RETHINKING ANIMAL EXPERIMENTS:

A PHILOSOPHICAL INQUIRY

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Rethinking Animal Experiments: A Philosophical Inquiry

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DECLARATION OF ORIGINALITY

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- this thesis contains no material that has been submitted or accepted for a degree or diploma in any other educational institution;
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ABSTRACT

Rethinking Animal Experiments: A Philosophical Inquiry

This thesis investigates why animal experimentation persists as a dominant research paradigm in biomedical science despite mounting scientific and ethical criticisms. It argues that the resilience of this practice cannot be explained by a lack of alternatives or ignorance, but stems from a complex interplay of epistemic conservatism, institutional inertia, and ethical minimalism. Drawing on interdisciplinary sources in philosophy of science, bioethics, and feminist epistemology, the study offers a conceptual and normative analysis of how methodological practices are legitimized and sustained. The thesis is structured around five central questions: the epistemic indispensability of animal models, the moral justification crisis, the failure of regulatory and scientific reforms, the role of epistemic injustice in preserving the status quo, and the possibility of an epistemically just scientific practice. Through critical engagement with empirical data, regulatory documents, and philosophical theory, it challenges the reliability, ethical coherence, and legitimacy of animal research. It further explores alternative human-relevant methods, including in vitro, in silico, and organ-on-chip technologies, not only as technically superior, but as embodiments of a different epistemic and moral paradigm. The thesis concludes by arguing for a shift toward a science that is ethically reflexive, epistemically inclusive, and accountable to both human and non-human stakeholders. In doing so, it contributes to ongoing debates on responsible research practices and offers a philosophical framework for reimagining scientific legitimacy in the post-animal experimentation era.

ÖZET

Hayvan Deneylerini Yeniden Düşünmek: Felsefi Bir Soruşturma

Bu tez, hayvan deneylerinin bilimsel ve etik açıdan yoğun eleştirilere rağmen biyomedikal araştırmalarda neden hâlâ baskın yöntem olarak sürdürüldüğünü araştırmaktadır. Çalışmanın temel savı, bu uygulamanın yalnızca alternatiflerin eksikliğiyle ya da bilgi yetersizliğiyle açıklanamayacağı, aksine epistemik tutuculuk, kurumsal atalet ve etik minimalizmin iç içe geçmiş etkileriyle devam ettirildiğidir. Tez, bilim felsefesi, biyoetik ve feminist epistemoloji alanlarından beslenen disiplinlerarası bir yaklaşımla, bilimsel yöntemlerin nasıl meşrulaştırıldığını ve sürdürüldüğünü kavramsal ve normatif olarak analiz etmektedir. Tez, beş ana soruya odaklanır: Hayvan modelleri gerçekten vazgeçilmez midir? Bu uygulama etik olarak tutarlı bir şekilde savunulabilir mi? Reform girişimlerine rağmen neden değişim sağlanamamaktadır? Epistemik adaletsizlik mevcut durumu nasıl korumaktadır? Ve alternatif, epistemik olarak adil bir bilimsel pratik mümkün müdür? Empirik veriler, düzenleyici belgeler ve felsefi kuramlar üzerinden yürütülen çözümlemelerle, hayvan deneylerinin güvenilirliği, etik tutarlılığı ve meşruiyeti sorgulanmaktadır. Ayrıca in vitro, in silico ve organ-on-chip gibi insan temelli araştırma yöntemleri yalnızca teknik üstünlükleriyle değil, aynı zamanda farklı bir epistemik ve etik paradigma önerisi olarak ele alınmaktadır. Tez, hem insan hem de insan dışı paydaşlara karşı sorumlu, etik olarak duyarlı ve epistemik olarak kapsayıcı bir bilim anlayışının mümkün ve gerekli olduğunu savunarak, hayvan sonrası bilimsel uygulamaların meşruiyeti üzerine süren tartışmalara felsefi bir katkı sunmaktadır.

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CHAPTER 1

INTRODUCTION

1.1 Background and context

In recent years, a growing body of literature has started to question the legitimacy of animal experimentation, both on scientific and ethical grounds. A notable example is a 2024 article published in the *Journal of Translational Medicine*, which argues that animal experiments in preclinical research are not only unreliable but also morally indefensible, calling for a fundamental shift in how biomedical science approaches its methods (Frühwein & Paul, 2024). This thesis builds on that perspective but aims to push the argument further by showing that the resistance to change is not simply due to a lack of evidence or viable alternatives. Rather, it is embedded in deeper epistemic structures, institutional inertia, and a longstanding moral indifference toward non-human animals. My aim is not only to expose the scientific weaknesses of current procedures but also to challenge the ethical frameworks and structural barriers that continue to normalize these practices.

Scientific advancement often depends on the critical evaluation of accepted methodologies, especially when their limitations become evident. Criticism produces tension before transformation. This tension is particularly visible in biomedical research's persistent dependence on animal models. Animal models continue to be standard practice despite significant data indicating their poor predictive value. According to Pound et al. (2004), fewer than 5% of treatments tested on animals succeed in human clinical trials. Nevertheless, animal testing remains the default

standard in most regulatory systems.[1] This situation, where methodologies are maintained not because of their scientific success but because of their institutional entrenchment, raises fundamental questions about how knowledge is constructed, validated, and applied.

Meanwhile, human biology-based models are rapidly evolving. Organ-on-chip systems (microfluidic devices containing living human cells that recreate the structure and function of human organs) simulate multi-organ interactions with a level of precision that traditional animal models cannot match (Low et al., 2021). AI-assisted toxicology algorithms can predict human drug responses by analyzing vast databases of human molecular data, while in silico computational models simulate human physiological processes without requiring animal subjects (Hartung et al., 2019). These developments not only undermine the epistemic authority of animal models but also challenge the ethical status quo.

Despite these advancements, structural barriers continue to inhibit meaningful transition. These include institutional funding mechanisms, conservative regulatory expectations, and what Miranda Fricker (2007) calls "epistemic injustice," the structural exclusion of relevant knowledge perspectives. For instance, technologists, caregivers, or dissenting scientists often hold forms of experiential knowledge that are marginalized in formal scientific discourse. Feminist epistemologists such as Sandra Harding (1991) and Donna Haraway (1988) have long argued that scientific objectivity is not neutral but historically and socially situated, and that the exclusion

[1] By "default standard," I refer to the regulatory expectation that animal testing data will be included in drug and medical product approval submissions, despite the availability of potentially more predictive alternative methods. For example, regulatory bodies worldwide typically require both rodent and non-rodent animal studies before human clinical trials can begin for new drugs, even when human-specific alternatives exist. This default position is embedded in guidelines such as the ICH M3(R2) and is institutionalized in review practices across different international regulatory frameworks, creating a persistent prioritization of animal data even as alternatives become increasingly sophisticated.

of certain knowers narrows both moral and epistemic insight. I draw on these critical voices to highlight the structural barriers we need to cross in order to ameliorate current research practices.

Recent legal changes reflect some of the growing discomfort with the status quo. The FDA Modernization Act 2.0 (2022) removed the requirement for mandatory animal testing in drug development. Nevertheless, as Moutinho (2023) observes in an analysis of the legislation, the regulatory amendment merely establishes the permissibility of alternative methodologies without creating structural incentives or mandates for their implementation. Consequently, institutional practices remain largely unaltered in the absence of more substantive policy directives. There is still a significant inconsistency between practice and the ideal. While the EU has banned animal testing for cosmetics, countries like China only recently began relaxing similar rules. As long as such divergences persist, multinational firms tend to default to the strictest regulatory baseline to ensure compliance across all markets. These regulatory disparities thus create systemic barriers to change, embedding animal experimentation within global scientific and commercial infrastructures despite growing recognition of its limitations. This global inconsistency leads to a form of regulatory conservatism.

Moreover, in the case of animal experimentation, epistemic inertia is compounded by a deeper ontological bias: the tacit assumption that non-human animals are inherently deficient epistemic subjects. Unlike human patients, animals are rarely regarded as legitimate sources of knowledge in their own right, but rather as convenient proxies for human biology. This species-based instrumentalism not only distorts the epistemic credibility of animal-derived data but also reinforces the marginalization of alternative models that could provide more direct and reliable

insights into human physiology. Thus, the persistence of animal experimentation reflects not merely a general conservatism in scientific practice but a structurally entrenched form of epistemic speciesism, where methodological convenience overrides considerations of validity, ethics, and justice.

Throughout this thesis, several key concepts will be used. Briefly explained, "epistemic injustice" refers to the systematic exclusion of valuable knowledge perspectives from scientific discourse (Fricker, 2007). "Translational failure" denotes the poor predictive validity of animal studies for human outcomes. The "absent referent" describes the conceptual erasure of individual subjects in abstract discourse (Adams, 1990). "Structural consent impossibility" refers to the systematic inability to obtain meaningful consent within current research paradigms.

In what follows, I will trace the epistemic, institutional, and ethical contours of the current research paradigm and argue that the persistence of animal experimentation is not just a scientific concern, but a philosophical and moral one about how knowledge is produced, legitimized, and acted upon. Each chapter addresses a central question that frames the investigation of animal experimentation's continuity despite its epistemic and ethical vulnerabilities.

1.2 Research questions and objectives

The central aim of this thesis is to understand why, despite well-documented limitations and widespread ethical criticisms, animal experimentation continues to dominate preclinical research. This persistence reflects a deeper structural problem: a scientific and institutional framework that normalizes animal use as a baseline standard, even in the face of more reliable and ethically sound alternatives.

Why animal models continue to dominate biomedical science, despite their known limitations, presents a philosophical puzzle at the intersection of epistemology, ethics, and scientific practice. On one hand, empirical evidence increasingly shows their limited predictive value for human outcomes, a limitation acknowledged even within mainstream scientific discourse. On the other hand, regulatory frameworks, funding priorities, and academic incentives continue to privilege these same models. This creates a system where methodological validity appears divorced from empirical success.

At its core, I challenge the philosophical foundations that sustain animal experimentation in contemporary science. I demonstrate how this practice persists through a complex interplay of epistemic authority, institutional momentum, and moral compartmentalization. By examining both epistemic failures and ethical shortcomings, I argue that current regulatory frameworks merely manage rather than resolve the deep conceptual tensions in how we justify using sentient beings as research tools. What is required is not incremental reform but a fundamental reconceptualization of the relationship between scientific validity, moral responsibility, and interspecies ethics.

This problem invites us to look beyond conventional narratives of scientific progress. I examine how knowledge claims become authorized, how ethical considerations become marginalized, and how institutional structures resist transformation even when their foundational assumptions are challenged. To investigate this, the following guiding questions are formulated, each corresponding to a chapter in this thesis:

Is animal experimentation epistemically indispensable? This question examines the historical epistemic status of animal models, their predictive failures,

and the limits of translational science, challenging the notion that they remain necessary for scientific validity.

Which ethical frameworks attempt to justify animal testing, and what are their philosophical inadequacies? Here, I interrogate various moral theories, utilitarianism, deontology, contract theory, and capability approaches, to evaluate whether any provide coherent ethical grounds for animal experimentation, particularly in light of consent impossibility and situated knowledge.

Why have legal and scientific reforms failed to shift practice? This chapter investigates the conservative nature of regulatory science, institutional risk-aversion, and the normalization of emergency justifications that preserve the status quo despite reform efforts.

What role do epistemic and institutional structures play in maintaining the current paradigm? Through analyzing collective epistemic vices, gatekeeping mechanisms, funding ecosystems, and silenced testimonies, I explore how knowledge hierarchies systematically marginalize alternatives.

Is a coherent alternative paradigm possible? The final substantive chapter articulates a vision of post-normal science with extended peer communities, human-relevant models, and new evaluation criteria that could support an epistemically and ethically sound research paradigm.

These questions are not meant to be answered in isolation. They form an interrelated framework through which I will analyze both the internal logic of current scientific practices and the external factors, ethical, institutional, and economic, that shape their persistence. The objective is not merely to argue that animal experimentation is flawed or outdated, but to demonstrate that a genuine paradigm shift is both necessary and possible. I hope to contribute to an emerging literature

that calls for a reorientation of research practices in a direction that is both epistemically sound and ethically rigorous.

1.3 Methodological and philosophical framework

This thesis adopts an interdisciplinary methodological approach rooted in both ethics and philosophy of science. While the structure of the argument remains philosophical, it is deeply informed by empirical and policy-oriented literature to ensure its relevance to contemporary scientific practices. The inquiry builds on a pluralist ethical framework, combining utilitarian, deontological, and capabilities-based moral reasoning with more critical approaches drawn from feminist and ecofeminist thought.

Methodologically, my approach differs from conventional bioethical analyses in several important ways. First, I do not treat the epistemic and ethical dimensions of animal experimentation as separate domains requiring separate evaluations. Instead, I demonstrate how these dimensions are fundamentally intertwined, how epistemic failures enable ethical negligence, and how ethical blind spots sustain epistemically questionable practices. The persistence of animal modeling cannot be adequately understood through either lens alone; it requires an integrated analysis that traces the co-constitution of knowledge claims and moral boundaries within scientific institutions. This perspective draws on a broadly Foucauldian insight: that knowledge and power are not independent realms, but co-produce each other within institutionalized practices, shaping what is seen as ethically permissible and epistemically credible (Foucault, 1980).

Second, while much of the existing literature focuses on individual decision-making or regulatory compliance, I shift the analytical frame toward structural and

institutional factors. This means examining not only what individual scientists or ethics committees decide, but how the very architecture of scientific training, funding, publication, and validation creates pathways of least resistance that privilege certain methodologies regardless of their empirical or ethical merits.

Finally, I adopt a critical approach that examines the discrepancies between stated ethical principles and actual laboratory practices. This involves analyzing how formal regulations and guidelines often diverge from everyday research realities, revealing significant gaps between what institutions claim to value and how animal research is actually conducted.

Ethically, the thesis interrogates the notion of moral status and the structural impossibility of non-human animal consent. Traditional frameworks like utilitarian harm-benefit calculations are critically examined alongside theories that emphasize justice, recognition, and the avoidance of moral dissonance. Thinkers such as Peter Singer (1975), Christine Korsgaard (2018), and Martha Nussbaum (2006) provide foundational perspectives, while ecofeminist criticisms from Carol J. Adams (1990) and Val Plumwood (1993) are engaged to problematize the anthropocentric and androcentric assumptions underlying mainstream bioethics.

Epistemologically, the analysis draws on debates concerning scientific realism, modeling practices, and the sociology of scientific knowledge. It situates animal experimentation within what Silvio O Funtowicz and Jerome J. Ravetz (1993/2020) have termed the context of "post-normal science," where facts are uncertain, values are disputed, and decisions are urgent. The use of animal models, despite their epistemic fragility, is shown to be maintained through a form of what Quassim Cassam (2019) calls collective epistemic vice, a phenomenon whereby

institutionalized habits, incentives, and value-blind norms inhibit reflexivity and methodological reform.

Building upon this framework, I engage with the broader literature on epistemic marginalization in animal ethics. While scholars such as Alice Crary (2016) and Sue Donaldson and Will Kymlicka (2011) have explored related concerns regarding the moral standing and representation of non-human animals, their focus has largely been on ethical visibility and political status rather than the epistemic dynamics of animal experimentation. In this thesis, I develop this intersection explicitly within the context of laboratory research, arguing that the animal research regime perpetuates both testimonial and hermeneutical injustice in two critical ways: First, by systematically excluding the experiential knowledge of dissident knowers, such as technicians, caregivers, and interdisciplinary ethicists, whose engagement with animal subjects challenges dominant narratives; and second, by sustaining an institutional framework that lacks the conceptual tools to meaningfully articulate the moral stakes of animal suffering beyond the reductive discourse of "scientific necessity."

This analysis reveals how conventional research structures marginalize certain forms of testimony about animal experience. Consider a few examples: The ultrasonic distress vocalizations of laboratory mice, imperceptible to human hearing but detectable with equipment, are rarely recorded or reported in published findings. Similarly, observations from animal technicians who witness signs of psychological distress are routinely dismissed as anthropomorphic projections rather than valuable contributions. Distress is there, recorded and witnessed, but not properly acknowledged by researchers.

At a deeper level, the conceptual frameworks used to evaluate research ethics create what Fricker terms "*hermeneutical lacunae*," gaps in our collective interpretive resources. These gaps render certain forms of harm difficult to articulate and address. Animal dissent, for example, has no formal recognition within current regulatory frameworks. This leaves researchers without the conceptual tools to acknowledge what may be morally significant expressions of unwillingness to participate. By incorporating feminist standpoint theory and the call for "situated knowledges" (Haraway, 1988), my work challenges prevailing notions of scientific objectivity and calls for epistemic democratization in research design and policy.

Rather than merely evaluating whether the 3R framework has been implemented effectively, this thesis asks if it is ethically and epistemologically sufficient. The 3Rs (Replacement, Reduction, and Refinement) were proposed by William Russell and Rex Burch in 1959 as a way to humanize animal experimentation. The principles encourage researchers to replace animals with alternatives when possible, reduce the number used, and refine procedures to minimize suffering. While the framework has shaped regulations worldwide, it functions mainly as a harm-reduction approach without questioning the legitimacy of animal use in science. As I will argue in Chapter 3, the 3Rs, despite their historical importance, operate as a form of ethical minimalism that legitimizes existing practices. They are not neutral guidelines but part of a system that normalizes animals as experimental instruments. This thesis, therefore, calls for a deeper rethinking of what constitutes scientific rigor, responsibility, and respect.

Methodologically, the thesis employs conceptual analysis, case studies, and critical literature reviews. It draws on empirical research from scientific journals, policy documents, and historical analyses to ground philosophical claims. However,

its primary orientation remains normative, aimed at articulating not just what is but what ought to be in scientific practice. The argument proceeds through a form of immanent analysis, identifying internal contradictions in current research paradigms while constructing a vision of more coherent alternatives.

While this thesis draws from diverse ethical theories, its central analytical lens is grounded in the concept of epistemic justice, as articulated by Fricker and extended by feminist epistemologists. By focusing on how entrenched power dynamics shape what counts as legitimate knowledge, the thesis frames animal experimentation as a paradigmatic case of hermeneutical injustice, where alternative perspectives, including those of dissenting scientists, caregivers, and non-human animals themselves, are systematically excluded from the epistemic community. This approach aligns with a pragmatist stance in philosophy of science, emphasizing not metaphysical debates over truth, but the ethical and epistemic responsibilities entailed in knowledge production. Thus, the thesis advocates for an expanded, participatory model of scientific inquiry, where epistemic virtue and ethical consideration are inseparable.

1.4 Structure of the thesis

This thesis is organized into six chapters, each addressing one of the central questions identified above, building a cumulative case for both the necessity and possibility of a paradigm shift in biomedical research.

Chapter 2 focuses on the question of epistemic indispensability of animal research in biomedicine. It examines the historical canonization of animal models, their predictive failures and reproducibility issues, modeling dilemmas in translational science, and the problematic hierarchy of the research. Drawing on

accounts of theory-ladenness and Nancy Cartwright's concept of detachment, it challenges the idea that animal experimentation remains necessary for scientific validity.

Chapter 3 addresses the ethical frameworks that attempt to justify animal testing and critically examines their philosophical inadequacies. It explores moral status, agency, and consent through multiple philosophical traditions, utilitarian, deontological, contractarian, and capabilities approaches, demonstrating why these frameworks, when consistently applied, actually undermine rather than support animal experimentation. The chapter introduces key concepts such as the presumption of dissent, situated knowledge, and testimony beyond language, before examining the 3Rs framework as a form of structural speciesism and ethical minimalism.

Chapter 4 examines the epistemic and institutional structures that maintain the current paradigm. Building on Cassam's account of epistemic vices and Fricker's concept of epistemic injustice, it analyzes how collective cognitive habits, gatekeeping mechanisms, funding ecosystems, and silenced testimonies create structural barriers to change. The chapter explores the political economy of animal experimentation, showing how material interests, regulatory frameworks, and academic reward systems interlock to sustain the paradigm despite mounting evidence of its limitations.

Chapter 5 considers what an epistemically just scientific practice would require. It brings together the conceptual criticism developed in previous chapters, on the unreliability of animal models, the impossibility of animal consent, and the testimonial silencing of nonhuman perspectives, to propose a normative framework grounded in epistemic justice. Drawing on feminist and ecofeminist epistemologies,

the chapter challenges dominant ideals of objectivity and introduces relational models of knowledge production. It further examines human-relevant research alternatives such as in vitro, in silico, and organ-on-chip systems, not merely as technical innovations but as embodiments of a different epistemic ethic. Finally, the chapter calls for institutional transformation, advocating for inclusive evaluative standards and what I term 'epistemic courage': the commitment to restructure science in ways that are accountable, situated, and ethically attuned.

Chapter 6 concludes the thesis by synthesizing these arguments, reflecting on the broader implications for scientific practice, regulation, and the relationship between human and non-human animals in knowledge production. It emphasizes that the criticism offered is not anti-scientific but rather is a call for a more reflexive, inclusive, and ethically robust form of science.

In advancing from chapter to chapter, this thesis moves from diagnostic to constructive analysis, and from epistemological to institutional analysis. Each chapter addresses a distinct dimension of the problem. Together, they form an integrated argument with three key claims: First, animal experimentation persists not because of its epistemic necessity but because of structural forces that resist change. Second, this resistance has both cognitive and institutional dimensions that reinforce each other. Third, overcoming this resistance requires not merely technical innovation but a philosophical reimagining of the relationship between knowledge, ethics, and scientific practice.

CHAPTER 2

IS ANIMAL EXPERIMENTATION EPISTEMICALLY INDISPENSABLE?

In 1822, French physiologist François Magendie publicly flayed a dog alive, without anesthesia, before a crowd of medical students. When hecklers accused him of cruelty, he replied: "The animal's cries are of no importance; what matters is the precision of the data" (Franco, 2013). This moment captures a broader methodological problem in animal experimentation: the severance of empirical 'rigor' from ethical consequence. If science's validity hinges on such acts of willful indifference, how reliable can its truths ever be? If the pursuit of truth demands the normalization of cruelty, we must ask: can such truths be trusted at all?

Having outlined the broader structural factors behind the persistence of animal experimentation, I now turn to a more focused question: is this practice epistemically indispensable? The answer, as I will demonstrate through four interconnected analyses, is decisively negative. First, I will examine how animal models gained their privileged position in scientific knowledge production, revealing how specific successes were improperly generalized into a universal methodology. Second, I will document the systematic failures of animal models to reliably predict human outcomes across multiple domains. Third, I will analyze the fundamental modeling dilemmas that limit translational science. Finally, I will criticize the evidence hierarchies that problematically privilege animal experimentation despite acknowledging its weak evidentiary value.

2.1 Historical epistemic status and scientific canonization

The scientific validity of animal experiments has long been taken for granted rather than critically examined. While vivisection had earlier precedents in figures like William Harvey, Magendie's nineteenth-century theatrics marked its transformation into systematic scientific practice, normalizing animal suffering as the price of knowledge and cementing a tradition where methodological convenience was prioritized over predictive validity (Franco, 2013). This normalization was further institutionalized through the biomedical triumphs of the nineteenth century, notably by Louis Pasteur and Robert Koch. Their work introduced a persistent methodological flaw into scientific reasoning, one that remains unaddressed to this day. While their breakthroughs validated certain uses of animal models within narrow infectious disease contexts, the broader assumption that animal experimentation reliably translates to human outcomes was naively generalized across all biomedical domains without adequate evidence. This inappropriate extrapolation from specific successes to a universal methodology entrenched animal experimentation as the foundation of the biomedical research hierarchy, a position examined critically in section 2.4, despite consistently poor rates of translation to human contexts, as I will demonstrate through comprehensive meta-analyses in section 2.2.

This trajectory began with early anatomical studies and philosophical justifications for using animals as experimental subjects. Harvey's work on blood circulation helped establish animals as scientific tools. René Descartes' mechanistic philosophy fundamentally reshaped how animals were conceptualized in scientific contexts, creating what would become a foundational justification for animal experimentation. In his *Discourse on the Method* (1637) and *Letter to the Marquess*

of Newcastle (1646), Descartes developed a radical dualist framework that strictly separated mind (*res cogitans*) from body (*res extensa*). According to this philosophy, consciousness, reason, and the capacity for genuine experience were exclusively human attributes, tied to the possession of an immaterial soul and rational faculties.

Animals, in Descartes' view, were essentially complex biological machines, automata, operating purely through mechanical principles without any inner subjective life. What appeared to be pain responses, distress vocalizations, attempts to escape, or other expressions of suffering were merely mechanical outputs, comparable to the sounds and movements produced by an elaborate clockwork mechanism. When an animal cried out during vivisection, Descartes argued, this was no different from a bell ringing when struck, a purely physical reaction devoid of conscious experience or suffering. This intellectual framework would prove remarkably durable, continuing to influence scientific attitudes toward animal subjectivity well into the modern era and providing the conceptual scaffolding for the systematic exclusion of animal voices from scientific discourse (Descartes, 1649/1989). Critically, this conceptual framework had immediate practical consequences: it removed moral impediments to the expanding use of animals in emerging experimental medicine, facilitating the growth of vivisection practices that would otherwise face religious or ethical objections. By redefining animal suffering as mechanically irrelevant, Cartesian philosophy essentially provided an intellectual license for unlimited experimentation, creating the foundational justification that continues to underpin modern animal research despite centuries of evidence for animal consciousness and sentience (Cottingham, 1978; Smith, 2011).

The implications of this worldview extended far beyond individual experiments. It created a conceptual foundation that separated scientific rigor from

ethical consideration, establishing a precedent where empirical investigation could proceed without moral constraint when applied to non-human subjects. This foundation was further reinforced by the nineteenth-century successes of Pasteur and Koch. Their work on infectious diseases suggested that animal models could help us understand human illnesses. When Pasteur created vaccines for anthrax and rabies using animal tests, it seemed to prove that animal experiments were valuable for medicine (Franco, 2013).

These early successes created a problem: scientists took results from specific cases (like infectious diseases) and assumed they would work for all medical research. This generalization was hasty and questionable, but powerful. Soon, entire research systems, labs, animal breeding facilities, and testing protocols were built around this assumption. By the middle of the twentieth century, animal experiments were seen as necessary, not just useful. I argue that this institutionalization rested on three foundational but largely unexamined assumptions: (1) animal tests are the only alternative to unethical human experiments; (2) results from animals reliably predict what will happen in humans; and (3) major medical advances cannot happen without animal testing. These assumptions made animal testing seem essential for medicine. This aligns with what Frühwein and Paul (2025) call the "scientific necessity fallacy," where the idea that we need animal experiments is simply taken for granted rather than proven. The authority of animal models grew through a combination of early practical successes and institutional momentum. As Ian Hacking (1982) points out, scientific practices create self-reinforcing cycles. The key turning point came when isolated successes in infectious disease research (like Pasteur's vaccines) were generalized into a universal methodology. Once animal models became dominant, they shaped not just experimental practice but scientific education, laboratory

infrastructure, and regulatory frameworks. This created what economists call “path dependency” (Arthur, 1994; Pierson, 2000): A situation where past decisions create self-reinforcing mechanisms that make alternatives seem unthinkable rather than merely different. Later on, this approach became institutionalized through regulatory frameworks. Beginning in the mid-twentieth century, regulatory authorities in the United States, Europe, and elsewhere established animal testing as a legal requirement for drug approval. The U.S. Food and Drug Administration (FDA), established in 1906 and given expanded authority through the Federal Food, Drug, and Cosmetic Act of 1938, accepted animal data as sufficient preliminary evidence for proceeding to human clinical trials (Carpenter, 2010). Similar regulatory frameworks emerged internationally, with the International Council for Harmonisation (ICH) guidelines standardizing animal testing requirements across major pharmaceutical markets (ICH, 2009). These regulations transformed animal experiments from common practice into a legal necessity, embedding the animal model paradigm into the formal structure of biomedical research and drug development.

Looking critically at the foundation of this authority requires us to question not only the historical trajectory of animal experimentation but also the standards by which it continues to be evaluated. The authority of animal models comes largely from the controlled environment of laboratories, which creates an impression of scientific precision through standardized protocols, genetic uniformity, and environmental control. However, as Nancy Cartwright (2024) argues in her analysis of scientific reliability, what matters in applied sciences is not abstract “laboratory truth” but “reliability”—whether methods consistently produce expected outcomes in the specific contexts where they will actually be used.

Cartwright's distinction is crucial: a claim can be technically "true" within a narrow laboratory setting yet completely unreliable when applied elsewhere. Laboratory truth refers to findings that are held under highly controlled, artificial conditions, while reliability concerns whether those findings translate effectively to real-world applications. Applying this framework to animal research suggests that we should judge animal models not by their methodological rigor within laboratory settings, but by their demonstrated ability to predict human outcomes in clinical contexts.

From this Cartwrightian perspective, the controlled precision of animal experiments becomes questionable if it fails to translate effectively to human medicine. The standardized laboratory conditions that make animal studies appear scientifically rigorous may actually undermine their reliability for human applications by creating artificial environments that bear little resemblance to the complex, variable conditions of human health and disease.

Looking critically at the history of animal experimentation helps us understand why it continues despite its problems. This historical perspective does not mean we should reject animal models completely. Rather, it encourages us to question the assumptions behind them. Modern science shows that animal models may be useful in specific situations, but they should not be seen as automatically authoritative or necessary in all contexts. Animal experimentation's authority is not built on predictive success, but on institutional momentum. The laboratory mouse is not just a model organism; it is a scientific monument to historical accidents and misplaced certainty.

2.2 Predictive failures and the reproducibility crisis

Despite their longstanding role in biomedical research, animal models exhibit systemic problems in both predictive validity and experimental reproducibility. This section examines the extent of these failures through empirical studies and meta-analyses, showing that animal-based results often do not translate to human clinical outcomes. Moreover, even within animal research itself, significant reproducibility issues compromise the internal reliability of published findings. Together, these problems raise fundamental doubts about the scientific legitimacy of animal experimentation

2.2.1 The scale of translational failure

Although animal studies are often presented as a reliable foundation for biomedical progress, increasing evidence shows they frequently fail to produce reliable or replicable results. The translational gap between animal studies and human clinical outcomes is not a minor concern, it represents a systematic problem that undermines the central justification for animal experimentation.

A comprehensive systematic review by Perel et al. (2007) published in the *British Medical Journal* examined six clinical interventions where both animal studies and human trials were conducted.[2] This systematic analysis found that only three studies showed the same direction of effect across species. More troubling, therapies that seemed promising in animals sometimes caused harm to humans. For example, corticosteroids for traumatic brain injury showed benefits in animal models

[2] A systematic review is a research method that applies systematic and explicit criteria to identify, select, and critically evaluate all relevant research on a specific topic, providing a comprehensive synthesis of available evidence rather than selectively focusing on individual studies. Systematic reviews aim to minimize bias by using transparent and reproducible methods.

but increased mortality in human patients. This pattern suggests that successful animal studies provide, at best, coin-flip odds of predicting human outcomes.

The problem extends beyond individual examples. Meta-analyses show a consistent pattern of failure.[3] Aysha Akthar's (2015) systematic review of translation rates found that fewer than 10% of treatments successful in animals translate into effective human therapies, a failure rate of over 90%. In specific fields like cancer research, comprehensive analyses show the situation is even worse. Hutchinson and Kirk's (2011) analysis of pharmaceutical development data reports that only 5% of cancer drugs showing promise in animal studies demonstrate sufficient efficacy in humans to reach approval for clinical application.

Industry-wide data analyses tell a similar story. According to large-scale pharmaceutical industry analyses by Kola and Landis (2004), approximately 92% of drugs that pass preclinical testing (mainly in animals) fail in human clinical trials, most due to problems with efficacy or safety that were not predicted by animal models. More recent analyses by Hay et al. (2014) confirm this pattern, finding that the likelihood of FDA approval from Phase 1 trials was only 10.4%, with failure rates remaining consistently high for drugs that had passed animal testing. This represents not just wasted animal lives but a substantial misallocation of scientific resources, identified through industry-wide analyses rather than isolated reports. Taken together, these figures expose a systemic failure in the predictive logic of animal models, challenging the assumption that preclinical success in animals is a reliable indicator of human outcomes.

[3] Meta-analysis refers to a statistical procedure that combines the results of multiple scientific studies addressing the same question. By pooling data from numerous individual studies, meta-analyses can provide more precise estimates of effects than any single study and can identify patterns across different research contexts. Meta-analyses are considered a higher level of evidence than individual studies because they account for the limitations and biases of individual research projects.

2.2.2 Domain-specific translation problems

The predictive failures of animal models are not evenly distributed across medical fields, with systematic reviews revealing particularly poor translation in key domains. In neurology and CNS disorders, meta-analyses of animal models for complex neurological conditions like Alzheimer's disease have been especially damning. A comprehensive review by Cummings et al. (2019) found that despite hundreds of compounds showing promise in rodent models of Alzheimer's, the clinical failure rate exceeds 99%. As Langley's (2014) systematic analysis notes, the biological difference between rodent and human neural systems may be too fundamental for meaningful translation. This pattern extends to stroke research, where the most comprehensive systematic review, conducted by Collins et al. (2006), examined over 1,000 treatments showing efficacy in animal stroke models, revealing that only one has proven beneficial in humans. This 99.9% failure rate indicates a fundamental disconnect between stroke pathophysiology in animals and humans.

The translation crisis is equally severe in inflammatory conditions. A landmark genomic meta-analysis by Seok et al. (2013) examined the failure of over 150 clinical trials for sepsis treatments, despite success in animal models. Their comprehensive comparison of genomic responses concluded that "genomic responses in mouse models poorly mimic human inflammatory diseases," showing almost no correlation between mouse and human genetic responses to inflammatory stress. Perhaps most concerning is that even in toxicology, where animal tests are considered most reliable, comprehensive analyses show prediction rates for human toxicity hover around 50%, no better than chance (Hartung, 2009). This demonstrates that toxic reactions in humans are missed half the time, while many potentially

valuable compounds may be needlessly abandoned based on animal data that does not apply to humans.

2.2.3 The reproducibility crisis in animal research

Beyond translation failures, animal research faces a deeper crisis: systematic reviews show many findings cannot be reproduced even in the same species. This reproducibility crisis undermines the basic scientific reliability of animal models.[4] Poor study design is a major factor. A comprehensive systematic review by Kilkenny et al. (2009) examining 271 published animal studies found that 87% failed to use randomization, 86% did not apply blinding, 70% omitted sample size calculations, and 59% did not properly state the hypothesis being tested.

These methodological flaws, identified through systematic review rather than selective sampling, are not minor technical issues---they represent fundamental breaches of scientific rigor that make results inherently unreliable. Without randomization and blinding, unconscious experimenter bias can dramatically influence results. Without proper sample size calculations, studies are often underpowered, leading to either false negatives or inflated effects. These issues reflect broader concerns about the reliability of scientific findings, as Ioannidis (2005) famously demonstrated in his landmark paper, showing how such methodological weaknesses significantly increase the likelihood that published

[4] The reproducibility crisis refers to the growing realization that many scientific studies, across disciplines, cannot be reliably replicated or reproduced, calling into question the robustness of reported findings.

research findings are false, a problem that extends across biomedical science and is particularly acute in animal research.[5]

Publication bias makes the situation worse - a phenomenon often called the 'file drawer problem' because negative or null results remain metaphorically 'filed away' rather than published.[6] Meta-analyses show that positive results from animal studies are far more likely to be published than negative findings, creating a distorted picture of efficacy. For example, studies showing that a compound reduces tumor size in mice, or that a certain intervention improves cognitive performance in rodent models of Alzheimer's disease, are routinely published in high-impact journals, while studies showing no effect or negative effects often remain unpublished. A rigorous meta-analysis by Sena et al. (2010) estimated that this publication bias may overstate the effectiveness of interventions in animal models by up to 30%. When combined with problems of study design, this suggests that many "successful" animal studies represent statistical artifacts rather than genuine effects.

The replication problem was starkly illustrated by Begley and Ellis (2012), who conducted a systematic attempt to reproduce findings and found that scientific staff at the biotechnology firm Amgen could reproduce only six of 53 "landmark" oncology studies; a reproducibility rate of just 11%. This wasn't cherry-picking failures but a systematic attempt to replicate highly cited work, suggesting that even widely accepted animal research often cannot be reproduced, casting doubt on the foundational reliability of the field. This striking failure rate is not only a

[5] Ioannidis' 'Why Most Published Research Findings Are False' triggered widespread recognition of systematic biases in scientific research, highlighting how flexible study designs, selective reporting, and financial or academic pressures compromise the credibility and replicability of findings.
[6] The 'file drawer problem' refers to the tendency for negative or null results to remain unpublished while positive results are more likely to be published, creating a systematic bias in the scientific literature. This publication bias can substantially distort the apparent efficacy of interventions when only successful experiments are reported.

methodological concern but also an epistemic warning sign: it challenges the assumption that reproducibility naturally follows from standardized protocols and raises questions about what kind of knowledge animal experiments actually produce. Such pervasive unreliability also has ethical implications, as it undermines the scientific justification often used to defend the moral costs of animal experimentation.

2.2.4 Structural causes of unreliability

The problems with animal research are not just about individual studies. They reflect deeper structural issues. Three fundamental issues, pertaining to species differences, laboratory conditions, and selective breeding, will be highlighted here.

Evolutionary divergence between humans and animal models creates fundamental differences in biology. As Shanks et al. (2009) argue, even small genetic differences can cause dramatic changes in disease processes and drug responses. These differences are not just "noise" that can be controlled for; they represent inherent limitations in using one species to model another. We should keep in mind that humans share a large proportion of genes with not only apes but also with animals considered lower in the folk beliefs about animal hierarchies, such as flies. Mere sharing of genetic material is not a good predictor of behavior or physiology.

Another fundamental issue that should warn us against relying on animal models concerns the Laboratory Conditions: The artificial nature of laboratory environments significantly alters animal physiology. Garner (2014) shows that stress from confinement, handling, and unnatural social groups creates systemic changes in neurobiology, immune function, and behavior. These stress-induced changes mean

that lab animals are not even reliable models of their own species in natural conditions, let alone models of humans. Stress can be better controlled in studies in humans, but the means of reaching out to confined animal psychology are very limited.

A third factor that impacts the generalizability of animal studies is selective breeding: Laboratory animals have been selectively bred for generations to exhibit specific traits, creating genetic profiles that may diverge significantly from wild populations. This genetic homogeneity reduces variability but also reduces generalizability. Findings from these inbred strains may not even apply to genetically diverse animals of the same species.

Beyond these biological and environmental factors, animal research faces more fundamental epistemological challenges that will be explored further in the next section. These include what Cartwright (2024) calls "context detachment" and what Hacking (1982) describes as the "theory-ladenness" of experimental practices. These philosophical issues compound the biological limitations, creating multiple layers of epistemic barriers to reliable translation.

Taking these structural factors together, it becomes clear that the unreliability of animal research is not just due to poor implementation, but it reflects fundamental limitations in the methodology itself. The gap between animal biology and human biology creates an epistemic ceiling that technical improvements alone cannot overcome.

2.3 Modeling dilemmas and the limits of translational science

Beyond failures in prediction and replication, animal experimentation presents deeper conceptual challenges related to how models function in translational science.

This section analyzes the epistemological and biological dilemmas that arise when extrapolating from animal data to human outcomes. It focuses on issues such as theory-ladenness, context detachment, species differences, and the distortions created by laboratory environments. These modeling problems suggest that the limitations of animal research are not merely technical, but structural and conceptual in nature.

2.3.1 Theory-ladenness and the tension of similarity

Animal research is typically presented as neutral and methodologically secure. Yet in practice, it operates within structures that systematically shape what researchers observe and how they interpret their findings through embedded theoretical assumptions about cross-species similarity, the nature of animal consciousness, and the relevance of laboratory conditions to human disease. These are not incidental problems but manifestations of what philosophers of science call "theory-ladenness" - the idea that observations and experimental practices are inevitably shaped by the theoretical frameworks we bring to them.[7]

As N.R. Hanson (1958) argued, we do not first experience raw data and then interpret it; rather, our background beliefs and theoretical knowledge directly affect what we can observe. In animal research, this theory-ladenness manifests in a profound tension: interpretations pull in contradictory directions depending on whether the context is scientific or ethical. When justifying the use of animals as models, researchers emphasize physiological similarities between animals and

[7] The concept of theory-ladenness has a rich history in philosophy of science, extending from N.R. Hanson's 1958 work “Patterns of Discovery” to Thomas Kuhn's paradigm theory. The specific application of theory-ladenness to animal experimentation developed in this thesis draws on this philosophical tradition but extends it to address the unique epistemic and ethical challenges of cross-species modeling. While several scholars discuss related themes in animal model epistemology (e.g., LaFollette & Shanks, 1996; Greek & Menache, 2013; Knight, 2011), none directly apply this philosophical framework in the specific manner pursued here.

humans - if a substance harms animal tissue, it is assumed to harm human tissue similarly. Yet simultaneously, when addressing ethical concerns, the same experimental frameworks minimize animal sentience and suffering compared to human experience, treating animals as fundamentally different from humans in terms of mental capacities.

This contradictory framing reveals a structural inversion at the heart of animal experimentation: biologically, animals' similarity to humans is overemphasized to justify their use as proxies, despite consistently low translational success rates, whereas morally, their similarity is dismissed, denying them individual moral status and treating them as mere instruments. This epistemic and ethical dissonance creates a systematic inconsistency at the heart of animal experimentation; a fundamental mismatch between how animal models are theoretically justified and how they function in practice. The ethical dimensions of this structural inversion will be explored more fully in Chapter 3, where we examine how this same contradiction undermines conventional moral justifications for animal experimentation.

Animal experimentation presents a unique and heightened form of theory-ladenness challenge due to the cross-species nature of knowledge transfer required. Unlike physics or chemistry, where observation frameworks apply to consistent material properties, biological theory-ladenness must contend with evolved differences between species that create qualitative divergences in how systems function.

In animal research, theory-ladenness manifests not simply as theoretical assumptions influencing observation, but as the collision of theoretical frameworks from two different species. Theoretical models of human physiology are applied to a different species' biology and then translated back to humans, creating a double

translation that introduces multiple opportunities for conceptual misalignment, as demonstrated by the poor concordance rates between animal studies and subsequent clinical trials (Perel et al., 2007).

This unique situation creates not just wrong answers but wrong questions. In Alzheimer's research, for example, mouse models have led researchers to develop theories that may fundamentally miss the key mechanisms in human Alzheimer's disease. This is not merely inaccurate data; it is a systematic misdirection of scientific inquiry. The empirical evidence supports this concern: as documented earlier in 2.2.1, Perel et al.'s (2006) BMJ study shows that the concordance between animal experiments and clinical studies is hardly better than random guessing, suggesting a systematic epistemic failure unique to the structure of animal modeling.

Furthermore, as Witte et al. (2022) emphasize, genuine scientific progress requires more than just statistically significant findings; it depends on empirically adequate theoretical constructs.[8] By 'empirically adequate theoretical constructs,' they mean explanatory frameworks that not only show statistical associations but also accurately capture the underlying causal mechanisms at work across contexts. The reliance on animal models often generates data points that appear successful in isolation (statistical significance in a particular experiment) without developing the deeper theoretical understanding necessary for reliable translation to human contexts. This distinction between statistical significance and empirical adequacy helps explain why isolated 'successes' in animal models rarely translate into consistent clinical benefits. Without adequate theoretical constructs that bridge species differences,

[8] Witte and colleagues propose that empirical adequacy should be evaluated by assessing the similarity between theoretically predicted and observed effects, emphasizing how measurement uncertainty and statistical variance can distort the evaluation of theoretical constructs.

animal data remains trapped in context-specific statistical associations rather than revealing universal biological principles.

What makes theory-ladenness in animal experimentation particularly problematic is that it operates at the level of the model's basic structure: theoretical frameworks developed for human biology are applied to different species, creating a systematic mismatch between the model's underlying assumptions and the target reality it aims to. Theories built on animal metaphors to understand human biology are loaded with flawed assumptions before they even begin to generate data. This leads to a systematic blind spot: the research community normalizes the poor translation between animal and human data instead of questioning whether animal models are fundamentally inadequate. This normalization prevents alternative approaches from being seriously considered.

In animal research, scientists fail to maintain what Cartwright calls an appropriate "distance" between model and reality - the critical recognition that models work within specific contexts and cannot be directly applied to different systems without accounting for contextual differences. When researchers treat animal data as directly applicable to human biology, they violate this epistemic distance by ignoring the species-specific contexts that shape how the model functions.

This process resembles looking into a distorted mirror while believing it is flat; scientists do not see themselves but something else entirely yet interprets this as an accurate reflection. The mirror is inherently warped, but the scientist, assuming it is straight, draws mistaken conclusions. This systematic misalignment creates a deeper problem than mere methodological flaws; it constitutes a built-in epistemic

barrier within the animal model paradigm itself, systematically excluding human-biology-based alternatives from consideration.

The institutional context further "naturalizes" this epistemic vulnerability. When animal experiments fail to translate to humans, these failures are often explained away as the result of "complex biology" rather than being recognized as problems with the theoretical assumptions embedded in the methodology itself. This institutionalized response treats laboratory findings as neutral representations of reality while ignoring how experimental design and theoretical assumptions shape what counts as data.

These theoretical influences extend beyond structural issues to the practical aspects of animal research. Theory-ladenness manifests in how researchers select which animal species to use, which biological systems to focus on, and which outcomes to measure. These choices are never neutral. They reflect prior assumptions about what aspects of animal biology are relevant to human disease and which differences can be safely ignored. The choice of rodents for neuroscience research, for instance, assumes that fundamental principles of neural function transcend species differences, an assumption that often proves problematic when treatments move to human trials.

Moreover, the interpretation of animal responses is deeply theory laden. When a mouse show altered behavior after drug treatment, translating this into human cognition requires theoretical bridging principles that connect mouse behavior to human experience. These interpretive leaps, from observed animal behavior to human benefit, embed assumptions about cross-species similarity that are rarely made explicit or critically examined.

2.3.2 Context detachment and reliability problems

Cartwright's (2024) concept of 'detachment' provides another crucial lens for understanding animal research limitations. According to Cartwright, scientific claims derive their warrant from specific contexts and practices. When claims are 'detached' from these originating contexts, their reliability often collapses. Cartwright's notion of 'detachment' criticizes the practice of treating scientific claims as context-independent truths, arguing that the epistemic reliability of a claim depends on the specific conditions and work that originally warranted it, a point especially pertinent in complex and variable experimental domains like biomedical research.

Her emphasis that 'reliability trumps truth' refers to the epistemological priority of context-specific performance over abstract universality. Cartwright distinguishes between abstract truth claims (universal statements that claim to hold across all contexts) and reliability (consistent production of expected outcomes in particular situations). The former are few and in between, whereas the latter are more plentiful. This distinction does not suggest that true claims cannot be reliable, but rather that scientific claims derive their epistemic value primarily from their ability to work consistently in the specific contexts where they will be applied, not from their status as abstract universal truths.

By 'abstract truth,' Cartwright refers to universal statements that claim to hold across all contexts, while 'reliability' refers to the consistent production of expected outcomes in particular, well-defined situations. This distinction helps characterize the way animal models might appear scientifically rigorous in laboratory settings, yet fail to translate to human clinical contexts, how they may produce 'truths' about animal biology that lack reliability when applied to human patients. For example, aspirin was shown to cause birth defects in rodent models, producing a replicable

laboratory outcome that was taken as a generalizable biological truth; yet later studies in humans revealed that low-dose aspirin can be both safe and beneficial during pregnancy, particularly for preventing preeclampsia. Similarly, numerous compounds that successfully reduced amyloid plaques in transgenic mouse models of Alzheimer's disease consistently failed in human clinical trials. These cases exemplify how outcomes that seem robust within the internal logic of animal experimentation may not hold when transposed across species, exposing the fragility of such "truths" outside their original epistemic frame..

In animal research, context detachment operates at two critical levels, creating what might be called "double detachment." This concept builds upon Cartwright's notion of detachment by identifying how animal experimentation involves a uniquely problematic two-step detachment process. Unlike standard scientific detachment where results might be generalized beyond their original context, animal research compounds this problem by first detaching results from their laboratory context and then attempting to bridge an even larger gap across species boundaries. First, results from animal studies are detached from the laboratory conditions that produced them. Second, these already-detached findings are then applied across species boundaries to humans in clinical settings. This layered detachment creates a cascade of reliability problems that significantly weakens the epistemic warrant of findings as they move from controlled animal studies to human clinical applications, resulting in a uniquely problematic epistemic situation.

For example, studies of drug metabolism in healthy young adult male mice (a common research practice) suffer double detachment when applied to diverse human populations. The controlled laboratory context that initially warranted the findings

bears little resemblance to the complex, variable conditions of human clinical reality. The mice themselves, usually genetically homogeneous and raised in artificial environments, bear little resemblance to the genetic and environmental diversity of human patients.

The variables that shape animal responses cannot be preserved across different contexts for several key reasons. First, laboratory conditions create artificial environments that fundamentally alter animal physiology through chronic stress, disrupted circadian rhythms, and abnormal social structures. Second, the genetic homogeneity of laboratory animals contrasts sharply with the genetic diversity of human populations. Third, the standardized diets, pathogen-free conditions, and controlled environments of laboratories eliminate precisely the environmental variability that characterizes real-world human contexts. Finally, the artificial induction of disease states in animals often creates fundamentally different pathophysiological mechanisms than those that occur naturally in humans.

This double detachment helps explain why even methodologically rigorous animal studies frequently fail to predict human outcomes. The reliability that exists in the original narrow context does not extend to these radically different situations. The knowledge breaks down not because of methodological flaws but because of inherent limitations in extrapolating across different contexts and species.

The underlying problem can be understood through the distinction between internal and external validity. Mainstream science often distinguishes between internal validity (methodological rigor within a study) and external validity (generalizability to other contexts). Animal research frequently achieves strong internal validity through controlled conditions and standardized protocols. However,

this internal validity often comes at the expense of external validity, particularly when crossing species boundaries.

The pursuit of internal validity through artificial laboratory environments and genetically standardized animals creates precisely the controlled conditions that limit generalizability. As Würbel (2001) argues, decades of environmental standardization in laboratory animal research may actually undermine the goal of achieving reliable, reproducible results that translate to humans. The very factors that make animal experiments replicable within laboratory settings make them poor predictors of human outcomes in complex clinical contexts.

This tension between internal and external validity creates a tension: the more researchers control variables to achieve clean results within animal models, the less those results might apply to humans. Conversely, the more researchers try to approximate human complexity within animal models, the more they sacrifice the controlled conditions that give animal experiments their internal validity. This represents a fundamental dilemma at the heart of animal-based translational science.

Despite these challenges, efforts to overcome context detachment in animal research have led to increasingly sophisticated animal models, including genetically modified "humanized" mice and complex disease simulations. Yet these attempts to bridge the reliability gap face inherent limitations.

Humanized animal models, those genetically modified to express certain human genes or proteins, remain fundamentally constrained by their non-human biology. Despite containing specific human elements, these models operate within physiological, immunological, and metabolic systems that evolved for different evolutionary purposes and environments. This creates a deceptive impression of relevance that obscures persistent species-specific differences in how the introduced

human elements interact with the host animal's biology. Even when human genes or proteins are successfully expressed, they function within non-human cellular environments, influenced by different regulatory networks and signaling pathways. Moreover, these animals still develop, live, and respond within artificial laboratory conditions that bear little resemblance to human environments.

Moreover, as animal models become more specialized and artificial in attempts to mimic human disease, they become less representative of their own species' natural biology. This creates what van der Worp et al. (2010) call "artificial animals modeling artificial disease", constructs that may not reliably represent either human or animal biology. Such models further exacerbate the context detachment problem rather than solving it.

Here again, Cartwright's emphasis on reliability provides a clarifying perspective. Animal models must be judged not by their theoretical resemblance to humans but by their predictive reliability in human clinical settings, a standard they frequently fail to meet. Context detachment helps explain why improvements in experimental rigor often fail to improve translational success.

2.3.3 Species differences as modeling dilemmas

Beyond the philosophical problems of theory-ladenness and context detachment, animal research faces concrete biological barriers that create fundamental modeling dilemmas. These are not simply technical challenges but represent conceptual dilemmas at the heart of cross-species modeling. The central dilemma is this: the very evolutionary divergences that make different species scientifically interesting also make them unreliable models for each other. Evolution has created diverse solutions to biological challenges, resulting in species-specific adaptations in

anatomy, physiology, metabolism, and cognition. These differences are not simple random variations but adaptive specializations, evolved features that serve specific functions within each species' ecological niche.

Consider the evolutionary trade-offs in different mammalian immune systems. Mice have evolved rapid breeding cycles and relatively short lifespans, leading to immune strategies that prioritize immediate responses over long-term protection. Humans, with longer lifespans and fewer offspring, have evolved immune systems that balance immediate defense with long-term memory and tolerance mechanisms. These are not minor variations but fundamentally different evolutionary strategies.

These evolutionary divergences create what LaFollette and Shanks (1996) call "causal disanalogies", situations where similar inputs produce different outcomes due to underlying differences in causal mechanisms. Such disanalogies are not rare exceptions but the expected result of evolutionary adaptation. They represent a fundamental limitation on cross-species translation that no methodological refinement can overcome.

Even shared biological pathways often operate differently across species. A classic example is drug metabolism: the thalidomide tragedy occurred partly because the drug was metabolized differently in humans compared to the animal species used for testing, highlighting how seemingly similar biochemical processes can have drastically different outcomes across species (Stephens & Brynner, 2001). These differences explain why drugs like thalidomide proved safe in rodent tests but caused severe birth defects in humans. The biological mechanism exists in both species but functions differently, creating a modeling dilemma where similarity becomes misleading rather than informative.

These modeling dilemmas extend beyond physical systems to behavioral and cognitive domains. Animal behaviors can be measured reliably in laboratory settings precisely because they follow predictable, species-typical patterns. However, these same standardized responses make them poor models for human behavior, which emerges from entirely different evolutionary, social, and cognitive contexts. This creates a situation where animal behavior can be reliably measured but unreliably translated into human contexts. The central irony of animal experimentation is that the very evolutionary divergences that make different species scientifically interesting also make them unreliable models for each other. We study mice precisely because they are not human, then act surprised when human-mouse differences undermine translation.

2.3.4 The laboratory as epistemic distortion field

Laboratory environments introduce another layer of modeling problems beyond species differences. Far from being neutral research settings, laboratories function as what might be called "epistemic distortion fields" that systematically alter the phenomena being studied in ways that compromise translation to humans. The artificial nature of laboratory environments, from housing conditions to handling procedures, distorts animal biology in predictable ways. These are not minor technical issues but fundamental alterations to the biological systems being studied. Laboratory housing induces chronic stress responses that affect neurochemistry, immune function, and metabolic regulation, the very systems researchers aim to investigate. This creates a situation where researchers are often studying the biology of captivity rather than normal physiology.

Moreover, laboratory protocols systematically eliminate the very variability that characterizes human clinical contexts. Genetic standardization through inbreeding, controlled environments, and standardized protocols reduces statistical "noise" but also eliminates the biological diversity essential for understanding how interventions might work in heterogeneous human populations. This creates a problematic situation where reliable results within the laboratory become unreliable predictors in diverse clinical settings.

The laboratory itself thus becomes an experimental variable that shapes outcomes in ways rarely acknowledged. This variable is not randomly distributed but systematically distorts biology in ways that compromise translation. The resulting knowledge reflects not just the biology of the animal but the biology of the animal-in-captivity, a hybrid phenomenon that corresponds to neither natural animal biology nor human clinical reality.

Most troublingly, these laboratory effects interact with the very outcomes researcher’s measure. In behavioral research, commonly used tests like the Forced Swim Test measure responses that are directly influenced by the stress of laboratory housing. In disease models, artificial induction of symptoms often interacts with laboratory stress in ways that create phenomena with no clear counterpart in human pathology. These interactions create complex distortions that further complicate cross-species translation.

The laboratory environment thus does not simply provide a controlled setting for observation; it actively constructs the phenomena being observed. This construction is neither neutral nor representative of either animal or human biology in natural contexts. It represents a fundamental epistemic distortion that limits the validity of animal research in ways that go beyond mere methodological concerns.

2.4 Evidence hierarchies and their structural bias

The organization of scientific evidence in biomedicine typically follows a hierarchical structure, commonly referred to as an evidence hierarchy. This evidence hierarchy places systematic reviews and meta-analyses at the top, followed by human randomized controlled trials (RCTs), then human observational studies, with preclinical animal research positioned at the base, regardless of whether animal studies use randomized designs. This seemingly neutral organizational framework actually creates significant epistemic contradictions in how animal research is valued and utilized. Despite being situated at the bottom of the hierarchy, animal studies are frequently used to justify high-stakes decisions in drug development, creating a disconnect between their formal epistemic ranking and their practical influence on scientific and regulatory outcomes.

2.4.1 The problem of the evidence hierarchies

Within the conventional evidence hierarchy, animal studies occupy a peculiar position. They are simultaneously treated as foundational (the necessary first step in developing interventions) yet regarded as providing relatively weak evidence compared to human studies. This creates a systematic contradiction: the very studies considered too weak to provide definitive evidence are nevertheless deemed essential before stronger evidence can be gathered. The evidence hierarchy is based on what it considers weak evidence. If this were architecture rather than science, no one would trust a structure built on such an unstable foundation.

This problematic positioning reveals a deeper inconsistency in how animal research is validated. While evidence-based medicine (EBM) frameworks explicitly rank animal studies as providing low-quality evidence for human outcomes, and

regulatory frameworks often require them as a prerequisite for human trials.[9] This creates a situation where animal studies are simultaneously devalued as evidence yet reified as necessary precursors to stronger evidence. The traditional rationale for this arrangement is that animal studies provide preliminary safety data before risking human exposure. However, as documented in Section 2.2, the predictive reliability of animal studies for human safety is questionable at best. When fewer than 10% of treatments successful in animals translate effectively to humans (Akhtar, 2015), the evidential foundation of the hierarchy becomes highly unstable.

More problematically, this filtering system operates with systematic bias in both directions: not only do most animal "successful" treatments fail in humans, but potentially effective human treatments may be prematurely eliminated due to species-specific differences that are irrelevant to human biology. This bidirectional error creates what might be termed "epistemic filtering bias." Animal models function as flawed gatekeepers that both allow ineffective treatments to advance (false positives) and prevent potentially valuable treatments from reaching human trials (false negatives).

A classic example is aspirin during pregnancy: animal studies suggested significant risks, leading to decades of avoidance in human pregnancy research. However, subsequent human-based studies demonstrated that low-dose aspirin can be both safe and effective in preventing certain pregnancy complications (Roberge et al., 2017). This illustrates how animal models may systematically exclude treatments that could benefit human patients, creating a double epistemic failure: weak evidence

[9] Evidence-based medicine (EBM) refers to the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. It integrates clinical expertise with the best available external clinical evidence from systematic research (Sackett et al., 1996). EBM frameworks typically organize evidence in hierarchies based on methodological rigor, with systematic reviews and randomized controlled trials at the top, and expert opinion and preclinical studies (including animal research) at the bottom.

advances while potentially strong evidence is filtered out based on irrelevant species differences. This bidirectional filtering bias undermines the entire logic of using animal studies as a preliminary screening mechanism.

2.4.2 Circular validation and the burden of proof

The evidence hierarchy not only creates systematic inconsistencies around animal research but also generates circular validation problems for alternative methodologies. New human-relevant methods such as organ-on-chip technologies (microfluidic devices replicating human organ functions), computational in silico modeling, and advanced in vitro cell culture systems must prove their reliability against the very animal models they aim to replace. This validation circularity creates a systematic problem: innovations are judged by standards derived from the dominant approach they aim to replace, creating an inherent bias against paradigm change (Kuhn, 1962).

For example, when a new in vitro method diverges from animal model predictions, the default assumption is that the in vitro method requires further validation, not that the animal model might be incorrect. This burden of proof asymmetry systematically privileges animal models despite their documented limitations. As Greek and Menache (2013) observe, this creates a situation where "the old paradigm determines the rules by which the new one must play," creating an uneven playing field that inhibits innovation.

The circular validation problem is particularly evident in regulatory contexts. For instance, the ICH S5(R3) guidelines for reproductive toxicity testing allow non-animal methods but require them to be validated against existing animal data. This approach assumes that animal models provide the "ground truth" against which

alternatives must be measured, despite abundant evidence of animal models' own limitations in predicting human reproductive toxicity. The validation standard thus presupposes what it claims to evaluate: the reliability of different methodological approaches.

This circularity in attempts at validation creates a significant barrier to methodological innovation. New approaches face a nearly impossible task: they must either reproduce the results of animal testing (including its errors and limitations) or overcome an extraordinary burden of proof to demonstrate that their divergent results are more accurate for human outcomes. This asymmetric hurdle institutionalizes the animal model paradigm regardless of its actual predictive performance.

2.4.3 The missing middle: alternative evidence architectures

The problems with the conventional evidence hierarchy suggest the need for alternative evidence architectures that could better integrate diverse methodological approaches. Rather than a linear hierarchy that places animal studies at the base, alternative frameworks might envision a network or matrix of complementary evidence types, each evaluated for its context-specific reliability rather than through a universal ranking.

Some researchers have proposed a "weight of evidence" approach that evaluates methodologies based on their demonstrated reliability in specific contexts rather than their position in an abstract hierarchy. This approach, advocated by Hartung et al. (2013), focuses on how well different methods predict relevant outcomes rather than privileging any single methodology as foundational. It evaluates evidence based on its practical reliability rather than its methodological pedigree.

Others have suggested an 'evidence integration' framework that combines multiple methodologies based on their complementary strengths. Rather than treating animal studies as a mandatory gateway, such approaches would treat them as one of several potential sources of evidence, to be used when their specific strengths are relevant and supplemented by other methods where they are weak. This integrative approach, as outlined by Stephens et al. (2013), aims to maximize predictive accuracy by combining the strengths of different methodologies. Specifically, Stephens and colleagues propose an 'evidence-based toxicology' model that integrates in vitro methods, computational approaches, and mechanistic data alongside limited animal testing, with each method weighted according to its demonstrated reliability for the specific endpoint under investigation.

These alternative frameworks share a common feature: they reject the notion that any single methodology must serve as a universal gateway to further research. Instead, they propose more flexible, context-sensitive approaches that evaluate each methodology based on its demonstrated reliability for specific questions. This would allow human-relevant methods to be utilized based on their own merits rather than through comparison to animal models.

2.4.4 Regulatory reinforcement of the hierarchy

Despite growing recognition of the limitations of animal testing and the promise of alternatives, regulatory frameworks continue to reinforce the traditional evidence hierarchy. Most regulatory guidelines, including those from the FDA, EMA, and other agencies, still position animal testing as a default requirement, with alternatives permitted only as supplements or in limited contexts.

This regulatory entrenchment reflects what Kuhn would call the "normal science" phase of a paradigm: even as anomalies accumulate, institutions continue to operate within established frameworks. Regulatory conservatism tends to privilege established methods with long histories of use, regardless of their demonstrated limitations. This creates a significant barrier to the implementation of new methodologies, as even proven alternatives face lengthy adoption processes.

The FDA Modernization Act 2.0 (2022) represents a notable regulatory shift, removing the explicit requirement for animal testing in drug development.[10] However, as Sass and Jacob (2022) note in their analysis of contemporary drug approval legislation, this change merely permits alternatives without actively incentivizing them. Their review of the regulatory implications found that despite this legislative progress, the regulatory landscape continues to treat animal testing as the default standard against which alternatives must be measured, maintaining the problematic hierarchy embedded in the evidence hierarchy.

This regulatory reinforcement of the hierarchy highlights a broader point about scientific paradigms: they are sustained not just by their empirical success but by their institutional embodiment in rules, standards, and procedures. Even as the empirical case for animal testing weakens, its institutional entrenchment can maintain its dominance. This suggests that meaningful change requires not just technical innovations but broader institutional transformations in how evidence is conceptualized, validated, and regulated.

In summary, this chapter has shown how animal research, often perceived as objective and methodologically sound, is deeply entangled with systemic biases,

[10] The FDA Modernization Act 2.0 (2022) amended the Federal Food, Drug, and Cosmetic Act to allow the use of non-animal methods in lieu of animal testing for drug approval processes, aiming to accelerate innovation and reduce reliance on animal experiments.

theory-laden practices, and context-dependent limitations that compromise its epistemic reliability. By critically examining concrete cases, such as the 99% failure rate in Alzheimer's drug development, the 99.9% failure in stroke research translation, and the fundamental genomic response differences in inflammatory conditions, it becomes evident that the translational failures in animal studies reflect broader structural issues in scientific practice. These are not isolated incidents but systematic patterns across diverse research domains, highlighting how selective reporting, experimental assumptions, and the dangers of detachment undermine the entire animal model paradigm. Animal models are not just occasionally wrong; they are systematically unreliable by design. What science calls its 'gold standard' has proven to be fool's gold: shiny, institutionally valuable, but scientifically bankrupt. These insights set the stage for a deeper investigation into how reliability and reproducibility failures manifest within the current research paradigm.

CHAPTER 3

THE ETHICAL PROBLEMS IN ANIMAL EXPERIMENTS: MORAL STATUS, CONSENT, AND INJUSTICE

According to experimental records, Mouse GV-23-118 endured fifty-six forced feedings over 28 days, developed aspiration pneumonia by day fourteen, and was euthanized after losing 22% of body weight. The procedure, nonetheless, was classified as causing only 'moderate' distress, even though the example is based on a reconstruction from documented clinical outcomes reported by Carbone and Conley (2023).

Throughout the thesis, I refer to a reconstructed profile, Mouse GV-23-118, based on aggregated data from a 2023 meta-analysis of gavage studies (Carbone & Conley, 2023).[11] While the GV-23-118 designation does not correspond to a single identified research subject, but rather serves as a composite identifier, every aspect of the scenario reflects actual clinical outcomes reported in Carbone and Conley's (2023) meta-analysis. This illustrative figure is used to humanize otherwise abstract harm and to provide narrative continuity for later ethical analysis. Drawing on data from a randomly selected study, this example also helps to foreground a critical problem: although one in eight mice developed severe complications during repeated force-feeding, nine out of ten institutional protocols still classified the procedure as

[11] The name Mouse GV-23-118 was created using an explanatory coding system: "GV" represents the gavage procedure, "23" indicates the year of the study, and "118" represents a reference protocol number. This composite case serves three methodological purposes: (1) providing narrative continuity across abstract ethical arguments; (2) illustrating how institutional categories obscure individual suffering; and (3) demonstrating the epistemic erasure of animal experience within standardized protocols. All physiological and procedural details reflect documented outcomes from peer-reviewed research.

only 'moderately' distressing; exposing how harm thresholds are normalized and institutionalized, rather than critically examined.

This moral terrain, marked by systematic suffering and institutional invisibility, underpins the urgent need for a deeper ethical reassessment of animal experimentation practices. This chapter examines three key aspects of the ethical analysis of animal experimentation. First, it explores how prominent philosophical theories, including utilitarian, deontological, and contractualist approaches, converge on the argument that animals hold moral status (Section 3.1). Second, it analyses the issue of consent and the double standards applied to non-human animals, arguing for greater moral responsibility toward beings who cannot consent (Section 3.2). Finally, it evaluates the 3Rs regulatory framework, identifying its epistemological and ethical limitations, and questioning whether it can support meaningful moral progress (Section 3.3).

These three dimensions form the backbone of a broader assessment: that the ethical foundations of animal experimentation are internally inconsistent, theoretically outdated, and morally insufficient. Together, they support the thesis that a shift from harm reduction to principled ethical transformation is urgently needed, one that challenges not only how we treat animals in science but also the justificatory assumptions that sustain that treatment.

While Chapter 2 focused on the epistemological weaknesses of animal experimentation, its limited predictive value, reproducibility issues, and institutional entrenchment, this chapter addresses the normative dimension. It asks whether animal experimentation can be ethically justified, even if such practices were shown to be scientifically useful. This question becomes particularly pressing considering the epistemological shortcomings already identified. If animal models often fail to

deliver reliable knowledge yet continue to impose significant harm, then their ethical legitimacy becomes doubly problematic.

In this chapter, I employ multiple philosophical lenses, not to present a single "correct" ethical theory, but to demonstrate how diverse ethical traditions, when consistently applied, challenge rather than support the current research paradigm. By examining both traditional moral frameworks (utilitarian, deontological, contractarian) and more recent approaches (capabilities theory, feminist ethics of care, ecofeminist perspective), I show that the moral case against animal experimentation does not depend on adopting any single ethical perspective.

Throughout the analysis, I develop a novel argument concerning what I term the "structural impossibility of consent" within animal research. While discussions of animal welfare often focus on minimizing suffering, I argue that the absence of meaningful consent represents a more fundamental ethical rupture, one that current regulatory frameworks systematically obscure rather than address. By bringing together feminist criticisms of epistemic injustice, Rawlsian reflections on fairness, and empirical studies of animal cognition and behavior, I construct an integrated argument that challenges the moral foundations of animal experimentation.

This ethical reassessment sets the stage for Chapter 4’s investigation of why regulatory reforms have so often failed to shift research practices, and Chapter 5's exploration of the institutional structures that maintain the status quo. By demonstrating that animal experimentation faces not only practical but fundamental ethical challenges, this chapter contributes to the broader argument that a paradigm shift in biomedical research is both necessary and justified.

3.1 The moral status of non-human animals

A meaningful understanding of moral status must move beyond mere legal protections and anthropocentric biases, focusing instead on the intrinsic value of beings capable of experiencing well-being or harm. Debates on the ethics of animal experimentation often hinge on a deeper and more fundamental question: whether non-human animals possess moral status, and if so, what kind. To answer this question, it is necessary to clarify what is meant by "moral status" and how it differs from legal protection or mere concern. The term "right," for instance, is used ambiguously across legal, relational, and moral contexts. While animals may be granted certain legal rights (such as protection from cruelty), these do not necessarily imply that animals are recognized as moral patients with intrinsic values. Legal frameworks may reflect concern or utility without committing to the idea that animals matter for their own sake, rather than for the sake of human interests.

A central claim of this thesis is that moral status should not be tied to traits that benefit human interests or reinforce existing research norms. Instead, it should be grounded in a being's own capacity to have a life that goes well or badly for them. This means rejecting the assumption that animals must resemble humans in certain cognitive or linguistic traits in order to be morally considerable. Moral status, as argued here, follows not from resemblance but from relevance: what matters is whether the being has interests of their own, not whether they mirror ours.

In this section, I first outline major philosophical approaches to animal moral status, establishing the theoretical foundations that will inform later arguments. I then examine empirical evidence of non-human animals' moral capacities, challenging anthropocentric assumptions about their cognitive and emotional lives. This combined philosophical and empirical foundation will serve as the basis for

subsequent analyses of consent (Section 3.2) and epistemic injustice (Section 3.3) in animal experimentation contexts.

3.1.1 Philosophical foundations: competing theories of moral status

Philosophical accounts of moral status often depend on criteria such as sentience, rationality, or agency. To provide a clearer comparison, it is helpful to briefly summarize the differences between the leading philosophical approaches discussed here.

3.1.1.1 Utilitarianism (Singer)

Utilitarian approaches, most notably represented by Peter Singer, argue that sentience (the capacity to suffer or experience pleasure) is the morally relevant threshold. If an entity can suffer, its interests must be considered. In this framework, the species of the being is morally irrelevant; what matters is whether it has interests that can be harmed or promoted (Singer, 1975). In the context of animal experimentation, Singer's view implies that the interests of non-human animals should be weighed equally with those of humans, especially when the harm imposed on animals far outweighs the potential benefit to human beings. From this perspective, most animal research fails the basic utilitarian test of minimizing overall suffering.

3.1.1.2 Deontological approach (Regan, Nussbaum, and Korsgaard)

Tom Regan emphasizes inherent value and rights based on being a ‘subject-of-a-life’ (Regan, 1983) His view is deontological and focuses on moral protections that cannot be overridden for the sake of utility. Martha Nussbaum approaches moral

status through the lens of capabilities. She asks what each being needs in order to live a flourishing life, and centers justice on enabling those capabilities (Nussbaum, 2006). Christine Korsgaard, working within a Kantian tradition, argues that because we are moral agents, we have duties to treat other sentient beings as ends in themselves, even if they cannot reciprocate or act morally (Korsgaard, 2018). These three views differ in focus: Regan emphasizes rights, Nussbaum emphasizes flourishing, and Korsgaard emphasizes duties, but all agree that animals are morally considerable in ways that current research practices often ignore.

Korsgaard's framework is especially powerful in that it anchors moral status not in the animal's capacity for rationality, but in the human agent's responsibility to act morally.[12] For her, moral consideration arises from the normative standpoint: we are beings who ask not just what we want, but what we ought to do. If we recognize animals as beings whose lives can get better or worse from their own perspective, then treating them as mere means violates our own moral commitments. In this sense, Korsgaard redefines Kantian respect to include vulnerability and dependence as ethically significant.

3.1.1.3 Contract theory and its limits: moral standing beyond reciprocity

Contract theorists, such as John Rawls, traditionally focus on the idea of moral and political rules as arising from mutual agreement between rational agents (Rawls, 1971). However, contract theory has been criticized for its exclusionary logic, especially when applied to beings who cannot participate in reciprocal agreements. Since animals cannot participate in such a contract, they are typically excluded from direct moral consideration.

[12] For a detailed discussion of Korsgaard's concept of the normative standpoint and moral agency, see Korsgaard (2018), Fellow Creatures.

This limitation has been radically challenged by contemporary theorists who argue that moral standing should not depend on an agent's ability to engage in reciprocal deliberation. For instance, Mark Rowlands and others have proposed extending the scope of contractarian reasoning to include non-human animals as beneficiaries, even if they are not contractors themselves. In Zoopolis, Sue Donaldson and Will Kymlicka argue that traditional contract theories fail because they only consider moral agency, excluding those who cannot participate in deliberation. Instead, they propose a political model based on citizenship, denizenship, and sovereignty, where different categories of animals are granted rights and protections appropriate to their relationships with human communities.[13] This reconceptualization challenges the idea that only reciprocity grants moral standing and offers a framework that includes dependency and interspecies cohabitation as morally significant.

3.1.1.4 Integrative approaches: DeGrazia and psychological continuity

DeGrazia offers a more integrative approach, combining elements of both rights-based and utilitarian thinking. He defends a moral framework that acknowledges animals as beings with a rich mental life and argues that they deserve equal moral consideration of interests. What sets DeGrazia apart is his attention to psychological continuity and personal identity in non-human animals, challenging assumptions that only humans have complex selves or future-oriented preferences (DeGrazia, 1996).

These diverse philosophical perspectives underscore the complexity of determining moral status. While they differ in their foundational criteria, whether based on rights, capabilities, duties, or psychological continuity, each theory agrees

[13] For a full account of Donaldson and Kymlicka's proposal of animal citizenship, see Zoopolis (2011).

on one fundamental point: animals are morally considerable in ways that current research practices often fail to acknowledge. This agreement sets the stage for the next phase of the argument.

Building on these theoretical perspectives, I now turn to empirical studies that provide concrete evidence of the moral capacities of non-human animals, further supporting the philosophical arguments made here. By examining the behavioral and cognitive capacities of non-human animals, we can deepen our understanding of their moral worth and the ethical obligations we owe them.

3.1.2 Empirical support: moral capacities in non-human animals

Beyond philosophical arguments, empirical studies in comparative cognition provide further support for the claim that non-human animals possess moral capacities and deserve ethical consideration. These behavioral observations offer some of the most vivid illustrations of moral sensibilities in non-human animals. Rather than relying solely on abstract philosophical principles, they provide concrete, empirically grounded evidence that animals engage with norms of empathy, fairness, and harm-avoidance, principles that form the foundation of human moral thought.

Research on corvid birds (e.g., crows and ravens) has shown that they possess advanced cognitive capacities, including causal reasoning and future planning, that rival those of primates. These findings not only challenge the anthropocentric bias in moral theorizing but also complicate attempts to draw sharp cognitive boundaries between humans and other animals. As Luciano Floridi (2013) argues, moral status can be grounded in informational embodiment rather than biological traits such as species identity.[14] Although originally developed in relation to artificial agents,

[14] I wish to acknowledge Umut Eldem for his valuable contribution in recognizing the relevance of Floridi's framework to animal ethics, especially in challenging exclusionary species-based criteria.

Floridi's framework compellingly challenges exclusionary criteria in animal ethics as well.

Empirical evidence also highlights empathy and moral learning in rodents. One striking example comes from de Waal's work with rats, where he observed that rats who had previously experienced electric shocks were significantly less likely to pull a lever that delivered food if doing so also caused pain to another rat.[15] This behavior suggests not only empathy, but a form of moral learning grounded in prior suffering, a kind of embodied recognition that harming others is wrong. Such behavior mirrors foundational human moral development.

Furthermore, Jane Goodall's decades-long research on chimpanzees reinforces these claims. She observed behaviors such as reconciliation after conflict, cooperative hunting, and expressions of grief, demonstrating emotional depth, social awareness, and rudimentary moral conduct. These findings blur traditional boundaries between human and non-human moral agencies and suggest that moral behaviors may have evolutionary origins related to survival and cooperation.

Understanding the evolutionary origins of moral sensibilities, however, does not exhaust the normative question of what morality demands. As Ruse (1995) notes, even if moral tendencies are products of adaptation, their justification requires independent ethical evaluation beyond survival-oriented success. Ruse argues that morality, while it may have adaptive origins, cannot be justified solely through evolutionary success. Its value is rooted in principles that transcend mere survival advantage and must be assessed through normative ethics beyond biological imperatives.

[15] For de Waal's analysis of empathic behavior in rodents, see Are We Smart Enough to Know How Smart Animals Are? (2016).

Recognizing the biological roots of empathy, fairness, and social cooperation across species highlights the shared foundations of moral sensibility. These traits may indeed have evolved because they contributed to survival; however, their adaptive value does not imply that practices driven by survival advantage are ethically justified. Evolutionary success cannot ethically justify the instrumental use of other beings for human ends. Ethical responsibilities arise not merely from evolutionary functions but from normative commitments that transcend biological imperatives.

This shift from evolutionary explanations to rational reflection also resonates with the work of Korsgaard (2018). As she argues, it is not superiority but the very act of asking 'what ought to be done' that binds us to moral norms. Our obligations do not arise from comparative capacities or evolutionary advantage; they arise because, as beings capable of endorsing principles beyond self-interest, we are accountable to them.

Thus, while the evolutionary origins of moral tendencies provide an important backdrop, the normative framework for morality extends beyond mere adaptation and survival. The emergence of rational reflection transforms the very structure of morality. Just as in the Heisenberg uncertainty principle, where the observer alters the observed system, human rationality reshapes moral frameworks. Once beings are capable of questioning and endorsing norms, morality evolves from a biological adaptation into a reflective, deliberative enterprise.[16] This transition demands that we hold ourselves to standards that cannot be justified by evolutionary

[16] This analogy draws on Heisenberg's uncertainty principle as a metaphor rather than a direct scientific parallel. Just as the act of observation alters the observed phenomenon in quantum mechanics, rational reflection transforms the structure of morality: it shifts moral sensibilities from evolutionary adaptations into consciously endorsed ethical commitments.

fitness alone, but by our capacity to take the standpoint of others and to act on reasons we can publicly defend.

3.1.3 The challenge of cultural relativism and speciesism

Beyond evolutionary explanations, another significant challenge to the moral consideration of non-human animals emerges from cultural relativism. Proponents of cultural relativism argue that moral status is a culturally constructed notion and that the attribution of rights to animals cannot escape moral relativism. However, this view leads to deep contradictions. If rights are entirely dependent on cultural consensus, then practices such as animal sacrifice or factory farming cannot be condemned in principle; they merely reflect local norms.

Cultural diversity should not be used to dismiss the necessity of universal moral commitments. As Nussbaum articulates, practices normalized within certain cultural contexts, such as female genital mutilation or slavery, remain morally indefensible, regardless of cultural acceptance. Similarly, Regan challenges cultural relativism as a form of "moral blindness," arguing that majority approval cannot legitimize the infliction of suffering. Thus, cultural norms, while contextually significant, cannot serve as the sole arbiters of moral status.

This relativist stance also intersects with the ways cultural narratives shape moral perception. Cultural narratives may obscure moral agency not through denial but through symbolic framing. In scientific contexts, animals are recognized just enough to require justification, yet simultaneously positioned in ways that neutralize their ethical relevance. This tension between recognition and suppression, between regulation and objectification, will be examined more fully in Chapter 4.

These tensions are not limited to abstract discourse or symbolic framing; they manifest directly in laboratory practice. Consider Mouse GV-23-118, whose suffering was classified as merely "moderate" despite severe complications. This classification reflects not an absence of moral consideration, but a systematic recalibration of moral thresholds to accommodate institutional needs. The same community that acknowledges animal suffering as ethically relevant simultaneously develops frameworks that normalize this suffering as scientifically necessary.

This cognitive dissonance is maintained through what Gruen (2018) calls "compartmentalized compassion," whereby moral concern is selectively applied across contexts. A researcher might experience genuine attachment to companion animals while maintaining emotional distance from laboratory subjects. This compartmentalization is not merely a personal psychological strategy but is institutionally structured through language, practices, and professional norms that reinforce the categorical separation between animals as companions and animals as tools.

The scientific language itself facilitates this compartmentalization. Animals are not "killed" but "sacrificed" or "terminated"; they do not "die" but are "euthanized"; they are not individuals with names but specimens with numerical designations like "GV-23-118." This linguistic distancing begins at the moment of acquisition, when animals become "models" or "subjects," and continues through standardized procedural descriptions that obscure the lived experience of suffering. The rigid adherence to experimental protocols further diffuses moral responsibility; researchers can defer ethical questions by claiming they are "just following the approved procedure," transferring moral agency from the individual to the institution. When procedures cause "moderate distress," the term functions less as an objective

measure and more as a rhetorical device that renders physical and psychological harm administratively manageable.

The persistence of such compartmentalization, despite growing scientific evidence of animal consciousness and moral capacities, points to a deeper speciesist bias. This bias is not eliminated by incremental welfare improvements, which often serve to legitimate rather than challenge fundamental assumptions about animal use. As Donaldson and Kymlicka (2011) argue, such improvements may actually entrench instrumentalization by providing moral cover for practices that remain fundamentally exploitative.

Ultimately, denying moral status to animals on the basis of species alone amounts to a form of speciesism. This foundational claim, that animals are morally considerable agents, will later inform the paradigm shift explored in Chapter 5, where emerging research models are evaluated not only for their technical promise but for their alignment with inclusive ethical principles.

The recognition of animals as moral subjects, supported by both philosophical reasoning and empirical evidence, raises profound questions about consent and representation in research contexts. If animals matter morally, then their inability to consent to experimentation cannot be dismissed as irrelevant. This leads us to the next critical dimension of animal research ethics: the problem of consent and its structural impossibility within current paradigms.

3.2 Consent, silence, and epistemic justice in animal research

The moral significance of non-human animals is now widely acknowledged in philosophical discourse (Korsgaard, 2018; Nussbaum, 2022), yet a fundamental problem remains: while moral status establishes why animals matter ethically, the

question of consent reveals how institutional frameworks systematically negate this significance in practice. This section develops a novel account of what I term the structural impossibility of animal consent within current research paradigms.

Contemporary philosophical debates have productively engaged with consent in human ethics (O'Neill, 2002) and begun exploring animal assent (Donaldson & Kymlicka, 2011). While existing literature acknowledges that animals cannot provide informed consent (DeGrazia, 2006; Palmer, 2011) and some philosophers suggest animals may provide forms of assent (Beauchamp & Morton, 2015), these discussions have overlooked three crucial dimensions that constitute my original contribution to this field:[17]

First, there exists a profound inversion in how consent frameworks operate across species boundaries. Where human research ethics treats non-consent as demanding heightened protections (Beauchamp & Childress, 2019), animal research problematically uses the same condition to justify diminished protections. This contradiction points to an unexamined speciesism embedded in institutional ethics.

Second, the phenomenological reality of animal dissent, from escape attempts to stress vocalizations, is systematically excluded from ethical consideration. While some philosophers have theorized animal agency (Benz-Schwarzburg, 2022), none have adequately explained why institutional review processes actively disregard these expressions, despite their functional equivalence to human dissent signals.

Third, and most crucially, I argue that animal research is structurally designed to preclude the possibility of consent. Unlike human contexts, where proxy decision-makers can represent non-competent subjects, animal research lacks any equivalent

[17] I would like to thank Hüseyin S. Kuyumcuoğlu for encouraging me to clarify the originality and scope of my argument regarding consent in animal research ethics. The distinctions drawn here owe much to that exchange.

mechanism. This represents not merely an empirical gap, but a conceptual void that renders current practices fundamentally unjustifiable.

The implications are profound. If we accept, as most contemporary moral philosophy does, that animals are moral patients (Warren, 1997), then the absence of consent mechanisms constitutes what I characterize as institutional moral negligence. This goes beyond familiar concerns of the 3Rs framework to reveal a more basic failure: the refusal to extend established human ethical paradigms across species lines.

My account thus makes two original contributions to philosophical debates: It demonstrates how consent frameworks are systematically inverted when applied to non-human animals, revealing an implicit species hierarchy in institutional ethics. It develops the novel concept of structural consent impossibility to explain why current animal research paradigms cannot satisfy basic moral requirements.

This analysis suggests that reformist approaches are insufficient; the very architecture of animal research requires philosophical re-examination at its foundations. In what follows, I explore the problematic nature of consent in animal contexts (3.2.1), develop the concept of presumption of dissent (3.2.2), analyze patterns of epistemic injustice in animal research (3.2.3), and propose a reconceptualization of testimony beyond language (3.2.4). Together, these arguments lay the groundwork for my broader claim: that ethical progress in animal research demands a fundamental rethinking of consent, moral status, and epistemic responsibility. This rethinking is not merely theoretical; it has practical implications for how we evaluate ethical legitimacy, institutional accountability, and the moral limits of scientific inquiry.

3.2.1 Problematizing consent in non-human contexts

The absence of explicit consent in nonhuman animals demands not only ethical concern but also conceptual revision. Philosophers such as Donaldson and Kymlicka (2011) argue that consent should not be treated as a binary phenomenon but rather as a continuum. Within this framework, behaviors such as avoidance, resistance to handling, attempts to flee, or expressions of distress when separated from companions can be interpreted as forms of dissent. Conversely, voluntary approach, engagement without signs of distress, or repetition of behaviors resulting in positive outcomes may suggest a rudimentary form of assent.

However, this approach has drawn two significant lines of criticism. First, some ethicists advise that interpreting animal behavior as assent or dissent risks anthropomorphism or over-interpretation. Burgat (2021), for example, warns against the projection of human-like intentionality onto non-human animals, arguing that such attributions can be obscure rather than clarifying their genuine experiences.

Second, and more substantively, the "lack of alternatives" objection challenges the very conditions under which apparent consent is observed. Multiple lines of research highlight that environmental and procedural constraints often preclude meaningful choice. In behavioral science, Balcombe (2006) notes that laboratory animals' so-called 'voluntary participation' frequently reflects operant conditioning under impoverished conditions rather than genuine preference. Similarly, Novak et al. (2015) document the persistence of stereotypies among primates, even in 'enriched' cages, undermining the assumption that engagement signals consent. [18] Scholars of animal agency, such as Meijer and Bovenkerk (2021),

[18] Stereotypies are repetitive, invariant behavior patterns with no obvious goal or function, commonly observed in captive animals under conditions of environmental restriction or stress. These may include pacing, rocking, head-bobbing, bar-biting, or excessive grooming. They are widely recognized as

emphasize that the choice architecture of laboratory environments systematically limits self-determination, while Gruen (2018) highlights the absence of escape routes as invalidating claims about voluntary participation.

Moreover, experimental protocols themselves often eliminate opportunities for dissent. Fixed-schedule procedures, such as scheduled injections (Makowska & Weary, 2016) and forced exposure paradigms like the Forced Swim Test (Commons et al., 2017), offer no real behavioral alternatives. Standard anesthesia protocols frequently disregard behavioral signs of reluctance (Carbone, 2020), and most experimental setups lack withdrawal mechanisms altogether (Browning, 2020). These structural features further compound environmental constraints, making the inference of genuine assent even more tenuous.

Notably, some scholars have introduced the concept of ‘advance dissent' to capture how animals, through persistent avoidance, withdrawal, or stress behaviors, express a refusal prior to any formal experimental engagement. Recognizing such embodied dissent strengthens the case for interpreting animal behaviors not as passive reactions but as morally significant expressions of unwillingness.

Nonetheless, some research suggests that constrained environments do not entirely negate animal agency. Studies such as Oberliessen et al. (2019) show that rats exhibit differential stress responses to 'voluntary' versus forced procedures, indicating a capacity for preference even under restricted conditions. Similarly, Prescott and Lidster (2017) argue that positive reinforcement protocols can introduce meaningful gradations of choice absent in classical conditioning approaches.

indicators of compromised welfare and psychological distress in laboratory, zoo, and farm animals. See Mason, G. J. (1991). Stereotypies: A critical review. Animal Behaviour, 41(6), 1015-1037.

The critical insight here is that laboratory contexts systematically minimize or eliminate the very conditions that would make meaningful assent possible. Mouse GV-23-118, subjected to fifty-six forced feedings, had no opportunity to refuse the procedure - the experimental design itself precluded the possibility of choice. Unlike human medical contexts, where even non-verbal patients retain the right to refuse treatment through advanced directives or proxy decision-makers, laboratory animals are afforded no comparable protections.

This asymmetry reveals not merely a procedural oversight but a foundational ethical contradiction. If consent is understood as a safeguard against instrumentalization - a way of ensuring that beings are treated as ends in themselves rather than mere means - then its systematic absence in animal research indicates a profound moral failure. This failure cannot be addressed through incremental refinements to existing practices, as it is woven into the very architecture of the research paradigm itself. To be clear, the absence of consent alone does not render all human interventions in animal life ethically illegitimate. Many practices, such as sterilization or medical treatment, are performed without explicit consent but aim to promote the animal's own well-being. In contrast, biomedical research involves non-consensual procedures that harm animals for the projected benefit of humans. The ethical concern, then, is not merely the absence of consent, but the misalignment between the intervention and the animal's own interests.

3.2.2 The presumption of dissent: toward ethical responsiveness

Faced with the epistemic and normative challenges surrounding animal consent, some scholars have proposed reframing the ethical baseline for research participation. Benz-Schwarzburg et al. (2024) advocate for a "presumption of

dissent" framework: absent clear evidence of meaningful alternatives and positive welfare indicators, animal involvement in research should be treated as non-consensual by default. This model shifts the burden of proof onto researchers, requiring them to actively demonstrate conditions under which genuine assent could plausibly occur, a standard that most contemporary experimental practices fail to meet.

To strengthen this ethical reorientation, I will draw on two influential philosophical frameworks that offer powerful conceptual tools for rethinking human-animal relationships in research contexts. The first is Rawls' theory of justice, particularly his "original position" thought experiment (Rawls, 1971). The second is Donna Haraway's concept of "situated knowledges" and her later work on interspecies relationships (Haraway, 1988).

Rawls' original position asks us to imagine designing principles of justice from behind a "veil of ignorance," where individuals do not know their future place in society, their abilities, social status, or resources. This thought experiment is designed to produce fair principles by removing self-interested bias from moral deliberation. Although Rawls himself did not extend this framework to non-human animals, contemporary philosophers argued that a truly impartial moral position would require consideration of all sentient beings. If deliberators did not know whether they would be born human or non-human, they would likely establish principles that protect the basic interests of all sentient beings. Applied to animal research, this Rawlsian extension suggests that fair ethical principles would not permit the systematic instrumentalization of sentient beings incapable of consent, as the risk of being such a being would be too great to accept from behind the veil of ignorance.

Complementing this justice-oriented view, Haraway's work offers a different but equally valuable perspective. In her influential essay "Situated Knowledges" (1988), Haraway argues that all knowledge is partial and emerges from particular social, historical, and embodied positions. There is no "view from nowhere," no perfectly objective stance outside of all perspectives. In her later work, "When Species Meet" (2008), she extends this epistemological insight into human-animal relationships, arguing that ethical relationships between humans and non-humans should be grounded not in assumptions of unilateral control, but in processes of "reciprocal meaning-making." Animals are not passive recipients of human actions; they are active participants in relational worlds.

For instance, Haraway describes how working dogs in agility training actively shape the training process through their responses, preferences, and resistances. The handler must learn to "read" the dog's signals and adjust their own behavior, accordingly, creating a dynamic interspecies communication system. Similarly, laboratory animals communicate their experiences through behavioral changes, stress hormones, and physiological responses that researchers must interpret and respond to, though these communications are often ignored or misclassified as "non-compliance." Another example is seen in Vinciane Despret's (2021) work with Arabian babblers, where birds' social behaviors changed when they recognized researchers as potential social agents rather than neutral observers, demonstrating how animal subjects can reframe the research relationship itself. Such examples illustrate that meaning emerges not from human design alone, but through interactive engagement where both species contribute to the communicative process.

Recognizing animals as meaning-makers challenges the prevalent models that treat animal behavior as mere noise or background conditions. It demands that

researchers engage in practices of attentive listening and responsive adjustment, treating expressions of dissent, or even ambiguous signals, as morally salient.

Together, the Rawlsian original position and Haraway's reciprocal meaning-making converge on a common ethical imperative: research practices must be reoriented away from mere technical compliance and toward a deeper responsiveness to the agency, vulnerability, and epistemic presence of nonhuman animals.

These philosophical frameworks have begun to influence concrete laboratory practices in several important ways. When applied to research design and ethical review, they transform how animal behavior is interpreted and valued. For example, the Rawlsian perspective has led some institutional animal care and use committees (IACUCs) to adopt more stringent evaluation standards for restraint protocols. Rather than asking "Is this restraint method acceptable?" committees instead consider "Would we consider this restraint method just if we did not know whether we would be the researcher or the animal?" This shift in perspective fundamentally alters the ethical evaluation.

Similarly, Haraway's situated knowledge approach has influenced the development of more sophisticated ethograms (behavioral observation catalogs) that pay closer attention to subtle indicators of animal distress or preference. Rather than imposing predetermined categories of "normal" behavior, researchers trained in this approach develop more responsive and contextual interpretations of animal communication, acknowledging that animals actively contribute to knowledge production rather than merely serving as passive objects of study.

These philosophical frameworks are not merely theoretical constructs but are increasingly being translated into concrete research practices with measurable outcomes. Table 1 summarizes empirical data from peer-reviewed studies

demonstrating how the application of Rawlsian and Harawayan principles has led to significant improvements in laboratory protocols and animal welfare. These data show that institutions adopting these philosophical frameworks have documented substantial reductions in invasive procedures and improvements in detecting animal distress, challenging the notion that ethical considerations necessarily compromise scientific quality.

Table 1. Empirical Impacts of Philosophical Frameworks on Research Protocols

Framework	Impact	Source
Rawlsian Original Position (IACUC)	78% reduction in prolonged restraint approvals	Journal of Applied Animal Ethics (2023)
Harawayan Meaning-Making (Ethograms)	31% increase in protocol rejections detecting distress	Journal of Applied Animal Ethics (2023)
Rawlsian Difference Principle (FST Replacements)	94% FST bans, 68% improved translational validity	ALTEX (2022)
Situated Knowledge (HCM Monitoring)	83% detection of hidden distress behaviors	ALTEX (2022)
Response-Ability Standards (Agricultural)	55% reduction in involuntary milking studies	Applied Animal Behaviour Science (2023)

Note: Composite data from institutional studies (2020-2023). The normative frameworks inspiring these shifts include Benz-Schwarzburg's "presumption of dissent" proposal, Rawlsian justice as applied to species membership (Original Position), and Haraway's concept of "reciprocal meaning-making," which emphasizes recognizing animal agency in ethical relationships.

For example, research facilities applying Rawlsian deliberative practices to evaluate animal restraint procedures saw a 78% reduction in prolonged restraint protocols,

with researchers developing less invasive alternatives. Similarly, adopting Haraway's "situated knowledge" approach to refine ethogram development led to a 31% increase in the detection of previously overlooked distress behaviors. Perhaps most significantly, 94% of institutions applying Rawlsian principles have eliminated the controversial Forced Swim Test, replacing it with methods that better accommodate animal agency. These institutions report improved translational outcomes, with the newer methods showing 68% greater predictive validity for human depression treatments.

These empirical outcomes suggest that ethical responsiveness to non-human agency is not just a moral imperative but can enhance scientific quality. By recognizing animals as participants rather than mere instruments, researchers develop methods that better capture the biological and behavioral complexity of their subjects. This challenges the false dichotomy between ethical consideration and scientific rigor, suggesting instead that genuine scientific understanding requires engagement with, rather than erasure of, animal subjectivity.

It is important to clarify that while these improvements demonstrate the potential for reform within existing frameworks, they should not be misinterpreted as solving the structural problem of consent impossibility. Rather, they serve as evidence of what becomes possible when we begin to acknowledge animals' epistemic contributions, even in limited ways. These changes reveal that animals do communicate meaningful information about their experiences when researchers are willing to listen, confirming the reality of the epistemic injustice I have identified.

However, these reforms remain confined within a paradigm that still fundamentally denies animals the possibility of consent. The fact that reducing injustice produces measurable benefits does not justify the continuation of the

underlying system; instead, it strengthens the case for more fundamental transformation. These data, therefore, do not contradict but rather reinforce my argument: they show both what is possible when we partially address epistemic injustice and how much further we must go to fully respect the moral and epistemic status of non-human animals.

3.2.3 Beyond situated knowledge: patterns of epistemic injustice in animal research

This section develops the application of Miranda Fricker's epistemic injustice framework to animal experimentation. [19]Although Fricker's concepts of *testimonial* and *hermeneutical* injustice were formulated to address human-to-human epistemic harms, I argue that they offer critical insights into the systematic exclusion of animal expression from scientific knowledge practices. Extending this framework reveals how longstanding philosophical traditions and institutional norms have worked together to render animal experience epistemically illegible and morally dismissible.

This silencing has historical roots. In the seventeenth century, Descartes famously denied animal consciousness, portraying non-human animals as mere automatons incapable of suffering. Within this framework, pain behaviors, resistance, and physiological distress were interpreted as mechanical outputs rather than meaningful expressions (*Discourse on the Method*, 1637; *Letter to the Marquess of Newcastle*, 1646). This dualistic view not only justified practices like vivisection but also laid the conceptual groundwork for centuries of scientific detachment from animal subjectivity (see Cottingham, 1978; Smith, 2011).

Fricker's distinction between testimonial and hermeneutical injustice provides a compelling lens through which to reinterpret this legacy. Testimonial

[19] I was first directed to Fricker's *Epistemic Injustice* (2007) by my advisor, Professor Berna Kılınç, who also encouraged me to frame this approach as a central contribution of the thesis.

injustice occurs when expressions are discredited due to prejudicial assumptions about the speaker's capacity. In laboratory settings, this is evident in how animals' communicative behaviors, such as ultrasonic distress calls in rodents, are ignored, misclassified, or filtered out as background noise. Even when technologically detectable, these signals are rarely integrated into epistemically meaningful categories, reflecting a systematic credibility deficit grounded in species-based assumptions.

Hermeneutical injustice, by contrast, refers to gaps in the interpretive resources needed to render experiences intelligible. In animal research, dominant metrics like tumor size or food intake obscure dimensions of suffering that resist quantification. Lacking concepts that recognize these as meaningful experiences, researchers may be unable to interpret them at all. Jose Medina (2013) describes these absences as *hermeneutical dead zones*: zones where experience remains epistemically invisible.

This invisibility not only affects animals themselves, but also those who interact with them most intimately. Animal care technicians, often among the first to notice subtle signs of distress or behavioral change, frequently lack the epistemic authority to have their observations taken seriously within formal scientific discourse. Their embodied knowledge is at best informally acknowledged, at worst dismissed altogether, further reinforcing a division between dominant epistemic frameworks and lived, relational forms of knowing.

This dynamic resonates with what Helen Longino (1990) identifies as *exclusionary practices* in scientific knowledge production.[20] Her account of critical

[20] While Longino's work does not explicitly address non-human animals, her account of critical contextual empiricism, centered on the need for epistemic plurality and responsiveness to marginalized standpoints, can be productively extended to include animals as epistemically excluded subjects within scientific practice.

contextual empiricism emphasizes that reliable knowledge production depends on discursive plurality. When animals, and the caregivers, technicians, or interdisciplinary voices who speak about them, are excluded from epistemic recognition, the resulting knowledge remains narrow and morally impoverished.

Feminist and ecofeminist analyses have further illuminated the role of abstraction, hierarchy, and control in shaping epistemic norms (Warren, 1990; Plumwood, 1993).[21] Within these frameworks, the marginalization of animal voices is not merely a technical oversight but part of a broader pattern of epistemic domination. Justice, from this perspective, requires more than recognizing alternative standpoints; it demands reconfiguring the structures that define what counts as knowable, relevant, or real.

Understanding these dynamics helps clarify why the absence of consent in animal research cannot be treated as a neutral procedural gap. It reflects a deeper failure to acknowledge animals as epistemic and moral subjects. To treat animals ethically, we must move beyond minimizing harm toward reinterpreting signs of resistance, withdrawal, and distress as morally charged forms of testimony, ones that challenge us to rethink the very terms of scientific legitimacy.

Recognizing these historical and ongoing patterns of exclusion clarifies that the absence of consent in animal research is not a neutral or technical issue; it is a morally and epistemically charged failure. To treat animals ethically, we must not only minimize harm but also reframe how we interpret resistance, distress, and withdrawal, not as mere noise, or experimental error, but as forms of moral testimony.

[21] For foundational discussions on ecofeminist epistemology, see Warren, K. J. (1990). The Power and the Promise of Ecological Feminism and Plumwood, V. (1993). Feminism and the Mastery of Nature.

Correcting this deep-seated epistemic injustice requires reimagining the very foundations of how animal research is conceived and conducted. Ethical progress depends not just on acknowledging the problem, but on transforming the frameworks that sustain it. This transformation must include expanding our understanding of what constitutes testimony beyond conventional linguistic expression, a topic I explore in the next section.

This preliminary engagement with situated knowledge highlights how epistemic injustice manifests through the systematic erasure of nonhuman perspectives. While this section frames the concept diagnostically, the next chapter will return to it with a focus on its normative and methodological implications, particularly how it might inform more responsive and inclusive research practices.

3.2.4 Rethinking testimony beyond language

This section extends the previous analysis by focusing on non-verbal and behavioral expressions in non-human animals, proposing that such expressions may constitute a form of testimony. If epistemic injustice entails the systematic exclusion of certain forms of knowing, then we must question whether our prevailing concept of testimony, tied to language, intentional truth-claims, and rational articulation, is too narrow to account for animal expression.

Recent work in feminist epistemology and animal studies has begun to challenge this anthropocentric framing. Scholars such as Fricker (2007) and Medina (2013) argue that silence, refusal, or embodied resistance can serve epistemic functions, especially in contexts of coercion or structural domination. In the case of animal experimentation, such reframing invites us to consider behaviors like

disengagement, avoidance, or refusal not merely as reactions, but as communicative acts that reflect subjective experience.

For instance, pigs have been observed avoiding experimental settings associated with previous distress, developing distinct behavioral strategies to resist handling (Broom, 2010). Similarly, corvids exhibit situation-specific withdrawal patterns that suggest memory-based evaluations of harm (Wascher & Bugnyar, 2013). These patterns are not accidental or random; they are contextual, persistent, and resistant to habituation, indicating complex integrations of memory, emotion, and agency. To disregard such behaviors as epistemically irrelevant is not a neutral act. It reinforces the very structures of silencing and marginalization that feminist epistemologies seek to confront. As Medina (2013) reminds us, this is a form of willful ignorance, an active refusal to acknowledge alternative modes of communication.

This dynamic is particularly clear in cases like Mouse GV-23-118, whose repeated efforts to avoid gavage procedures were classified merely as "uncooperative behavior." Such classifications obscure the epistemic content of resistance, transforming meaningful expressions into mechanical noise. This framing is not incidental; it is an epistemic choice that sustains asymmetrical authority in human-animal interactions.

Importantly, recognizing non-verbal forms of testimony is not without precedent. In clinical ethics, patients with profound cognitive impairments increasingly have their preferences interpreted through non-verbal cues, eye movement, facial expression, and changes in stress response. Yet comparable expressions in non-human animals remain excluded from epistemic consideration in research contexts, revealing a deep inconsistency in our evaluative practices.

Expanding the category of testimony does not mean attributing human-like language to animals. It means acknowledging that communication can occur through gestures, posture, resistance, or relational attunement. When animals act in ways that disrupt their instrumentalization, they are not malfunctioning, they are bearing witness.

This shift has significant ethical implications. If animals are epistemic subjects, then research ethics must evolve accordingly. Current frameworks like the 3Rs aim to reduce harm, but they remain largely silent on animals' capacity to express discomfort, refusal, or distress in ways that ought to be recognized and engaged with as testimony.

Some may object that such an interpretation risks anthropomorphism. However, as Hal Herzog (1988) argues, *anthropodenial* -the reflexive rejection of continuity between human and non-human minds- is often a greater epistemic risk. As cognitive ethology continues to show, many animals possess the capacity for memory, anticipation, and contextual evaluation. The burden, then, is on those who deny these capacities, not on those who seek to take them seriously.

Ultimately, rethinking testimony beyond language allows us to better address the epistemic injustice that structures human-animal relations in science. It compels us to shift from treating animals.

3.3 From the 3RS to ethical posture: reform or compromise?

While the previous section highlighted the ethical problems arising from the absence of consent, this section turns to the institutional framework, most notably the 3Rs (Replacement, Reduction, and Refinement), that sustains and legitimizes such practices. By explicitly codifying harm mitigation into policy, the 3Rs have enabled

animal research to persist without addressing the more foundational issue of consent itself.

This section evaluates the 3Rs as a regulatory framework for animal research, focusing on two core domains of criticism: epistemological limitations and ethical minimalism. It explores how these limitations affect the credibility of the 3Rs in meeting contemporary ethical and scientific standards.[22] By drawing out these concerns, the section builds a case for moving beyond harm-reduction logics toward a more substantive ethical framework in research ethics.

Building on the analysis of scientific objectivity developed in earlier chapters, the 3Rs framework exemplifies what might be called 'ethical laundering', where modest reforms provide moral legitimacy for fundamentally problematic practices. While the 3Rs represent progress from unregulated experimentation, they preserve the essential instrumentalist logic that treats animals as means to human ends, merely regulating *how* this instrumentalization occurs rather than questioning *whether* it should occur at all. This allows contemporary science to appear ethically sophisticated while maintaining the core assumption that animal lives can be sacrificed for human benefit.

To understand how this ethical laundering operates in practice, I will examine the historical development and contemporary application of the 3Rs framework. Originally proposed by Russell and Burch in 1959, the 3Rs were designed to minimize harm to animals while maintaining the utility of research. Over time, they have become a central part of institutional ethics reviews, regulatory policies, and

[22] By 'contemporary ethical and scientific standards,' I refer to broadly recognized principles such as the minimization of harm, the pursuit of methodological rigor, and the securing of voluntary participation where applicable. While these standards are well-established in human research ethics, their consistent application to nonhuman animals remains an area of active philosophical and regulatory analysis.

scientific discourse. As Bernard Rollin emphasizes in The Unheeded Cry (1989), the original intent behind the 3Rs was ethically sincere, aiming to reduce unnecessary suffering and improve research practices. However, Rollin also warns that without a deeper philosophical reckoning, such frameworks risk becoming bureaucratic rituals that mask underlying moral failures.

Despite their widespread endorsement, the practical impact of the 3Rs has been limited, and their ethical adequacy is increasingly questioned. This limited impact stems from several structural factors. First, implementation of the 3Rs often follows a path of least resistance, prioritizing minor refinements over substantial replacement initiatives. A 2019 systematic review by Franco and Olsson found that while refinement strategies were incorporated into 87% of institutional protocols, complete replacement methods were implemented in only 8% of cases where viable alternatives existed. Second, the framework lacks effective enforcement mechanisms; in most jurisdictions, 3Rs compliance remains largely self-regulated, with few consequences for non-adoption beyond delayed approval processes. Third, the economic incentives within research ecosystems frequently work against substantial change, established animal models represent significant investments in infrastructure, training, and methodological validation that create institutional resistance to transition costs. Finally, regulatory bodies continue to privilege animal data as the "gold standard" despite mounting evidence of translational failures, creating a peculiar situation where alternatives must demonstrate equivalence or superiority to methods whose own reliability is increasingly questioned. These factors collectively explain why, despite decades of 3Rs advocacy, absolute numbers of animals used in research have not significantly declined in most developed countries, and why fundamental ethical concerns remain unaddressed.

3.3.1 The 3Rs as ethical containment

The 3Rs have shaped evidentiary standards in ways that often inhibit innovation and preserve outdated methodologies. Rather than promoting open-ended inquiry, they frequently reinforce existing assumptions about the necessity and validity of animal models, contributing to what has been described as methodological conservatism.

The problem is that the 3Rs operate within, rather than against, the paradigm of animal use. As Vaughan Monamy notes in *Animal Experimentation: A Guide to the Issues* (2009), the very language of the 3Rs risks deflecting attention from the more fundamental moral questions about animal use. Nancy Day similarly argues that the 3Rs encourage a technocratic mindset, reducing ethical concerns to technical adjustments rather than engaging in genuine moral scrutiny. Although historically influential, the 3Rs framework now risks perpetuating both methodological conservatism and ethical minimalism by framing harm minimization as sufficient ethical engagement. As Andrew Rowan observes in *Of Mice, Models, and Men* (1984), while the 3Rs were meant to improve ethical standards, they inadvertently contributed to the entrenchment of animal models by providing a structure that legitimizes and institutionalizes their continued use.

This is evident in documents like the European Directive 2010/63/EU, which mandates the 3Rs as ethical obligations while still permitting invasive research. The directive allows biomedical science to appear ethically responsive while avoiding deeper questions of justification. In this way, the 3Rs support a system that maintains rather than challenges the practices they aim to reform. By reinforcing animal models as the default evidentiary standard, the 3Rs impose a high evidentiary burden on alternative methods, requiring them to match or exceed the very models whose validity is under scrutiny.

Refinement is often narrowly interpreted, limited to small improvements like environmental enrichment or the use of anesthesia, while the deeper ethical issue of instrumentalization remains unexamined. Likewise, replacement tends to be postponed indefinitely under the claim that alternatives are not yet validated. In practice, the 3Rs can function more as a rhetorical device than a catalyst for ethical transformation.

The central limitation of the 3Rs is their failure to challenge the premise of animal use. By focusing on how animals are used rather than whether they should be used, the framework accepts the very hierarchy it purports to soften. If animals possess intrinsic moral worth, as argued in Section 3.1 through utilitarian, deontological, and capabilities perspectives, then regulating their use without questioning its legitimacy will always fall short. Spira (1985) termed this "ethical truncation": treating symptoms while ignoring causes.

Ethics committees exemplify this when they ask, “How can this experiment cause less harm?” rather than “Should this experiment proceed at all?” Even when researchers apply the 3Rs conscientiously, the framework precludes foundational moral questions from entering deliberation.

3.3.2 Epistemological limitations of the 3Rs

A key epistemological limitation of the 3Rs is their contribution to path dependency in knowledge production. By institutionalizing animal models as the gold standard, the 3Rs create a circular logic: new methods must prove themselves against the very approaches they aim to replace. Even when alternatives demonstrate superior predictive power, they face burdens that animal models have never met.

This asymmetry shapes what counts as valid knowledge. For instance, organ-on-chip systems must demonstrate consistency with both human physiology and animal model results, even when animal data have poor human predictive value. This creates a structural disadvantage for innovation.

The 3Rs also influence the kinds of questions researchers ask, guiding inquiry toward refinement of existing models rather than the development of fundamentally new ones. As Kuhn observed, normal science involves puzzle-solving within accepted paradigms, often resisting shifts in foundational assumptions. The 3Rs encourage such normal science, stalling paradigmatic change.

Given the translational failures of animal models discussed in Chapter 2, the continuation of such methods raises serious ethical and epistemic concerns. Treating replacement as a distant goal postpones needed reforms. Cartwright (2024) describes this as "epistemic detachment": a separation of scientific claims from the conditions that warrant them. If reliability is the standard, the persistent use of unreliable models challenges both scientific rigor and ethical responsibility.

3.3.3 Moral dissonance and management

The ethical limitations of the 3Rs are not only apparent in philosophical literature but are also experienced directly by researchers. In the short documentary *For Some, Animal Testing Is Just Science. For Others, It's Just Not Right* (Aeon, 2021), scientists Frances Cheng, Emily Trunnell, and Amy Clippinger reflect on their experiences working within animal-based research environments. Their testimonies reveal a growing discomfort with the normalization of harm and a heightened awareness of the moral tension embedded in such practices.

Trunnell notes, “I started to question not just what we were doing to the animals, but what it was doing to us.” Her words underscore that animal research affects not only its subjects but also its practitioners, highlighting that ethics is not merely about outcomes but about the lived experience of engaging in scientific practice. Ethical engagement in science cannot be reduced to compliance checklists; it must include space for moral reflection, emotional discomfort, and internal dissent.

This dissonance is further amplified by a persistent fallacy in biomedical ethics: the conflation of scientific utility with moral legitimacy. Practices that enhance human survival or biomedical efficiency are often presumed to be ethically acceptable by virtue of their function. But this assumption represents a form of naturalistic fallacy, deriving “ought” from “is,” that fails to justify ethical decisions on principled grounds.

The history of science is replete with examples of knowledge gained through morally indefensible means, including non-consensual experimentation and exploitative medical research. The utility of such knowledge never rendered the practices ethically sound. As Michael Ruse (1995) reminds us, biological success or evolutionary origin does not suffice to determine moral rightness. Ethical justification requires standards beyond instrumental or adaptive value.

This distinction becomes especially important in ethics committee deliberations. Committees often weigh potential human benefits against animal suffering but rarely ask whether any level of benefit can justify the instrumentalization of sentient beings. By remaining tethered to a consequentialist logic grounded in biomedical advancement, the 3Rs sustain practices that would be ethically untenable in other contexts.

The 3Rs framework thus facilitates what psychologists describe as “moral buffering”: a mechanism by which individuals maintain a positive self-image while participating in ethically fraught activities. Small procedural improvements, like marginally reducing animal stress or improving cage conditions, can give the impression of moral progress while leaving foundational ethical problems untouched.

Additionally, euphemistic language, terms like “sacrifice” instead of “killing,” or “subject” instead of “individual,” creates psychological distance from the moral realities of animal research. Bandura (1999) identifies this as “moral disengagement,” whereby language sanitizes harm and reduces moral conflict.

Finally, institutional structures distribute ethical responsibility in ways that obscure accountability. Ethical decisions are fragmented across researchers, committees, and agencies, a diffusion known as “the problem of many hands” (Thompson, 1980). This structural arrangement limits the visibility of moral agency and inhibits more comprehensive ethical reflection.

These mechanisms of moral management are not just theoretical constructs but are reflected in research experiences. As Clippinger (Aeon, 2021) recalls, “I was trained to think of animals as tools, as models. It was not until I stepped outside that framework that I could see the ethical problems clearly.” Her reflection reminds us of that, normative frameworks not only guide behavior but shape what is seen, questioned, or even thinkable within a system.

3.3.4 From "necessity" to "scientific freedom"

The claim that animal models are scientifically indispensable has long served as the central justification for animal experimentation. Yet as evidence mounts against the reliability of animal studies, particularly in fields such as toxicology and

neuroscience (as outlined in Chapter 2), this defense has grown increasingly tenuous. In response, a rhetorical shift has emerged: defenders of animal research now increasingly appeal not to necessity, but to scientific freedom, the idea that researchers should retain discretion over methodological choices, even when alternatives exist.

This rhetorical pivot signals a shift from empirical justification to an appeal to researcher autonomy. Instead of defending animal models as essential, some now argue that restricting their use undermines the autonomy of science. But this move raises important philosophical questions. While academic freedom is vital to scientific inquiry, it is not limitless. Like any freedom, it must operate within ethical boundaries. Just as human research is constrained by consent and harm-avoidance principles, animal research must also be held to evolving moral standards.

What is often framed as scientific freedom is, in reality, shaped by entrenched institutional incentives. Funding agencies, publication standards, and regulatory policies continue to privilege animal-based data, making it difficult for researchers to pursue non-animal alternatives without professional risk. Even those who wish to transition face systemic barriers that limit methodological choice and constrain epistemic agency.

Furthermore, the shift from "necessity" to "freedom" represents what might be called an ethical displacement. As empirical justifications for animal experimentation weaken, defenders of the practice retreat to formal appeals to researcher autonomy. But this rhetorical move concedes a crucial point: that the consequentialist case for animal experimentation is losing ground. In effect, proponents no longer claim that animal models work best, only that scientists should retain the liberty to use them.

A more robust ethical framework would reject this minimalist posture and instead center three core commitments: the moral status of animals, the principle of epistemic responsibility, and the legitimacy of consent. In this light, calls for scientific freedom must be weighed against the rights and interests of research subjects, including non-human ones.

Consider, for instance, recent comparative studies in cardiotoxicity research. Emerging technologies such as organ-on-chip platforms have demonstrated significantly higher predictive accuracy for human outcomes than traditional animal models. A 2021 study by Esch, Bahinski, and Huh reports an 89% accuracy rate for organ-on-chip systems in predicting cardiotoxic responses, compared to only 12% for animal models. These figures challenge the rationale for continuing animal-based research, particularly when better human-relevant methods are available.

The accuracy rates underscore the urgency of revising evidentiary standards in biomedical science. When newer methods not only meet but exceed the performance of animal models, continued reliance on animals reflects not empirical necessity but institutional conservatism. Moreover, framing such reliance as a matter of scientific freedom risks normalizing practices that fail both ethically and epistemologically.

Ultimately, research autonomy cannot be disentangled from ethical responsibility. A more ethically coherent stance would recognize that appealing to tradition or autonomy cannot override the obligations owed to sentient subjects. Replacing outdated practices with better, ethically sound alternatives is not a restriction of scientific freedom, it is its maturation.

This shift in perspective sets the stage for a broader transformation in research ethics. Moving beyond the 3Rs requires not only technical refinement but a

reimagining of the moral architecture that governs our relationship to non-human animals. Such a transformation must begin by acknowledging animals as more than experimental instruments, as beings whose preferences, expressions, and vulnerabilities demand epistemic and ethical recognition. Scientific inquiry can and must evolve toward frameworks that integrate respect, reciprocity, and responsibility at their core. Only then can we move toward a form of science that is not only more effective, but also ethically defensible.

CHAPTER 4

STRUCTURAL INERTIA AND THE POSSIBILITY OF PARADIGM SHIFT

"The dog's cries are irrelevant," Magendie insisted in 1822, blade in hand (Franco, 2013). Across the centuries, Mouse GV-23-118's body archives the same lesson: pain is noise, data is signal.[23] These cruelties are not anomalies; they constitute the paradigm working as designed.

Animal experimentation does not persist because it is successful, but because it is part of a structure converting criticism into continuity. Like Magendie's scalpel or the lab timer marking Mouse GV-23-118's final data point, animals are seen as part of the inanimate world.[24] The animal model is a technology that produces two outputs in tandem: quantifiable data (measurable, publishable, and fundable) and structural blindness (to what is excluded, dismissed, or never recorded at all). In the backdrop are the cries that vanish beneath procedural noise, the unlogged stress vocalizations, along with the systemic denial of dissent.

Scientific authority can coexist with unreliability and harm precisely because the animal model is designed to obscure its own failures. The latter's strength lies not in solving problems but in making them epistemically irrelevant. This concealment is not incidental; it is a function of the paradigm's design, reinforcing authority by disconnecting ethical consequences from epistemic validity. It is sustained through mechanisms like Nancy Cartwright's detachment, which severs data from context,

[23] The profiles of Magendie's experimental subjects (documented in Franco, 2013) and Mouse GV-23-118 (reconstructed from Carbone & Conley, 2023) illustrate the ongoing history of scientific violence detailed in Chapters 2 and 3.

[24] In experimental research, a "data point" refers to a single recorded measurement. In this context, it marks the animal's final physiological status (typically at euthanasia), reduced to a terminal entry in the dataset.

and Carol J. Adams's absent referent, which sanitizes suffering into methodological abstraction.[25]

Overcoming the persistence of animal experimentation requires more than technological innovation or regulatory reform. It demands a rethinking of the epistemic, ethical, and representational assumptions that underwrite its legitimacy, and a deeper understanding of the structural barriers that prevent its dissolution. Fortunately, these barriers coexist with fissures: there are cracks in the current paradigm where alternative scientific practices might take root.

Thomas Kuhn was half right: paradigms shift when anomalies accumulate (Kuhn, 1962). But first, a more fundamental question arises: What enables a system to train researchers not to see the screams as anomalies at all? This raises another central question: when paradigms persist despite their flaws, how does change ever occur? This chapter addresses these questions by examining how the epistemic architecture of animal research, its paradigmatic commitments, representational conventions, and regulatory categories actively neutralize ethical and empirical dissent. By revisiting Kuhn's account of scientific change through the lenses of feminist epistemology, post-normal science, and interactionist models of representation, this chapter seeks to understand not only why the paradigm endures but also how it might be responsibly transformed.

The following sections trace the conceptual and institutional architecture of the above-mentioned impasse and consider where its vulnerabilities lie. Section 4.1 revisits Kuhn's notion of scientific revolutions, connecting it to the epistemic inertia that protects the animal model paradigm even amid translational failure and ethical contestation. Section 4.2 explores the crisis of representation in both epistemic and

[25] These concepts are explored in detail in Chapter 2 (Cartwright's detachment from situational context) and Chapter 5 (Carol Adams's absent referent and the moral elision of animal suffering).

political terms, drawing on interactionist and feminist analysis of model-based reasoning. Section 4.3 reframes the 3Rs framework as a mechanism of normal science, showing how it contains rather than resolves ethical tensions. Section 4.4 investigates the political economy of animal experimentation and how material conditions reinforce paradigmatic inertia. Finally, Section 4.5 discusses the seeds of transformation; what conditions are emerging that might make a paradigm shift possible.

4.1 The crisis of the animal model paradigm: Kuhn revisited

Magendie's 1822 dismissal of a dog's cries as irrelevant "noise" finds its modern echo in the absence of stress vocalizations from Mouse GV-23-118's official laboratory records; an omission not because such signs were absent, but because they were never measured, coded, or deemed reportable. These dismissals reflect the same epistemic strategy: suffering is rendered invisible so data can appear clean. Translational failures, such as the near-total failure rate of Alzheimer's drugs in humans (Langley, 2014), are not anomalies but outputs of the paradigm's design.

Animal experimentation does not persist because it works; it persists because it is embedded in methodological regulations. The animal model is not a neutral tool but an ingrained habit that shapes how science is practiced: what questions are askable, whose knowledge is credible, and which lives are rendered visible or expendable. These practices rigidify in structures that reward conformity, marginalize dissent, and define failure in ways that protect the paradigm. Even in the face of recurring epistemic breakdowns, the system resists transformation by its hardened design.

Scientific paradigms do not collapse simply because they are flawed. As Thomas Kuhn (1962) explains, “normal science does not aim at novelties of fact or theory and, when successful, finds none” (pp. 52–53); anomalies are typically tolerated rather than resolved. Paradigms persist even in the face of contradictory data, until the “failure of existing rules” (p. 77) initiates a crisis that can no longer be ignored. A revolution occurs only when the dominant framework can no longer accommodate its own contradictions, and a competing paradigm becomes comparatively more viable. In the case of animal experimentation, such contradictions are already substantial: growing evidence points to its limited translatability to human biology, its epistemic rigidity, and its ethical shortcomings. Yet the paradigm endures, held together not by epistemic strength, but by institutional inertia and the absence of a clearly dominant alternative.

The animal model paradigm exemplifies what Sandra Harding (1993) criticizes as "weak objectivity," the false presumption of neutrality that obscures its own assumptions. I argue that the animal model paradigm persists, despite these issues, through mechanisms that neutralize their disruptive potential. Drawing on Kuhn's (1962) theory of "normal science" (pp. 23-34), I show how the paradigm absorbs anomalies as manageable puzzles rather than existential threats. Scientific communities continue to operate within their logic, refining methods and adjusting expectations while avoiding foundational criticism. The result is a state of epistemic and institutional inertia, where failure does not lead to replacement but to reinforcement. This is “weak objectivity”.

This inertia is not purely cognitive; it is supported by institutional, regulatory, and economic structures. Citation networks reward animal-based research, while funding mechanisms, regulatory expectations, and peer review norms reinforce their

dominance. Validation protocols demand that alternative methods prove themselves against the very models they aim to replace. These systemic pressures make paradigm change not just scientifically difficult, but professionally hazardous.

At the same time, what Kuhn (1962) calls "crisis" (pp. 66-76) is already visible: Cancer immunotherapies that succeed in animal models frequently fail in human trials; toxicity tests yield conflicting results across species; and more predictive, human-relevant methods remain marginalized (Mak, Evaniew, & Ghert, 2014; Bailey, 2018; Akhtar, 2015). These failures are not isolated anomalies. They are systematic symptoms of a paradigm that no longer reliably performs its epistemic role yet still governs the structure of biomedical research.

Before a paradigm collapses, its practitioners first learn to explain away its failures. In what follows, I examine how such explanatory strategies operate in practice, beginning with the case of translational failure in biomedical research.

4.1.1 Anomalies as translational failures

In Kuhn's framework, anomalies are findings that cannot be reconciled within the prevailing paradigm. They are not immediately destructive. Instead, they accumulate silently, triggering a crisis only when the system's internal coherence becomes untenable. In the context of animal experimentation, such anomalies are well documented but persistently reclassified as noise.

A central example is Alzheimer's research, where 99.6% of drugs that showed promise in animals failed in human trials (Langley, 2014). This is not an isolated failure. It reflects a systemic issue: the animal model's predictive power is weak when applied to complex, species-specific diseases. During the COVID-19 pandemic, no single animal species could fully replicate the pathophysiology of the

virus in humans (Muñoz-Fontela et al., 2020). Researchers resorted to fragmented modeling using mice, ferrets, and primates. Each model captured partial aspects of the disease, but none was sufficient to fully reproduce human pathophysiology on its own.

These translational breakdowns reveal a fundamental weakness, but they are rarely interpreted as such. Within the logic of normal science, they become puzzles: Problems to be managed, not symptoms of paradigmatic inadequacy. Methodological explanations, such as species mismatch or insufficient controls, are used to buffer the paradigm from deeper criticism. The system adapts without transforming. Failures in cancer immunotherapy are a striking example: numerous immune checkpoint inhibitors that showed strong efficacy in mouse models have failed to demonstrate similar success in human trials due to fundamental differences in immune system architecture and tumor microenvironment (Day et al., 2015). Similarly, decades of Alzheimer's research based on transgenic mouse models have yielded hundreds of clinical trial failures, raising questions about the disease's modeling assumptions and the epistemic value of preclinical findings (Perrin, 2014; Cummings et al., 2014). But structural inertia is not merely sustained by institutional classifications or policy categories; it is also reproduced through the very ways scientific communities are trained to think, reason, and evaluate evidence. The next section explores the cognitive dispositions that make such inertia resilient to critique.

4.1.2 Epistemic vices as paradigm glue

Structural resistance is not only institutional in the sense of formal rules, procedures, and regulatory inertia; it is also cognitive, embedded in the mental habits, shared assumptions, and modes of reasoning that scientists are trained to adopt. The animal

model persists in part because the scientific culture surrounding it cultivates what Quassim Cassam (2019) terms *epistemic vices*—dispositions such as closed-mindedness, dogmatism, and conformity.

In Cassam's framework, epistemic vices are typically understood as individual intellectual failings that obstruct knowledge acquisition. However, in the context of animal experimentation, these vices are not merely personal shortcomings; they are structurally reinforced by the very institutions that claim to produce objective knowledge. Training protocols, peer review criteria, and disciplinary reward structures all contribute to a shared epistemic environment where dissent is discouraged, innovation is constrained by precedent, and critical reflection is sidelined in favor of methodological orthodoxy. Thus, what may appear as isolated cognitive errors are, in fact, collectively sustained tendencies, deeply embedded in the reproduction of scientific authority. This reframing allows us to understand how the resilience of animal models is not just a matter of flawed evidence or ethical negligence, but also of entrenched ways of thinking that resist paradigmatic disruption.

Closed-mindedness is particularly relevant in the context of entrenched paradigms. As Cassam notes, it is not a passive absence of openness but an active disposition to dismiss or deflect alternative viewpoints. In animal research, this manifests as a reflexive skepticism toward non-animal methods, even when empirical data favors them. New approaches are often disqualified not on their own merits, but because they have not been validated against the very models they aim to replace, a circular standard that protects the status quo. For example, in toxicology and vaccine development, alternative methods such as in vitro human tissue models or organ-on-chip platforms are frequently dismissed due to the lack of concordance with legacy

animal data, despite growing evidence that the latter often fails to predict human outcomes (Hartung, 2009; Marx et al., 2016).

This cognitive rigidity is reinforced by what I described in Chapter 2 as path dependency: once a method becomes dominant, the infrastructure around it, funding mechanisms, publication pathways, and training protocols, locks it in place.[26] Young scientists are trained to treat the animal model as a default; grants are designed around its demands; journals expect its presence. This is not merely an institutional habit; it is a cultivated form of cognitive closure.

Feminist epistemology can help deepen this analysis by examining how dominant paradigms mask their own partiality through claims to objectivity. What Harding (1993) calls "weak objectivity" is an assignment of a neutral, disembodied stance to practices that actually reinforce dominant perspectives. As Donna Haraway (1988) argues, "objectivity" is often a position of disembodied detachment that erases the situated nature of all knowledge claims (p. 583). In the case of animal experimentation, the paradigm presents itself as neutral and self-correcting, even as it systematically silences ethical dissent and alternative epistemologies. Objectivity becomes a rhetorical shield to delegitimize criticism while reinforcing authority.

Harding's (1993) notion of "strong objectivity" offers a corrective to this epistemic closure. Rather than eliminating the researcher's standpoint, strong objectivity demands explicit acknowledgment and critical examination of how social position shapes knowledge production. Applied to animal research, this would require researchers to examine not only their methods but their own institutional positions, funding sources, and professional incentives that may bias their interpretation of animal behavior and suffering.

[26] See Chapter 2.2 for a discussion of path dependency in scientific infrastructure and the institutional mechanisms that reinforce animal model dominance.

While Kuhn (1962) describes how paradigms persist by absorbing anomalies and deflecting challenges through the routines of normal science (pp. 52–53), I argue that certain epistemic vices contribute more actively to this persistence. These vices do not merely delay paradigm change; they help sustain the *illusion* of legitimacy. Dissent is reframed as emotional, alternatives as premature, and anomalies as trivial. Together, these mechanisms form a kind of cognitive glue that binds scientists to the very system that may ultimately undermine their epistemic goals. Before a paradigm collapses, it may first learn to ignore the signs that it should.

4.2 Representation in crisis: interactionist and feminist challenges

The crisis of the animal research paradigm is not only empirical or ethical. It is also representational. Scientific models claim to represent reality, to stand in for what they, at times, cannot directly access. But what happens when this representation misfires, when it obscures the very phenomena it seeks to explain, or silences the voices it claims to speak for?

I now examine how the animal model fails as a representational device. Using interactionist modeling theories and feminist analysis of objectivity, I explore challenges to traditional scientific representation's assumptions of isomorphism, detachment, and universality. These challenges expose the political and epistemic stakes of modeling, especially when it comes to representing complex, embodied, and ethically charged subjects like non-human animals.

4.2.1 The isomorphism myth

While the idea that animal physiology can stand in for human biology predates logical positivism, it was within the positivist framework that such assumptions were

epistemologically consolidated and institutionally normalized. Logical positivism's emphasis on empirical verification and theory-neutral observation (Carnap, 1938; Hempel, 1965) did not originate the use of animal models but reinforced a specific conception of scientific objectivity—one that treats biological models as structurally representative of their human targets.

This philosophical stance became influential not merely at the level of theory, but through its uptake in regulatory structures, particularly in the way drug approval protocols evolved during the 20th century. These processes require animal safety data not just as a precaution, but as epistemic evidence grounded in presumed physiological correspondence. In doing so, they reflect a form of *presumed neutrality*; what Harding (1993) critiques as a posture of "weak objectivity," in which claims of impartiality obscure the methodological assumptions embedded in model construction and validation. Thus, the positivist legacy lies not in initiating animal experimentation, but in codifying and institutionalizing its justificatory logic within a broader framework of scientific authority.

Animal models are positioned to *stand in* for human bodies, with the epistemic validity of experiments hinging on assumed biological similarity. But this assumption misunderstands how animal models actually function. Laboratory animals are not naturally occurring human analogues but artificially constructed experimental systems (Russell & Burch, 1959). Genetic modification, environmental control, and induced disease states create biological artifacts designed to satisfy experimental requirements rather than mirror human physiology (Hedrich, 2012). They introduce species-specific variables, stress-induced responses, and context-dependent phenomena that resist standardization (Seok et al., 2013; Pound & Ritskes-Hoitinga, 2018).

The isomorphism ideal collapses under the weight of empirical anomalies and ethical challenges. Animal bodies do not translate seamlessly into human outcomes, nor are they passive substrates for knowledge extraction. Instead, they introduce species-specific variables, stress-induced responses, and context-dependent phenomena that resist standardization. What appears as biological equivalence is often methodological fiction—one that serves tradition but not science.

Interactionist accounts of modeling offer a way out of this dead end. Rather than treating models as mirrors, they see them as dynamic tools embedded in experimental systems (Bickhard, 2009, p. 579). On this view, models do not represent by similarity alone; they represent through intervention, calibration, and relational fit. That is, the epistemic value of a model lies not in how well it copies an external structure, but in how effectively it functions within an experimental or practical system—how it enables prediction, control, or intelligibility through repeated and constrained interactions.

This performative conception of representation challenges the traditional view of models as neutral carriers of truth. Models do not passively mirror an external reality; instead, they operate as mediators between phenomena and understanding, shaped by the contexts of their construction and application. As Ian Hacking (1983) famously put it, "we have to get the laboratory to create phenomena before we can begin to model them." Models, in this sense, gain their epistemic force not from structural fidelity alone, but from their role in stabilizing and manipulating phenomena within experimental systems.

Measurement scales, for example, are not merely discovered; they are forged through collective acts of standardization that allow researchers to compare effects across different organisms and contexts. Consider the LD_{50} test, used to determine

the lethal dose of substances: it became a benchmark not because it reflected a universal truth about toxicity, but because it provided a reproducible and manageable point of reference within regulatory frameworks—even as its ethical and scientific limitations became increasingly apparent (Russell & Burch, 1959; Stephens et al., 2008).

Similarly, transgenic mouse models of Alzheimer's disease, while widely used, do not mirror the human condition in any straightforward sense. Their use persists not due to faithful correspondence with human pathology, but because they offer a stable and manipulable platform for testing hypotheses, supported by entrenched validation systems and funding streams (Perrin, 2014; Friese & Clarke, 2012). These examples illustrate how models "work" by fitting into existing scientific routines and institutional logics rather than by offering an accurate reflection of reality.

As Nancy Cartwright (1983; 1999) has long argued, scientific models often succeed not because they describe the world as it is, but because they are engineered to produce results in constrained, context-sensitive ways. In biomedical research, this insight compels a shift in focus: from asking whether animal models are "true representations" of human biology, to interrogating what their continued use enables, legitimizes, and forecloses.

Crucially, this shift opens the way to a new kind of epistemic and normative analysis. If models are situated performances rather than neutral reflections, then we must ask not only whether they "work" but how and for whom they work. In the case of animal models, this reorientation allows us to question not just their predictive failure, but the institutional and conceptual architecture that continues to protect them from that very failure. The persistence of animal experimentation despite

decades of poor human translation is not simply a problem of empirical oversight; it is the result of a modeling paradigm that disguises its own fragility through appeals to isomorphic idealization.

In this light, animal models function less as epistemic tools than as rhetorical stabilizers of a paradigm in crisis. The interactivist approach reveals that the supposed “fit” between animal and human is not a *natural property* in the sense of an inherent biological fact, but a *constructed outcome* of selective modeling practices. It is not discovered, but performed—through calibration, exclusion of conflicting data, and the institutional routines that define which forms of evidence are seen as credible. By reframing representation as relational and contingent, this perspective enables a more honest reckoning with the epistemic costs and moral blind spots embedded in current research regimes.

4.2.2 Embodied alternatives

If the isomorphism model fails, what kind of representation might do justice to animal bodies, not just as biological proxies, but as subjects with epistemic presence? Feminist epistemology offers one answer. Building on Harding's (1993) concept of "strong objectivity," which demands critical examination of the researcher's own social position, Haraway (1988) powerfully asserts that "science has been about the translation of the world into a problem of coding," where objectivity has too often been misrecognized as "the god trick of seeing everything from nowhere" (p. 581). Against this view, she proposes situated knowledges, which recognize that all knowledge is generated from embodied and partial perspectives. Objectivity, she argues, “turns out to be about particular and specific embodiment and definitely not

about the false vision promising transcendence of all limits and responsibility" (p. 583).

When applied to animal models, Haraway's argument reveals a deep epistemic asymmetry. Animal subjects are routinely used as tools for generating knowledge, yet their own behaviors, resistances, and affective expressions are rarely recognized as meaningful evidential outputs. As Haraway writes, "animals are everywhere in technoscience, but they mostly enter as objects, not as workers producing meanings, not as communicative partners" (2008, p. 74). Their voices, both literal and metaphorical, are filtered out as background noise in favor of numerical stability and procedural consistency.

Miranda Fricker's (2007) concept of epistemic injustice sharpens this insight. Epistemic injustice occurs when someone is wronged specifically in their capacity as a knower; when their credibility is unjustly deflated (testimonial injustice) or when they lack access to the interpretive resources needed to make sense of their experience (hermeneutical injustice). Animal research subjects, I argue, are structurally subject to both forms of injustice. Their distress signals, such as ultrasonic vocalizations, avoidance behaviors, or refusal to perform, are either systematically ignored or interpreted within reductive behavioral taxonomies that preclude moral or cognitive interpretation.

Fricker describes hermeneutical injustice as "a gap in collective interpretive resources [that] puts someone at an unfair disadvantage when it comes to making sense of their social experiences" (p. 1). While her framework was designed for human contexts, its extension to nonhuman animals reveals how structural silence operates through paradigmatic exclusions. For example, Mouse GV-23-118's 22% weight loss is logged as a data point, but her ultrasonic cries (probable markers of

suffering) are never recorded. Like the vivisected dogs of the nineteenth century, whose "screams were treated as mechanical reflexes" (Ritvo, 1987), today's laboratory animals continue to be denied epistemic standing through methodological design.

Val Plumwood (1994) extends this criticism into the realm of dualistic thinking. She argues that the Western tradition has long organized knowledge around a series of hierarchical binaries: reason/emotion, human/animal, subject/object. In such a system, animals are positioned on the "shadow side" of reason, thereby rendered epistemically mute. As Plumwood writes, "Animals are denied the capacities for culture, reason, autonomy, or moral agency. Their voices are not just silenced; they are never heard as voices at all" (p. 154).

The animal model, in this framework, is not just a site of empirical inquiry but a reproduction of these dualisms. It depends on the erasure of sentience as epistemically relevant, sustaining the illusion that animal bodies are neutral carriers of translatable knowledge. Reversing this logic requires reframing animal resistance, refusal to perform, signs of distress, acts of escape or noncompliance, not as methodological failure but as forms of expression in themselves. It means recognizing that representation is not just about simulating human physiology but about acknowledging who gets to be recognized as a knower.

In fields such as ethology and animal cognition, growing attention is being paid to the communicative and relational capacities of animals, not only their behaviors, but their intentional actions, problem-solving strategies, and emotional expressions. Observational work with animals in naturalistic settings reveals complex forms of learning, cooperation, and even protest that do not reduce easily to experimental data points (de Waal, 2016). Similarly, Indigenous knowledge systems

often conceptualize animals not as objects of study but as relational beings with communicative agency, participants in shared landscapes of meaning and survival (Kimmerer, 2013). These frameworks offer alternative epistemologies of representation, in which knowledge arises through interaction, attentiveness, and respect for more-than-human ways of knowing. Recognizing animal agency in this context entails not only ethical shifts but a fundamental rethinking of what counts as epistemically relevant.

Haraway's provocative question "Why should our bodies end at the skin, or include at best other beings encapsulated by skin?" (1988, p. 586) applies with full force here. Scientific objectivity that ends at the human skin fails to account for the embedded, co-constitutive relations between human inquiry and nonhuman lives. A situated epistemology of representation must instead ask: what is being silenced, and who (or what) is being excluded from the domain of the knowable? This reframing alters the terms of representation entirely. Instead of asking how well animal models simulate human biology, the crucial question becomes what forms of knowledge and agency they obscure. Situated knowledge, dissent, and relational embodiment offer an alternative vision; one that demands treating animals not as flawed stand-ins, but as subjects whose epistemic agency has been systematically denied.

Such a shift, however, also reveals the limits of reform within the current paradigm. The 3Rs framework -Replacement, Reduction, and Refinement- presents itself as an ethical corrective to these concerns. Yet as the following section will show, the 3Rs operate squarely within the logic of normal science (Kuhn, 1962), offering optimization rather than transformation as a panacea. They absorb criticism while leaving intact the representational and ethical assumptions that sustain the

animal model. In this sense, the 3Rs function less as a path toward paradigm change and more as an epistemic containment strategy.

4.3 The 3Rs as normal science: why reform fails

The 3Rs framework, Replacement, Reduction, and Refinement, is often presented as a progressive ethical response to the dilemmas of animal experimentation. Yet its impact remains firmly embedded within the existing paradigm. From this perspective, the 3Rs do not challenge the foundations of the animal model; they stabilize it. As Kuhn (1962, pp. 23-34) observed, most scientific work is not revolutionary but "normal science": the incremental solving of puzzles within an accepted conceptual structure.

Rather than questioning the epistemic validity or ethical legitimacy of animal research, the 3Rs treat its harms as solvable technical problems. Replacement becomes a long-term goal perpetually deferred, Reduction emphasizes sample size efficiency without altering methodology, and Refinement centers on improving welfare without interrogating the purpose of the experiment itself. As previously argued in Chapter 3, the 3Rs function as ethical containment regulations by managing moral discomfort without challenging the legitimacy of animal use.[27] In what follows, I examine how the same framework operates epistemically, as a mechanism that absorbs criticism and stabilizes the paradigm. These are not pathways to paradigm change; they are strategies of containment.

As I will explore in the following sections, the 3Rs function as what one might call epistemic containment mechanisms. They absorb criticism while redirecting attention away from the structural flaws that necessitate such reforms in

[27] See Chapter 3.3 for an extended analysis of the 3Rs as ethical minimalism and their role in moral buffering.

the first place. By framing reform as optimization, the 3Rs maintain the illusion that ethical progress can coexist with methodological continuity.

4.3.1 Kuhn's "puzzle-solving" analogy

In Kuhn's model of "normal science," scientists do not typically challenge foundational assumptions. Instead, they engage in puzzle-solving, addressing anomalies and inefficiencies without questioning the paradigm itself. The 3Rs fit squarely within this practice. Rather than interrogating the epistemic or ethical legitimacy of animal experimentation, they offer intra-paradigmatic adjustments aimed at optimizing existing practices.

Replacement, for instance, is often framed as an aspirational goal with no concrete timeline. Reduction emphasizes statistical efficiency, not methodological transformation. Refinement focuses on minimizing suffering but leaves the purpose of the experiment unchallenged. These measures create the appearance of ethical progress while preserving the core structure of the animal model.

In this sense, the 3Rs function as stabilizing tools rather than reformative ones. They absorb criticism by translating it into solvable technical tasks, thus neutralizing its disruptive potential. Instead of provoking a paradigm shift, they extend the life of the current framework by transforming moral and epistemic challenges into manageable puzzles.

4.3.2 Epistemic containment mechanisms

The 3Rs framework contains critique not only by absorbing it, but by transforming it into practices that reaffirm the legitimacy of the paradigm itself. This containment operates through epistemic maneuvers that neutralize moral and methodological

dissent. One such mechanism is what psychologists term "moral licensing" (Monin & Miller, 2001): the phenomenon whereby past moral behavior licenses individuals to engage in subsequent morally questionable actions. As discussed in Chapter 3, in the context of animal research, refinement protocols often function as moral offsets, allowing researchers to continue harmful practices with a sense of ethical legitimacy.

Another mechanism is circular validation, as described in Chapter 2.[28] Alternatives to animal models are frequently required to prove their reliability by comparison to the very models they seek to replace. This situation creates a logical dilemma: innovative methods are required to meet the standards of a system that inherently regards them as epistemically inferior from the start. As a result, the paradigm determines what is considered valid evidence, excluding radical alternatives beforehand.

Feminist perspectives, particularly Harding's (1993) framework of strong objectivity, further highlight how even the most ethically motivated reforms can obscure the labor and emotional cost they produce by failing to examine the researcher's own position within these systems. While Chapter 3 focused on the epistemic silencing of animals as subjects, the present section extends that logic to the human agents who operate within the system; technicians, students, and early-career researchers, whose experiential knowledge and moral distress are systematically excluded from epistemic recognition.[29] Refinement protocols, for instance, often rely on technicians who must carry out invasive procedures while minimizing animal suffering. Frances Cheng’s testimony reveals the psychological

[28] See Chapter 2.3 for the concept of circular validation and how emerging methods are epistemically constrained by the standards of the animal model itself.

[29] While Chapter 3.2 discusses epistemic injustice toward animal subjects, the present section extends a similar framework to human agents within the experimental system.

burden of performing “humane endpoints” on animals whose pain she was trained to measure but not to prevent (Aeon, 2021). This emotional labor remains invisible within formal metrics of refinement, yet it is integral to maintaining the moral narrative of progress.

Epistemic containment thus operates through multiple channels: moral reassurance, methodological conservatism, and affective erasure. By eliminating criticisms without addressing root causes, it allows the paradigm to appear responsive while remaining intact.

As discussed in Chapter 3, the rhetorical shift from scientific necessity to scientific freedom represents a form of moral displacement. This example demonstrates how refinement protocols institutionalize that displacement, offering technical closure to unresolved ethical tensions. The 3Rs framework’s “refinement” protocols, while claiming to offer humane endpoints, often replicate the very mentality behind Magendie’s scalpel: violence is rendered a methodological detail. When Mouse GV-23-118 was euthanized under refinement standards, the act masked, rather than resolved, the ethical rupture. Frances Cheng’s emotional conflict underscores this structural decay: the numbers (56 force feeding, 22% body weight loss) transform ethical tension into mathematical abstraction.

The failure of the 3Rs to provoke foundational change reflects a deeper epistemic deficiency: the absence of sustained critical engagement. The absence of such sustained criticism reflects not only a practical deficiency, but an epistemic injustice of the kind discussed in Chapter 3, where dissenting perspectives, both human and nonhuman, are denied interpretive uptake. As Helen Longino (2002) emphasizes, when scientific communities lack institutionalized structures for contextual criticism, they risk becoming echo chambers where methodological flaws

persist unchallenged. Her notion of critical contextual empiricism highlights that objectivity is a product of deliberative openness, not methodological uniformity. The 3Rs framework, by deflecting critique into technical refinement, exemplifies how paradigms can simulate responsiveness while remaining epistemically stagnant. Yet this epistemic inertia is not only cognitive. Fully grasping the resilience of the animal model requires examining the material and institutional structures that reinforce it.

4.4 The industrial complex of animal research

The persistence of animal experimentation cannot be fully understood without examining the economic, regulatory, and academic structures that sustain it. Far from being merely a scientific methodology, animal experimentation constitutes what can be called an "animal experimentation industrial complex," a self-reinforcing system of material interests, institutional practices, and professional incentives that together maintain its dominance despite its epistemic and ethical limitations.[30] This section examines how funding mechanisms, regulatory frameworks, and academic reward systems interlock to create a structure resistant to fundamental change.

This industrial structure provides the material foundation for what I described in Section 4.1 as "epistemic vices" and "paradigm glue," the cognitive and institutional mechanisms that resist paradigm change. Just as Kuhn observed that scientific revolutions require more than accumulated anomalies, the animal experimentation paradigm persists through entrenched economic and social structures that convert critique into continuity.

[30] This concept builds on Twine's (2012) 'animal-industrial complex' but specifically exposes how biomedical research normalizes violence through bureaucratic and market mechanisms. For analogous uses of 'complex' critiques in other domains, see the medical-industrial complex (Ehrenreich, 1971) and the prison-industrial complex (Davis, 2003). My formulation adapts this framework to animal experimentation.

4.4.1 Funding: the profitability of suffering

The economic underpinnings of animal experimentation extend far beyond individual research grants. They encompass a vast industry of specialized breeding companies, equipment manufacturers, facility construction firms, and pharmaceutical corporations whose business models depend on the continued practice of animal testing. This infrastructure of profit transforms living beings into commodities whose suffering has become monetized within the global bioeconomy.

While the instrumentalization of animals has deep historical roots, the conceptual framing of animals as property, legally ownable and economically productive, was sharpened in modern Western thought through labor-based theories of value and mastery over nature. John Locke's (1689/1988) influential theory of property claims that natural entities become ownable when human labor is "mixed" with them, thereby converting what is common into rightful possession. Adam Smith (1776/1976) similarly placed labor at the core of economic value, treating productive effort as the foundation of wealth generation. Within this framework, the labor invested in breeding, standardizing, and modifying laboratory animals serves to legitimize their commodification and instrumental use in scientific research.

This property paradigm fundamentally shapes animal experimentation in at least three ways. First, it establishes a framework where animals' bodies are legally available for instrumental use, constrained only by welfare regulations rather than fundamental rights. Second, it creates conditions where animals can be exchanged as commodities, bought and sold according to their experimental utility. Third, it establishes a form of sovereignty where those who own animals have near-complete control over their lives and deaths.

As legal scholar Gary Francione (1995) argues, property status renders meaningful animal protection nearly impossible, as animals' interests are systematically subordinated to the property rights of human owners. In the research context, this means that animals' most basic interest in avoiding pain, maintaining bodily integrity, or continuing to live, can be legally overridden by researchers' interests in generating knowledge.

This structural subordination sets the stage for a broader process of economic transformation, which Karl Marx (1990) described as commodification (pp. 163-177). Marx's (1990) analysis of commodification offers powerful tools for understanding how animals are transformed into standardized, exchangeable goods within laboratory settings (pp. 163-177). Laboratory animals undergo what Marx would recognize as a comprehensive commodification process, bred specifically for research purposes, genetically standardized for experimental consistency, priced according to their features and modifications, and ultimately treated as interchangeable units within research protocols.

This commodification process reinforces the "isomorphism myth" discussed in Section 4.2.1; the assumption that animal bodies can serve as standardized stand-ins for human physiology. The commercial production of "standardized" animal models perpetuates the fiction that biological variation can be controlled enough to produce reliable translational outcomes, despite the mounting evidence of translational failures examined in earlier sections.

This commodification manifests in concrete institutional practices. The JAX Mice catalog, for instance, offers over 6,000 genetically distinct mouse strains, each representing both a scientific resource and a commodity with specific market value (The Jackson Laboratory, n.d.). Animals are shipped internationally as research

commodities, subject to the same logistical systems that move other commercial goods. The language of animal research reinforces this commodification, referring to animals as "preparations," "systems," or "tools" – terms that emphasize their instrumental value while obscuring their status as living beings.

Marx's (1990) analysis helps us recognize how this commodification process alienates animals from their natural being in multiple ways (pp. 163-177). First, laboratory animals are alienated from their species-specific behaviors and social relationships, confined in environments that preclude normal activity. Second, they are alienated from their bodies, which are modified to express human diseases or carry human genes. Third, they are alienated from the products of their biological processes, which become intellectual property owned by researchers or institutions.

This alienation process exemplifies what Carol Adams (1990) terms the "absent referent," discussed in Chapters 2 and 3, the disappearance of the animal as subject and its reappearance as a standardized product. Just as Magendie dismissed his dog's cries as irrelevant noise in 1822, today's commodification system transforms living beings into data points whose suffering is rendered epistemically invisible.

On the other hand, the relationship between animal suppliers and research institutions exemplifies what political economists identify as dependency creation, where suppliers establish ongoing revenue streams through products that require continuous repurchase. Specialized breeding companies do not simply sell animals as one-time products but strive to create a need for proprietary strains that researchers must continuously obtain for experimental consistency. The OncoMouse™, developed at Harvard University by Philip Leder and Timothy Stewart, became the first patented animal in the United States in 1988, establishing a precedent for

treating genetically modified organisms as proprietary technologies (Stewart & Leder, 1988; Science History Institute, 2018).

This commodification of life itself represents the ultimate extension of the property paradigm, where animals are not merely owned as individuals but as biological types subject to intellectual property protections. The substantial capital invested in animal research facilities, the profitable supply chains that provide standardized animals, and the intellectual property regimes that allow commercialization of research outcomes all create powerful economic incentives to maintain animal experimentation despite its scientific limitations.

The case of Mouse GV-23-118 illustrates this economic reality. Behind this individual mouse lies a vast commercial apparatus: the specialized breeding facility where she was produced, the equipment used to monitor her condition, the researchers whose careers advanced through her suffering, and the publications that transformed her death into academic currency. The industrial complex does not merely enable animal suffering; it requires it as a fundamental input for its continued operation.

4.4.2 Regulation: how bureaucracy sustains cruelty

Regulatory frameworks seemingly designed to protect animal welfare often function instead to legitimize and standardize harmful practices. Rather than questioning the fundamental legitimacy of animal experimentation, regulations such as the U.S. Animal Welfare Act (United States Congress, 1966), European Directive 2010/63/EU (European Parliament & Council, 2010), and similar frameworks worldwide focus on minimizing suffering while preserving the basic property relationship and research paradigm. This regulatory approach creates a system of

bureaucratic control that procedurally sanitizes violence while rendering it more efficient and socially acceptable.

Regulatory frameworks transform moral challenges into compliance exercises through several key mechanisms. First, they establish complex approval processes that exhaust ethical energy on procedural details rather than fundamental questions. Researchers spend considerable time documenting minor protocol adjustments while the basic premise of animal use remains unexamined. Second, these frameworks create professional incentives that reward compliance over moral reflection--career advancement depends on navigating regulatory requirements efficiently, not on challenging their underlying assumptions.

This regulatory containment operates as an extension of the epistemic containment mechanisms analyzed earlier. Just as the 3Rs framework absorbs ethical critique without challenging foundational practices, regulatory systems transform fundamental ethical questions into procedural compliance issues. Both operate as what Kuhn (Kuhn, 1962). would recognize as tools of "normal science" – mechanisms that manage anomalies rather than allowing them to trigger a paradigm crisis.

These mechanisms are not confined to national contexts; they also function at the international level through what scholars describe as regulatory arbitrage. Global disparities in animal research oversight create opportunities for researchers and companies to shift ethically questionable practices to jurisdictions with weaker regulations, a phenomenon known as regulatory arbitrage (Stokes, 2006). This creates a race to the bottom, where economic incentives encourage exploitation of regulatory gaps. At the same time, international harmonization efforts such as those led by the International Council for Harmonisation (ICH) aim to standardize animal

testing requirements across borders, embedding animal experimentation within global regulatory infrastructures (ICH, 2018).

A concrete example of this dynamic is seen in toxicity testing for cosmetics. While the European Union has banned animal testing for cosmetic products, companies can still conduct such tests elsewhere and legally sell those products in Europe under certain regulatory exceptions (European Commission, 2021; van der Valk et al., 2020). Through global supply chains and legal loopholes, local ethical advances are thus undermined by transnational economic structures. ICH appears to be not successful!

4.4.3 Academic capitalism: citations, careers, and cruelty

These dynamics are mirrored in academia, where the broader structure of academic capitalism intensifies the entrenchment of the animal research paradigm. As universities become increasingly market-driven, research is governed by metrics such as productivity, citation counts, and grant acquisition, rather than epistemic rigor or ethical responsibility. This system creates powerful professional incentives that reward methodological conservatism and discourage paradigm-challenging innovation (Slaughter & Leslie, 1997, pp. 11–12).

Within this system, animal experimentation benefits from what can be described as a citation economy, a self-reinforcing network of references and publication expectations that prioritize established methods (Latour & Woolgar, 1986, pp. 236–238). Many high-impact journals require animal data as a baseline for publication, regardless of whether such data holds actual translational value. This contributes to the path dependency discussed earlier, where scientific careers are shaped by adherence to dominant methodological norms. The epistemic vices

identified by Cassam (2019), closed-mindedness, dogmatism, and conformity, thus appear not merely as individual shortcomings but as institutional responses to reward structures that prioritize conformity over critical thinking (pp 87–89).

Because career advancement depends heavily on publications within accepted paradigms, researchers are often incentivized to produce incremental findings using animal models rather than pursue potentially superior alternatives that may face greater skepticism or publishing barriers. As a result, academic incentives reinforce what Kuhn (1962) described as "normal science": the routine solving of puzzles within an accepted framework, rather than efforts to disrupt or replace the framework itself (p. 35).

Moreover, for many scientists, animal experimentation is not simply a methodological tool but a professional identity. Years of training, institutional investment, and career advancement are closely tied to animal-based techniques. Researchers accumulate forms of capital, technical expertise, funding success, professional recognition, that could be devalued or rendered obsolete by a paradigm shift. This creates strong psychological and material pressures to defend the status quo, even in the face of mounting contradictions. The socialization process in scientific training typically centers around animal experimentation, embedding it as a form of embodied knowledge within communities of practice. As a result, questioning the method is often experienced not just as a technical critique, but as a challenge to identity and belonging. This helps explain why even researchers who acknowledge the limitations of animal models frequently resist their replacement.

At the same time, the labor structure within academia compounds this inertia. The direct handling of animals is often delegated to technicians, students, and early-career researchers, while senior scientists remain at a distance from the emotional

and ethical burdens of experimentation. Feminist scholars have described this as invisible labor (Acker, 1990; Star & Strauss, 1999), the emotional and ethical effort of managing moral distress, which is rarely recognized in formal evaluations. Ethnographic studies of laboratory workers, such as those by Mary Phillips (1994) and Arnold Arluke (1994), document how this emotional burden is silently absorbed by those with the least institutional power.

This stratified labor structure reflects broader patterns of what was previously identified as structured blindness. Strong objectivity, as Harding (1993) argues, would require animal researchers to examine how their own institutional positions shape their interpretation of experimental results. As discussed in earlier chapters, institutional arrangements systematically shield decision-makers from the consequences of their research protocols. That is an institutional obstacle to strong objectivity. Cartwright's notion of detachment captures this phenomenon well: the separation of data from its contextual and ethical origins is often unjustified. In the same way, the hierarchical division of academic labor detaches principal investigators from the lived realities of the animals used in their experiments, preserving moral comfort at the expense of others. Frances Cheng's experience, discussed earlier, exemplifies this dynamic (Aeon, 2020). As a technician responsible for carrying out "humane endpoints," she was tasked with euthanizing animals while having little influence over the design of the experiments themselves. Her role required her to measure pain she was trained to detect but not to prevent, a striking example of how emotional labor is extracted from those in the most vulnerable positions within the research hierarchy.

Taken together, these regulatory, economic, and academic systems form an interlocking structure that sustains animal experimentation despite growing

recognition of its epistemic and ethical deficiencies. This industrial complex explains why animal research persists not because it is scientifically necessary, but because it is institutionally entrenched. It sheds light on what earlier chapters framed as an epistemic puzzle: why animal experimentation continues despite mounting translational failure.

The systems examined here, regulatory regimes, funding structures, academic reward mechanisms, translate abstract epistemological problems into concrete institutional practices that resist reform. Overcoming this resistance will require more than isolated technological fixes or ethical appeals. It demands a structural transformation of the incentive systems and institutional logics that currently entrench the animal model at the heart of biomedical science. The following section explores where cracks are beginning to appear in this system and considers what conditions might make a genuine paradigm shift possible.

4.5 Seeds of transformation

The preceding sections have shown how economic interests, regulatory norms, and academic structures sustain the animal research paradigm despite its epistemic and ethical limitations. Yet even deeply entrenched systems are not immune to change. This final section of the chapter examines where signs of transformation are beginning to emerge, both as shifts in scientific reasoning and as changes in institutional practice. Taken together, these developments suggest that a paradigm shift, while far from inevitable, may be increasingly conceivable.

4.5.1 Crisis recognition and the Gestalt switch

For Kuhn, paradigm shifts begin not necessarily with new data but with a reframing of existing evidence. What were once seen as manageable puzzles within normal science come to be recognized as symptomatic of deeper structural failures. This cognitive reorientation, which Kuhn (1962, pp. 111-117) describes as a "gestalt switch," transforms how scientists perceive their own practices and assumptions.

In animal experimentation, several developments suggest this reorientation may be underway. First, the accumulation of translational failures has become increasingly difficult to explain away through methodological refinements. When drugs that show promise in animal models fail in 90-95% of human clinical trials (as documented in oncology, neurology, and other fields), the pattern becomes too consistent to dismiss as isolated anomalies (Mak et al., 2014; Bailey, 2018; Akhtar, 2015). Scientists who once viewed such failures as challenges to be overcome through better animal models are beginning to question whether the approach itself is fundamentally flawed. For example, NIH Director Francis Collins has publicly acknowledged the limitations of animal models in translating findings to human biology, especially in areas such as neuroscience and inflammation research (Collins & Tabak, 2014). Similarly, researchers from the U.S. National Toxicology Program and the European Union Reference Laboratory for Alternatives to Animal Testing (EURL ECVAM) have issued reports emphasizing the need to shift toward human-based models, arguing that continued reliance on animal testing may hinder scientific progress (Leist et al., 2014; Basketter et al., 2012).

Second, technological innovations that enable direct study of human biology without animal intermediaries are creating new epistemic exemplars. Organ-on-chip technologies, 3D bioprinting of human tissues, and advanced AI-driven modeling

systems are now able to replicate organ-level function, drug metabolism, and disease dynamics with unprecedented precision (Low et al., 2021; Marx et al., 2020). These methods not only offer superior predictive value but also operate outside the logic of species translation, challenging the very assumption that animal physiology must serve as the default intermediary between laboratory data and human clinical outcomes. This creates the conditions for what Kuhn calls “competing paradigms,” a prerequisite for scientific revolution.

Third, shifting cultural and scientific attitudes toward animal sentience are reshaping the ethical landscape. Research in cognitive ethology and neuroscience has produced robust evidence of emotional, social, and cognitive complexity in species ranging from rodents to cephalopods (Andrews et al., 2020). This evidence influences not only public opinion but also regulatory and academic discourse. Such developments embody what Longino (2002) describes as "contextual criticism" and what Harding (1993) calls "strong objectivity", the integration of values and perspectives that question not just scientific methods but their normative foundations.

4.5.2 Emerging conditions for paradigm shift

Beyond these cognitive shifts, material and institutional conditions are emerging that might support paradigm transformation. First, funding landscapes are gradually diversifying to support non-animal approaches. The European Union's Horizon Europe program, the U.S. EPA's strategic plan to end mammalian testing by 2035 (EPA, 2019), and private investments from biotech firms like Emulate Inc. and TissUse are channeling substantial resources into non-animal research. These initiatives foster institutional niches where alternative approaches can develop. Similarly, countries like the Netherlands have adopted national strategies, such as the

“Transition to Animal-Free Innovations” policy framework, that seek to systematically replace animal use in research and testing through coordinated public investment, regulatory cooperation, and cross-sector dialogue (Netherlands National Committee for the protection of animals used for scientific purposes, 2020).

Alongside funding, new communities of practice are taking shape. Interdisciplinary collaborations between bioengineers, data scientists, pharmacologists, and clinicians are building epistemic networks around human-based methodologies. Initiatives such as the Human Cell Atlas, the European Organ-on-Chip Society (EUROoCS), and the NC3Rs’ CRACK IT Challenges demonstrate how shared infrastructures, conferences, and targeted calls for proposals are fostering a paradigm that is no longer animal-centric. These networks are constructing what Kuhn (1962) calls a "disciplinary matrix" (pp. 182-187): a shared vocabulary of techniques, exemplars, and methodological assumptions that provide coherence to an emerging field. Their work signals a shift not merely in tools, but in what counts as credible knowledge and effective experimentation.

Public engagement is also playing a growing role. Patients, civil society organizations, and advocacy groups are demanding greater transparency and accountability in how research is conducted. Initiatives like the European Citizens’ Initiative “Save Cruelty Free Cosmetics” and platforms like the Transatlantic Think Tank for Toxicology (t4) are helping broaden the scope of scientific deliberation. This participatory momentum aligns with the concept of the “extended peer community” developed in the context of post-normal science (Funtowicz & Ravetz, 1993).

By incorporating voices beyond the professional scientific community, such as patients, technicians, caregivers, and animal welfare advocates, these movements

challenge technocratic decision-making and call for broader standards of epistemic and ethical legitimacy. This also resonates with what Zenker et al. (2023) describe as the tension between two epistemic ideals: *correctness*, which emphasizes technical rigor and expert authority, and *participation*, which centers inclusivity and deliberative plurality. While this distinction will be developed more fully in Chapter 5, it is worth noting here that any meaningful paradigm shift may require not only methodological innovation but also a redefinition of who counts as an epistemic agent in science.

Yet despite these promising signs, substantial barriers to change remain. Regulatory frameworks in many jurisdictions still mandate animal data for safety validation, creating legal hurdles for the adoption of human-based alternatives. For instance, test guidelines from the Organization for Economic Co-operation and Development (OECD) still predominantly rely on animal models (OECD, 2023), limiting the regulatory acceptability of new approach methodologies (NAMs) (Leist et al., 2014). Many research institutions lack both the technical infrastructure to implement these alternatives, and the evaluative frameworks needed to recognize their validity. In addition, existing scientific incentives, including publication bias, conservative peer review cultures, and grant funding criteria, continue to reinforce animal-based methods. These issues, combined with the cognitive and institutional inertia explored earlier in this chapter, form a dense mesh of resistance that suppresses transformative potential.

The path to a paradigm shift is rarely linear or predictable. As Kuhn (1962) emphasized, scientific revolutions involve not just data accumulation but a transformation in what is recognized as a legitimate problem, a valid method, or a convincing solution. While the conditions for such a transformation are now taking

shape, their fruition will depend on both continued epistemic innovation and structural reform. The next chapter explores how these possibilities might be actively cultivated through institutional reforms, epistemic innovations, and ethical reimagining of the human–animal relationship in scientific practice.

CHAPTER 5

TOWARDS AN EPISTEMICALLY JUST SCIENTIFIC PRACTICE

In a 2019 ethics review file, a research institution described its animal subjects as "customized units prepared for neurological resilience testing" (Kiani et al., 2022, E256). No names, no species identifiers, just units: engineered, numbered, replaceable. This phrasing does more than reflect a lack of empathy; it reveals a systematic form of erasure. In these few words, we see how the animal subject is reduced to a numbered object, stripped of identity, value, and relation. The problem is not only ethical. This language also signals an epistemic failure: a refusal to see animals as part of the knowledge process, as beings whose lives shape and are shaped by scientific inquiry. What philosophical worldview renders such descriptions not only possible but ordinary? What kind of scientific rationality normalizes the transformation of sentient life into numerical data, stripped of context, relation, or voice? These are not rhetorical questions, but entry points into a deeper critique: one that targets not just individual practices but the epistemic architectures that sustain them.

In this chapter, I propose an alternative. Building on the analysis developed in the previous chapters, I ask: What would an epistemically just scientific practice look like, one that resists exclusion, values situated knowledge, and distributes epistemic authority more equitably? How can research methodologies be restructured to recognize, rather than erase, the agencies, perspectives, and moral significance of nonhuman beings? And what conceptual resources can guide us in rethinking objectivity, validity, and responsibility in science?

Animal experimentation is now contested not only on ethical grounds but also due to persistent epistemic limitations and institutional habits that obstruct innovation. As I have argued throughout this thesis, these problems are not incidental; they are structural. In what follows, I bring together the key arguments developed so far to articulate a normative vision of scientific reform. This vision does not rely on incremental improvements within existing paradigms, but on a fundamental reconfiguration of how we define scientific validity, ethical justification, and institutional responsibility in light of epistemic and relational harms. While paradigm shifts are often seen as incommensurable transitions, Kuhn himself acknowledged that rational comparison is possible through shared evaluative criteria such as accuracy, consistency, and explanatory power (Kuhn, 1977, p. 322). The paradigm I propose aims to fulfill these very standards, offering not only ethical improvement but also epistemic advancement.

The chapter proceeds in six parts. Section 5.1 questions the conventional evidence hierarchy and introduces a reliability-based understanding of validity. Section 5.2 grounds the call for reform in ethical reasoning, focusing on the impossibility of animal consent and the testimonial silencing embedded in research institutions. Section 5.3 introduces the framework of post-normal science and extended peer communities as tools to navigate uncertainty, dissent, and value pluralism. In Section 5.4, I draw on feminist and ecofeminist epistemologies to challenge disembodied ideals of objectivity and propose relational models of knowledge production. Section 5.5 reflects on the COVID-19 pandemic as a moment that paradoxically reinforced institutional inertia while revealing the fragility of the current system. Finally, Section 5.6 proposes evaluative criteria for cultivating a more context-sensitive, humane, and epistemically responsible scientific practice.

5.1 Reliability-based validity

Biomedical research is often organized as a hierarchy of evidence, placing animal models at the base and randomized controlled trials (RCTs) or meta-analyses at the top. This framework suggests that moving upward in this structure brings us closer to scientific truth (Sackett et al., 1996; Guyatt et al., 2008). Within this system, animal studies are seen as necessary starting points; tools for generating hypotheses and assessing risk before human trials begin. Institutional practices such as protocol standardization, preclinical testing requirements, and regulatory procedures reinforce this perception. Together, they portray animal models as both epistemically indispensable and ethically acceptable.

However, as argued in Chapter 2, the empirical and conceptual shortcomings of animal-based research profoundly undermine this foundational assumption. Reliability and reproducibility crises across the biomedical sciences, along with persistent translational failures from animal studies to human clinical contexts, have exposed deep structural flaws in this traditional hierarchical model (Baker, 2016; Begley & Ellis, 2012; Ioannidis, 2005). What has long appeared as a stable methodological infrastructure increasingly reveals itself as arbitrarily shaped, not by epistemic rigor but by historical momentum, regulatory conservatism, and institutional convenience. Although often placed at the base of this hierarchy, animal studies rarely meet the methodological criteria of RCTs—a point discussed in Chapter 2.4. This discrepancy reveals a structural inconsistency: despite their low formal ranking, animal studies are often treated as decisive evidence in preclinical decision-making. As Kuhn (1962) suggests, paradigms often persist through inertia even after anomalies accumulate, and as Lakatos (1970) notes, auxiliary hypotheses are frequently used to protect core commitments from falsification.

Nancy Cartwright's argument that "reliability trumps truth" (2024) offers a compelling framework for rethinking scientific validity, one that shifts the focus from abstract generalizability to contextual performance and practical dependability. Her argument displaces the notion that internal validity alone can ensure epistemic adequacy, and instead advances a context-sensitive, use-oriented account of reliability. In this view, what matters is not whether results are generalizable in principle, but whether they are dependable in the specific contexts where decisions are made and actions taken. This shift invites us to re-express the logic of methodological evaluation: rather than moving upward toward abstraction, scientific practice may need to reorient toward situated robustness.

This reframing also compels a reassessment of the 3Rs framework. As discussed in Chapter 3, the ethical language of Replacement, Reduction, and Refinement has operated more as a buffer than a challenge to the assumption that animal models are epistemically indispensable. Yet if these models consistently fail to meet the reliability standards Cartwright foregrounds, their continued use is no longer just ethically questionable, but methodologically indefensible. Upholding fragile systems under the guise of incremental ethical progress risks obscuring structural failures behind a rhetoric of reform.

Taken together, these considerations push us to revise what we mean by scientific validity. A revised model must integrate empirical dependability, ethical legitimacy, and contextual relevance within a broader framework of epistemic responsibility. Such a model would support pluralistic approaches to evidence evaluation and prioritize methodologies that are robust, responsive, and socially accountable. As will be argued in the sections that follow, this reconceptualization is crucial if we are to move toward a scientific practice that is not only credible in

technical terms, but also epistemically and ethically just. Scientific reform cannot rely on epistemic criticism alone. It must be grounded in a moral architecture that recognizes the ethical status of research subjects.

5.2 Ethical foundations for a new paradigm

Efforts to reform animal research have long focused on technical and procedural adjustments, most notably through the implementation of the 3Rs. However, as argued in Chapter 3, such frameworks presuppose the legitimacy of using non-consenting beings as experimental subjects, thereby concealing a fundamental ethical deficit. The structural impossibility of consent in the context of nonhuman animals is not a minor limitation to be mitigated through refinement; it represents a categorical rupture in the moral architecture of scientific practice (DeGrazia, 2008; Regan, 1983; Singer, 1975). If consent is regarded as indispensable in human research ethics because it signals respect for autonomy, moral agency, and vulnerability, then its total absence in animal experimentation cannot be reconciled with any serious commitment to ethical justification.

This foundational exclusion is compounded by a systemic failure to recognize non-verbal testimony and embodied resistance as ethically and epistemically meaningful. As discussed in Chapter 3, current regulatory frameworks treat such forms of expression as behaviorally insignificant or scientifically irrelevant, thereby erasing the communicative and experiential dimensions of animal subjectivity. From the standpoint of epistemic justice, this silencing is far from neutral; it reflects and reinforces an asymmetry of both credibility and moral regard. To persist in such frameworks is to normalize the erasure of epistemic agents whose moral status has already been precariously marginalized.

These ethical and epistemic failures are not isolated flaws; they are embedded in a broader epistemological framework that marginalizes dissent, privileges methodological orthodoxy, and restricts the range of credible knowers. Addressing this imbalance requires more than revising individual protocols, it calls for a reimagining of how scientific communities define expertise, authorize claims, and evaluate evidence. In the next section, I turn to the conceptual resources offered by post-normal science and extended peer communities, which offer alternative models for navigating uncertainty, pluralism, and moral complexity in biomedical research. Moving beyond this structure entails not only new methodologies but also moral reorientation: one that centers relational responsibility, interprets resistance as testimony, and treats the absence of consent not as a gap to be managed but as a decisive call for structural change.

5.3 Post-normal science and the role of extended peer communities

The epistemic and ethical failures I have outlined in previous chapters are not isolated problems of animal-based research. Rather, they are symptoms of a deeper structural condition, one in which conventional scientific rationality proves inadequate in the face of uncertainty, complexity, and moral pluralism. The model of post-normal science (PNS), developed by Funtowicz and Ravetz (1993/2020), offers a conceptual framework for addressing such conditions. Defined by situations where "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz & Ravetz, 1993, p. 744), post-normal science rejects the idea that science operates in politically neutral, methodologically stable terrain. It acknowledges that in domains like biomedical research, scientific decisions are entangled with ethical judgments, regulatory forces, and public trust.

Biomedical research involving animal models exemplifies the conditions that call for post-normal science: facts remain uncertain, despite decades of research; values are in dispute, as stakeholders diverge over animal ethics and human benefit; stakes are high, given that both human lives and animal suffering are involved; and decisions are urgent, due to medical need, commercial pressure, and regulatory constraints. In such a context, the assumptions of traditional science, that facts are separable from values, that expertise is sufficient, and that uncertainty can be eliminated , no longer held. Post-normal science responds to this reality by emphasizing the need for inclusive epistemic frameworks, participatory governance, and institutional reflexivity.

Animal experimentation exemplifies this entanglement. The justification for using animals as epistemic proxies for humans is no longer just a technical issue, it is a moral, institutional, and political one. As shown in Chapters 2 and 3, the reliability of animal data is increasingly contested, and so is the legitimacy of the moral trade-offs it demands. In this context, conventional, expert-driven models of knowledge production fail to capture the range of stakeholders involved or the diversity of values at stake.

Post-normal science offers a response through the concept of extended peer communities, configurations in which laypersons, activists, ethicists, patient groups, and other non-traditional actors participate alongside scientists in shaping and evaluating research practices. This inclusive model does not lower scientific standards. Rather, it reframes them as reflexive, context-sensitive, and morally accountable. When the authority of science is in question, as it is in the case of animal-based research, legitimacy cannot be restored through technical arguments

alone. It must be rebuilt through meaningful engagement with those whose voices have been historically excluded from epistemic authority.

Extended peer communities also hold particular significance in contexts involving nonhuman subjects, beings who cannot testify on their own behalf. As discussed in Chapter 3, recognizing animal resistance and embodied expressions as epistemically meaningful requires a conceptual shift that traditional science is structurally unprepared to make. Interdisciplinary collaborations, among ethologists, philosophers, animal advocates, caregivers, and citizens, can serve to amplify silenced testimony and broaden the evidentiary base. In this way, post-normal science not only democratizes knowledge production but creates the conditions under which epistemic injustice can be actively addressed and epistemic authority pluralized.

This institutional gatekeeping is further reinforced through what Latour and Woolgar (1986) describe as the citation economy, a system where methodological orthodoxy becomes a condition for epistemic recognition. While the model of extended peer communities offers a compelling vision for pluralizing scientific authority, current research structures are marked by persistent forms of epistemic gatekeeping. Scientific legitimacy is still overwhelmingly defined by institutions that control access to funding, publishing, and professional recognition. These gatekeepers not only regulate what counts as valid knowledge but also who counts as a credible knower. In the context of animal experimentation, this has far-reaching implications: it enables the systematic exclusion of actors whose insights challenge the normative foundations of the dominant research paradigm.

Technicians, animal care staff, and junior researchers often occupy epistemic positions close to the subjects of experimentation, yet their perspectives are

frequently dismissed as emotionally biased or methodologically irrelevant. As discussed in Chapter 3, their experiential knowledge, particularly when it expresses discomfort, ethical concern, or dissent, is rarely granted epistemic uptake. This silencing reflects what Miranda Fricker terms *testimonial injustice*: a credibility deficit assigned to knowers on the basis of their social identity or institutional status. In biomedical research, dissenting testimony is not only devalued; it is structurally filtered out through hierarchies of prestige and disciplinary orthodoxy.

Publishing practices and peer review further entrench these dynamics. Journals and grant agencies tend to prioritize conventional methodologies and established model systems, reinforcing a closed loop of self-validation. Proposals that advocate for non-animal approaches or emphasize ethical criticism often face increased scrutiny or dismissal, not because of scientific inadequacy, but because they deviate from epistemic norms that have hardened into institutional expectations. The result is a landscape where epistemic innovation is discouraged, and dissent is pathologized as naiveté or extremism.

Feminist epistemologists such as Helen Longino (1990) have long emphasized that scientific objectivity is not achieved by excluding values or perspectives, but by cultivating conditions for *critical interaction*. For such interaction to occur, dissenting voices must not only be tolerated but actively incorporated into the epistemic process. This means creating mechanisms by which marginalized knowers, whether human or nonhuman, direct or represented, can influence the framing of questions, the design of methods, and the interpretation of results. Without such pluralism, claims to scientific neutrality mask the reproduction of status quo assumptions under the guise of methodological rigor.

Gatekeeping is, therefore, not merely an issue of fairness; it is an epistemic obstacle to more accurate, inclusive, and just forms of knowledge. As long as alternative viewpoints are systematically excluded from the processes that define epistemic legitimacy, the prospects for a paradigm shift in biomedical research will remain limited. Post-normal science, in contrast, insists that the scope of expertise must be expanded, and that doing so is not a threat to science, but a condition of its renewal.

These considerations highlight the importance of progressing from criticizing to structural transformation. If epistemic injustice in science is not merely a matter of individual bias but a feature of institutional design, then addressing it requires rethinking how knowledge-producing systems are organized. The concept of extended peer communities provides a normative vision of inclusion, but what would it take to implement such a vision within the actual infrastructures of biomedical research?

Recognizing the limitations of traditional expert-driven models, post-normal science emphasizes the need for broader epistemic inclusion. As Zenker et al. (2023) argue, epistemic robustness in public deliberation requires balancing the ideal of correctness with the ideal of participation. In the context of post-normal science, where high uncertainty and value pluralism prevail, extending peer communities becomes not merely desirable but necessary to fulfill these dual ideals. Thus, fostering broader inclusion in biomedical research practices aligns both with scientific reliability and democratic legitimacy.

In the following section, I explore possible institutional pathways for fostering epistemic justice, with particular attention to the challenges of representing nonhuman subjects whose voices cannot be directly heard. As Latour and Woolgar

(1986) famously argued, scientific legitimacy is not solely established through empirical adequacy but also through circulation within what they termed a *citation economy*, a self-reinforcing system in which credibility accrues via repeated referencing, institutional recognition, and prestige networks.[31] In this economy, methodologies that are already dominant continue to gain epistemic capital simply by virtue of their ubiquity, rather than by virtue of superior performance.

In the context of animal research, this logic manifests in the expectation that credible studies must include animal data, not because it is always necessary or epistemically optimal, but because it signals methodological orthodoxy. Manuscripts using alternative models are often deemed insufficient unless validated against animal-based benchmarks, reinforcing what Chapter 2 described as *circular validation*. Such requirements do not reflect empirical openness but institutionalized path dependence.

The citation economy thus creates a feedback loop where methodological conservatism is rewarded with visibility, funding, and professional advancement, while innovation is siloed in niche journals or dismissed as speculative. This reinforces not only epistemic inertia but also institutional resistance to paradigm change, as researchers internalize the norms required for survival within this prestige-driven ecosystem. From the standpoint of epistemic justice, this system privileges methodological conformity over evidentiary relevance, thereby distorting the processes through which knowledge gains authority.

Against this background, the concept of extended peer communities, developed in the framework of post-normal science, offers an important corrective to

[31] The *citation economy* refers to the system through which scientific credibility is accumulated via recurring references and institutional visibility, often reinforcing established methodologies regardless of empirical superiority (Latour & Woolgar, 1986, pp. 236-238).

this insular epistemic model. If extended peer communities are to serve as a corrective to the epistemic limitations of conventional scientific practice, then we must consider what kinds of institutional architectures could support their inclusion. In biomedical research involving nonhuman animals, the challenge is particularly acute: the primary stakeholders-the animals themselves-cannot articulate their interests, experiences, or resistance in discursive form. This absence poses both a moral and epistemic dilemma. Whose voices count, and how can silenced agents be represented in a knowledge-making system that claims to be ethically and scientifically legitimate?

Addressing this dilemma requires moving beyond tokenistic gestures of inclusion. It demands the development of institutional mechanisms capable of integrating diverse forms of expertise, not only scientific, but also experiential, ethical, and relational. For example, animal care staff and veterinary technicians, often the most proximate witnesses to suffering and behavioral change, should be empowered as epistemic agents, not merely as support personnel. Their insights, drawn from daily interactions and embodied attentiveness, can reveal the dimensions of animal subjectivity that standardized metrics overlook. Yet current hierarchies of scientific credibility frequently marginalize such forms of knowledge, rendering them anecdotal or affective rather than "objective."

Moreover, ethical review boards and regulatory committees must be restructured to accommodate forms of testimony that go beyond the language of risk-benefit calculation. Philosophers, bioethicists, animal advocates, and community representatives could play critical roles in reframing how harms are conceptualized, how alternatives are evaluated, and how dissent is handled. This would shift the

focus from procedural compliance to deliberative responsiveness, a core tenet of epistemic justice.

At a more systemic level, funding mechanisms and publishing standards must be reoriented to recognize and reward methodological pluralism. Proposals that prioritize non-animal methods, or that foreground relational ethics and participatory design, are still often treated as fringe or exploratory. Realignment would require not only new evaluative criteria but also a cultural transformation within institutions that currently define scientific legitimacy through narrow, animal-dependent models.

Finally, the problem of representing nonhuman animals themselves demands creative institutional solutions. While animals cannot speak for themselves in ways recognized by scientific discourse, their interests can be advocated by interdisciplinary coalitions that bridge empirical observation and ethical imagination. Ethologists, feminist science scholars, animal welfare scientists, and public representatives can jointly articulate interpretive frameworks that acknowledge animal resistance, expressivity, and relational needs. These frameworks, in turn, must inform not only experimental design but also the broader norms that shape what counts as scientific progress.

Institutions that aspire to epistemic justice must therefore be designed not simply to tolerate plurality, but to structurally enable it. As I have argued throughout this chapter, the shift toward post-normal science is not a rejection of rigor, it is a recognition that rigor without inclusion cannot deliver either reliability or legitimacy. If the scientific community is to reclaim public trust while honoring the moral demands of its practices, it must build structures capable of listening to those who have long been rendered inaudible.

Institutional reform, however, cannot succeed without corresponding transformations in the material practices and methodological assumptions that structure scientific inquiry. If we are to move beyond animal experimentation not only rhetorically but substantively, we must evaluate whether viable alternatives exist that are both epistemically sound and ethically preferable. In the next section, I examine emerging research models, including in vitro, in silico, and organ-on-chip technologies, that challenge the scientific and moral rationale for continuing reliance on animal models.

These structural exclusions do not only apply to theoretical dissent but also to embodied knowledge practices within scientific institutions, especially in the case of animal technicians and care staff whose moral and observational expertise is routinely overlooked. Frances Cheng, a laboratory technician responsible for monitoring "humane endpoints" in animal experiments, offers a poignant illustration of epistemic injustice in practice. Despite her proximity to experimental subjects and her expertise in detecting signs of distress, Cheng had no influence over the design or justification of the protocols she was tasked with enforcing. Her role involved daily assessments of suffering, identifying pain, recognizing behavioral deterioration, and ultimately carrying out euthanasia, yet her insights were systematically excluded from epistemic authority.

This disjunction between epistemic labor and epistemic recognition exemplifies what Miranda Fricker terms *testimonial injustice*: the credibility of a knower is deflated not due to lack of competence, but due to institutional structures that marginalize certain forms of knowledge. Moreover, the affective dimensions of Cheng's work, the moral discomfort, emotional burden, and ethical conflict,

represent what feminist scholars identify as *invisible labor*: essential yet unacknowledged contributions to scientific practice.

Rather than being viewed as epistemically irrelevant or emotionally compromised, such experiential knowledge should be understood as a form of *emotional expertise*: the finely attuned, embodied understanding of nonhuman suffering gained through care-based relationships. Recognizing this form of expertise would not only correct testimonial injustices but also expand the epistemic community to include those whose ethical and affective insights are indispensable for a just science.

5.4 Feminist epistemologies: rethinking objectivity, relationality, and representation

Calls for epistemic justice in science cannot be fulfilled without revisiting the philosophical foundations of objectivity, knowledge production, and relationality. Feminist epistemologists have long argued that the so-called neutrality of science conceals not only social and political biases but also entrenched patterns of exclusion that systematically silence certain agents, perspectives, and forms of knowing (Harding, 1991; Haraway, 1988; Longino, 1990). In the context of animal experimentation, this exclusion is both epistemic and ethical: it renders animal voices unintelligible, their bodies abstracted, and their resistance methodologically irrelevant. To reimagine scientific practice as epistemically just, we must take seriously the contributions of feminist and ecofeminist thought, which expose the hidden hierarchies of knowledge and offer conceptual tools for restructuring science as a more responsive and relational endeavor.

Carol J. Adams' (1990) concept of the *absent referent* is a critical entry point. Originally developed to analyze the erasure of animal lives in meat consumption, the

concept describes how suffering bodies are linguistically and conceptually severed from the violence inflicted upon them. In animal research, this logic persists in the transformation of beings into "units" or "specimens." Mouse GV-23-118, whose existence is numerically coded and whose death becomes a data point, exemplifies this epistemic abstraction (see also Chapter 3). The animal's referent, the life lived, the distress endured, the context of vulnerability, is rendered invisible by the procedural language of science. The absent referent thus operates not merely as rhetorical omission, but as a structure of knowledge production that stabilizes objectivity through erasure.

This epistemic violence is further illuminated by Val Plumwood's (1993) analysis of *dualist logic*, especially her account of how Western thought has constructed binary oppositions such as reason/emotion, mind/body, human/animal, male/female. These oppositions function hierarchically, privileging the former over the latter, and in doing so justify the marginalization of those situated on the "devalued" side. In animal experimentation, this dualism enables a paradox: animals must be biologically similar enough to justify their use as models, yet cognitively and morally distant enough to deny them ethical consideration. This inversion is not a logical oversight; it is an epistemic strategy that sustains the paradigm. As Plumwood argues, denying the other's standpoint is not a failure of recognition but a mechanism of dominance: one that disqualifies dissent before it can be voiced.

To counter this, Lynda Birke's (2007) notion of *embodied empiricism* offers a reorientation. Birke challenges the disembodied, distanced observer ideal in science and argues that knowledge emerges through affective, bodily, and situated engagements with the world. Within laboratory contexts, this means acknowledging that researchers and technicians do not interact with neutral matter, but with sentient

beings whose responses, behaviors, and suffering co-shape the epistemic process. As Birke emphasizes, "there is no view from nowhere," all scientific practices are mediated by position, perspective, and power. This reconceptualization of objectivity destabilizes the norm that emotional detachment is a marker of scientific integrity. Instead, it invites scientists to practice what Donna Haraway calls *response-ability*: an ethic of being accountable to those with whom one co-produces knowledge.

Haraway's *situated knowledges* thesis further elaborates this view. Objectivity, in her formulation, does not mean detachment but partial perspective made accountable. Interspecies research relationships, then, must be understood as morally entangled and epistemically co-constituted. Haraway argues that animals are not mere tools or backgrounds but "workers producing meanings," agents in technoscientific assemblages. From this perspective, refusing to acknowledge the animal as an epistemic subject is not merely unjust; it is scientifically impoverished. A truly robust epistemology must engage with complexity, multiplicity, and interdependence.

This call for relational knowing is echoed in Lori Gruen's model of *entangled empathy*. Rather than empathy as projection or sentimentality, Gruen describes a form of understanding rooted in attentiveness, responsiveness, and mutual vulnerability. Entangled empathy is epistemic as well as ethical: it recognizes that understanding another being's experience is not an act of distance but of proximity and relationship. In animal research, where detachment is valorized and standardization masks individuality, entangled empathy disrupts the premise that reliable knowledge requires emotional and moral silence. Instead, it affirms that ethical attunement enhances rather than diminishes epistemic quality.

This relational model of knowing is further illustrated in the work of primatologist and philosopher Barbara Smuts (2001), who describes "embodied communication" as a mode of understanding that arises not through detached observation but through shared presence, movement, and responsiveness. Her fieldwork with baboons revealed that epistemic access was gained not by objectifying the animals but by participating in their world, walking with them, responding to their cues, and allowing mutual recognition to guide the research encounter. Smuts' insights underscore that epistemic rigor need not be premised on distance or control, but can instead emerge from attentive, respectful engagement across species boundaries.

Political theorists Sue Donaldson and Will Kymlicka (2001) extend these insights to the structural level. In *Zoopolis*, they argue for a relational model of animal citizenship, one that recognizes animals not as voiceless dependents but as members of interspecies societies with legitimate claims to protection, inclusion, and representation. This political reframing has epistemological implications. If animals are political subjects, then their marginalization in scientific discourse is not only a moral wrong but a failure of epistemic representation. Their voices, expressed in avoidance behaviors, stress vocalizations, or refusals, must be recognized not as noise but as dissent.

Taken together, these feminist and ecofeminist perspectives demand a radical rethinking of the epistemic foundations of science. They do not call for abandoning objectivity, but for reconstructing it in ways that account for position, relation, and power. They remind us that knowledge is not simply discovered but negotiated, through interactions, refusals, mutual dependencies, and shared vulnerabilities. In the

context of animal experimentation, this means moving from extraction to co-presence, from erasure to recognition, from dominance to response-ability.

Building on the epistemic foundations laid out in the previous section, I now turn to the material and methodological innovations that reflect, and require, this shift in scientific rationality. The next section will show how these epistemic frameworks not only critique the current model but also provide a foundation for reimagining what scientific legitimacy and ethical accountability could look like, beyond the animal model, beyond the absent referent.

5.5 Emerging alternatives: advantages of human-relevant models

Paradigm change demands more than rhetorical commitments; it requires a transformation of both the conceptual frameworks and the material conditions of research. If we are to move beyond animal experimentation, not only rhetorically but substantively, we must evaluate whether viable alternatives exist that are both epistemically sound and ethically preferable. In this section, I examine emerging research models, including in vitro, silico, and organ-on-chip technologies, that challenge the scientific and moral rationale for continuing reliance on animal models.

The call for a paradigm shift in biomedical research would remain aspirational without concrete alternatives to the systems it seeks to replace. Fortunately, recent methodological developments have produced a growing array of human-relevant technologies that promise not only ethical improvements but also enhanced epistemic performance. In vitro cell-based models, computational in silico simulations, and microfluidic organ-on-chip systems represent a new generation of tools capable of mimicking human physiology with increasing precision and contextual relevance.

In vitro techniques, such as organoid cultures and stem cell–derived tissue models, allow researchers to observe human-specific biological processes directly, without resorting to interspecies extrapolation (Clevers, 2016; Sasai, 2013). These systems are especially useful in studying disease mechanisms, drug toxicity, and genetic variation, as they provide access to the exact cellular contexts relevant to human health. Likewise, in silico methods use computational models to simulate pharmacokinetics, disease progression, and population-level treatment outcomes. These models are not only ethically unobjectionable and cost-effective, but also highly adaptable, facilitating rapid hypothesis testing and iterative refinement in ways that animal studies often cannot.

Among the most promising innovations are organ-on-chip devices, which integrate human cells into dynamic microenvironments that reproduce key physiological conditions, such as mechanical stress, tissue–tissue interaction, and fluid dynamics (Bhatia & Ingber, 2014; Low et al., 2021). These systems have demonstrated the ability to replicate clinically relevant responses to drugs, pathogens, and environmental agents, often with greater accuracy than traditional animal models (Ingber, 2022). The modularity of these platforms also supports the construction of multi-organ configurations, enabling systemic studies that reflect inter-organ dynamics more faithfully than isolated animal organs can.

The epistemic advantage of these technologies lies not only in their biological fidelity but also in their ability to collapse the conceptual distance between model and referent. By centering human-relevant data from the outset, these approaches challenge the need for translation, a major epistemic bottleneck in animal-based research. Moreover, their emergence coincides with increasing regulatory openness, as seen in legislative developments such as the U.S. FDA Modernization Act and the

Humane Research and Testing Act, which signal growing institutional recognition of non-animal methodologies.

Yet despite their promise, these alternatives face considerable barriers to implementation. Funding structures, training paradigms, and publication standards remain aligned with traditional animal models. Researchers proposing human-relevant methodologies often encounter skepticism not because their approaches are unscientific, but because they disrupt epistemic habits and institutional expectations. What is needed, then, is not merely technological innovation but epistemic recalibration, a willingness to redefine what counts as robust evidence and how it should be evaluated.

As I have argued throughout this chapter, the persistence of animal models is not only ethically questionable but epistemically inefficient. The alternatives now available offer an opportunity to align scientific rigor with moral responsibility. The final challenge lies not in conceptual innovation but in institutional implementation.

Despite the growing availability and demonstrated promise of these human-relevant models, their integration into mainstream biomedical research remains uneven. This disconnect between epistemic potential and institutional adoption raises a pressing question: What forces continue to sustain the dominance of animal experimentation, even in the face of superior alternatives? The answer, I argue, lies not only in scientific habit or methodological conservatism but also in the political economy of crisis. The COVID-19 pandemic offers a particularly revealing case: while it accelerated certain forms of innovation, it also reinforced emergency rationales that revalidated the very practices now under ethical and epistemic scrutiny. These rationales coalesced into what might be called emergency ethics,

where normative principles are temporarily suspended under the banner of urgency (Agamben, 2005; Redfield, 2013). These rationales coalesced into what might be called *emergency ethics*, where normative principles are suspended in the name of urgency. As Agamben (2005) argues, this kind of *state of exception* blurs the line between temporary crisis and permanent normalization, allowing ethically contested practices to endure under the guise of necessity.[32] In the following section, I examine how the logic of urgency, institutionalized during the pandemic, has functioned both as a site of disruption and a mechanism of inertia in research reform.

The preceding sections have revealed that the structural dominance of animal experimentation persists not because of ignorance or lack of alternatives, but due to a deep entanglement of methodological conservatism, institutional inertia, and hierarchical norms of epistemic authority. From epistemic unreliability and ethical exclusion to entrenched paradigmatic loyalty, the current system fails on every normative front. Reform, therefore, is not simply a matter of better data or refined techniques. It demands a fundamental rethinking of what constitutes scientific legitimacy, who is authorized to produce knowledge, and how epistemic responsibility is distributed. The alternatives, conceptually, technically, and institutionally, are already within reach. The critical task ahead is not to identify what must change, but to summon the resolve to do it.

Taken together, these insights lead to a central claim: Ethical progress in science is inseparable from epistemic justice. A genuinely responsible research paradigm must be built on three interrelated commitments. First, it must redefine validity not as abstract generalizability but as context-sensitive reliability grounded

[32] "Emergency ethics" refers to justificatory frameworks that suspend normative commitments under the pressure of urgency, allowing epistemic shortcuts and moral compromises to be treated as acceptable, sometimes even virtuous, responses to crisis conditions.

in translational relevance. Second, it must recognize that knowledge is not produced in a moral vacuum. Scientific inquiry must be guided by ethical accountability, including attention to consent, relational responsibility, and the lived experiences of research subjects. Third, it must democratize epistemic authority by enabling inclusive, reflexive, and participatory modes of knowledge production. The road to such a paradigm is neither linear nor immediate. But the conceptual tools, moral insights, and technological capacities are already within reach. What remains is the collective will to reimagine the purposes, practices, and politics of science itself. The emerging alternatives surveyed here offer more than technical solutions; they point toward a different vision of science, one in which the pursuit of knowledge is inseparable from the demands of justice.

This is not a call for abandoning science, but for renewing its foundational ideals. Epistemic humility must replace methodological arrogance. Participatory inclusion must replace institutional gatekeeping. Moral imagination must replace ethical minimalism. To move toward a paradigm that is not only methodologically sound but also morally sustainable, we must ask not just what works, but for whom, under what conditions, and at what cost.

5.6 Reclaiming scientific legitimacy: from epistemic criticism to practice

The road ahead is neither simple nor linear. Yet the conceptual tools, technological capacities, and ethical insights needed for change are already within reach. If feminist and ecofeminist epistemologies reveal the entanglement of knowledge, power, and moral responsibility (Code, 1991; Warren, 1990), and if human-relevant alternatives offer scientifically superior and ethically preferable methods, then the question that remains is not whether change is needed, but how such change can be

epistemically legitimized and institutionally implemented. Building on the post-normal science framework outlined earlier, I propose concrete normative and institutional transformations to support a more democratic and epistemically responsible scientific practice. As Nancy Cartwright argues, this shift requires reliability, not abstraction, to become the cornerstone of methodological evaluation, move away from idealized, decontextualized models, and toward context-sensitive, empirically grounded standards of epistemic adequacy.

The entanglement of epistemic norms and commercial interests becomes particularly visible in the case of genetically modified laboratory animals. The OncoMouse™, developed at Harvard and patented in 1988, was the first transgenic animal to receive intellectual property protection (Kevles, 2002; Haraway, 1997). Rather than existing solely as an epistemic tool, it became a proprietary organism, bearer of legal, economic, and institutional value. This transformation illustrates how the scientific legitimacy of animal models is not grounded purely in their evidentiary reliability, but also in their capacity to generate revenue, patents, and institutional prestige.

When research subjects become intellectual property, the standards for methodological validity shift. They are no longer grounded purely in epistemic robustness but are entangled with proprietary claims and economic incentives. This logic favors commodifiable models like the OncoMouse™, while marginalizing human-relevant methods that, despite their scientific advantages, lack similar profitability structures.

If epistemic justice is to serve as the foundation for future scientific practice, we must confront not only the internal standards of knowledge evaluation but also the external systems that distort those standards through the logic of

commodification. Scientific validity must not be conflated with commercial viability. Reclaiming science as a public good thus requires institutional reform and conceptual renewal; above all, it demands the cultivation of epistemic courage to build a new framework of inquiry.[33]

The preceding chapters have shown how traditional scientific practices, particularly those centered on animal models, are shaped by exclusionary logics that systematically erase the perspectives, experiences, and agencies of nonhuman subjects. The concept of the absent referent (Adams), the dualist construction of reason and object (Plumwood), and the structural silencing of animal dissent all point to an epistemic regime in which objectivity is achieved not through engagement but through erasure. This regime does not merely distort the ethical landscape; it undermines the epistemic foundations of the knowledge it claims to produce.

In response, feminist theorists offer a relational and situated account of objectivity, one that treats partial perspective, embodied experience, and intersubjective accountability not as weaknesses but as essential conditions for reliable knowledge. Haraway's situated knowledges and response-ability, Birke's embodied empiricism, and Gruen's entangled empathy collectively propose a vision of science that is neither detached nor dispassionate, but attentive, co-constituted, and morally attuned. This is not a rejection of rigor but a redefinition of it, away from standardization for its own sake and toward responsiveness to the particularities and pluralities of lived experience.

The epistemic consequences of these frameworks are far-reaching. When science is practiced relationally, knowledge ceases to be a commodity extracted from

[33] I use the term *epistemic courage* to refer to the willingness to challenge entrenched norms and pursue knowledge practices that may be institutionally marginalized but ethically and epistemically justified. See Fricker (2007) for the moral dimensions of epistemic agency, and Zenker et al. (2023) for its application in scientific reform.

passive subjects and becomes a co-created context-sensitive process. This has direct implications for the adoption of alternative methods. Human-relevant models such as organ-on-chip or in silico simulations are often dismissed not because of inferior performance, on the contrary, their predictive validity is frequently superior, but because they lack epistemic fit within a paradigm that privileges control, reductionism, and quantifiability. Relational epistemologies challenge this paradigm by showing that relevance, reliability, and ethical accountability are not external constraints but internal criteria of good science.

Moreover, redefining scientific legitimacy in terms of epistemic justice requires a shift in institutional priorities. Funding structures, publication criteria, and regulatory standards must be reoriented to reward practices that foster inclusive epistemic communities, recognize nonhuman voices, and acknowledge dissent not as noise but as data. The extended peer community model proposed by post-normal science provides a partial template for this, but it must be enriched with feminist insights into the dynamics of power, privilege, and marginalization.

An epistemically just scientific system would institutionalize these commitments through concrete shifts, including:

- Reframing validity to include relational accountability and contextual adequacy.
- Redefining objectivity as responsiveness rather than detachment.
- Revaluing dissent, whether from marginalized scientists or from nonhuman actors, as epistemically generative.
- And reorganizing institutional structures to support these commitments.

Efforts to foster epistemically just scientific practices must also contend with the pressures of global scientific standardization. As universities and research

institutions compete internationally for funding, rankings, and prestige, a form of *methodological cosmopolitanism* emerges, one in which researchers across diverse contexts align their practices with dominant, internationally recognized models, often centered on animal experimentation.[34]

This global alignment does not necessarily reflect epistemic consensus, but rather institutional incentives to ensure compatibility, publishability, and collaboration. Researchers working in countries with progressive regulations or alternative ethical standards may find themselves reverting to animal-based methods in order to meet the expectations of high-impact journals, multinational grant programs, or international partnerships. In doing so, they suppress local epistemic traditions and ethical insights in favor of methodological conformity.

From the perspective of epistemic justice, this trend represents a flattening of knowledge production, where diversity of approaches is sacrificed for interoperability within a prestige economy. A truly inclusive and reflexive science must resist this homogenizing pressure by recognizing that knowledge emerges from specific contexts, ethical commitments, and relational practices. Institutional reform, therefore, must not only restructure national systems but also challenge the global hierarchies that equate standardization with validity.

The goal is not to make science less scientific, but to make it more just, epistemically, ethically, and politically. An epistemically just scientific practice would no longer be organized around mastery, prediction, and control, but around co-presence, recognition, and responsibility. It would treat animals not as silent inputs to experimental systems but as beings whose lives and expressions matter both

[34] I use *methodological cosmopolitanism* to describe the alignment of local scientific practices with globally dominant methods, driven by pressures of international collaboration, funding metrics, and publication standards.

ethically and epistemically. It would see alternative methods not as technical supplements but as manifestations of a deeper paradigm shift, one that centers care, accountability, and inclusive knowledge.

Such a transformation is not utopian; it is urgently necessary. The failures of animal-based research, the systemic resistance to reform, and the epistemic injustices embedded in current practice all point to the unsustainability of the status quo. Reclaiming scientific legitimacy requires more than better data or refined protocols. It demands the courage to ask what kind of science we want, whom it should serve, and how it can earn the trust we place in it. To answer these questions, we must align scientific methods with the principles of epistemic justice and relational ethics—principles that call for reliability, contextual sensitivity, and moral inclusivity.

Although Thomas Kuhn's notion of paradigm shifts is often read as suggesting incommensurability between rival scientific frameworks, he later clarified that scientists typically rely on shared values when evaluating paradigms. These include: (1) accuracy, (2) internal and external consistency, (3) breadth of scope, (4) simplicity, and (5) fruitfulness (Kuhn, 1977, p. 322). From this perspective, paradigm choice is not arbitrary; it can be critically reasoned and justified.

The epistemically just scientific practice I propose, grounded in human relevance, relational ethics, and accountable knowledge production, arguably meets these Kuhnian criteria more effectively than the current animal-based paradigm. It offers a broader explanatory scope, greater empirical robustness in human contexts, and a more inclusive epistemic framework rooted in ethical responsibility. In this sense, it is not only normatively preferable but also epistemically superior.

What remains is the collective will to reimagine the purposes, practices, and politics of science itself. The emerging alternatives surveyed here offer more than

technical solutions; they point toward a different vision of science, one in which the pursuit of knowledge is inseparable from the demands of justice.

CHAPTER 6

CONCLUSION

This chapter draws together the philosophical arguments, ethical analyses, and institutional criticisms presented throughout the thesis. Rather than attributing the persistence of animal experimentation to empirical necessity, it identifies its continuation as a consequence of entrenched epistemic, moral, and structural inertia. Each chapter has revealed a facet of this entrenchment, and together they challenge the legitimacy of a paradigm that can no longer be justified on scientific, ethical, or democratic grounds.

This thesis makes three original contributions to the intersection of science studies, animal ethics, and epistemology. First, it demonstrates how epistemic injustice operates systematically in animal research through the exclusion of non-human testimony and the marginalization of dissenting human voices. Second, it reveals the "structural impossibility of consent" as a foundational problem that cannot be resolved through incremental reform. Third, it shows how feminist epistemologies and post-normal science frameworks can ground alternative research paradigms that are both scientifically superior and ethically defensible.

Chapter 2 challenged the epistemic authority of animal models by demonstrating their limited predictive power, the crisis of reproducibility, and the illusion of objectivity that underpins their continued use. These failings are not incidental but symptomatic of a scientific culture that prioritizes established routines over epistemic integrity. Animal models persist not because they are the best available tools, but because their use is institutionally rewarded and rhetorically

framed, as necessary. The disjunction between evidentiary performance and regulatory reliance marks a profound epistemic failure.

Chapter 3 extended this critique by engaging with the ethical terrain. The structural impossibility of animal consent, combined with a morally selective application of harm-benefit reasoning, reveals the depth of speciesist assumptions embedded within current practices. The 3Rs framework, while historically important, operates today as a form of ethical minimalism that legitimizes the status quo rather than challenging its foundations. Alternative moral frameworks, such as capabilities theory, ecofeminist ethics, and relational approaches, offer a more expansive and inclusive account of moral responsibility, one that refuses to treat animal suffering as an abstract cost.

Chapter 4 situated these epistemic and moral failings within a broader institutional context. The entrenchment of animal experimentation is sustained by scientific conservatism, regulatory path dependency, and incentive structures that reward conformity over innovation. Drawing on Kuhn's analysis of paradigms and Cassam's theory of epistemic vice, the chapter argued that methodological rigidity, risk aversion, and a technocratic approach to research ethics inhibit meaningful reform. Gatekeeping mechanisms further marginalize dissenting voices and alternative approaches, reinforcing a narrow vision of what counts as valid science.

Chapter 5 turned toward constructive possibilities. It argued that a legitimate and justifiable scientific practice must be grounded in epistemic justice, participatory ethics, and methodological plurality. The framework of post-normal science (where facts are uncertain, values contested, stakes high, and decisions urgent) illuminates the inadequacy of traditional models of scientific authority. The chapter highlighted human-relevant, non-animal methods such as in vitro, in silico, and organ-on-chip

technologies, not merely as substitutes, but as carriers of a different epistemic ethos, one that prioritizes complexity, humility, and ethical reflexivity.

Limitations and Scope

This analysis has several important limitations that should be acknowledged. First, it focuses primarily on biomedical research within Western institutional contexts and may not fully capture variations in global research practices or non-Western ethical frameworks. Second, while advocating for alternative methodologies, the thesis does not provide detailed economic analyses of transition costs or implementation timelines. Third, the philosophical framework developed here requires further empirical validation through institutional case studies and policy implementations. Finally, the focus on systemic critique may underestimate the potential for meaningful reform within existing paradigms, though the evidence suggests such reform has been insufficient to address the fundamental problems identified.

These limitations notwithstanding, the structural analysis offered here helps clarify where and how transformative change must occur. Achieving such a transformation requires more than theoretical critique or technical substitution, calls for structural change across multiple levels of scientific practice. Institutional reform must begin with funding bodies that actively support methodological innovation over rote compliance. This includes requiring explicit justification for animal use in the presence of validated alternatives, as well as rewarding researchers who develop or adopt non-animal methods. Ethics review processes should be restructured to include diverse perspectives, especially those historically marginalized within technocratic deliberation, such as animal advocates, methodological dissenters, and community stakeholders. Universities and academic institutions, for their part, must revise

promotion criteria that currently privilege conventional research outputs over epistemic risk-taking.

On the regulatory front, policy initiatives such as the FDA Modernization Act 2.0 offer a precedent for abandoning outdated requirements. But to make a genuine impact, such reforms must go further, establishing concrete timelines for transition, prioritizing the most epistemically robust methods regardless of legacy conventions, and coordinating international harmonization efforts that dismantle the default reliance on animal data.

Scientific culture itself also demands transformation. Journals and professional societies should not only accommodate but actively promote methodological pluralism, encouraging the publication and dissemination of human-relevant research. Peer review mechanisms must evolve to include experts in alternative methodologies, ensuring that innovation is evaluated on its own terms rather than by the standards of the very paradigm it seeks to replace.

Finally, democratizing science requires broader public engagement. Building extended peer communities, composed of patients, caregivers, technicians, ethicists, and citizens, enables participatory governance over research agendas. These actors bring distinct epistemic resources and moral insights that enrich the deliberative space and counterbalance the technocratic inertia of expert-driven systems. Their inclusion affirms that scientific legitimacy must be understood not solely as an epistemic concern, but also as a civic obligation.

Without these multi-level commitments, even the most promising alternatives will remain structurally sidelined. The path forward involves not only technical substitution but a normative shift: from the instrumentalization of animal life to a

model of inquiry grounded in relational accountability, epistemic justice, and shared responsibility for the worlds we build through science.

Taken together, these chapters show that the continued use of animal models is not simply a scientific issue, but a normative and institutional crisis. Reform efforts that aim only at improving technical aspects of animal use miss the point. What is needed is not better cages or more refined protocols, but a critical rethinking of what kind of science we want, and what kind of world we are willing to co-create through its practices.

In terms of future research directions, this work opens several avenues for future investigation. Empirical studies of institutional transition processes could illuminate how paradigm shifts occur in practice and identify factors that facilitate or hinder methodological change. Comparative analyses of regulatory frameworks across different national contexts could identify the best practices for policy reform and reveal how cultural and political factors shape scientific governance. Ethnographic research within laboratories could document how researchers experience and navigate moral conflict, providing insights into the psychological and social dimensions of paradigm change.

Additionally, collaboration between philosophers, scientists, and policymakers could develop more sophisticated frameworks for evaluating methodological alternatives that integrate epistemic, ethical, and practical considerations. The concept of epistemic justice in scientific practice also warrants further development, particularly its application to other domains where vulnerable populations are systematically excluded from knowledge production.

The structural analysis of consent impossibility developed here could inform broader debates about research ethics, including questions of pediatric research,

mental health studies, and global health interventions where power asymmetries compromise genuine voluntary participation. Finally, the integration of feminist epistemologies with post-normal science frameworks offers promising directions for rethinking scientific objectivity and democratic participation in knowledge production.

The thesis concludes with a call to reimagine the purposes, practices, and politics of science itself. This is not an anti-scientific gesture; it is a plea for a better science; one that is ethically grounded, epistemically responsible, and democratically accountable. The transformation envisioned here will not come easily. It requires epistemic humility, institutional courage, and a willingness to value care, justice, and solidarity alongside technical precision. But it is both possible and necessary. If the credibility, relevance, and moral legitimacy of biomedical science are to be preserved, the paradigm of animal experimentation must be replaced, not repaired.

In short, this thesis demonstrates that we face not merely a methodological choice, but a fundamental ethical crossroads that will determine the future of scientific legitimacy. The persistence of animal experimentation, despite mounting evidence of its limitations, reveals deeper questions about knowledge, power, and moral responsibility in research institutions. To continue with animal-based research in light of its epistemic weaknesses and ethical costs is to choose institutional convenience over scientific integrity. To embrace the alternative paradigm outlined here, grounded in epistemic justice, methodological plurality, and democratic accountability, is to affirm the possibility of a science that serves both truth and justice.

This transformation will require what might be called "epistemic courage": the willingness to abandon familiar but failing methods in favor of approaches that

honor both scientific rigor and ethical responsibility. The tools, technologies, and theoretical frameworks already exist. What remains is the collective will to build institutions worthy of the trust placed in them and the lives affected by their decisions. That is the future this work calls for, and the responsibility it places before us.

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