Companion Animals as Technologies in Biomedical Research

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In this paper we examine the use of companion animals (pets) in studies of drugs and devices aimed at human and animal health and situate it within the context of philosophy of technology. We argue that companion animals serve a unique role in illuminating just what it means to use biological technologies and examine the implications for human-animal relationships. Though philosophers have often treated animals as technologies, we argue that the biomedical use of companion animals presents a new configuration of ethical and technological concerns that deserves more attention. Though it seems that companion animals solve many of the ethical dilemmas caused by the use of laboratory animals, the use of companion animals presents its own set of ethical concerns. This paper contextualizes the use of companion animals in research.

1. Introduction

When article co-author Ashley Shew announced to our colleagues in the College of Veterinary Medicine that she had osteosarcoma a few years ago, the reaction was shock. Of course, people get cancer. But we've been embedded with folks from engineering, business, and veterinary medicine at our university, working as part of an Interdisciplinary Graduate Education on Regenerative Medicine, and people in veterinary medicine are very familiar with osteosarcoma as a canine disease—one that is much rarer in humans. Osteosarcoma kills many dogs. It typically requires amputation of

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the affected leg, and while radiation and/or chemo may slow down the progress of the disease, the outlook for a pet diagnosed with osteosarcoma remains very poor. Osteosarcoma is a primary cancer of the bones that metastasizes rapidly. In humans, osteosarcoma presents largely as a pediatric disease, with two-thirds of cases occurring in childhood and adolescence. In humans, when it is caught before it has metastasized (typically to the lungs), the five-year survival rate is about 70%; after the disease has metastasized, the five-year survival rate ranges from 15 to 30% in humans. The protocol for treatment of osteosarcoma in humans involves several rounds of intense chemo, followed by surgery (amputation or limb salvage surgery) to remove the bony tumor, followed by more chemo. The treatment takes about a year, with a longer subsequent period of physical therapy, and much of the chemotherapy requires in-patient hospital stays.

People in the human osteosarcoma community often lament the fact that there have been few advances in the chemotherapy regimens since the late 1980s. The effects of the treatment, both immediate and long-term, are often devastating; long-term side effects often include hearing loss and tinnitus, kidney problems, sterility and early menopause, chemo brain, heart issues, and immediate problems include severe mouth sores, infections, rashes, and more. Treatments for osteosarcoma have changed very little in the past 30 years. Progress on improving treatment protocols has stagnated because of the small number of people who suffer from the disease. Medicine considers osteosarcoma an "orphan disease"—it is rare enough that it provides little incentive for drug companies to invest in research, and it receives little research support from larger cancer charities. However, osteosarcoma affects canines at a much higher rate than it does humans, and one of the biggest hopes for osteosarcoma patients lies in translational research, studies performed on animals that benefit both human and animal health. With their much higher incidence of the disease, companion canines present a rich population of study.

This paper originates from discussions with our colleagues on the topic of regenerative medicine, which includes stem cell science, tissue engineering, and other techniques aimed at the recovery, regrowth, and creation of organic matter for applications in human and animal health. Although we do not employ cases exclusively from the field of regenerative medicine, we do think that companion animals will increasingly be used as test studies for human health as regenerative techniques call for real-world injuries and diseases from which to extrapolate, investigate, test, and heal. Regenerative medicine therefore presents a particular experimental situation that highlights the way that we humans categorize and treat various types of animals.

Companion animals (also known as pets) are animals kept for company; humans find pleasure in the lives of these animals. The category of companion animals excludes livestock, laboratory or research animals, working animals, and sporting animals. If you google "companion animals," you'll likely find studies on how canines reduce blood pressure in humans, or some of the wealth of other studies that look at how companion animals improve human health just by their companionship. But this paper is not about the direct human health benefits of keeping or living with companion animals. This paper concerns the use of companion animals for the testing of biomedical devices, treatments, and drugs—the treatment of companion animals as technologies, and the ambiguities this position reveals about how we already view other animals as technologies. It's already been well established that we can think about laboratory and working animals as technologies (Roman 1984; Lynch 1988; Bulliet 1975), and it has been suggested that companion animals may also be technologies (Pitt 2010). We attempt here to make sense of what the use of companion animals in the testing of biomedical devices and drugs—as technologies—tells us about pets, pet owners, and the human-animal relationship more generally. We also aim to introduce companion animals as a rich subject for reflection within philosophy of technology; framing companion animals as technologies in biomedical contexts provides a window into what our use of other technologies means to those instruments—into our relationships with what we see as things.

2. Companion Animals

"Companion animals" is not a tidy category. Therapy and working animals can serve for companionship at times; dogs, for example, can and do perform multiple roles in the lives of their owners. But the category as it is usually viewed includes species of cats, horses, small rodents (mice, gerbils, hamsters, etc.), birds (canaries, parrots, parakeets), reptiles (snakes, lizards), fish, hermit crabs, pigs, etc. Companion animals are often domesticated species, but not always. Companion animals' value to their owners often comes from their companionship, interest, beauty, affection, sociability, or humor. Tropical fish, for example, are often prized for their beauty; dogs are often noted and valued for loyalty and friendship; and the keeping of cats remains a mystery to all concerned. In the United States alone, citizens currently keep 78.2 million dogs and 86.4 million cats as pets (Humane Society 2012). Companion animals outnumber children at a rate of 4 to 1 (Halper 2013).

Companion animal testing—that is, testing experimental therapies, devices, and drugs for particular health conditions on personal pets who already have those health conditions—seems like it might sidestep some of the ethical concerns associated with laboratory animal testing. Personal pets have an advocate who is concerned (often very concerned) for that animal's health, safety, well-being, and mental state. Unlike laboratory animals, pets are not anonymized or de-personalized; they do not spend their lives in laboratories or cages. In some ways, companion animals as a test group better mirror the contexts of human health: personalized treatment, varying home environments, various diets, native injuries and ailments, and differing levels of activity.

Some diseases that exist in companion animals have an analogue in human health, including bone cancers and heart defects in dogs, kidney disease in cats, tendon and joint issues in horses and dogs, and more. In this context, trying new treatments on truly ill animals (as opposed to laboratory species bred, altered, or induced to have health problems that have human analogues) provides important information about the treatment's effectiveness and potential use in humans. This translational research—research on non-human animals that can be translated into cures and treatments for humans—is becoming increasingly important within the biomedical sciences.[1]

This seems straightforward. But once situated within the context of biomedical research, the companion animal assumes a position that is more fractured, contested, unsettled, and ethically ambiguous. Studies that enroll companion animals are unique, and we must understand both the studies' uniqueness and the uniqueness of the human-pet relationship in order to understand the claim that in biomedical contexts, companion animals often function as novel kinds of technology.

3. Situating Companion Animals: Human-Animal Relationships

Historian Richard Bulliet lays out his account of human-animal relationships in his book *Hunters, Herders, and Hamburgers* (2005). Bulliet (who is known for his 1975 book *The Camel and the Wheel*, which describes how the camel replaced the wheel as the dominant form of technology in some parts of the world, and which won a prize from the Society for the History of Technology), gives a provocative account of human-animal relationships across human history. He explains how human-animal relationships have evolved over eons, and how this evolution affects the way humans today witness, understand, and regard animals. Bulliet's eras of human-animal relationships are not hierarchical. In other words, one stage is not better than any other: a culture that still regards animals in an "earlier" mode is

1. There are now journals, including the *Journal of Translational Medicine* and *Clinical and Translational Medicine*, and programs devoted to translational medicine, including ones at Duke, UCSF, and UT Southwestern.

not lesser than a culture in a "later" mode. Instead, Bulliet offers a historical account of how our relationships with animals have changed. Understanding this history can provide insight into how we think about non-human animals today.

Bulliet's first era of human-animal relationships is Separation. Separation is an unknown period for which no historical record could exist. Separation is the time when humans split off from other hominids, when we started to think of ourselves as distinct from and superior to other animals. To have a sense of a human-animal relationship, humans must see themselves as separate from other animals—as importantly different, as humans and not as animals. As we start to separate ourselves, we start to move to the second stage.

Bulliet's second stage is the era of *Predomesticity*. In Predomesticity, humans share space with animals. Animal symbolism becomes prominent. Over time, shared space with animals shades into use of animals, and animals are divided into the categories of wild and tame. Humans begin to spend more time surrounded by tamer species.

Domesticity is Bulliet's third era. In this era, humans create domestic animals, breeding animals and refining species for distinct purposes. With this shift to viewing animals as workers, the spiritual or romantic connection to animals of earlier eras is lost, for it's hard to feel spiritually connected to a beast of burden. The animals that humans see most frequently in this era are animals who serve human beings, those that have been bred for tasks. Humans become further distanced from "nature" and are separated from wild things by language, thought, and physical distance.

The fourth and final stage of the human-animal relationship is Postdomesticity. Now that people seldom share space with any but companion animals, concerns about animal welfare start to blossom. According to Bulliet, this is the stage where American and some European cultures are today. In this stage, humans are distanced from other species, and civilization witnesses a surge of elective vegetarianism and objections to slaughter, channeling the need for flesh into video games and other violence of a modern era.

Overall, the trajectory through these categories is one of increasing alienation from animals and animality. While Bulliet's account may or may not map onto historical reality, the arc he traces in our relationships with animals, and his account of our current arrangement (with its daily interactions and conceptual distancing), provide an interesting lens through which to look at human-animal relationships today.

That we even discuss "human-animal relationships" suggests that we made a distinction between ourselves and all other species at some point in the past (we do not discuss animal-animal relationships), and in modern life, this conceptual wedge continues to separate us from animality (Bulliet 2005). But biomedical translational research emphasizes the similarities between non-human animals and humans; such research relies on the animality of human beings. In other words, translational research makes explicit the similarities between humans and non-human animals by focusing on diseases which translate between the species. While some translational research is conducted on laboratory animals, studies involving companion animals exist. These studies throw into question our treatment of all animals in the biomedical context, push for greater "patient advocacy" in this arena, and suggest that both animals and humans are treated as technologies in the practice of science. Nowhere is it more evident that we regard our pets and ourselves as technologies as in their use as test subjects.

To use Bulliet's terms, translational medicine brings us back to a place where we consider animals and humans to be a part of the same category; it is premised on the idea that animals are sufficiently like humans to matter. When autologous stem cells are used on horse ligament injuries, we analogize towards the human; if the treatment goes well, we hope that human ligaments will respond to similar treatment. When we enroll dogs with naturally occurring osteosarcoma into trials of new chemo regimens, we hope that any success for them will translate into success for our children. Our concerns about animal welfare are also about human welfare. We would see these animals have improvements in health, and we hope that our bodies will respond similarly. In a post-domestic era, when the animal rights movement has taken off and many protocols exist to guide research on animals, we simultaneously use animals and believe that they are like us. The context of the work relies on animals being like us in very specific ways—and in only those ways.

4. Categories of Animals

Our understanding of animals and of our relationship to them depends on a kind of bracketing—a placing of animals into different categories. These categorizations affect the human-animal relationship and all of the historical, religious, symbolic, political, economic, philosophical and ethical dimensions that it entails. Over time, different animals are assigned to different categories and considered in category-specific and morally significant ways. Although the different categories of animals in use remain fluid and regularly contested, categorical schema do exist.

For example, as Sarah Wolfensohn (2007) explains, in the context of veterinary research and laboratory studies, certain animals are viewed as pure technologies—purely instrumental. Animals like the nude mouse are bred to be standardized animal models, and that is all they are. Lab animals like the nude mouse are often considered to suffer the most insult to their welfare, yet these animals are perhaps the most regulated, and their public advocates are perhaps the most vociferous. Generally, only specific types of animals are "condemned" to the laboratory and its confusing harm-benefit logics. We see the same types of categorical divisions in wild life; wild animals capture the hearts of many, and interest in wild life remains high. But some wild animals who are condemned to particular categories (such as the pest category) are subject to marginalization and eradication. Categorical divisions exist between the laboratory and the wild (zoo animals are laboratory; park animals are wild, and farm animals come with their own philosophical ambiguities), but pets used for experimental research trouble these categories. It seems that there is no one model under which we can understand our relation to non-human animals. We construct a varying and confusing set of relations with different types of animals. These different categories are accompanied by ever-evolving and fiercely contested attitudes towards suffering and welfare, human-animal obligations, what is natural, harm to animals vs. benefit to humans, cost, etc. The policies and regulations in place are inconsistent and do little to mitigate the confusion. We exterminate some; we test drugs on others; we protect and love some of the remaining.

Pets generally receive some of the best treatment—not hunted, not carelessly eradicated, not used for meat.[2] Indeed, in veterinary medical research, treatment of pets is often considered a "family management" issue, and it is often determined by the psychological state of the owners as well as their financial capabilities and geographic location. Pets' special status is visible in the emotional response to euthanasia and animal control measures being used on populations of dogs and cats without owners; these are often considered tragic in a way that the intentional elimination of rats and skunks is not. And although egregious harms and animal abuse do occur, adopted and owned pets usually have good lives compared with other categories of animals.

We keep pets for all sorts of reasons. The breeding history, morphology, physiology, and behavioral and genetic traits of our pets are usually less conditioned, directed, and manipulated than their laboratory counterparts. Unlike nude mice, for instance, who are bred to a strict standard (Wolfensohn 2007), the category of canines contains both intentionally standardized breeds and mutts. But companion animals in biomedical research are a border category; they do not neatly fit into either the pet or the laboratory animal category. Pets in the laboratory offer novel opportunities to reflect on how we categorize animals, human-animal relationships, and what these categories and relationships say about our science and broader

2. And, of course, some types of animals will be pets in one place and meat in another.

cultural interests. With their own history of domestication, with their prominence in human happiness and experience, their role as economic objects, and with their proximity to humans and thus to sophisticated sciences—research, development, therapy—the border category of companion animals in research rests at the nexus of science, technology, animal, and human.

Pets in the laboratory are both a new and an old phenomenon. Indeed, the animal rights movement is rooted in concerns about the use of dogs in laboratories; the Brown Dog Affair in the United Kingdom ignited the anti-vivisectionist movement, and Life Magazine's 1965 coverage of the case of Pepper, a beloved pet who was kidnapped and sold for medical experimentation that ended in her death in 1965, led to public outcry and the passage of the 1966 Animal Welfare Act in the United States (Engber 2009). These changes in policy and research protocols were sparked by the treatment of canines—a group of animals whose feelings we take very seriously (after all, we think of them as having feelings for us). But dogs have always been both companions and technologies; we've relied on dogs for comfort, companionship, sport, work, research, and more—think of Ivan Pavlov's famed drooling dogs, St. Bernard dogs doing winter rescue work, Dalmatians in firehouses, and corgis trotting after Her Majesty Queen Elizabeth. In Bulliet's terms, in Postdomesticity, our only regular contact with animals is with companion animals, and this is shaping how we think about all animals; our concern about dogs and other companion animals is drastically changing the ways we think about using animals in research. The use of companion animals in research presents an opportunity to reconceptualize how we categorize companion animals—a category that only recently became firm.

5. Scenarios of Companion Animal Testing

While the theory of how animals are categorized and of their relations to humans should be developed, our interest here is in very real-world cases—in specifics of how humans use animals classified as laboratory animals in biomedical research and how this compares to our use of companion animals in controlled research studies. This section explores the following three areas of research that feature companion animals in the dual roles of patient and research subject:

(a) dilated cardiomyopathy (DCM) in Doberman Pinschers;
(b) joint, tendon, and bone issues in horses; and
(c) osteosarcoma in dogs.

Although other cases involving different illnesses, injuries, and animals exist, these three areas of research are particularly illustrative for a number of reasons.

The diseases or injuries listed above have one or more of the following characteristics: they are congenital, they are acutely prevalent in an individual animal population, and they are often presently untreatable (often fatal). These areas of research also serve as established animal models for the equivalent diseases and/or injuries in humans, with the potential for breakthroughs to cross over into human medicine. Thus, the work done by basic researchers, translational scientists, and clinicians to treat the three above conditions has the potential to produce a significant and direct impact on the health and well-being of both companion animals and humans. These three particular biomedical contexts, which serve to illuminate the practice of using companion animals as technologies require brief explanation.[3]

(a) DCM in Dobermans

Dilated Cardiomyopathy (DCM) is an insidious congenital disease of the myocardium (or muscle tissue of the heart) that is characterized by a gradual decline in muscle function associated with cardiac dilatation, impaired contraction of the ventricles, and predominantly left-sided congestive heart failure (Everett et al. 1999; Wess et al. 2010). DCM typically progresses undetected, with few or no symptoms. In fact, death is often the first clinical indicator of the disease (Purina 2009). Although known to affect larger breeds such as Newfoundlands, Cocker Spaniels, and Great Danes, DCM occurs at a higher rate in Doberman Pinscher populations than in any other breed. Unfortunately, reliable data on the etiology, development, and morbidity of the disease in Doberman populations does not exist. Clinical appraisals of the situation remain quite bleak. According to several estimates, as many as 30 to 40 percent of all Doberman Pinschers are affected by DCM; of these, nearly 50 percent eventually die suddenly from ventricular arrhythmia or erratic heartbeats (Purina 2009). Dobermans living with the disease often develop a severe cough and experience extreme lethargy, but these symptoms appear only intermittently, and when they do, often go undetected or misdiagnosed.

A recent increase in awareness of the extent and severity of the disease, coupled with the failure of conventional treatment options, has led to a surge of interest in clinical trials that test nontraditional therapies on companion or client-owned Doberman Pinschers with DCM. At the vanguard of such research, several studies are testing techniques that harness the power of the client-owned Doberman's own stem cells to target and rejuvenate areas of the heart affected by the disease. Studies using this method,

3. Another common translational animals model is kidney disease in cats, but we felt that three examples served the goals of this paper.

known as stem cell transplantation therapy, are still in their early stages. However, scientists express optimism that if stem cells can be properly harvested and cultured, they can also be reintroduced into the patient—a process known as autologous transplantation, since the stem cells are both derived from and transferred back into the same Doberman, posing little to no risk of immune rejection. They can then be directed to migrate towards the site of the injured or dying cardiac cells (Purina 2009). Once there, scientists believe that these stem cells (often taken from the bone marrow of a Doberman's humerus in its front legs and femur in its back legs) will "secrete growth factors that stimulate and stabilize [the damaged cells], thus improving organ function" (Purina 2009). This description of stem cell transplantation therapy is greatly simplified, for it is an immensely complex and time-consuming process. However, if these procedures are successful, they would not only immediately improve the health of DCM-affected Dobermans and the emotional well-being of their human owners, but also contribute enormously to our understanding of the role of disease and the functioning of the heart in both human and nonhuman animals. Richard Vulliet (University of California-Davis and medical director of ReGena-Vet Labs) and Amara Estrada (University of Florida College of Veterinary Medicine) are pioneering these stem cell technologies, and studies involving client-owned Dobermans are currently underway.

(b) Tendon and Ligament Injuries in Horses

Stem cell therapies are also being developed to address the widespread prevalence of bone, tendon and ligament injuries in client-owned pet and performance horses. The nature and severity of these injuries vary greatly from horse to horse due to factors such as age, breed, and the kinds of exercise that the horses engage in—for instance, as part of a rigorous sport or performance regimen. Thus, there is great discrepancy in treating bone, tendon, and ligament injuries across the field of equine medicine. For instance, traditional bone repair relying upon mechanical implantation of plates and screws poses numerous problems over the long-term healing process of an injured horse (Smith 2008). It is often a "race" between the failure of the implants before the bone is properly healed and the development of equine supporting limb laminitis, a condition where a horse, typically with a bone fracture, shifts its entire body weight to one or more of its uninjured limbs, damaging its feet (Smith 2008). The horse often experiences great pain, inflammation, and changes in blood flow; when current therapies fail, the horse is often euthanized.

Scientists in the field of regenerative medicine, however, hope to address some of these contributing factors by developing novel stem cell therapies.

The use of mesenchymal stem cells (MSCs) to treat fractures avoids some of the challenges of the internal fixation methods mentioned above; this constitutes, according to some, a "major breakthrough in veterinary medicine" (Smith 2008). MSCs can differentiate into a variety of cell types, including tendon, bone, cartilage, and muscle, and these cells are also showing great utility in the treatment of other types of injuries. Although most programs are still in their infancy, teams such as the University of California Davis Stem Cell Regenerative Group, housed at the Center for Equine Health, are using MSCs to regenerate whole tissues, tendons, and ligaments in the laboratory; MSCs could thus be used to address injuries and illnesses as wide-ranging as strain-induced tendon and ligament damage and degenerative joint disease. Scaffold technologies and gene therapies are also promising new tools in the veterinary scientists' toolbox.[4] Because the horse is an established animal model for focal cartilage injuries, other techniques and procedures may follow on this research.

(c) Osteosarcoma in Dogs

A variety of non-stem cell treatments are being tested in dogs with osteosarcoma, and these trials in canine companions hold great promise for the small human population devastated by this aggressive cancer. Osteosarcoma, the most common type of bone tumor in dogs, can be found in all dog breeds (and, rarely, in cats) (PetMD). The current treatment in both humans and dogs is systemic chemotherapy paired with amputation or limb-sparing surgery (where rods or cadaver bone are used to replace sections of bone). The same types of chemo are standard for both humans and canines with osteosarcoma: doxirubin/adriamycin and cisplatin, sometimes with the addition of others (Hoskins 2004).[5] The chemo protocols for this cancer cause toxicity of the kidneys and heart, and in humans, they require that a port device be inserted to deliver the chemotherapy.

For each of these described species, researchers see animals as models for human disease—as both living beings who deserve health and technologies for improving the long-term health of human beings. The researchers aim to understand and improve health for both animals and humans. What we see in these research practices is a new way to imagine and treat health for both people and pets. We also see companion animals crossing the

4. For further reading, Koch et al. 2009 provides an excellent overview of the field of regenerative medicine and equine injuries.

5. Although this reference is from 2004, the protocols developed in the late 1980s and early 1990s for osteosarcoma are the ones that are currently used. Because of the small population of osteosarcoma patients among humans and lower levels of funding for pediatric cancers, improvements in the chemotherapy treatment of osteosarcoma are slow to come.

boundary between categories, a crossing that shows the instability and fungibility of the categories to which we assign animals. The next section will examine in more detail how these categories operate, and how companion animals as research subjects trouble them.

6. Philosophy of Technology on Animals

Scholars of philosophy of technology have discussed animals in five different ways: some view animals as technologies; some see them as being opposed to technologies; some see them as input-output machines; some treat them as metaphors; and (the most common attitude) some don't address animals in any meaningful way at all. Philosophers who hold the first view—that animals are themselves a form of technology—generally examine humans' development and use of domesticated working animals. Domestication and selective breeding are human techniques that produce the technologies (the animals) that help us, say, herd sheep, have eggs for breakfast, or hunt. In this view, animals are reduced only to their relationships and use to human beings: dogs and chickens are seen as tools, created and shaped for the use and convenience of human beings. This is the view articulated by Paul Thompson of Michigan State, who has written on bioengineered animals and who, with his research group, maintains a blog on "Bio-Engineered Animal Awareness" (http://bio-engineeredanimalawareness.tumblr.com/). While Thompson is critical of the reduction of animals to only technologies, Thompson and his group recognize the ways that animals—especially food animals—are processed and understood by our wider culture. His work highlights the ways we treat animals as technologies and commodities (Thompson 1997). This critical-but-realistic view is shared by Joseph C. Pitt, a philosopher who also breeds Irish Wolfhounds, who has spoken about the ways that breeders of working and show dogs select for different traits and characteristics. In his view, modern farm animals, modern companion species, and (given our long history of arranged marriage and reproduction) even humans are all species whose development and evolution have been deliberately shaped by intentional selection, and therefore constitute technologies (Pitt 2010).

The second group of philosophers of technology treats animals as completely separate from technology. The story goes like this: humans are different from animals because humans make tools, and tools make technologies.[6] In the words of historians of technology Melvin Kranzberg and Carroll W. Pursell, Jr., "[m]an made the tools, but the tools also made

6. Co-author Ashley Shew calls this addition of language about technology as a humans-only project "the Human Clause" in her book *Animal Constructions and Technological Knowledge* (2017).

the man" (Kranzberg and Pursell, 1967, p. 8). In this account, it is our tool use that distinguishes *homo technologicus* from all other species, that makes us superior. This view is widely held in our culture, and it has its roots in Judeo-Christian texts concerning stewardship and care-taking of animals, especially those employed in human service.

There are cases of tool-using animals, of course. To answer these cases while maintaining humans' categorical difference from animals, philosophers of technology dismiss animals' tool-use as mechanical, simply a matter of inputs (stimulus) and outputs (behavior). This viewpoint is expressed in some of the foundational texts of Western philosophical thought: Aristotle's *Metaphysics*, Aquinas's *Summa Theologica*, Descartes's *Discourse on the Method*, and Kant's *Lectures on Ethics*. This third attitude toward animals is influenced by behaviorism and computation logic, and philosophers of technology who hold this attitude extrapolate from input-output machines to the behaviors of animals, which they read as simplistic and unreflective (Baird 2004; Ferre 1988). Newer scholarship on animal tool-use and the relationship of humans to technology shows more nuance (Blad 2010; Shew 2017).

The fourth way that philosophers treat animals is as metaphors for technologies. We talk about the evolution of technology—a phrase that nods toward nature to describe the most "unnatural" of things, technologies. People who want to show that some technological innovation is possible often compare it to the products and production of nature—to the way spiders spin silk, to how bacteria reproduce, to the minute piece-by-piece construction of anthills. Animals are used in this way not because they themselves are viewed as interesting objects of study but because they demonstrate some model of possibility or serve as the impetus for new, creative human approaches to realizing a particular technology. This view of animals and animal constructions as metaphors for human technological capabilities is strongly present in the literature on nanotechnology and biotechnology, and many people who have popularized and journalized science (such as Eric K. Drexler, Ed Regis, and Richard Smalley) rely on metaphors from nature to aid understanding of current and future technological science (Drexler 1986, Regis 1990).

The most common way that philosophers of technology discussed animals is simply to not discuss them at all, even when an animal study would be relevant or when a case study would be enriched by an animal case. Animals are usually absent from technology studies. The recent "engineering turn" in philosophy of technology uses engineering and what engineers do as a representation of all technological thinking, design, and politics, and this turn has both served to distract from larger understandings of technology and to obscure studies of animal construction, understanding, and practice.[7] When we work exclusively within an engineering framework, questions about animal life and relation are occluded by questions of technical knowledge and politics. The increasing research in biomedicine that uses companion animals as a technology of biomedical engineering must broaden this disciplinary frame.

7. Companion Animals as Technologies in Research

The cases of companion animals as medical and veterinary research subjects challenge the simplified categories within which animals are usually lumped. Companion animal research carries with it an idea that we can help non-humans and humans in health at the same time, a concept sometimes called One Health. To some philosophers of technology, this might seem to be a case where animals serve both as technologies and are opposed to technologies. Using animal models for human health implies that the animals are used like other types of technology—computerized simulations and cell cultures on which researchers test treatments. Animals, like devices and scientific models, serve as a medium for testing. However, companion animal bodies, like human bodies, are sites of organic conditions of injury and disease, and the complexity of each individual animal's case denies and resists simple technologization. Laboratory animals—animals used exclusively for research—have their injuries or illnesses induced, and researchers standardize the animals' conditions as much as possible, and the researchers cause harm to initiate the research process. But companion animals have organically developed a particular disease, which means that researchers are working primarily for the health of the animal. The use of companion animals actually reveals more about how human bodies are used in the context of medicine, and perhaps asks us to rethink our complete abstraction of the body from the person, both in humans and in laboratory animals. To think of bodies as models and individuals as representations requires a detachment from context and rich life histories. This detachment has always already existed with regard to laboratory animals, who are bred to be normalized toward particular standards and to present particular phenomena.

Does the use of companion animals in research mitigate the ethical concerns about the well-being of laboratory animals? Laboratory animals reap no benefits from their participation in the research, and their lives are often sacrificed, either for autopsy or at the end of the experiments.

7. Joseph C. Pitt, in *Thinking about Technology* (2000), explicitly moves to examine engineering as a subset of technology. Engineering has been prominent in technology studies by philosophers and historians, including the work of Carl Mitcham, Darryl Farber, Ann Johnson, Cyrus Mody, Walter Vincenti, etc.

Unlike laboratory animals, companion animals have advocates in their owners, and research in which they participate aims to benefit both human and animal health—often to directly benefit that companion animal subject. These animals are not mere means to health outcomes. But although companion animal research avoids some of the ethical concerns about biomedical animal research, it opens up other complications. The use of companion animals reveals the weirdness and illogicality of how we currently categorize animal species—always in terms of human use and benefit, always in terms of how we project instrumentality and utility onto animal bodies as technologies. In this context, our narratives about pets change to focus on use, and this, in turn, enables us to look more critically at how we situate and imagine laboratory animals.[8] By thinking through how companion animals serve as technologies in biomedical research while retaining our concern for their feelings and wellbeing, we bring into relief our lack of concern for other animals' and species' feelings and wellbeing. Just as coverage of the Brown Dog and Pepper led to new policies protecting all animals' welfare, considering the use of companion animals in research can drive a more critical understanding of animal technological ethics.

We love pets and exterminate pests, and our relationships with animals are anything but clear. Donna Haraway's work explains the false binary that "human-animal" invokes, and Pitt has examined the falsity of the natural/artificial distinction (Haraway 2013; Pitt 2000), upon which Bulliet's era of separation depends. These false binaries are further challenged by the emerging configurations of translational medicine and the increased testing on companion animals, which emphasize human-animal similarity while still instantiating a hierarchy based on difference. Pets in drug and device testing throw into relief the ethical tensions inherent in loving and using something or someone else. Making sense of our love for and obligations to our pets tells us about our obligations to the other live things we create and maintain, for laboratory use, farm use, as food, and in many other situations.

If it seems that the use of pets in biomedicine is expanding, especially in the context of regenerative and translational therapies, this is because the use of pets disrupts categories that have ossified in the past 50 years—a period when researchers distanced themselves from animal subjects,

8. Thinking about use is also bolstered by thinking about model organisms, the picking of experimental object, and this history; see Ankeny and Leonelli 2011; Burian 1993. The prominence of use can and should be explored through several approaches. Though this paper is not centered on philosophy of biology, philosophers of biology provide resources for systematically thinking some of these categorical distinctions through, particularly when it comes to selection of what constitutes a good class of animals or organisms to test with particular interests in mind.

stopped publishing animal names in papers, and attempted to project a veneer of objectivity. This change coincides with an increasing movement to Bulliet's age of Post-domesticity. We cannot maintain our notion of separateness between animals and humans when we consider translational research. But the assortment of animal categories in the multiple different organizations that regulate and govern animal testing and use,[9] as well as the multiple and overlapping animal categories we each informally maintain, creates a patchwork of human values about the importance of animals. The use of companion animals in biomedicine demands that we consider the differences between tools and people—that we decide which living things are not, in fact, things. Animals have not until now received wide, sustained consideration in philosophy of technology, but these emergent new categories and their disruption should play a role in our discipline's future considerations, especially as philosophy of technology and science and technology studies (STS) increasingly overlap in shared concerns about the actors and agents that shape history and practice.

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9. USDA (federal US Department of Agriculture), OLAW (non-governmental Office of Laboratory Animal Welfare), AALAC (International Association for the Assessment and Accreditation of Laboratory Animal Care), and local IACUC (Institutional Animal Care and Use Committees) have different and overlapping rules and categories that universities and researchers conducting research with animals must consider. OLAW regulates the widest range of species, while the USDA is concerned with animals used in the production of food.

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