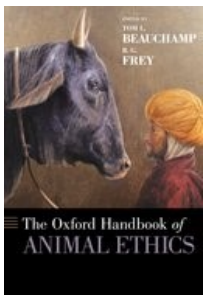

The Oxford Handbook of Animal Ethics

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CHAPTER

29 Animal Experimentation in Biomedical Research

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Abstract

This article discusses the conditions under which it is permissible and advisable to use animals in biomedical experimentation. The "Common View" is that there are moral limits on what we can do to nonhuman animals, but humans can use them when doing so advances significant human interests. This view entails that animals have some moral status, but not a demandingly high status. The idea also states that most people believe that medical experiments using animals do wind up benefiting humans. The "Lenient View" holds that even if animals have moral worth, their worth is so slight that humans can use them virtually any way we wish. The "Demanding View" holds that the moral worth of animals is so high that it bars virtually all uses of animals in biomedical research.

Keywords: biomedical experimentation, moral limits, human interests, moral status

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SHOULD we use animals in biomedical experimentation? Most people think so. They embrace the Common View, which includes both moral and empirical elements. The two-part moral element is that although (a) there are moral limits on what we can do to (some) nonhuman animals, (b) humans can use them when doing so advances significant human interests.[1] Put differently, they think nonhuman animals have some moral worth—that their interests count morally—although that worth is not especially high. The empirical element is that biomedical experiments using animals significantly benefit humans. The truth of these claims would morally justify the practice.

The Common View is one among many views about the moral permissibility of biomedical experimentation using animals. This view is best seen as resting near the center of a moral continuum, with the Lenient View at one extreme and the Demanding View on the other.[2] The Lenient View holds that even if animals have moral worth, their worth is so slight that humans can use them virtually any way we wish and for any reason we wish. The Demanding View holds that the moral worth of animals is so high that it bars virtually all uses of animals in biomedical research. The Lenient and the Demanding Views share one significant

claim: each thinks we need to determine only the moral worth of nonhuman animals to morally evaluate the practice of animal experimentation. However, few people would agree. Most people think we must also
p. 797 know the extent to which biomedical research ↳ on animals benefits humans. Perhaps they are mistaken. Still, since this view is so common, it is a prudent place to begin.[3]

The Moral Status of Nonhuman Animals

Historically, few people have had moral qualms about using animals for their purposes.[4] Even so, most would not have harmed their nonhuman animals frivolously. It would be imprudent for a farmer to fail to feed the pigs she planned to eat or to fail to care for the ox she needed to pull her plow. That would be unwise, just as it would normally be unwise for us to let our houses or automobiles deteriorate. However, few people would have thought that there is anything *intrinsically* wrong with killing an animal or making it suffer,[5] just as few people today would think there is anything *intrinsically* wrong with taking a sledgehammer to their cars. To that extent, the Historical View is a form of the Lenient View. By the mid-1700s, that view began to give way to the Common View. (For a more detailed historical accounting, see the first two chapters in this *Handbook*.)

Indirect Limits on What We Do to Animals

Since what we do to nonhuman animals often benefits or harms humans, we have a reason to be morally concerned about them. Killing someone else's dog is wrong because it harms the animal's owner—much as someone harms her by throwing acid on her Saab or burning her favorite coat. Killing millions of honeybees or overfishing the ocean is wrong because these actions diminish limited resources humans need—much as we would by burning a million acres of Sequoias for a campfire. Disemboweling one's own dog in public would be wrong because it would offend many humans—much as someone would by belching loudly and repeatedly in a quiet romantic café. Finally, hitting, taunting, or killing animals is arguably wrong since people who do so are thereby more likely to mistreat humans.[6] All these considerations limit what we can permissibly do to or with nonhuman animals.

Although these provide plausible human-based reasons for not harming some nonhuman animals, most people do not think these considerations capture the most important moral consideration: harming animals is wrong because of what it does to the animals themselves. In this way the Common View diverges from the Historical View.

Direct Limits

Few people think it is morally acceptable to nail a fully conscious and unanesthetized dog to a board and then slowly disembowel it so we can determine the layout of its organs or see how its blood flows. Few think it is morally acceptable to roast an unanesthetized, fully conscious pig to slightly enhance the taste of pork
p. 798 tenderloin. ↳ According to the Common View, the wrongness of these actions cannot be exhaustively explained by the fact that such actions indirectly harm humans; they are also—indeed primarily—wrong because they harm animals. The harm, according to most people, is that such actions cause pain to animals. How is this relevant to an assessment of biomedical experimentation using animals? Mammals and birds—the most common laboratory animals—can feel pain, and most experiments cause lab animals pain.[7] Most people think we must consider this pain when deciding how to act; they think we should not make these animals suffer needlessly.

Many other people think this is only part of the moral story. They think it is also wrong to kill some animals, at least to kill them without good reason. They believe that animals' lives are valuable. Of course, there are important disagreements about just how valuable nonhuman animals' lives are, and there are disagreements about what counts as a good reason for killing them. Some think we are justified in killing a nonhuman animal only for the same reasons that would justify killing another human—for example, in self-defense. Many others would not go nearly so far, but they would think humans need a compelling reason to take an animal's life. Still others think that any minor human interest would suffice. Still, this much seems true: most people would be appalled at a neighborhood child who shoots squirrels with his BB gun just so that he can watch them writhe in pain and at a businessman who kills a wild gorilla so that he can use its shellacked skull as a spittoon.

How might we explain the idea that nonhuman animals have a valuable life that counts morally? Those who embrace this view likely endorse Tom Regan's claims that some nonhuman animals are "subjects-of-a-life." Regan claims animals have:

> beliefs and desires; perception, memory, and a sense of the future, including their own future; an emotional life, together with feelings of pleasure and pain; preference- and welfare-interests; the ability to initiate action in pursuit of their desires and goals; a psychophysical identity over time; and an individual welfare in the sense that their experiential life fares well or ill for them, logically independent of their utility for others and logically independent of their being the subject of anyone else's interests.[8]

In this view, if we kill a nonhuman animal, we deprive it of a future it desires; we ignore its legitimate interests. Some with moral misgivings about killing nonhuman animals will not buy this explanation. They think nonhuman animals' lives are morally valuable, albeit less valuable that those of humans. "Normal (adult) human life is of a much higher quality than animal life, not because of species, but because of richness; and the value of a life is a function of its quality."[9] In this view, animals' lives cannot be taken cavalierly, but they can be taken if necessary for a significant public good.

Since Regan's view is highly controversial, we might make more progress if we begin by examining animal experimentation assuming only the weaker view that it is wrong to cause an animal needless pain, coupled with the idea that many laboratory animals' lives—especially mammals—have some value, even if that
p. 799 value is not high. After all, virtually all sides of this debate embrace these views—researchers as ↳ well as animal activists, and, according to the Gallup poll, also the American public. Of course, there are still significant disagreements about (a) how valuable nonhuman animals' lives are, (b) what constitutes a good reason for taking their lives or causing them pain, and (c) whether most biomedical experiments using animals provide such a reason.

Knowing that animals have moral worth only lets us know that their interests should count. It does not tell us how *much weight* their interests have or *how* those interests should be counted. These questions are distinct, in part because they usually reflect different theoretical stances. Those who speak of nonhuman animals' interests as having *weight* often embrace some form of consequentialism where the animals' interests, whatever they happen to be, are balanced against competing human interests. If their interests are sufficiently weighty, then we are morally limited in what we can do to animals.

Regan will reject this approach; he will reject any talk of "balancing interests." He thinks that animal interests—like human interests—are not subject to moral calculation, but are rather morally protected by rights.[10] On his deontological view, it is not just that rights are weightier than other considerations; they are trumps that can never be overridden in the pursuit of human goods.

Those who embrace this view think that discussing potential benefits of biomedical experiments using animals is morally irrelevant. On their view, it wouldn't matter if experiments benefitted humans enormously. They would be immoral in precisely the same way and for the same reason that we think nonconsensual experiments on humans, including those performed by the Nazis or in the Tuskegee syphilis study, would be immoral.[11] Right or wrong, most people reject this defense of abolitionism. They think that the benefits of animal experimentation matter morally. It is to this issue that I now turn.

Benefits of Animal Experimentation

The empirical element of the Common View holds that the practice of biomedical experiments using animals substantially benefits humans. This claim, when conjoined with the second moral component of the Common View—the claim that we can use animals when doing so significantly benefits humans—is thought to justify the practice. Notice, though, what follows from saying that the benefits to humans *outweigh* moral costs to animals. It acknowledges that the interests of nonhuman animals carry moral weight.

Since nonhuman animals' interests have moral weight, their interests will sometimes constrain the pursuit of human interests. Clearly they do. All sides of the debate think that we should not keep lab animals in squalid conditions, and all sides think that we should anesthetize laboratory animals against substantial
p. 800 pain, unless there are compelling scientific reasons why we cannot. These are important concessions. ↳ For in the world of limited finances, the money experimenters use to care for (and anesthetize) animals is money they cannot use to conduct more experiments. All sides to the debate thereby acknowledge that respecting the interests of animals limits animal experimentation. Therefore, the issue is not *whether* the interests of animals should constrain animal experimentation. The issue is *how much* and *under which conditions* they should constrain it.

The Prima Facie Case for Animal Experimentation

The case for thinking that experimenting on animals will significantly benefit humans rests on three interlinked pillars: (1) the common sense idea that we can legitimately generalize what we learn from animals to human beings; (2) the claim by many medical historians that animal experiments have been essential for most major biomedical advances; and (3) plausible methodological reasons supporting the common sense and historical arguments. I examine each pillar in turn.

Common Sense Argument

The common sense argument is plausible. We see broad biological similarities between humans and animals, particularly other mammals. Given that, we infer that: the skeletal structure of humans will resemble that of chimpanzees; the blood of humans and rats will circulate in similar ways; the mechanisms whereby rabbits and humans exchange gasses with the air will be comparable; and the reactions of humans and guinea pigs to toxic substances will be akin.

This argument form is plausible. Disputants on all sides of this debate use it. Researchers use these analogical arguments to explain why they think we can safely generalize from animals to humans. Defenders of animals' interests use them to show that nonhuman animals morally resemble human beings. They claim that chimpanzees reason, that dogs scheme, and that rats grieve because these animals act in the same ways humans act when they reason, scheme, or grieve. I suspect, in the end, that the precise forms of these analogical arguments are relevantly different. Still, as a starting point of inquiry, and in the absence of contrary evidence, it is reasonable to make inferences from animals to humans.

Historical Evidence

Historical evidence reinforces the common sense view. According to the American Medical Association:

> [V]irtually every advance in medical science in the 20th century, from antibiotics and vaccines to antidepressant drugs and organ transplants, has been achieved either directly or indirectly through the use of animals in laboratory experiments. The result of these experiments has been the elimination or control of many infectious diseases—smallpox, poliomyelitis, measles—and the development of numerous life-saving techniques—blood transfusions, burn therapy, open-heart and brain surgery. This has meant a longer, healthier, better life with much less pain and suffering. For many, it has meant life itself.[12]

p. 801 Biomedical advances are not simply the result of research seeking a cure to a specific disease or condition (applied research). Basic research—research aimed at understanding "how living organisms function, without regard to the immediate relation of their research to specific human disease—also prompts biomedical discoveries."[13] Finally, it is not just that animal experimentation was necessary for past discoveries, but also it will be essential for future ones. As Sigma Xi claims: "an end to animal research would mean an end to our best hope for finding treatments that still elude us."[14]

Scientific Rationale Supports History and Common Sense

There are good methodological reasons reinforcing the common sense and historical pillars of the argument.

Good Science Requires Controlled Experiments. Scientists want tightly controlled experiments where they can exclude any factors that might skew the study's results. Only then can they be confident they have discovered a causal relationship rather than a mere correlation. However, meeting this scientifically high standard with human subjects is scientifically difficult and often morally impermissible. Suppose researchers want to know if smoking causes heart disease in humans. (a) They cannot merely compare the incidence of smokers who die from heart disease to that of nonsmokers. There may be other factors (e.g., lifestyle choices) that are the primary culprit. (b) Researchers can design reasonably reliable epidemiological studies that exclude many extraneous features (e.g., patients' diets) that could skew the study's results. However, these studies face two problems: (1) designers cannot be confident they know which factors are relevant; (2) even if they knew all relevant factors, they often rely on patients' self-reports to determine if those factors are present (if they smoke or drink and how much they exercise, etc.). However, self-reports are notoriously unreliable. These factors explain why epidemiological studies, although valuable, have several marks against them. (c) In principle, scientists *could* conduct wholly controlled studies on humans: they could seriously limit subjects' motion, their exposure to relevant environmental factors, and their diets. However, controlling humans in these ways would be morally unacceptable. So what is a serious and moral scientist to do?

Intact Systems. Some have suggested that we could use human cells and tissue cultures rather than humans or animals. For some purposes and at some testing stages, we can. However, defenders of biomedical research using animals claim these micro methods are insufficient when we need detailed information about the causes of, or possible cures for, a human disease. Humans and animals are not, they note, loose associations of biological parts; rather, they are intricately related "intact systems." Just as one cannot model the workings of a computer by looking at chips and hard drives lying on a table, one cannot model complex human biomedical behavior by looking at detached human body parts. Only one intact system can reliably model another.[15]

An Intermediate Conclusion

The prima facie case for the validity and importance of biomedical experimentation using animals is
p. 802 plausible. To challenge the case, objectors must show that the ↳ status of nonhuman animals is greater than, or that the benefits of experimentation are less than, most people suppose. In the next section, I address the second possibility, starting with concerns about the prima facie empirical argument.

Evaluation of the Prima Facie Case

The Common Sense View

The common sense argument for the effectiveness of biomedical experiments using animals is sensible. Animals and humans are similar in obvious ways; the issue is whether they are sufficiently similar to justify biomedical inferences from animals to humans. Whether they are depends on the other pillars of the argument. That is where the real work of the prima facie argument is being done.

The Historical Argument

Those defending animal experimentation claim that virtually every medical advance is attributable to that practice. In a minimal sense they are correct. The history of most biomedical discoveries during the last seventy-five years will reveal at least some experiments using animals. However, simply because something is part of a development's history does not mean that it was a causally significant—let alone a necessary—element of that history. Virtually all biomedical scientists drank milk as infants. However, that does not establish that milk drinking leads to biomedical knowledge. Not every element of a history is a significant causally contributory factor of that history.

Researchers are, in most cases, *legally required* to use animals for most biomedical experiments. Given the law, *of course* the use of animals is part of the history of biomedical discovery. So we must determine the degree to which the correlation reflects facts about scientific discovery rather than the state of the law. Defenders of experimentation would argue that it is the former. They contend that surveys of primary research show that this correlation is not simply, or even primarily, an epiphenomenon of the legal system.

There are good reasons to take these surveys seriously, but there are also good reasons to be careful in accepting their findings unquestioningly. Although academic journals and books will report some dissimilarities between animals and humans, they likely underreport them. When scientists are working within a guiding paradigm, we should expect failures to be underreported. If a researcher is trying to discover the nature of human hypertension, and conducts a series of experiments on a gazelle, only to discover that gazelle rarely develop hypertension, then she will likely not report her findings, not because she wants to suppress relevant information, but because most scientists won't be interested (unless, of
p. 803 course, they had ↳ thought about developing a gazelle model of hypertension). Even when scientists do report negative findings, others are less likely to discuss them—especially if the results do not explain the failure. Therefore, these failures, even if common, will rarely be well-known parts of the history of biomedical discovery, although occasionally failures are mentioned if researchers explain why the experiment failed.[16]

We have similar reasons to be careful when interpreting standard histories of biomedical research. When historians of medicine discuss the history of a biomedical advance, they typically underreport failed experiments, even experiments that appear in the primary research literature. This, too, is normal. Historians chronicle events that they think illuminate history. For instance, American historians do not

mention the vast majority of events in our country's past—for example, a two-minute extemporaneous stump speech Adlai Stevenson gave during his second failed run for the presidency. Barring some unusual reason, describing this speech in detail would be a distraction. We do the same thing when telling our personal stories: we focus on events that elucidate our current understanding of ourselves. We downplay, forget, or omit elements of our histories we consider tangential. Biomedical historians likely will not mention (even if they know about) most failed experiments; they see them as diversions from, rather than illuminating elements of, the scientific narrative. Since the use of nonhuman animals is integral to the current biomedical paradigm, we should expect histories to emphasize the successes of that paradigm.

These considerations give us grounds for caution when interpreting both primary research and historians' claims, especially since most of us seek evidence supporting our antecedently held views.[17] We often fall prey to the shotgun effect or we unintentionally engage in selective perception. If I fire a shotgun in the general direction of a target, several pellets will likely hit it. Since researchers conduct thousands of experiments annually, we would expect some substantial successes when surveying the practice over decades. The researcher then commits the fallacy of selective perception if she counts the hits and ignores the misses. For instance, researchers have been trying to understand ALS (Lou Gehrig's disease) for more than seventy years. Yet in "terms of therapeutic treatment of this disorder, we're not that much further along than we were in 1939 when Lou Gehrig was diagnosed."[18] To date, investigators have only found one drug that benefits humans with the disease, and that benefit is slight: it helps extend the patient's life for a few months. Yet researchers continue to employ the same mouse model of ALS that has guided research for years. Even advocates of these experiments acknowledge "previously, medications that have been found to be effective in the mouse model of ALS have not shown benefit when brought to human clinical trials."[19] Given advocates' belief in the power of animal models, they do not construe these failures as a mark against the practice. They continue to hope that each new drug with beneficial results in mice will have similar affects in humans. When they eventually find a beneficial drug, then advocates of biomedical research using animals will doubtless cite the success as proof of animal experimentation's enormous value, despite the previous significant failures.[20]

Opponents of animal experimentation often commit the same fallacies by focusing exclusively on the
p. 804 practice's failures; and failures there are. However, critics ↳ often forget that failures are common in science. We need more than just lists of putative successes and failures. We need to discuss evolution—the overarching biological theory. Why? Although particular scientific "facts" inform and shape theories, theories give us a framework for understanding, interpreting, and evaluating putative facts, especially when the facts are conflicting.

In later sections, I explain how evolution informs this debate. First, I offer some additional "facts" that suggest the limitations of the practice. I want it to be clear that the failure of the mouse model of ALS is not unique.

Some Empirical Evidence Undermining the Reliability of Animal Experimentation

Many people have heard about problems with animal testing on thalidomide, a drug that caused serious physical defects in more than ten thousand children worldwide, but did not appear to have any adverse effects in standard laboratory animals (although researchers later found some species in which the effects were similar). I want to mention other findings that, although less well known, are more instructive. Rats and mice are closely related species; they resemble each other far more than either resembles humans. Despite their close relationships, chemicals that induce cancers in rats produce cancers in mice in only 70% of the time.[21] That is not a wholly insignificant correlation, of course, but it is far from perfect. Then, in roughly a third of these cases, chemicals that produce cancer in both animals do not produce cancer at the same site. This is extremely troubling when we are trying to understand the causes of and mechanisms for treating cancer, sufficiently troubling that it prompted a leading team of researchers to conclude that, in its current form, "the utility of a rodent bioassay to identify a chemical as a 'potential human carcinogen' is questionable."[22]

The problem even pervades the history of one of researchers' vaunted successes. In the early years of polio research, scientists focused almost exclusively on one animal model of the disease, a form of the disease in rhesus monkeys. This obsession, according to researcher and medical historian J. R. Paul, made research focus on the wrong route of infection, and therefore likely delayed the discovery of a treatment for polio by twenty-five years.[23]

There is especially strong evidence of significant biomedical differences between humans and nonhuman animals in teratology (study of abnormal development): "False positives and false negatives abound. Once one has established that a drug is a teratogen for man, it is usually possible to find, retrospectively, a suitable animal model. But trying to predict human toxicity—which is after all what the screening game is about—is quite another matter."[24] It is difficult to find a suitable animal model even in nonhuman primates, our closest relatives.[25] These differences are so profound that we cannot safely generalize findings in animals to humans even for drugs within the same chemical or pharmacologic class.

Finally, species' differences are common in the endocrine system. "[G]enerally the same or very similar
p. 805 hormones are produced by corresponding glands of different ↳ vertebrates. Despite the general similarities, hormones do many different things in different vertebrates."[26] Because the endocrine system plays such a central role in overall function of the body, differences in these systems are amplified elsewhere in the organism. "The poor predictiveness of animal studies for humans thus becomes comprehensible in terms of interspecific variations in endocrinology."[27] These variations are the products of evolution, are conservative inasmuch as they "use" the same biochemical building blocks across species, but they are radical inasmuch as they use those endocrinal blocks for different functional ends.

These brief examples do not show that biomedical experiments using animals are worthless. All areas of even mature sciences have experimental failures. However, these examples do indicate that there are important differences between species. We need a theoretical framework to interpret empirical results, a theory to explain just why we should expect significant species differences. It is to evolutionary theory that I now turn for this framework.

Evolution and Its Influences

Understanding Similarities and Differences Between Species

The current practice of biomedical research is grounded in the work of eighteenth-century French physiologist Claude Bernard.[28] Bernard wanted to make physiology a *real* science by adopting the methods of physics. For him that meant that all life—like all matter—was fundamentally the same. By testing on one species, we can straightaway discover important biological information about another:

> Experiments on animals, with deleterious substances or in harmful circumstances, are very useful and *entirely conclusive* [emphasis mine] for the toxicology and hygiene of man. Investigations of medicinal or of toxic substances also are wholly applicable to man from the therapeutic point of view; for as I have shown, the effects of these substances are the same on man as on animals, save for differences in degree.[29]

Bernard is partly right. There are clear commonalities between species. Having discovered that numerous species of mammals, reptiles, amphibians, and birds have blood circulating throughout their bodies, we can infer that the same will be true of a related species we have not yet examined. To that degree we can generalize from species to species. However, this fact can easily mislead us. We are considering a much narrower issue: Can we reliably infer details of specific human diseases by experimenting on laboratory animals?

To address this question, I must explain the nature and use of animal models of human biomedical phenomena. Researchers seek to identify or create a condition in laboratory animals (AIDS, cancer, etc.) that
p. 806 resembles some human condition they ↳ want to understand. They then proceed in two different ways. Some seek to better understand the nature of the condition in nonhuman animals.[30] This is a form of basic research with no direct application to humans, although the knowledge gained may eventually be used in humans. We will explore this use of animals later.

Other researchers engage in applied research. They directly seek a cure for some human disease or condition. After identifying a potential animal model of the human disease, they may give the animal a drug or excise a growth, or see if implanting stem cells alters that condition. If the intervention cures the animals or attenuates the disease, then others may try the same intervention in a small number of humans—first to see if it is relatively safe (it doesn't cause any significant adverse effects), then to see if it is efficacious. If it is both safe and efficacious, then the researcher will try the intervention in a larger sample of humans. If it is significantly unsafe or demonstrably inefficacious, then they will either modify or abandon the idea.

Two Issues about Models in Applied Research

We now see that to assess the benefits of biomedical experimentation using animals we must answer two different empirical questions. One, is the disease in the laboratory animal relevantly similar to the human condition it supposedly models (the *similarity problem*)? Two, if the models are similar, can we reliably generalize from animals to humans (the *inference problem*)? These issues are clearly related, albeit distinct.

There are always some similarities and some differences between a condition or disease in animals and in humans. I earlier noted obvious ways in which species are similar. They are also different, and different in ways that are biomedically significant. Mice are the standard model of human cancer. However, although 80% of human cancers are carcinomas, sarcomas and leukemia are more common in mice.[31] Additionally, most AIDS research has been guided by animal models in primates, despite important differences between the conditions in the two species: "The only nonhuman primate species that can be reproducibly infected by

HIV is the chimpanzee .... [However] HIV does not replicate persistently in chimpanzees, nor does HIV consistently cause AIDS in this species."[32]

Of course, not all differences undermine inferences from animals to humans. Although a human femur is different from a gorilla femur, most differences will be irrelevant if orthopedists simply want to know how to repair a fractured human femur. On the other hand, seemingly miniscule differences may turn out to be highly significant. Therefore, before we can rely on a model, we must know if the condition in the animal model is *relevantly* similar to the human condition. That is not easy to do.

Suppose, though, we do know that they are highly similar. We must still determine if the methods which prevent, control, or cure the disease in nonhuman animals will do the same in humans (the inference problem). In a not-insignificant number of cases, the answer is "No." As I noted earlier, ALS researchers
p. 807 have long relied on what they deemed a promising mouse model of the disease. Yet after years ↳ of study, the interventions that work in the mouse have been, with one minor exception, unsuccessful in humans.

Although these two questions are independent, they are linked. We often know if differences are relevant only after we discover if research leads to a cure for, or at least an attenuation of, the human condition. However, we cannot know that it leads to a cure or an attenuation until we have conducted tests in both animals and humans. That shows why experiments on animals cannot do what they aim to do—that is, give us *confidence* in predictions about human biomedical phenomena prior to human testing. Still, it may be that animal models are sufficiently similar to the corresponding human condition so that we can make qualified, albeit still useful, inferences about humans. Before we can ascertain that fact, we must determine how common and how deep species differences are. That requires understanding the profound ways that evolutionary forces shape biological organisms.

Evolutionary Influences Prompt Changes

Over evolutionary time, the environments in which animals lived and competed changed. Some animals' food sources either died or became more plentiful. Animals that adapted to their new environments survived or even flourished, while those that did not adapt either disappeared or became less successful. Evolutionary processes prompted biological differences between closely related species, differences that go all the way to the building blocks of life: "[T]he genomes and chromosomes of modern-day species have each been shaped by a unique history of seemingly random genetic events, acted on by selection pressures over long evolutionary times." [33] This history is relevant for assessing biomedical experimentation using animals.

Organizational Complexity Amplifies Adaptive Changes

Defenders of animal experimentation note that animals and humans are highly organized, intact systems. That fact, they claim, is why we must experiment on animals rather than on human parts. They are right by half. Since animals are intact systems, we should be cautious when making inferences from experiments on isolated tissues to humans. However, what this fact gives with one hand, it takes away with the other. The same factors also give us reason to be cautious about making biomedically significant inferences from nonhuman animals to humans. Evolutionary pressures reward species that have advantageous adaptations. These adaptations are frequently biomedically significant. Because humans are intact systems, the adaptations' biological significance is often amplified in one or more of the following four ways.

First, structures and processes interacting with adaptations must change to accommodate them. "New parts evolved from old ones and have to work well with the parts that have already evolved."[34] These accommodations partly explain why beneficial adaptations are rarely unqualifiedly beneficial. Changes advantageous in one niche may become detrimental if the climate changes, a new predator appears on the
p. 808 scene, or the individuals relocate to a new environment. For instance, a single ↳ gene for sickle-cell anemia

is highly beneficial in a malaria-prone environment. The same trait is highly detrimental (because offspring with two sickle-cell anemia genes usually die before fifty years of age) once malaria has been controlled or people susceptible to the trait relocate to a malaria-free area.

Second, a beneficial adaptation might prompt potentially detrimental changes elsewhere in the organism. Humans are more fit because they have relatively large brains. Brain size, though, is limited by skull size. Therefore, humans could develop larger brains only if there were compromises elsewhere within the organism. When human skulls became larger to permit larger brains, human infants had to be born earlier; they were therefore more dependent on parental care than are most mammals. Having more developed cognitive skills is beneficial. Being wholly dependent on one's parents for longer makes human infants especially vulnerable. For instance, more than half of deaths from hunger-related problems are in children under five years of age. Such compromises are ubiquitous. "The body is a bundle of compromises, compromises which, even if they currently serve (or once served) some fitness advantage, now cause disease."[35]

Third, organisms often retain elements of their evolutionary pasts even when those elements no longer promote survival—for example, the human appendix. These structures may affect biochemical processes or create the possibility of detrimental, even life-threatening, conditions, such as appendicitis. Other elements of their evolutionary pasts may significantly influence cellular and metabolic functions.[36]

Fourth, resulting differences between two species may be exaggerated if their "molecular clocks" (the rate at which their DNA and proteins evolve) are different. Although the human and mouse genomes are approximately the same size, "There has been a much longer period over which [genomic] changes have had a chance to accumulate—approximately 80 million years versus 6 million years .... [Moreover] rodent lineages ... have unusually fast molecular clocks. Hence, these lineages have diverged from the human lineage more rapidly than otherwise expected."[37]

In concert, these factors lead to important differences between species, differences greater than those we might initially expect. These give us a reason to think that the results of animal experiments will rarely be straightforwardly applicable to human beings.

Functional, Explanatory, and Causal Properties

To understand the effects of evolutionary change, we must distinguish three perspectives from which we can describe biological phenomena. In talking about ways in which all life is the same we mask these differences. (1) Sometimes we talk about ways an organism functions within its environment: that it moves, exchanges gases with the air, takes in nourishment, and the like. In so doing, we are talking about an organism's *functional properties*. (2) At other times, we describe an organism's mechanisms for achieving these functions. In so doing, we are talking about its *causal properties*. Finally, (3) we sometimes describe an organism's mid-level properties, properties we can see as either causal or functional. For instance,
p. 809 breathing is ↳ a functional property inasmuch as it identifies the fact that an organism exchanges gasses with the air, and it is a causal property inasmuch as it describes (albeit abstractly) a mechanism for performing that function (the *way* the organism oxygenates its blood). I call these dual-purpose properties *explanatory properties*.

Each way of describing an organism's properties serves a different but important purpose. Evolutionary theorists focus on organisms' functional properties to describe how natural selection favored a creature within its environmental niche. Functional properties are also key to understanding a creature's moral status, since, as I noted earlier, a creature counts morally if it can feel pain, think, or emote.

However, biomedical researchers are not currently investigating either functional or explanatory properties since these do not explain disease or uncover cures. In the early years of biomedical discovery, researchers did seek to understand common biological functional properties like the circulation of the blood.[38] Now they are only tangentially interested in these properties. Researchers know *that* the blood circulates; now they want to know the ways blood absorbs oxygen or the way it responds to certain chemicals. In short, they want to identify and understand an organism's causal mechanisms.

Researchers evidence this focus both explicitly and implicitly. They study biological systems to understand what causes or exacerbates a disease or condition. Then they implicitly demonstrate this focus when making inferences from animals to humans. Unless researchers assume that laboratory animals and humans have relevantly similar causal mechanisms, they have no reason to think that a drug or chemical that is harmful to animals will also be harmful to humans. As researchers with the Carcinogenic Potency Project put it, "Without data on the *mechanism* of carcinogenesis, however, the true human risk of cancer at low dose is highly uncertain and could be zero."[39]

Unfortunately, although the distinction between these three perspectives is important, researchers and their apologists either do not notice or appreciate them, or else they assume that if two animals share any properties then they must share all related ones. Neither assumption is plausible. Of course most animals share abstract functional properties: they move within their respective environments, they gain nourishment, and they excrete wastes. Many share the same explanatory properties: most use lungs to exchange gasses with the air. However, only someone guided by the Bernardian paradigm would infer that humans and nonhuman mammals therefore have similar causal mechanisms for all or even most biomedically significant phenomena.

For instance, although cats, rats, pigs, and humans all successfully metabolize phenol (metabolizing phenol could be a functional or even an explanatory property), the mechanism of metabolism varies widely between species. There are two primary mechanisms. Some species metabolize phenol primarily using only one mechanism. For example, pigs rely entirely on one while cats use only the other. Other species use both mechanisms roughly equally.[40] Species differences are evident even in closely related species: humans and New World monkeys use different metabolic pathways.[41] Why do these differences matter? Because
p. 810 researchers often speak as if the condition or disease being studied in laboratory animals strongly ↳ resembles the condition in humans. Evolutionary theory suggests that is not a plausible expectation. We thus have reason to think that nonhuman animals are not, in general, strong models of human biomedical phenomena.

Strong Models

This claim that animals are strong models of human biomedical phenomena might be true if we were talking about functional or explanatory properties. Those properties *are* broadly similar across most mammalian species. However, biomedical researchers using animals study creatures' biomedically significant (causal) mechanisms. It is only by studying these that researchers can understand the causes of, and identify potential cures for, human disease. However, inferences from animals to humans will be questionable if the condition in the laboratory animal differs causally from the human condition. Given the myriad ways that evolutionary forces shape an organism's biological systems, we should expect causal differences. Many differences run all the way to the genome.[42] These differences are not simply, or even primarily, in the number of genes a species has, but in whether, when, and how those genes are expressed (the particular order and manner in which genes turn on or off).[43] That explains why even two seemingly similar animals may be so different biomedically.

In short, evolutionary theory—the theoretical glue of modern biology—gives us reason to expect that a biomedically significant condition in an animal will never be exactly like the condition in humans.

Researchers are usually satisfied if they can find or create a condition in laboratory animals that symptomatically resembles the human condition. However, symptomatic similarity does not guarantee causal similarity. That is why interventions that cure a disease or condition in laboratory animals not infrequently fail in humans. The history of biomedicine is littered with such cases. Researchers have tested 85 potential AIDS vaccines in 197 different human clinical trials. However, although many of these were promising in animal trials (that's why they proceeded to clinical trials), "just 12% of these trials have reached Phase II [an early phase of human testing with a small number of human subjects], only seven (3.5%) have reached Phase III [a later phrase with more human subjects], and altogether, 18 trials were prematurely terminated."[44] One vaccine seemed especially promising given its effects in animals. However, researchers had to stop the clinical trial midstream because it appeared to increase people's susceptibility to HIV/AIDS.[45]

As I was completing this paper, researchers reported one study in which a new vaccine was 31% effective.[46] Some defenders of research have hinted that this just shows how successful animal experimentation is. However, believing that a single and relatively minor success demonstrates the predictive power of animal models simply illustrates the psychological power of the shotgun effect and of selection attention. If this is a success, and we cannot be confident that it is since this is a single study, it comes only after twenty-five years of failures. Perhaps some advocates will claim that all the failures are worth the eventual success.
p. 811 However, that is a ↳ separate question and a moral issue I address shortly. The issue here is the predictive power of animal models. A single minor success (if it is a success) after a quarter century of failures is hardly proof of the predictive power of animal studies.

Where does this situation leave us? Concrete examples and evolutionary processes give us reason to think that animal models are always different to some degree from the human condition they model. Inferences from animals to humans are never certain. In the end, I suspect all serious researchers know that. Talk about animal models being "entirely conclusive for the toxicology and hygiene of man"[47] is just an artifact of the public debate over biomedical experimentation using animals.

Most cautious defenses of the practice usually employ another strategy when defending biomedical experimentation using animals: (1) they emphasize the value of basic research, or (2) they claim that animal models, although causally different from the human condition they model, are similar enough to that condition to justify inferences from animals to humans. I will examine each suggestion in turn.

Other Defenses of the Practice

Basic Research. Many defenders of biomedical experimentation using animals claim that basic research has been profoundly beneficial to humans.[48] Basic research does not directly seek a cure for any disease. Rather it seeks to understand fundamental biomedical phenomena—although this understanding, advocates say, empowers other researchers to find cures for human diseases or conditions. For instance, if basic research explains the causal mechanisms whereby mutant superoxide dismutase 1 induces motor neuron death in a mouse, then clinicians and applied researchers may have insight into ways to prevent, control, or cure human patients with this disease. I have no doubt that some basic research yields applied biomedical fruit. However, we must be careful not to overestimate these benefits. While Comroe and Dripps claimed that well over half of all clinical advances were traceable to basic research, the Health Economics Research Group found that the real figure is much lower, somewhere between 2% and 21%.[49]

Additionally, basic research is also partly vulnerable to the previous arguments about species differences. Knowing how mutations cause neuronal death in a mouse might be scientifically interesting, but on its own, it will not illuminate the mechanisms in humans if the mouse and the human are causally relevantly different. To that extent, basic research will not predictably have the indirect benefits often attributed to it.

Weak Models and Dynamical Systems Theory. We might also think that animal models are valuable if the conditions in animals and humans are *sufficiently* similar to *generally* justify inferences from one to the other. This would be plausible, if, as Bernard thought, biological systems were simple systems, ones where small differences between the model and the condition modeled make little if any difference. However, we have strong evidence that biological systems in higher animals are not simple; they are complex with extensive interactions and feedback mechanisms. Even a small change one place in an organism can have
p. 812 significant effects elsewhere ↳ in that organism. The behavior of complex systems is best explained by *dynamical systems theory*—or what is colloquially called "chaos theory."[50] This theory explains why even seemingly minor differences between two creatures may result in widely different reactions. "Among rodents and primates, zoologically closely related species exhibit markedly different patterns of metabolism."[51]

Where does this leave us? Both empirical evidence and evolutionary theory give us reason to think that inferences from nonhuman animals to humans are never certain. However, it does not show that the practice of using animals as models of human disease does not have reasonable levels of probability or that it has not benefitted humans. The moral question is whether any benefits are morally worth the costs. I now turn now to that question.

The Moral Costs of Animal Experimentation

I begin by combining two strands of argument. Some defenders of biomedical research using animals offer deontological arguments for the practice—arguments that seek to explain why humans can use animals for their purposes. I say a bit more about those arguments at the end of the paper. However, since virtually everyone now acknowledges that nonhuman animals have some moral status, most defenders of the practice employ in significant measure a consequentialist justification of the practice. They claim that biomedical experimentation using animals is justified because of its enormous benefits to human beings. As Carl Cohen, who begins by offering a deontological justification of the practice, puts it:

> When balancing the pleasures and pains resulting from the use of animals in research, we must not fail to place on the scales the terrible pains that would have resulted, would be suffered now, and would long continue had animals not been used. Every disease eliminated, every vaccine developed ... indeed, virtually every modern medical therapy is due, in part or in whole, to experimentation using animals.[52]

Most defenders of biomedical experimentation think that this point supplies a devastating response to any criticism of animal experimentation. They think everyone (a) will acknowledge the enormous benefits of the practice and (b) will acknowledge that such benefits morally justify that practice. These are highly debatable assumptions. One, the earlier arguments suggest that claims about animal experimentation's benefits are bloated. Two, even if animal experimentation has significant benefits, there are enormous moral costs of the practice that defenders do not acknowledge or address. These costs might well be sufficiently great to undermine the legitimacy of the practice, no matter what its benefits. This position might be an alternative
p. 813 route to defending some form of abolitionism. I am unable to fully ↳ evaluate that claim here. What seems minimally true is that defenders must establish profound, and perhaps overwhelming, benefits of experimentation to morally justify the practice.

The Moral Scales

Researchers need to demonstrate the success of animal experimentation even if animals had no moral worth. If animal experimentation were only marginally beneficial, the practice would be a terrible waste of scarce public resources. Our need to demonstrate its success increases once we note that researchers, like most of us, think that nonhuman animals—at least mammals, the most common laboratory animals—have moral status. If nonhuman animals were devoid of value, or if their value were morally negligible, then the impact of experimentation on them would not enter the moral equation. Defenders of research accept that the costs to animals must be given due consideration—not only before permitting the general practice of biomedical experiments using animals, but arguably before we determine if any particular line of experimentation is morally justifiable.[53] For present purposes, I assume that although nonhuman animals have non-negligible moral status or value, their value is considerably less than that of humans. Even granting them minimal value raises potent moral objections to animal experimentation. If arguments against research are potent on this minimalistic assumption, then defenders of research will be vulnerable to arguments showing that the moral value of animals remotely resembles that of humans.

As Cohen's claim suggests, we often think about the choice as two options resting on an old-fashioned set of scales, with the benefits to humans on the right pan of the scales, and the costs to animals on the left. When we ordinarily make a utilitarian calculation, we assume that the creatures in each pan have the same moral worth. Therefore, when deciding what to do, we need consider only (a) the extent of the harms and benefits and (b) the number of creatures harmed or benefitted. However, since I am plausibly assuming that nonhuman animals have less moral worth than humans do, we must modify the relative costs and benefits accordingly. Although this is difficult to specify with precision, we can take inspiration from "cruelty to animal" statutes on the books in most developed countries. Although what counts as "cruelty to animals" varies from jurisdiction to jurisdiction, we can definitely say that it is wrong to inflict excruciating pain on an animal merely to bring a human some tinge of pleasure. Most people think it wrong to roast a chimpanzee alive to make a bookend from its hand or to slowly kill an elephant so we can use its tusks for a paperweight.

Here's the idea. Even if creatures$_A$ have less moral worth than creatures$_H$, as long as the former have non-negligible worth—of the sort specified by "cruelty to animal" statutes—then there are circumstances under which morality demands that we favor them over the latter creatures. If the harm to creatures$_A$ is considerably greater than the benefits to creatures$_H$—or if there are considerably greater numbers of creatures$_A$ suffering that harm—then morality demands that we favor ↳ the former in those circumstances. With this adjustment in place, a utilitarian would hold that the moral permissibility of an action would be the product of (a) the moral worth of the creatures that suffer and benefit, (b) the seriousness of the wrong and the significance of the benefit of those respective creatures, and (c) the number of such creatures that suffer and benefit.[54]

p. 814

That shows that the calculation is more complicated than defenders of animal experimentation suggest. In the public debate, they often cast the choice as one between "your baby or your dog." Since the baby is worth more than the dog, then everyone will choose the baby. However, the choice has not been, nor will it ever be, between "your baby and your dog." Single experiments, and certainly not lone experiments on single animals, will *never* lead to any medical discovery. Only coordinated sequences of experiments can lead to discovery. This is a point about the nature of science; it is not unique to biomedical experimentation. All scientific experiments are part of a pattern of activity—an institutional practice—and discoveries are made though an organized pattern of experimentation. Therefore, the core issue is whether that practice or institution significantly benefits humans. Consequently, we must reformulate the moral question: is this practice—or some attenuated version of it—morally justified even though it kills and causes pain to a significant number of animals?

Two Moral Assumptions

This way of framing the issue still makes it appear that we begin with the scales evenly balanced. Or, if they are tipped, they are tipped in favor of humans since we think that humans have greater moral worth than nonhuman animals. Doubtless that is why defenders such as Cohen claim the benefits of research "incalculably outweigh the evils."[55] However, this claim ignores two widely held moral views, which, if true, tip the scales sharply in favor of nonhuman animals. If I am correct, then defenders of biomedical research using animals must show significant benefits of experimentation to even the scales, let alone to tip them in favor of experimentation. Even if they can do that, we should fully appreciate the moral costs of such research. These costs are generally overlooked or ignored by those defending the practice.

Acts Are Morally Weightier than Omissions

Imagine any morally bad condition. Most people assume it is worse to bring that condition about than allowing it to happen. It is morally worse to kill someone than to let her die, to steal than to fail to prevent theft, and to lie rather than to fail to correct a lie. This claim comes in two forms. The absolute view holds that it is categorically worse to do harm than to fail to prevent it: it is always worse to cause a harm than to fail to stop another harm from occurring, no matter how benign the first and how serious the second. The relative view holds that it is worse to cause a harm than to fail to prevent one, although not categorically so. In some circumstances it is permissible to do a small harm to prevent a much greater one.

p. 815 Regardless of which form one holds, most people think that it is not only worse to do harm than to fail to prevent harm, but that it is *much* worse. Although specifying how much worse is difficult, I can illustrate. Although most people would be aghast if Ralph failed to save a drowning child, particularly if he could have done so with little effort, they would not think Ralph nearly as bad as his neighbor Bob who held a child's head under water until she drowned. Minimally, "much worse" means this: the person who drowns the child should be imprisoned for a long time—if not executed—while the person who allowed the child to drown should not be punished at all, although perhaps she should be morally censured.

If the person had some special duties to the child—for instance, if she were a lifeguard at the pond—then we might hold her liable for the child's death, although even then we would not charge her with first-degree murder. If we did punish her, we would claim her obligation arose because of her special status: she voluntarily assumed responsibility for people swimming in her pond. The current issue we are discussing, however, is about the function the difference between doing and allowing plays in our moral thinking when people have not assumed any special responsibility for those who are harmed. Here the situation is quite different. Even in European cultures with "Good Samaritan" laws, someone who violates such laws—say, by not saving a drowning child—may be punished, but far less severely than someone who kills a child.[56] That signals a profound moral difference.

How is this relevant to the current debate? The researchers' calculation requires rejecting this widely held belief that there is a significant moral difference between harm we do and harm we do not prevent.[57] The experimenter knowingly kills—and often inflicts pain and suffering on—creatures with non-negligible moral worth to prevent future harm to humans. Put more abstractly, she causes harm to prevent future harm. Experimenters would likely contend that the moral asymmetry between doing and allowing is applicable only if the wrong perpetrated is morally equal to the wrong not prevented. Since animals are not as valuable as humans, then the wrong permitted is morally weightier than the wrong perpetrated.

However, the doing/allowing distinction has moral bite even if the harm not prevented is worse than the harm perpetrated. Although it is worse for a child to die than for a child to be spanked for inappropriate reasons, most people think this difference in moral weight is outweighed by the moral asymmetry between what we do and what we allow. That is, most people will think an adult has done something worse if he

spanks his child (or worse still, a strange child) for inappropriate reasons than if he fails to feed a starving child on the other side of the world.[58]

A defender of research might respond that this example is irrelevant since both cases involve children—creatures of the same moral worth. For reasons offered earlier, this objection is misguided. Although the relative worth of creatures enters the moral equation, it is not the only factor. We must also include the seriousness of the harm (significance of the benefit), the number of creatures subjected to that harm (benefitted), and, especially relevant to the current discussion, whether we cause or merely permit the harm. For instance, Ralph intentionally chooses not to send money that would keep a starving Pakistani
p. 816 child alive. His next door neighbor, ↳ Bob, picks up a stray puppy, takes it home and kills it slowly, causing it great pain. Although the law would do nothing whatsoever to Ralph, Bob would be charged with cruelty to animals. Finally, although most people in the community would not condemn Ralph for his inaction, they would roundly condemn Bob for his cruelty and callousness. They would not want to live next door to Bob, nor to have him as a veterinarian.

Some animal researchers might argue that they have special obligations to people—obligations that override the force of this asymmetry. That is not plausible. Lifeguards are hired to save those specific people swimming in their pools from drowning. Animal researchers are not hired to save particular people from kidney disease. They are hired to conduct experiments on animals. Everyone may hope that these experiments would benefit anyone who happens to have the disease. However, that does not mean that the researchers have special obligations to these as-yet-unidentified people. Special obligations are just, that, special: direct obligations to particular, identifiable individuals. Here's a clear way to see the point. If a lifeguard fails to rescue someone swimming in his pool, he can be subject to both civil and criminal penalties. No one who dies of renal failure could sue (let alone successfully sue) an animal experimenter who failed to find a cure for the disease.

Finally, even if we could make sense of the claim that researchers have special obligations to humans who might benefit from their research, it is more plausible to think that they have special obligations to their laboratory animals, since by law investigators are specifically required to care for them.[59]

Consequently, if this asymmetry is morally relevant, it is relevant even given the presumed difference in moral worth. Therefore, unless the benefits to humans are substantially greater than the costs to animals, then these will not outweigh the special immorality of causing harm. How much greater the benefits must be depends in part on whether defenders hold the absolute or relative form of the distinction. However, it is enough to acknowledge that experiments that kill numerous animals and yield only slight benefits to humans will not cut the moral mustard.

Some theorists do not accept this moral distinction; they think there is no moral difference between what we do and what we permit. For them, this asymmetry provides no objection to animal experimentation. Although I have sympathies with this claim, it is not a position most defenders of research embrace. If defenders of animal experimentation do not think that doing harm is worse than failing to prevent harm, then they think that we should pursue any activity that yields benefits greater than that activity's costs. If we could achieve extremely important biomedical benefits only by invasive, nonconsensual experiments on humans, then these would be morally justified. This is a most unwelcomed consequence for most defenders of animal experimentation since they categorically reject nonconsensual invasive biomedical experiments on humans.[60] That denial cannot be defended by those who reject the first asymmetry. At most they can say that such experimentation could be justified only if the benefits were substantial, and because such conditions are rarely satisfied, then nonconsensual experiments on humans are rarely justified.

p. 817 Even this line of defense will be difficult to hold. It is implausible to think that invasive experiments on non-consenting humans would never yield substantial biomedical benefits to many humans. Apparently,

German experiments on inmates taught us a fair bit about treating burns and Japanese experiments on prisoners of war taught us about infectious agents. This should not be surprising. Humans are the best test subjects. If invasive nonconsensual experiments on humans are justified if the benefits are high enough, then nonconsensual experiments will sometimes be justified.

I am not taking a stance on the moral significance of the doing/allowing distinction. My claim is that most defenders of research will be uncomfortable either embracing or denying its significance. If advocates categorically reject invasive nonconsensual experiments on humans, then they must (a) think that nonhuman animals are devoid of moral worth or (b) believe it is categorically worse to commit an evil than to fail to prevent one. The first option clashes with their claim that animals' interests go on the moral scales. The second raises an additional justificatory hurdle to defending the practice since experimenters do harm to prevent harm. Perhaps, though, experimentation is acceptable if the benefits of experimentation are overwhelming.

Definite Harms are Morally Weightier than Possible Benefits

To make matters worse for consequentialist defenders of experimentation, the trade-off is not between harm we do to animals and human suffering we fail to alleviate. That description masks the fact that the suffering of animals is definite while benefits to humans are merely possible. It is sometimes legitimate to give up some definite benefit B in the hope of obtaining a greater benefit B_1—if B_1 is sufficiently great. For instance, I might give up $10 to obtain a 10% chance of gaining $200. Generally speaking, it is reasonable for me to forego a definite benefit B for another benefit B_1, if the product of the utility and probability of B_1's occurring is much greater than the utility of B (being definite, its probability is 1). Therefore, researchers must show that the product of the probability and utility of benefits to humans is greater than the product of animals' definite harm (adjusted for their diminished value) and the number of animals who suffer.

Demanding that researchers establish that any particular experiment will be successful is too stringent. The issue is whether we can reliably predict that the *practice* of experimentation will produce sufficient benefits for humans, benefits that outweigh the costs to nonhuman animals. We will have difficultly doing so because both the utility and the probability of the practice are unknown, while the harm to animals is substantial and definite.

Rejecting this second assumption also comes at considerable cost. It would be the height of foolishness to give up any good G1 for the mere chance of obtaining some other good G2 if G2 were not greater than G1. Abandoning this assumption would be to abandon rationality itself.

What Really Goes on the Scales?

Cohen's accounting of what goes on the moral scales is incomplete. When determining the benefits and costs of animal experimentation, we must include not only the costs to animals (which are direct and substantial), but also the costs to humans (and animals) of misleading experiments. I earlier noted that J. R. Paul claimed that adherence to animal models of polio delayed the development of a vaccine for more than two decades. Many lives were lost or ruined because of this delay.

Animal experiments also seriously misled us about the dangers of smoking. By the early 1960s, human epidemiological studies showed a strong correlation between lung cancer and smoking.[61] Nonetheless, Northrup brushed off the claim that smoking caused cancer thusly, "The failure of many … investigators to induce experimental cancers, except in a handful of cases, during fifty years of trying, casts serious doubt on the validity of the cigarette-lung cancer theory."[62] Finally, an AIDS vaccine researcher has concluded, "The lack of an adequate animal model has hampered progress in HIV vaccine development."[63] These three

cases show that there will be substantial costs *to humans* of relying so heavily on animal experimentation. We should count these costs.

Researchers insist that we should put possible benefits on the scales, since no benefits are certain. That is reasonable, at least if we also include possible costs. For instance, some people speculated that AIDS was transferred to the human population through an inadequately screened oral polio vaccine given to 250,000 Africans in the late 1950s. Such a claim has been widely repudiated.[64] However, even if it is false, something like it might be true. After all, we know that one dangerous simian virus (SV40) entered the human population through inadequately screened vaccine.[65]

Finally, and perhaps most importantly, what is crucial is not the benefits animal experimentation did and will produce, but the benefits that only it could produce. We must determine (a) the role that medical intervention played in lengthening life and improving health,[66] (b) the contribution of animal experimentation to medical intervention, and (c) the benefits of animal experimentation relative to those of nonanimal research. In sum, what goes on the moral scales are not all the purported benefits of experimentation, but only the *increase* in benefits relative to alternatives. Since we do not know what the alternatives would have yielded, determining that increase will be difficult. Minimally, though, we have no reason to think that none of the advances attributable to animal research would have been made without that research.

A Final Dilemma

Deontological Concerns

The previous discussion explores consequentialist concerns about animal experimentation. The practice also faces deontological objections. I mentioned the most obvious one earlier. Tom Regan claims that animals are subjects of a life, and, as such, cannot be used for human purposes.[67] Many animal activists
p. 819 embrace Regan's ↳ idea, though, rightly or wrongly, a majority of people reject it.[68] However, we can combine elements of Regan's view with some empirical arguments in this essay to frame a dilemma for defenders of animal experimentation.

Biomedical researchers claim (1) that biomedical experiments using animals are *scientifically* justified because (carefully selected) nonhuman animals are good models of human biomedical phenomena, and (2) that these experiments are *morally* justified because humans and nonhuman animals are morally relevantly different. To scientifically justify inferences from animals to humans, defenders must identify substantial and pervasive *causal* similarities between humans and nonhuman animals. To morally justify the practice they must find sufficient relevant *functional* differences between humans and nonhuman animals. Defenders of research claim it is easy to do the latter: humans have cognitive and emotional abilities that nonhuman animals lack, at least in sufficient degree.[69] As Cohen put it, "Animals ... lack this capacity for free moral judgment. They are not beings of a kind capable of exercising or responding to moral claims. Animals therefore have no rights, and they can have none."[70]

As it turns out, there is mounting evidence that the mental lives of nonhuman animals are far richer than people historically supposed.[71] However, we can sidestep this question. Defenders of experimentation will have trouble supporting the combination of (1) and (2), whether the differences in mental abilities are great or slight.

To see why, we must understand how scientists explain the presence of cognitive and emotional traits in humans and their absence in animals. The usual answer is that humans have an advanced cerebral cortex, which nonhuman animals lack. Human mental superiority is reflected in differences between our respective "encephalization quotient" (EQ), the ratio of the "brain weight of a species with the brain weight of an

average animal of the same approximate body weight .... According to this formula, the actual brain size of humans comes out to six times what we would expect of a comparable mammal."[72] There is little doubt that the average human is more cognitively sophisticated than the average nonhuman animal, and that we can best explain this difference by differences in our respective brains. However, because biological systems are highly interconnected intact systems, it is implausible to think that human brains, and thus cognitive abilities, evolved without significant biological changes elsewhere in the organism. To think this could have happened researchers must embrace bio-Cartesianism.

Bio-Cartesianism

Descartes claimed that the mind and the brain are ontologically distinct substances operating in wholly different domains and then had a problem getting these substances to interact. Animal experimenters have unconsciously adopted a biological corollary—what Niall Shanks and I call bio-Cartesianism.[73] Animal researchers assume that the brain, although formed by the same evolutionary pressures that shape other biological systems, somehow developed independently of those other systems. This makes no evolutionary
p. 820 sense. Higher-order cognitive abilities evolved ↳ because they were advantageous to the creatures' survival, and, having developed, shaped those creature's biological systems and behavior:

> [S]ome types [of monkeys] have higher EQs than others and [that connects] ... with how they make their living: insect-eating and fruit-eating monkeys have bigger brains for their size, than leaf-eating monkeys. It makes some sense to argue that an animal needs less computing power to find leaves, which are abundant all around, than to find fruit, which may have to be searched for, or to catch insects, which take active steps to get away.[74]

These evolved cognitive differences affect noncognitive biological systems; we must consider these differences in the practice of biomedicine. As one animal research handbook cautions:

> When selecting nonhuman primates because of their close relationship to humans, choice of species of nonhuman primate is important. For example, a completely vegetarian species may not be as useful because of differences in microflora of the intestine, which may affect drug metabolism.[75]

Once we understand the ways that cognitive functioning is related to other biological systems, we can state this deontological dilemma for defenders of research: they must embrace bio-Cartesianism to morally defend their practice and they must reject it to scientifically defend their practice. They embrace it by claiming that humans and animals are sufficiently different to morally permit animals' use as experimental subjects. They reject it by invoking the "intact systems" argument to scientifically defend the practice. Defenders of experimentation cannot have it both ways. If nonhuman animals and humans are sufficiently similar to think that inferences from the former to the latter are scientifically legitimate, then they are likely sufficiently similar cognitively to think that nonhuman animals have significant moral worth. If nonhuman animals and humans are sufficiently different functionally to morally justify the practice, then they are likely sufficiently different biologically so that we have greater reason to suspect that inferences from animals to humans will often be suspect.

Conclusion

I have tried to identify and evaluate arguments for biomedical experimentation using animals. Animal experimentation is not useless as critics sometimes aver. However, neither are the benefits of the practice as clear, direct, or compelling as defenders commonly claim. Likewise, I do not think that the moral arguments defending the practice are wholly wanting, nor are they as persuasive as defenders claim. There are significant moral costs of the practice.

Defenders of the practice carry the moral burden of proof. The moral onus always rests on anyone who wishes to harm sentient creatures, to do what is, all things being equal, a moral wrong. Because people on
p. 821 ↳ both sides of this debate acknowledge at least some level of moral status for nonhuman animals, defenders must provide clear evidence that the value of the institution of research exceeds its moral costs. I suspect that their most promising way of scientifically defending the practice would emphasize limited and focused basic research. The results of that research will rarely yield immediate and direct benefits. However, they arguably provide a broad understanding of biological processes that may suggest promising curative strategies. Whether such benefits are sufficient to morally defend the practice is another question.[76]

Notes

1. A 2003 Gallup poll found "96% of Americans saying that animals deserve at least some protection from harm and exploitation," even if many reject the idea of "animal rights." "Public Lukewarm about Animal Rights," http://www.gallup.com/poll/8461/Public-Lukewarm-Animal-Rights.aspx (accessed January 18, 2010).

2. As far as I know, no one has ever used this particular classificatory scheme. However, I think it will soon become apparent that it nicely categorizes the range of moral views.

3. I am not using claims about "what most people believe" as a surreptitious way of grounding controversial moral claims. However, I think ethicists should begin by addressing common moral views, even if we later conclude that these views are mistaken. What justifies the claim that this is what most people believe? I am a competent speaker of the English language who has discussed these issues with thousands of students at dozens of universities worldwide.

4. Keith Thomas, *Man and the Natural World: Changing Attitudes in England 1500–1800* (London: Allen Lane, 1980), pp. 17, 25, and 31.

5. Lori Gruen, "Moral Status of Animals," *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (Summer 2003), http://plato.stanford.edu/entries/moral-animal/ (accessed February 17, 2010).

6. Immanual Kant, *Lectures on Ethics* (Indianapolis, Ind.: Hackett Pub. Co., 1980), p. 239.

7. David DeGrazia and Andrew Rowan, "Pain, Suffering, and Anxiety in Animals and Humans," *Theoretical Medicine* 12 (1991): 193–211. 10.1007/BF00489606

8. Tom Regan, *The Case for Animal Rights* (Berkeley and Los Angeles: University of California Press, 1983), pp. 243–48.

9. R. G. Frey, "Moral Standing, the Value of Lives, and Speciesism," in *Ethics in Practice: An Anthology*, 3rd ed., ed. H. LaFollette (Oxford: Blackwell Publishers, 2007), pp. 192–204.

10. Regan, *Case for Animal Rights*, pp. 151–55.

11. R. J. Lipton, *Nazi Doctors: Medical Killing and the Psychology of Genocide* (New York: Perseus Publishing, 2000); Tuskegee Syphilis Study Legacy Committee, "A Request for Redress of the Wrongs of Tuskegee," (1996), http://hsc.virginia.edu/hs-library/historical/apology/report.html (accessed May 15, 2003) .

12. American Medical Association, *Use of Animals in Biomedical Research: The Challenge and Response* (Chicago: American Medical Association, 1992), p. 11.

13. J. H. Comroe Jr. and R. D. Dripps, "Scientific Basis for the Support of Biomedical Science," *Science* 192 (1976): 105–
p. 822 11 10.1126/science.769161 ; J. H. Comroe Jr. and R. D. Dripps, "Ben Franklin and ↳ Open Heart Surgery," *Circulation Research* 35 (1974): 661–69; S. Zola, "Basic Research, Applied Research, Animal Ethics, and the Animal Model of Human Amnesia," in *Why Animal Experimentation Matters: The Use of Animals in Medical Research*, ed. E. F. Paul and J. Paul (New York: Transaction Publishers, 2001), pp. 79–92.

14. Sigma Xi, "Sigma Xi Statement of the Use of Animals in Research," *American Scientist* 80 (1992): 73–76.

15. American Medical Association, *Use of Animals in Biomedical Research*, p. 27.

16. The first meta-analysis of the standard mouse model of ALS reveals that "'positive' results are often considered more interesting and hence more likely to be published." Michael Benatar, "Lost in Translation: Treatment Trials in the SOD1 Mouse and in Human ALS," *Neurobiology of Disease* 26 (2007): 6.

17. Psychologists claim that humans are often mislead by "confirmatory biases." See David Dunning's *Self-Insight: Roadblocks and Detours on the Path to Knowing Thyself* (New York: Psychology Press, 2005), pp. 46ff 10.4324/9780203337998 .

18. B. Patoine, "Pitfalls and Promise on the Road to ALS Therapeutics," The Dana Foundation (2009), http://www.dana.org/news/publications/detail.aspx?id=19766 (accessed September 12, 2009).

19. ALS Association, "Trial of Arimoclomol in SOD1–Positive Familial ALS Opens for Enrollment," (2009), http://www.alsa.org/patient/drug.cfm?id=1414 (accessed July 27, 2009).

20. Jim Schnabel, "Standard Model," *Nature* 454 (2008): 683.

21. L. B. Lave, F. K. Ennever, H. S. Rosencrantz, and G. S. Omenn, "Information Value of the Rodent Bioassay," *Nature* 336 (1988): 631–33. 10.1038/336631a0

22. L. S. Gold et al., *Misconceptions about the Causes of Cancer* (Vancouver: Fraser Institute, 2002), p. 35; L. S. Gold, T. Slone, N. Manley, and L. Bernstein, "Target Organs in Chronic Bioassays of 533 Chemical Carcinogens," *Environmental Health Perspectives* 93 (1991): 233–46 10.1289/ehp.9193233 .

23. J. R. Paul, *The History of Poliomyelitis* (New Haven, Conn.: Yale University Press, 1971), pp. 384–85.

24. L. Lasagna, "Regulatory Agencies, Drugs, and the Pregnant Patient," in *Drug Use in Pregnancy*, ed. L. Stern (Boston: ADIS Health Science Press, 1982), p. 15.

25. B. M. Mitruka, H. M. Rawnsley, and D. V. Vadehra, *Animals for Medical Research: Models for the Study of Human Disease* (New York: Wiley, 1976), pp. 467–68.

26. A. Gorbman et al., *Comparative Endocrinology* (New York: Wiley, 1983), p. 33.

27. J. Hart, "Endocrine Pathology of Estrogens: Species Differences," *Pharmacologial Therapy* 47 (1990): 203–
18. 10.1016/0163-7258(90)90087-I

28. American Medical Association, *Use of Animals in Biomedical Research: The Challenge and Response*; Hugh LaFollette and Niall Shanks, *Brute Science: Dilemmas of Animal Experimentation* (New York: Routledge, 1996).

29. Claude Bernard, *An Introduction to the Study of Experimental Medicine* (Paris: Henry Schuman, Inc., 1949), p. 125.

30. Hugh LaFollette and Niall Shanks, "Two Models of Models in Biomedical Research," *Philosophical Quarterly* 45 (1995): 141–
60. 10.2307/2220412

31. B. Alberts et al., *Molecular Biology of the Cell*, 5th ed. (New York: Taylor & Francis, 2008), p. 1207.

32. Lee, "Acquired Immunodeficiency Disease Vaccines: Design and Development," in *AIDS: Biology, Diagnosis, Treatment and Prevention*, fourth edition, edited by V. T. DeVita, Jr (Philadelphia, PA: Lippincott-Raven Publishers, 1997), p. 609.

33. Alberts et al., *Molecular Biology of the Cell*, p. 205.

p. 823 34. Coyne, Jerry, *Why Evolution Is True* (New York: Viking, 2009) p. 81.

35. R. M. Nesse and G. C. Williams, *Why We Get Sick: The New Science of Darwinian Medicine* (New York: Crown Publishers, 1995), p. 4.

36. Coyne, *Why Evolution Is True*, pp. 57–79.

37. Alberts, et al. *Molecular Biology of the Cell*, p. 249.

38. Zola, "Basic Research, Applied Research, Animal Ethics, and the Animal Model of Human Amnesia," pp. 79–92.

39. Gold et al., *Misconceptions about the Causes of Cancer*, p. 34.

40. J. C. Caldwell, "Comparative Aspects of Detoxification in Mammals," in *Enzymatic Basis of Detoxication*, vol. 1, ed. W. Jakoby (New York: Academic Press, 1980), pp. 87–110.

41. E. A. Hodgson, *Textbook of Modern Toxicology* (Hoboken N.J.: Wiley Interscience, 2004), p. 177. 10.1002/0471646776

42. Alberts et al., *Molecular Biology of the Cell*, p. 205.

43. Coyne, *Why Evolution Is True*, pp. 62–80.

44. J. Bailey, "An Assessment of the Role of Chimpanzees in AIDS Vaccine Research," *Alternatives to Laboratory Animals* 36 (2008): 381–428. See pages 386–409 and 412–15 for detailed information drawn from the International AIDS Vaccine Initiative.

45. J. Lauerman, "Merck Aids Vaccine Failure May Doom Promising Study," *Bloomberg.com*, 2009, http://www.bloomberg.com/apps/news?pid=20601109&sid=axb42ai9OAlw (accessed August 22, 2009).

46. M. Falco, "Combo Vaccine Reduces Risk of HIV Infection, Researchers Say," *CNN*, 2009, http://www.cnn.com/2009/HEALTH/09/24/hiv.vaccine/index.html (accessed August 18, 2009).

47. Bernard, *Introduction to the Study of Experimental Medicine*, p. 125.

48. Comroe and Dripps, "Scientific Basis for the Support of Biomedical Science;" Comroe and Dripps, "Ben Franklin and Open Heart Surgery," pp. 661–69.

49. Health Economics Research Group (London: Brunel University, 2003), p. iii.

50. Stephen H. Kellert, *In the Wake of Chaos: Unpredictable Order in Dynamical Systems* (Chicago: University of Chicago Press, 1993).

51. J. C. Caldwell, "Comparative Aspects of Detoxification in Mammals," pp. 85–113 and 106.

52. Carl Cohen, "The Case for the Use of Animals in Biomedical Research," *New England Journal of Medicine* 315 (1986): 865–70 10.1056/NEJM198610023151405 , here p. 868.

53. J. Smith, and K. Boyd, *Lives in the Balance: The Ethics of Using Animals in Biomedical Research* (Oxford: Oxford University Press, 1991), pp. 138–39.

54. LaFollette and Shanks, *Brute Science*, pp. 247–61.

55. Cohen, "Case for the Use of Animals in Biomedical Research," p. 868.

56. H. M. Malm, "Bad Samaritan Laws: Harm, Help, or Hype," *Law and Philosophy* 19 (2000): 707–50, here pp. 744–45.

57. S. R. L. Clark, "How to Calculate the Greater Good," in *Animals' Rights: A Symposium*, ed. D. Patterson and R. Ryder (London: Centaur Press, 1977), pp. 96–105.

58. Such a view is clearly implied by John Arthur in his "Rights and the Duty to Bring Aid," in *World Hunger and Morality*, ed. Will Aiken and Hugh LaFollette (Upper Saddle River, N.J.: Prentice-Hall, 1996), pp. 39–50.

59. See Institute for Laboratory Animal Research, *Guide for the Care and Use of Laboratory Animals* (Washington, D.C.: National Academies Press, 1996), p. 2, http://www.nap.edu/openbook.php?record_id=5140&page=1.

60. Cohen, “Case for the Use of Animals in Biomedical Research,” p. 866; American Medical Association, *Use of Animals in Biomedical Research*, pp. 1, 7.

p. 824 61. See E. Brecher, and R. Brecher, *The Consumers Union Report on Smoking and the Public Interest* (Mount Vernon, N.Y.: Consumers Union Press, 1963).

62. E. Northrup, *Science Looks at Smoking: A New Inquiry into the Effects of Smoking* (New York: Coward McCann, 1957), p. 133.

63. Lee, “Acquired Immunodeficiency Disease Vaccines,” p. 609.

64. For a different view, see B. F. Elwood, and R. B. Striker, “Polio Vaccine and the Origin of AIDS” (Letter to the Editor), *Research in Virology* 144 (1993): 175–77 10.1016/S0923-2516(06)80027-0 .

65. Leonard Hayflick, “Human Virus Vaccines: Why Monkey Cells?” *Science* 733 (1972): 813–14. 10.1126/science.176.4036.813

66. T. McKeown, *The Modern Rise of Populations* (New York: Academic Press, 1976), especially chapter 5.

67. Regan, *Case for Animal Rights*, pp. 243–45.

68. Gallup Poll, “Public Lukewarm about Animal Rights.”

69. M. A. Fox, *The Case for Animal Experimentation: An Evolutionary and Ethical Perspective* (Berkeley and Los Angeles: University of California Press, 1986).

70. Cohen, “Case for the Use of Animals in Biomedical Research,” p. 866.

71. D. G. Griffin, *Animal Minds* (Chicago: University of Chicago Press, 1992); R. J. Hoage, and L. Goldman, eds., *Animal Intelligence: Insight into the Animal Mind* (Washington, D.C.: Smithsonian Institution Press, 1986); C. Allen and M. Bekoff, *Species of Mind: The Philosophy and Biology of Cognitive Ethology* (Cambridge, Mass.: MIT Press, 1997); M. Bekoff, C. Allen, and G. Burghardt, eds., *The Cognitive Animal* (Cambridge, Mass.: MIT Press, 2002).

72. Fox, *Case for Animal Experimentation*, p. 38.

73. LaFollette and Shanks, *Brute Science*, pp. 238–41.

74. M. A. Edey and D. C. Johnson, *Blueprints: Solving the Mystery of Evolution* (New York: Penguin Books, 1989), pp. 189–90.

75. Mitruka et al., *Animals for Medical Research*, p. 342.

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Suggested Reading

Beauchamp, Tom L. “Opposing Views on Animal Experimentation: Do Animals Have Rights?” *Ethics and Behavior* 7 (1997): 113–21. 10.1207/s15327019eb0702_3
Google Scholar WorldCat Crossref

Bekoff, Mark, Colin Allen, and Gordon Burghardt, eds. *The Cognitive Animal*. Cambridge, Mass.: MIT Press, 2002.
Google Scholar Google Preview WorldCat COPAC

Bernard, Claude. *An Introduction to the Study of Experimental Medicine*. Paris: Henry Schuman, Inc., 1949.
Google Scholar Google Preview WorldCat COPAC

Cairns-Smith, A. G. *Seven Clues to the Origin of Life*. Cambridge: Cambridge University Press, 1985.
Google Scholar Google Preview WorldCat COPAC

Cohen, Carl. “The Case for the Use of Animals in Biomedical Research.” *New England Journal of Medicine* 315 (1986): 865–70. 10.1056/NEJM198610023151405
Google Scholar WorldCat Crossref

Comroe Jr., J. H., and R. D. Dripps. “Scientific Basis for the Support of Biomedical *Science.*” *Science* 192 (1976): 105–11. 10.1126/science.769161
Crossref

DeGrazia, David, and Andrew Rowan. “Pain, Suffering, and Anxiety in Animals and Humans.” *Theoretical Medicine* 12 (1991): 193–211. 10.1007/BF00489606
Google Scholar WorldCat Crossref

p. 825 Dresser, Rebecca. “Standards for Animal Research: Looking at the Middle.” *Journal of Medicine and Philosophy* 13 (1988): 123–43.
Google Scholar WorldCat

Edey, Maitland A., and Donald C. Johnson. *Blueprints: Solving the Mystery of Evolution*. New York: Penguin Books, 1989.
Google Scholar Google Preview WorldCat COPAC

Fox, Michael A. *Case for Animal Experimentation: An Evolutionary and Ethical Perspective*. Berkeley and Los Angeles: University of California Press, 1986.
Google Scholar Google Preview WorldCat COPAC

Grant, Jonathan, Liz Green, and Barbara Mason. *From Bedside to Bench: Comroe and Dripps Revisited*. Uxbridge, U.K.: Health Economics Research Group, Brunel University, 2003.
Google Scholar Google Preview WorldCat COPAC

LaFollette, Hugh, and Niall Shanks. *Brute Science: Dilemmas of Animal Experimentation*. New York: Routledge, 1996.
Google Scholar Google Preview WorldCat COPAC

Mayr, Ernst. *Toward a New Philosophy of Biology*. Cambridge, Mass.: Harvard University Press, 1988.
Google Scholar Google Preview WorldCat COPAC

Nesse, Randolph M., and George C. Williams. *Why We Get Sick: The New Science of Darwinian Medicine*. New York: Crown Publishers, 1995.
Google Scholar Google Preview WorldCat COPAC

Norcross, Alasdair. “Animal Experimentation.” In *Oxford Handbook of Bioethics*, edited by Bonnie Steinbock, pp. 648–67. Oxford: Oxford University Press 1997.
Google Scholar Google Preview WorldCat COPAC

Regan, Tom. *The Case for Animal Rights*. Berkeley and Los Angeles: University of California Press, 1983.
Google Scholar Google Preview WorldCat COPAC

Shanks, Niall, and Ray Greek. *Animal Models in Light of Evolution*. Boca Raton, Fla.: Brown Walker Press, 2009.
Google Scholar Google Preview WorldCat COPAC

Sigma Xi. "Sigma Xi Statement of the Use of Animals in Research." *American Scientist* 80 (1992): 73–76.
Google Scholar WorldCat

Singer, Peter. *Animal Liberation: A New Ethics for Our Treatment of Animals*. 2nd ed. New York: New York Review, 1975.
Google Scholar Google Preview WorldCat COPAC

Smith, J. A., and Kenneth M. Boyd, eds. *Lives in the Balance: The Ethics of Using Animals in Biomedical Research*. Oxford: Oxford University Press, 1991.
Google Scholar Google Preview WorldCat COPAC