011).

Most research done on animal emotions measure negative feelings such as stress or pain. It was found that 74% of articles from 1990 to 2016 that have to do with animal emotions can be found using the keywords: “fear, stress, pain, anxiety, and depression,” and only 6% of articles that involved animal emotions are concerned with positive feelings (de Vere & Kuczaj, 2016). Negative emotions, or “negative matterings,” as used by Philosophy Professor Beth Dixon, are all actions or events that harm animals, and can include both emotional and physical pain (Rollin, 2011). Observed incidents of negative mattering include elephants displaying grief at the loss or absence of a loved one, a cow mooing for months after her calf is separated from her, and an orphaned gorilla becoming depressed after the loss of its mother (Bekoff, 2000).

On the other hand, “positive matterings” are emotions felt such as play, love, happiness, and excitement (Bekoff, 2000). Dogs have been observed seeking out play with one another, and if the partner

refuses to play, the dog will then play with objects or itself. Love has been seen in the courtship of whales by the way a male and female physically behave with each other (Bekoff, 2000, de Vere & Kuczaj, 2016).

How are emotions are measured?

It can be difficult to distinguish between a positive or negative emotion in nonhuman animals based on behavioral responses alone, and there's no way to know for certain the thought process that an animal goes through (de Vere & Kuczaj, 2016, Dawkins, 2006). There are also factors that may affect how an individual organism may react to an emotion based on its own traits and personality along with the organism's pre-existing mood (Dixon, 2001, Mendl et al., 2010). A mood can be "free-floating" which means that it exists even in the absence of an event, and this can influence an organism's decision on how to react to an emotion felt (Mendl et al., 2010). However, researchers have been studying animals in laboratories and through field work to gain evidence about animal emotions through observing a combination of behavioral, bodily, and neural responses.

Behavioral responses can be observed by "asking" an animal what it wants (Dawkins, 2008). By performing "reward-punishment" experiments and using "positive reinforcers" (something that the animal desires) along with "negative reinforcers" (something the animal does not like), behavioral responses will be induced that can be studied and corresponded with emotional states based on the situation (Dawkins, 2000, Mendl et al., 2010, Dawkins, 2008).

Reward-punishment experiments allow discrete emotions to emerge in response to a positive or negative event (Mendl et al., 2010). Animals can work in order to obtain something that they find positively reinforcing. For example, they can press levers, open doors, or move weights to obtain a

“reward” (Dawkins, 2008). If the animal does not obtain the reward it was seeking, then it could be observed feeling frustrated or angry. If the animal does obtain the reward, and is willing to perform the task again, then it is clear that the reward is something that the animal *wants* and it can be said the animal experiences a positive emotion (Dixon, 2001, Dawkins, 2008).

By either the presence of a negative reinforcer or the absence of a positive reinforcer, the animal will perform an observable behavioral response. Behavioral reactions include the animal’s facial expression, posture, manner of walking/moving, and vocalizations (Bekoff, 2000). For example, we know that food and a mother’s young offspring are positive reinforcers, and it has been observed that cows will roll their eyes, where a large amount of the eye white is visible, when they are shown one of these positive reinforcers and unable to reach it. Therefore, we can assume that the cows roll their eyes in frustration due to the absence of a positive reinforcer (Dawkins, 2008).

Bodily responses are always associated with emotions. These responses are autonomic and include reactions such as a bodily odor, change in heart rate, increased attention/focus to threat, fluctuating hormone levels, variations in body temperature, increased blood pressure, and changes in brain activity (Mendl et al., 2010, Dawkins, 2008).

Brain activity can be recorded and studied with brain imaging techniques (Dawkins, 2008). For example, in fMRI studies performed on dogs it has been found that the activity levels of certain areas of the brain correlates with the emotional valence of both dog and human vocal stimuli (de Vere & Kuczaj, 2016). It was also found that the greatest caudate activation was observed in response to the scent of a familiar human, and this indicated a positive reinforcer and therefore a positive emotion (de Vere & Kuczaj, 2016). It has also been proposed that there are “cross-talks” of brain activity that link mood with

discrete emotions, and these can be activated during a range reward-punishment events (Mendl et al., 2010).

ETHICS

Human morals

It is known that humans have basic moral principles along with sympathy, and these two things may act together or separately in cases. Sympathy is a complex psychological process where a person imagines how his or herself would feel if he or she was in another person's situation and then identifying the feelings and reactions to those feelings and vice versa (Lekan, 2004). Sympathy can also be understood as a "strong feeling of compassion" for another person, and the desire to help it which may be based on moral notions (Lekan, 2004).

Care theorist and philosopher, Brian Luke, describes the "care approach" to animal ethics as a "direct sympathetic awareness of animal suffering" which is born from existing emotional experiences (Lekan, 2004). Because sympathetic awareness derives from emotional experiences, it is not a *result* from reflecting on moral principles, although at times moral values may play a role in why a person is feeling sympathetic or how a person may react to feeling sympathetic (Lekan, 2004).

However, a person does not always need to have sympathy to know that something is morally wrong (Lekan, 2004). Moral principles are knowing what is wrong and what is right in a situation. Philosophers and justice theorists, Peter Singer and Tom Regan, argue that the "justice approach" to animal ethics is based primarily on moral principles and explain that the "unfair treatment" of animals is a

moral wrongdoing (Lekan, 2004). Singer and Regan also claim that the challenge justice theorists face is proving to skeptics that nonhuman animals share morally relevant properties with humans, and even if skeptics agree that nonhuman animals *do* share some properties they still may deny that humans and animals have the same moral value (Lekan, 2004). However, most experts that have studied animals and their emotions can conclude that, in at least some species, animals share some type of moral capacity with humans where they behave compassionately and sympathetically (Dixon, 2001).

It is also believed by experts that sentience and the ability to feel pain is what is necessary for a being to deserve moral consideration (Lekan, 2004). Sentience is the ability to feel emotions and it is agreed that at least some species of nonhuman animals possess at least the basic consciousness, or “building blocks,” of emotions (Dawkins, 2006). Therefore, because of sentience and shared moral capacity, it can be concluded that at least some species of animals are entitled some, if not all, the moral value that humans have.

Why animal suffering matters

Pain is necessary for living, but *too much* pain will cause suffering that is detrimental to life. Suffering refers to the experience of negative emotions and a state that an organism would work to get out of or avoid (Dawkins, 2008). Assuming that animals are entitled to some sort of moral consideration because they are sentient and have the ability to feel pain, animal suffering should matter to researchers, students, and scholars (Dawkins, 2006).

The *inability* to feel physical pain can cause an organism to suffer as well. Physical pain is an “alarm system warning” and sends a message to the brain when there is an injury or some other harm

done to the body (Rollin, 2011). The inability to feel pain can be due to a prior injury, genetic malfunction, or nerve-destroying disease, and this often times leads to disease, infection, and eventually death (Rollin, 2011).

The lack of feeling is the kind of suffering that brought the People for the Ethical Treatment of Animals (PETA) to fame in 1981. At the Institute of Behavioral Research in Silver Spring Maryland, paralysis experiments were conducted on monkeys. The monkeys were deprived of sensory input into their spinal cords in order to give them denervated arms which resulted in the monkeys gnawing and licking at their arms (Evans, 2014). A PETA activist was working in the laboratory undercover and secretly photographed the monkeys and contacted the authorities. As a result, the monkeys were confiscated and Congress ordered for the research to be discontinued (Evans, 2014).

Science cannot tell humans how to feel about animal suffering, but it does provide us with reason as to why we have moral beliefs about them. Humans know that it is morally wrong to inflict pain on another organism, so by understanding that animals can suffer and feel pain then it may affect how a human treats an animal (Dawkins, 2008).

ANIMAL RESEARCH/TESTING

What animal research/testing is

Animal test subjects can be used in many capacities. Animals are used by colleges, pharmaceutical companies, hospitals, and biotechnology companies in order to test drugs, cosmetics, home products, surgical procedures, and to investigate diseases and bodily systems (Evans, 2014). These

research, or laboratory, animals often die from procedures, or they are euthanized after the experiment is complete (Evans, 2014).

The Federal Hazardous Substances Labeling Act of 1960 applies to household products. Product safety testing in the United States involves exposing chemicals to animals in areas such as the eyes and skin (Evans, 2014). These tests include acute and chronic toxicity tests, skin and eye irritancy tests, genetic tests, birth defect tests, and cancer potential tests (Evans, 2014).

Toxicity tests on these products are required in order to determine if the ingredients are in fact hazardous (toxic, corrosive, flammable, combustible, irritating to the skin, or generates any kind of pressure when under certain conditions) (Evans, 2014). These tests are performed through ingestion, inhalation, or skin contact (Evans, 2014). Toxicity testing also determines the concentration of the substance necessary in order to kill 50% of the research animals that are being used in a certain period of time (Evans, 2014). These tests are usually performed on rabbits because they cannot blink in order to flush out the chemicals (Evans, 2014).

Cosmetic testing on animals is not required by law, but it's recommended by the FDA and how drug testing carried out is not specified by the FDA (Evans, 2014). However, pharmaceutical companies usually test new drugs on at least two different species of nonhuman animals to discover any toxic side effects, the appropriate dosage of the drug, how the drug is metabolized by the body, and how quickly the drug passes through the body (Evans, 2014).

The majority of animal testing is done for biomedical purposes (biology and biochemistry) at universities and hospitals (Evans, 2014). As of 2005, this area made up about 32% of all animal testing

procedures (Watts, 2007). However, surgical/medical training and behavior research only makes up a small portion of animal research annually, but this is the category of testing that is particularly criticized because animals are often not allowed to regain consciousness or they are euthanized after the procedure is complete (Evans, 2014).

Problems with animal research/testing

The FDA found that nine out of 10 drugs that are effective and safe on animals, did not pass in human clinical trials (Goodman et al., 2012). In a paper on acute toxicity studies that was given at the ninth symposium of the Federation of European Laboratory Animal Science Associations, 12 drug companies and research organizations' views were shared; most felt that the animal data they collected had limited value and three claimed that they only did these studies because they were required to, but the data itself was of no use (Watts, 2007). It has also been found that mice as research animals do not adequately mimic human inflammatory diseases, 150 drugs that successfully treated a sepsis-like condition in mice eventually failed in human clinical trials, human bodies that receive xenotransplanted organs (organs from animals) often reject these organs, and there is evidence that testing involving chimpanzees as subjects rarely accelerates new discoveries or advancements for humans in regards to infectious diseases (Evans, 2014).

Although there are various laws and agency regulations that are concerned with animal research, the language is vague and maltreatment still happens in the laboratory. For example, the Animal Welfare Act includes regulations about the housing and care of the laboratory animals and the licensing, registration and record-keeping requirements for the facility, but the requirements that must be met are vague and the inspection of the facility doesn't have many exact guidelines (Evans, 2014). Some of the

“major requirements” for proposed animal research under the Animal Welfare Act include: procedures must minimize or avoid pain, discomfort, and distress to the research animals, and if a procedure causes suffering, then pain-relieving drugs must be given unless the withholding these drugs is justified, researchers are required to consider alternative forms of testing that will not cause more than slight pain to the animal and if an alternative is not acceptable then reasons for why not must be provided, and researchers must provide a written statement assuring that the research does not unnecessarily duplicate a previous experiment (Evans, 2014). The concern with these regulations is that they are open ended. How can a researcher draw the line between “slight pain” and “too much pain?” What is a “justified” reason for not administering pain-relieving drugs? How can a researcher prove that an alternative test is not acceptable without even trying it first? How much of a difference does there need to be between a current experiment and a previous one?

Abuse and neglect has also been observed in research facilities, and in some cases it has been exposed by animal welfare organizations such as People for the Ethical Treatment of Animals (PETA). For example, in 2010 one of PETA’s many videos exposed an animal facility in North Carolina of many instances of maltreatment and neglect (Evans, 2014). These instances included workers shouting and cursing at animals, squirting the animals with bleach, dragging them by the ears, throwing the animals, not treating sores and the animals’ other health conditions, and allowing the animals to live in their own waste (Evans, 2014). Once these findings were made public, the facility closed down and relinquished all the animals to shelters and rescue organizations (Evans, 2014).

Alternatives to animal research/testing

There are various alternatives to testing on animal subjects. One way would be using synthesized human tissue, organs, and cells that are grown in culture (Evans, 2014). Some synthesized human skin is even commercially available. For example, MatTek is a company that has been marketing synthesized human skin for over ten years (Watts, 2007). Its product, EpiDerm, is composed of a sheet of human skin cells that grow on the surface of a culture medium within a small well (Watts, 2007). A solution is tested by dripping it onto the surface of the sheet then rinsing it off after a certain period of time, and the viability of the cells indicates the toxicity of the solution/chemical (Watts, 2007). Cell cultures have been used in vaccine development and testing, and has improved existing vaccines such as those used for rabies and polio (Watts, 2007).

Another alternative to animal testing is microdosing. Microdosing is tested on humans and uses drug doses that are too small to create a pharmacological effect or harmful reaction (Watts, 2007). This has been made possible by methods that can detect substances in the plasma and blood at very small concentration levels (Watts, 2007).

Mathematical models and computer simulations are also alternative solutions. The database that would hold all of the information needed for simulations and models will have to rely on past animal experiments. However, once the data is compiled, and the relations between molecular structure and activity is understood, the toxicity of a new substance can be predicted with the help of a computer instead of an animal (Watts, 2007).

William M. S. Russell and Rex L. Burch published *Principles of Humane Experimentation Technique* in 1959, which advocates for the reduction, refinement, and replacement of animals used in

research (Evans, 2014). These principles, also known as the “3 Rs,” call for reducing the numbers of animals in testing and the number of procedures that require whole animals, refining practices to reduce animal pain, distress, and suffering, replacing “higher” animal species with “lower” ones, and eventually replacing animal testing with alternative methods (Evans, 2014). The book was practically ignored until the 1980s when protesting animal testing became more widespread, and to this day the 3 Rs are just guiding principles for the United States, not legal requirements (Evans, 2014).

However, the United Kingdom seems to take the 3 Rs more seriously. In May of 2004, the UK government established the National Centre for the Replacement, Refinement, and Reduction of Animals (NC3Rs) which replaced the Medical Research Council’s Centre for Best Practice for Animals in Research (Watts, 2007). The EU also made a commitment in 1991 that requires the commission and member states to “actively support the development, validation and acceptance of methods which could reduce, refine or replace the use of laboratory animals,” (Watts, 2007). It is believed by some researchers that the EU’s steps toward non-animal research methods is a chance to lead the world (Watts, 2007).

ETHICS AND ANIMAL RESEARCH/TESTING

In 1948, the first national survey was conducted by the National Opinion Research Center and it was found that 84% of the public supported animal research, while only 8% opposed it (Goodman et al., 2012). Historically, medical testing (versus product and cosmetic testing, for example) is the area of animal research that has accumulated the most support among the public (Goodman et al., 2012). However, it has been found that the moral acceptability of medical testing on animals among the public has been falling since 2001, and today multiple sources suggest that somewhere between 40 and 60% of the public is opposed to animal research in general, and the numbers continue to rise (Evans, 2014,

Goodman et al., 2012). Greater access to the media and internet has given the public more exposure to how animals are actually treated in laboratories which may account for some of the more recent shifts in beliefs (Goodman et al., 2012).

Many people have an emotional reaction to the idea of animals in distress, and those who are opposed to animal testing claim that the biological, emotional, cognitive, and moral similarities between humans and nonhuman animals make the practice of animal research unethical due to the suffering that the animals experience (Evans, 2014, Goodman et al., 2012, Dawkins, 2006). They argue that the pain and suffering that is imposed on laboratory animals is “too high a moral price to pay” for research (Evans, 2014).

Those who support animal testing argue that the benefits to humans outweigh the costs to animals (Evans, 2014). Researchers who support animal research make note of the veterinary and medical advances that have resulted from testing on nonhuman animals (Goodman et al., 2012).

Despite Darwin’s observations of emotions in nonhuman animals throughout the 19th century, scientists in the 20th century were taught that animals are emotionless “robots,” and scientists did not criticize this dogma (Bekoff, 2000, Rollin, 2011). This idea of nonhuman animals being emotionless “robots” or “machines” conditioned to react to stimuli, was the theory of René Descartes, a *17th century* French philosopher and scientist who performed experiments on live rabbits and dogs during the Renaissance (Bekoff, 2000, Evans, 2014, Goodman et al., 2012). Even today scientists and researchers who directly work with laboratory animals use clinical terms such as “animal models” and “specimens” in attempt to emotionally detach themselves from the animals as beings (Goodman et al., 2012).

Aside from researchers and scientists, in 2011 it was found that only 27% of college graduates disapprove of animal research and that people's support for animal testing increased as education level increased (Goodman et al., 2012). This may be because people with more formal education have been exposed to the idea of animal testing through information that explicitly promotes the practice such as biology and psychology textbooks (Goodman et al., 2012).

However, a growing number of students are opposing dissection in classrooms, where dead animals make up a small portion of research animals used in the U.S. each year (Evans, 2014). The National Science Foundation first urged schools to implement more hands on science material in the 1960s, and that's when dissection first became a norm in the classroom (Evans, 2014). Since then, there have been laws and policies created that have allowed students to opt out of dissection experiments or learn with alternative methods, such as computer models, as students have expressed more ethical and moral concerns with dissection in the classroom over the years (Evans, 2014).

CONCLUSION

As more evidence and knowledge about nonhuman animals' capabilities to feel a range of emotions accumulates, people are growing more morally concerned about the pain and suffering of animals used in testing and research. More research should be done on animal emotions in order to further understand how different emotions are felt, why they are felt, and how various species react to certain emotions. In addition, more alternatives to animal testing need to be proposed and current alternatives, such as computer simulations and mathematical models, need to be perfected.

In order for researchers to be more considerate of animal suffering, and for animal testing to eventually be eliminated altogether, first the United States must use more detailed language in legislation such as the Animal Welfare Act, and government agencies must have tighter restrictions and more specific standards for regulating testing facilities with regards to living conditions, pain control, medical attention, and general animal welfare so that the research animals are not suffering. Secondly, researchers are taught that animal testing is acceptable and are able to distance themselves from the fact these research animals are in fact living organisms that, like humans, have the ability to feel emotions and possess moral values. Therefore, researchers, along with scholars and students, must be re-sensitized to the notion that nonhuman animals are in fact sentient beings and that it is morally wrong to knowingly inflict pain onto another sentient being. Lastly, the United States must start familiarizing itself with the idea of reduction, refinement, and replacement of animals used in research whether this is done through the government or researchers themselves. By taking action now to tighten current regulations and to re-sensitize researchers, scholars, and students, it would make the goal of implementing the reduction, refinement, and eventual replacement of animals in research more achievable in the future.

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