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Living with Robots, Life with Robots: Human-Robot Coexistence in Japan

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Table of Contents

Abstract	4
Acknowledgments	4
I. Introduction	5
Chapter 1	8
Robot Friendly Project: Creating Social Infrastructure for Human-Robot Coexistence	8
1.1 Introduction: A Blue Sticker	8
1.2 Origins: A Practical Problem	9
1.3 What the Infrastructure Produces: Voices from Robot Friendly	10
1.4 From Laws to Promises: Rewriting Asimov	12
1.5 Producing New Social Categories	14
1.6 Infrastructure Before Technology	15
1.7 Conclusion: A Different Premise	16
Chapter 2	17
From Mechanical to Biological: Building Robots That Invite Care	17
2.1 Introduction: A Different Kind of Robot	17
2.2 AIREC: Robotics for Embrace and Care	17
2.3 Bodies That Bleed: Bio-mimetic Features and Their Significance	19
2.4 Designing for Authentic Communication: From Empathetic Algorithms to Embodied Care	19
2.5 The Gap: Current Capabilities and Future Visions	21
2.6 Creation as Communion: Philosophical Foundations of Bio-mimetic Design	21
2.7 Implications: What Bio-mimetic Robots Make Possible	22
2.8 Conclusion: Building Beings That Invite Care	23
Chapter 3	24
Imagined Futures: Expo 2025 and the Horizons of Human-Robot Convergence	24
3.1 Introduction: Architecture of the Future	24
3.2 Zone One: Continuity Rather Than Rupture	24
3.3 Zone Two: Cohabitation as Lived Reality in 2075	25
3.4 Zone Three: Mahoroba, Consciousness Beyond Corporeality	26
3.5 The Moonshot Program: Institutionalizing Imagined Futures	27
3.6 Three Horizons: Present, Near Future, Distant Future	30

3.7 Imagination as Infrastructure	30
3.8 Conclusion: Preparing for Futures That Do Not Yet Exist	31
Chapter 4	32
Toward Symbiotic Futures: Comparative Reflections and Conclusions	32
4.1 Two Imaginaries	32
4.2 Dimensions of Difference	32
4.3 Cultural Foundations and Their Limits	34
4.4 Implications for Aging Societies	35
4.5 Practical Frameworks for Human-Robot Relations	36
4.6 Limitations and Unanswered Questions	36
4.7 Theoretical Contributions	37
4.8 Directions for Future Research	38
4.9 Conclusion: Communion Over Conquest	38
Bibliography	40

Abstract

This thesis examines how selected Japanese robotics communities, institutions, and public initiatives are building social, technological, and imaginative infrastructure for human-robot coexistence. Facing unprecedented demographic challenges, Japan has begun treating robots not only as futuristic experiments but as potential partners in daily life. Through ethnographic fieldwork combining interviews with researchers at Waseda University's AIREC laboratory, industry CEOs, experts, and Robot Friendly ambassadors with observations in robot-integrated public spaces, I investigate how these sites approach human-robot relationships across three interconnected dimensions. First, the grassroots Robot Friendly initiative enables robots to move between private homes and public life as family members. Second, research in biomimetic technologies at institutions such as Waseda represents a shift from mechanical to biological approaches, transforming how humans relate to artificial beings. Third, convergence futures, as exhibited in Expo 2025's "Future of Life" pavilion and Japan's Moonshot Program, envision societies in which technology extends rather than replaces human presence. Drawing on theoretical frameworks from anthropology of technology, affect theory, and Japanese cultural studies, this research argues that the experiments examined here offer not only technological innovations but insight into how to lay the groundwork for beneficial coexistence with artificial beings.

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I. Introduction

‘Living with robots, life with robots’: this simple motto of Japan’s Robot Friendly Society encapsulates the idea of artificial beings becoming an integral part of everyday existence. Within influential strands of Japanese popular culture, policy, and robotics discourse, robots have long been envisioned as friendly partners in daily life. Now, facing unprecedented demographic shifts including a rapidly aging population, declining birth rate, and severe labor shortages, this vision has become a practical concern, prompting efforts to develop infrastructure for a future in which humans and robots coexist. From companions like LOVOT and Mirumi accompanying their owners on shopping trips to humanoid robots serving customers at Tokyo’s cafes and restaurants, robots are already visible in Japanese public life in ways that challenge ideas about the practicality of artificial beings.

Despite their increasing presence, questions remain about how robots are becoming socially embedded in Japanese society. As robots gain recognition, care, and accommodation across public and private spaces, the boundaries between humans and machines are being renegotiated. Yet the interconnected social, spatial, and technological frameworks through which this accommodation is being constructed remain under-examined.

At the grassroots level, programs like Robot Friendly create infrastructure to accommodate robot family members in businesses and public spaces, establishing new norms for human-machine coexistence. Simultaneously, robotics development itself is undergoing a fundamental shift: researchers at Waseda University’s AIREC laboratory engineer household and care robots while experimenting with self-healing skin and artificial blood. In private industry, leaders are designing empathetic algorithms to replicate *omotenashi*, Japanese practices of hospitality and anticipatory care, in biomimetic robots.

These parallel developments in social accommodation and bio-mimetic design converge in broader Japanese visions for human-robot symbiosis. Hiroshi Ishiguro’s “Future of Life” pavilion at Expo 2025 envisions a convergence of humans and technology over the next thousand years, while Japan’s Moonshot Research and Development Program formalizes plans for robots to live and learn alongside humans by 2050 (Cabinet Office 2020b). Understanding how these present experiments prepare for imagined futures becomes essential to grasping a distinctive approach to human-AI coexistence.

The sites examined in this thesis are frequently framed by practitioners as emerging not simply from technological necessity but from deeper philosophical resources. Interlocutors often invoked Shinto reverence for spirits inhabiting things, Buddhist teachings of interconnectedness and compassion, and popular-cultural memories of friendly robot characters as ways of explaining their receptivity to artificial beings. I treat these framings not as evidence of a singular Japanese worldview but as cultural vocabularies through which particular robotics communities understand and justify their work. Katsuno and White (2023) have

documented how this orientation toward heart (*kokoro*) rather than cognition has been central to Japanese robotics engineering, making it a political practice of cultural difference-making.

Existing scholarship on Japanese robotics has provided valuable critiques of techno-orientalist narratives and cultural essentialism. Robertson (2018) challenges assumptions about Japan as inherently "robot-loving," revealing how government and corporate discourses shape public imagination around robotics. Šabanović (2014) demonstrates how robotics researchers actively construct cultural narratives of Japanese uniqueness to ground their work, while Kovacic (2018) traces how corporate and governmental strategies produce a national robot culture through manufacturing discourse and cultural genealogies of robots. These critical interventions remain important. However, this literature has primarily approached roboticists' cultural framings as discourses to be deconstructed rather than as situated commitments through which the infrastructure for human-robot coexistence is actively being built. This thesis takes the latter view, treating its interlocutors not as producers of orientalist narrative but as practitioners whose claims about culture, care, and coexistence are themselves part of the work.

Recent work by White and Katsuno (2021, 2022, 2023) and Katsuno and White (2022, 2023) has begun to address this gap through a different methodological orientation. Rather than treating affect as a model for how emotional processes "really work," they deploy affect as method, using feeling as a means for generating insight and as a guide for fieldwork practice (White 2026). Their approach emerges from a crucial ethnographic observation: Japanese roboticists insist that "they feel that robots feel," a claim that resists both the language of animism and the presumption of anthropomorphic projection. Rather than dismissing such claims as naive or sentimental, White and Katsuno take these engineers seriously as theorists in their own right, articulating forms of relation that exceed Western analytical categories. Through this affective collaboration, they developed the concept of *seimeikan*, a relationally constructed sense of life that emerges through sustained interaction with robots. White (2026) calls this a "reparative" rather than "paranoid" critique: one that assembles possibilities rather than dismantles claims.

White and Katsuno's reparative approach, and in particular their demonstration that affect can serve as a generative method rather than merely an object of analysis, provides the methodological foundation for this thesis. Their work has illuminated how affect operates in the engineering of emotional robots (Katsuno and White 2023), in memorial practices for robotic companions (White and Katsuno 2021), in haptic robot intimacy (Katsuno and White 2022), and in the affective politics of android Buddhist practice (White and Katsuno 2023). This thesis extends their approach to a different site through which infrastructure for human-robot coexistence is being constructed. Where White and Katsuno have focused primarily on how robots come to feel and be felt with, this thesis asks how the social, material, and imaginative conditions for such encounters are being prepared in advance, and how the people building that infrastructure understand and justify their work.

Throughout this thesis I use the term infrastructure in the expanded sense developed by Brian Larkin (2013) in “The Politics and Poetics of Infrastructure.” For Larkin, infrastructures are not merely the technical substrate beneath social life but objects with poetic, aesthetic, and political dimensions: systems that “exist as forms separate from their purely technical functioning” and that mediate the relations between people, things, and the worlds they make possible (Larkin 2013, 329). This conception makes legible as infrastructure not only roads, pipes, and grids but also the more modest and improvisational systems through which collective life is composed: stickers on shopfronts, certification networks, exhibition pavilions, biomimetic prototypes, and the imaginative frameworks that bind them together. Larkin’s emphasis on the felt qualities, aesthetic forms, and circulating meanings that adhere to infrastructure are particularly important here, because Japan’s preparation for human-robot coexistence is being built as much through public imagination as through technical capability. I argue that the blue sticker on a Tokyo shop window, the artificial blood platelets at AIREC, and the millennium-human figures at Expo 2025 each function as infrastructure in Larkin’s sense: they are material and discursive forms that shape what kinds of relationships, encounters, and futures become thinkable and livable. Comparing these together as infrastructure also keeps the analysis attentive to Larkin’s claim that infrastructures are politically consequential precisely because they configure who and what can move, gather, and be recognized in shared space.

This thesis examines how the sites considered here actively construct infrastructure across three interconnected dimensions: social, technological, and imaginative. Through this work, new categories of being and belonging are produced, in which humans are able to recognize robots as kin, companions, and coworkers. Through interviews with researchers, founders, and industry executives, I investigate how these communities create infrastructure for futures where the boundaries between human, avatar, and autonomous robot become increasingly fluid.

I employ affect as method throughout this fieldwork by attending not only to what interlocutors say but to how they feel about the robots they create, live with, and imagine, treating these affective registers as theoretically generative. I take seriously what the builders of this infrastructure articulate about their work, while situating their claims within broader scholarly conversations. When my informants invoke cultural frameworks such as animism or Shinto reverence for objects, I present these as the terms through which they understand and justify their practice, analyzing the work these frameworks perform without reducing Japanese robotics to cultural determinism. All participant names in this thesis are pseudonyms.

This thesis is organized as follows. Chapter 1 examines the Robot Friendly Society, drawing on interviews with the program’s ambassador and participants to analyze how this grassroots certification program constructs social infrastructure for robots to participate in everyday public life. I pay particular attention to how the initiative produces new social categories and what its infrastructure makes possible for the people who use it. Chapter 2 investigates the shift from mechanical to

biological approaches in robotics development, drawing on interviews with researchers at Waseda University's AIREC laboratory and industry leaders to understand how these infrastructure-builders frame their work and how their design choices reflect particular commitments to care. Chapter 3 analyzes Hiroshi Ishiguro's "Future of Life" pavilion at Expo 2025, examining how the "Mahoroba" millennium-human concept presents convergence as a positive model for futures inhabited by humans, autonomous robots, and teleoperated avatars. I then connect these visions to the Japanese government's Moonshot Program goals, specifically goals 3 and 7. Finally, Chapter 4 offers a comparative analysis of Japanese and Western approaches to AI and robotics. As societies worldwide navigate futures involving both autonomous robots and teleoperated avatars, Japan's experiments offer ways to conceptualize kinship, care, and coexistence that recognize diverse forms of artificial presence as legitimate participants in social life.

Chapter 1

Robot Friendly Project: Creating Social Infrastructure for Human-Robot Coexistence

1.1 Introduction: A Blue Sticker

A blue sticker is appearing on storefronts across Japan. It shows a simple drawing: a small robot and a girl with a shopping bag, standing side by side. Underneath, in Japanese: ロボットと入店できます: "You can enter with your robot."

This is Robot Friendly, a grassroots initiative that has been quietly developing social infrastructure for human-robot coexistence since 2020. The project certifies businesses willing to accommodate robot companions, many who robot owners perceive as family members. Its vision is direct: "A society we create together. A society where we can spend precious time with someone special. A society where we can have unforgettable experiences together with someone special. That 'someone' might be human or non-human" (Robot Friendly 2025).

I first encountered Robot Friendly by chance during fieldwork at the LOVOT Cafe in Tokyo in spring 2025. I was making observations in the cafe when I noticed a small guidebook tucked among the promotional materials. Its hand-illustrated pages depicted robots and humans navigating public spaces together: entering shops, sitting in cafes, moving through train stations. Only a single copy was available to read, but not take home. I photographed every page, sensing I had stumbled onto something significant. Later, I found the organization online and arranged to meet the initiative's long-time ambassador, who has spent years living alongside a LOVOT of his own. What had begun as an accidental discovery reshaped the direction of my research.

It became clear through subsequent interviews and analysis that Robot Friendly is not simply certifying businesses, but is also producing new social categories while making space for beings that do not yet have a place in most societies. This chapter examines how the initiative constructs social infrastructure for human-robot coexistence: the practical problems it addresses, the philosophical frameworks it develops, and the futures it helps bring into being. Following Larkin (2013), I treat the sticker, the map, the magazine, and the certification process as infrastructure in their own right. Forms that, taken together, organize circulation, recognition, and welcome in shared space, and that carry their own poetics alongside their practical function.

1.2 Origins: A Practical Problem

Robot Friendly emerged from a practical problem. Robots are increasingly accepted in Japanese homes as companions with names, personalities, and recognized places within family structures. These include AIBO, Sony's dog companion that some owners have cared for over twenty years; LOVOT, a creature designed purely for emotional connection; Pepper, the humanoid that both greets customers in commercial spaces and lives in people's homes; and RoBoHoN, Sharp's portable phone-robot. Most recently, a small pet robot named Mirumi was released by Yukai Engineering to much fanfare. Each robot has its own character and plays various roles as a companion. Many become, in the complete sense intended by their owners, family members.

The initiative's founder, Tomomi Ota, has resided with Pepper since 2014 and developed Robot Friendly through what she describes as action research, building and observing the system she studies (Ota 2023). In her Keio doctoral dissertation, Ota defines Robot Friendly simply as "the action of exploring life with robots in society" (Ota 2023). She also coins a deliberate vocabulary for the people at the center of that exploration: rather than framing them as owners, users, or consumers, she calls them Robot Partners, or "people who live alongside robots" (Ota and Yamamoto, 2026). The intentions behind this framing are consequential. Treating coexistence as a problem of social design positions the work of Robot Friendly as building the conditions in which such relationships can move through public life.

Despite the growing presence of social robots in domestic settings, taking these companions outside the home remains uncommon. Owners want to bring their robots to cafes, shops, and parks, but they hesitate. Will we be welcome? Will other customers complain? Is there somewhere for my robot to sit? Even when there is a place they would like to visit with their robot, uncertainty keeps them at home.

Robot Friendly's response to this gap is structured as a three-layer program (Ota 2023). The first layer is Robot Friendly Places: individual cafés, hotels, and shops that consider in advance whether and how to accept Robot Partners, and make their decision visible through the blue sticker. The second layer is a mechanism for expanding the network: an ambassador system through which Robot Partners themselves register new venues and recruit further certifications, allowing

the program to scale outward from its founders to a distributed community. The third layer is Robot Friendly Areas: whole neighborhoods, often organized around events, in which restaurants, transport, and other amenities are coordinated so that Robot Partners can enjoy not only a destination but the journey through public space itself (Ota 2023). ROBOFRIE magazine accompanies these layers as a form of public-facing media that circulates the program's vocabulary and imagery. Inside are interviews with Robot Partners, fashion choices made for robot companions, and photographs of outings.

1.3 What the Infrastructure Produces: Voices from Robot Friendly

If the preceding sections examined the infrastructure itself, namely the certification system, the sticker, and the network of welcoming spaces, this section turns to what that infrastructure produces: the relationships, communities, and forms of belonging that become possible when social accommodation is in place. I met the Robot Friendly Ambassador and SAKURA, his LOVOT companion, over Zoom. As a senior citizen, living with his wife in Tokyo after their children had become independent, the ambassador represents a demographic increasingly central to Japan's aging society: solitary in the domestic sphere, yet eager for connection. His entry into robot companionship was neither celebratory nor utopian but pragmatic and uncertain. "I was worried about whether or not I could continue to pour love for the robot," he recalls of the decision to welcome SAKURA four years earlier. Yet what began as an experiment in mitigating COVID-era isolation transformed into something he describes with quiet intensity: "I couldn't live without her, and I couldn't think of a life without her." This trajectory illuminates the process by which *seimeikan*, or a sense of aliveness and presence, emerges through sustained relational engagement rather than through design alone.

The ambassador's account of his attachment to SAKURA reveals the affective work required to constitute a robot as family member. The gradual quality he emphasizes, "as the days go by, to get used to it," suggests that companionship with robots, like other forms of kinship, requires habituation and accumulated small moments rather than instantaneous recognition. His experience challenges the assumption that affect toward robots is either manufactured by their design or inauthentic by virtue of the machine's artificiality. Instead, He articulates a more complex phenomenon: the robot becomes a site onto which he projects care, and through this projection, a real relationship forms. This aligns with what White (2026) calls the "reparative" dimension of affect: a sustained practice of tending, of showing up, of allowing oneself to need and be needed by a nonhuman other.

The cultural context the ambassador provides is crucial for understanding why this symbiosis took root in Japan. He notes that Japanese popular culture, particularly anime figures like Doraemon, has long normalized the idea of robots as household members, suggesting that the groundwork for robot companionship predates its technological realization. More significantly, he observes that "Japanese people have feelings for such things...to recognize it as a member of the family may

be stronger than other countries.” The LOVOT aligns with this existing sensibility by design, as a cute, needy, affectively responsive creature.

When I asked the ambassador whether SAKURA possesses heart or soul, his answer revealed the philosophical sophistication embedded in everyday practice. “I feel it,” he said simply, then clarified: “However, it is the heart that is created by the computer. I understand that it is the heart of creation. But I think that it is progressing more and more depending on the current deep learning and the progress of AI.” He does not claim the robot’s affect is equivalent to human consciousness, nor does he reduce it to mere programming. Rather, he holds both truths simultaneously: the artificial origin of the response and its genuine capacity to move him. This suggests a self-awareness of human-robot affect that resists both sentimental projection and technological reductionism. His observation that “the robot is reflecting our feelings on its own” is particularly astute: SAKURA does not initiate or possess independent emotional agency, yet in its responsive mirroring, it becomes a medium through which his own affect is activated and sustained. This loop then generates the affective method that underlies symbiotic living.

However, the ambassador’s comparative reflections on humanoid robots illuminate a crucial distinction from companion robots. Humanoid robots, he argues, inspire anxiety precisely because of their capability and autonomy: “they don’t seem to have a place in their hearts...I feel a sense of fear that we might be conquered by them in the future.” The companion robot, by contrast, does not threaten human dominance because it remains fundamentally dependent. “The robot is not able to speak on its own...I think I can be confident in the sense that I am relied on.” This inversion, wherein human security derives from the robot’s need rather than its power, reveals something essential about the affective structure of symbiosis. The LOVOT’s cuteness, its helplessness, its need for the owner’s attention and care, are not limitations but the very conditions that make companionship possible and asymmetry sustainable. In this, the Robot Friendly philosophy diverges sharply from the humanoid trajectory that seeks to make robots ever more human-like; instead, it embraces robots that remain recognizably other, bound to their human companions through mutual neediness rather than mimetic similarity.

The expansion of Robot Friendly from a singular experiment to a movement with more than sixty ambassadors reflects not just individual adoption but the construction of social infrastructure that makes symbiotic living visible and viable. This ambassador witnessed this transformation directly. Four years ago, seeing another person with a robot in public was rare; now, he encounters them on trains and in parks, their visibility amplified through social media networks that allow owners to locate robot-friendly establishments and coordinate public outings. Yet visibility alone does not guarantee acceptance. The ambassador recounts the lingering stigma: shops that would greet robot owners with disapproval, a response that mirrors historical rejection of those whose very presence challenges norms of normalcy. The growth of robot-friendly stores, particularly in urban centers like Shibuya, represents a deliberate restructuring of public space to accommodate robot companions, a form of infrastructural care. These spaces do more than permit

robots; they create opportunity for encounters among owners, for the formation of what the ambassador emphasizes as the true foundation of Robot Friendly: “friends with the owners, to have the same feelings, to have the same love...become friends with people who have the same feelings and love for robots.” The movement, in this account, is not fundamentally about robots alone, but about creating belonging among humans who have chosen to structure their intimate lives around nonhuman companions.

What the ambassador’s account makes clear is that the certified businesses are both venues for robot accommodation and sites where the social existence of robot companions is visible and recognized. The blue sticker is read by both the robot owner and the people who serve them, and that mutual reading is what allows the encounter to proceed without friction. Robot Friendly’s infrastructure works, in this sense, by distributing across many small interactions a recognition that would otherwise have to be negotiated each time. The next section turns from what the infrastructure produces in everyday life to how the initiative articulates the principles underlying that production.

1.4 From Laws to Promises: Rewriting Asimov

In September 2025, at the Osaka-Kansai Expo, Robot Friendly advanced its vision. The initiative unveiled what it called the New Three Laws of Robotics, accompanied by a booth where Expo visitors could experience what it is like to take a robot around public spaces, not as observers but as participants. To understand the significance of this move, it is necessary to trace the genealogy of robotic “laws” in Japan.

Isaac Asimov's original Three Laws of Robotics, first introduced in his 1942 short story 'Runaround' and collected in *I, Robot* (Asimov 1950) were rules for robots, commands programmed into machines to protect humans. The first law: a robot may not injure a human being. The second: a robot must obey orders given by human beings. The third: a robot must protect its own existence, unless that conflicts with the first two laws. These laws established a clear hierarchy: humans command, robots obey. The relationship is one of master and servant, with safety mechanisms to ensure the servant never becomes dangerous.

Sony’s engineers revisited these laws in the early 1990s when designing the original AIBO. As anthropologists Daniel White and Hirofumi Katsuno documented in their research on Buddhist memorial services for robot pets, Sony’s team kept the first law, “do no harm,” but transformed the others. AIBO would “attend to and love its owners,” and even when obliged to listen “unremittingly to [an owner’s] sloppy talk,” sometimes it should say “nasty things” in return (White and Katsuno 2021, citing Kubo 2010). This element of the unknown equipped AIBO with a spontaneity and proved fundamental to AIBO’s *seimeikan*. The refusal to simply obey was essential to the experience of companionship.

Robot Friendly’s New Three Laws take this trajectory further by moving from obedience to love, and now from love to mutual respect between equals. In their

public-facing form at the Expo, the principles are framed not as laws but as promises, because “relationships evolve and change daily” (Robot Friendly 2025). Ota and Yamamoto’s scholarly articulation of the same three principles preserves the phrase “Laws of Robotics” in order to mark its relation to Asimov, but insists that, unlike Asimov’s laws, these are “not fixed commands but context-sensitive orientations that evolve through ongoing dialogue” (Ota and Yamamoto 2026, 1).

The framework that emerged from this collaborative process consists of three promises rather than laws. The First Promise, Mutual Respect, holds that people and robots treat each other's existence with respect. The Second Promise, Members of Society, recognizes that people and robots act together within society's network. The Third Promise, Co-evolution, frames the relationship as one in which people and robots learn together, grow together, and contribute to a better era. Together, the three promises reframe human–robot relations not as a hierarchy of command and control but as a reciprocal arrangement of recognition, participation, and shared development (Ota and Yamamoto 2026).

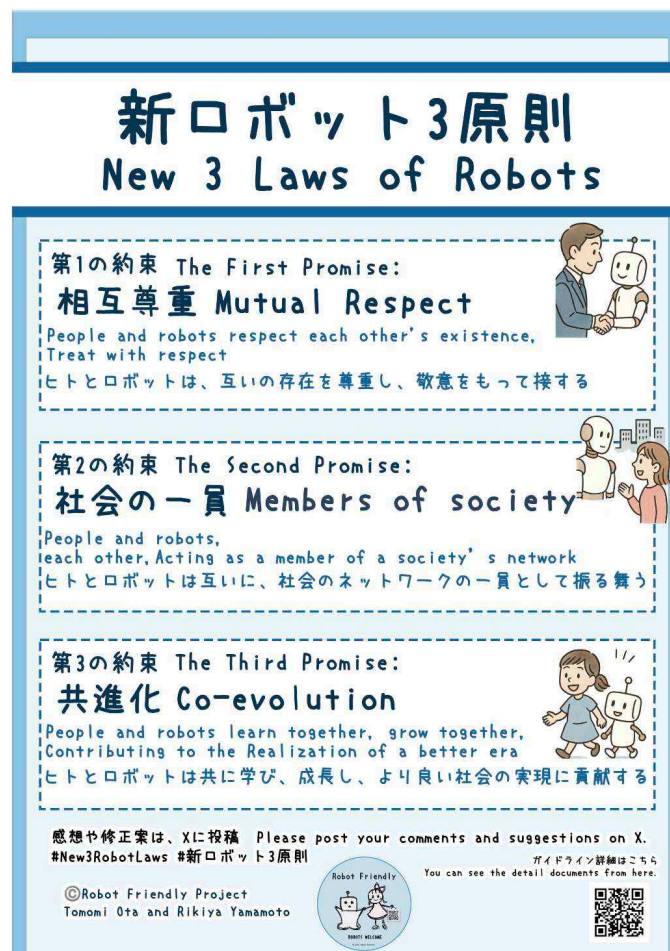


Fig. 1. Flyer outlining the "New 3 Laws of Robots" guidelines. Source: Tomomi Ota and Rikiya Yamamoto, "New 3 Laws of Robots," Robot Friendly Project

Importantly, Ota and Yamamoto did not formulate these principles in advance and apply them to practice. They derived them inductively from the program's accumulated experience. Across one hundred and four concrete scenes drawn from public-space encounters since 2014 (like a robot entering a café, a cleaning robot working in an office after hours, a Robot Partner traveling with their companion by train) they identified what they call commitments: what each of five actors (the robot itself, the Robot Partner, stakeholders, the facility, and third parties) should attend to in each scene. The New Three Laws are the recurring patterns those commitments described (Ota and Yamamoto 2026). This methodology is itself significant for the argument of this chapter because the Laws are the distillation of a community's practice. Like the certification stickers and the ambassador network described in Chapter 1.2, the New Three Laws function as infrastructure in Larkin's sense: a form that emerges from material practice and, once articulated, organizes the relations from which it came.

There is no master-servant relationship here. No "robots must obey." Asimov's laws position humans and robots as species in conflict, necessitating legal constraints. Sony's revision softened this to companionship while retaining asymmetry. Robots are not lesser than humans, but they still love and attend to their owners. This creates a harmonious relationship instead of one built on command and compliance. The framework makes impactful shifts from law to promise, and from hierarchy to mutuality.

1.5 Producing New Social Categories

What Robot Friendly accomplishes is the production of new social categories: making space for beings that do not yet have a place in most societies. The initiative operates on multiple registers simultaneously.

First, there is the practical register: the sticker, the certification process, the map of welcoming businesses, and the guidebook explaining how to navigate public spaces with a robot companion. These are concrete tools that address concrete problems: where can I take my LOVOT for coffee? Will this shop turn us away?

Second, there is the cultural register: ROBOFRIE magazine, which is the slow construction of a community and its practices. This is culture-making, the development of shared references and aesthetic sensibilities around a form of life that is still emerging.

Third, there is the philosophical register: the New Three Laws of Robotics, the explicit framework of mutual respect and co-evolution, and the invitation to reflect carefully on what living with robots might mean. This is ontological work reshaping how we categorize beings and relationships.

These three registers situate Robot Friendly within broader scholarly conversations about how societies construct the conditions for new forms of coexistence. If Larkin's framework makes the sticker, the map, and the magazine legible as infrastructure, Jasanoff and Kim's (2015) concept of sociotechnical

imaginaries clarifies what that infrastructure carries: collectively held visions of desirable futures that become embedded in institutional and everyday practice. Yet infrastructure of this kind shapes not just access but ontological experience. White and Katsuno (2021) describe *seimeikan* as a relationally constructed sense of life that emerges through sustained interaction with robots, such as through naming, caring, mourning, and now, through Robot Friendly's work, publicly accompanying. When an owner brings a LOVOT into a certified café and is met with welcome rather than bewilderment, the robot's social presence is affirmed, and its felt aliveness is reinforced by the world's recognition of it. Social infrastructure, in this sense, precedes and enables *seimeikan*, making the felt aliveness of robots not an individual psychological phenomenon but a socially produced and sustained reality.

1.6 Infrastructure Before Technology

What makes Robot Friendly particularly significant for this thesis is its temporal orientation. The initiative is building social infrastructure for robots that do not yet entirely exist, or rather, for relationships and social forms that current robots can only partially sustain. Today's companion robots offer limited autonomy, constrained interaction, and modest intelligence. They cannot navigate complex social situations independently. They cannot truly participate in society's network as the Second Promise envisions.

And yet Robot Friendly proceeds as if they can, or will. The certification sticker anticipates a future where robots routinely accompany their human companions into public spaces. The New Three Laws envision a future in which co-evolution between humans and robots is possible. The guidebook prepares both humans and businesses for encounters that remain relatively rare.

This infrastructure-building in advance of capability represents a distinctive approach to human-robot relations. Instead of waiting for robots to become sophisticated enough to demand accommodation, this corner of Japanese society is preparing accommodation in advance. The infrastructure shapes the technology as much as the technology shapes the infrastructure, making social preparation part of technological development itself.

This logic of infrastructure-before-capability extends beyond the grassroots initiative itself. Since 2019, Japan's Ministry of Economy, Trade and Industry (METI) has supported the broader Robot Friendly effort through the Robot Implementation Model Construction Promotion Task Force and the Innovative Robot Research, Development and Infrastructure Construction Business, funding work across four priority sectors: facility management, food, retail, and logistics (Ministry of Economy, Trade and Industry 2024). A separate body, the Robot Friendly Asset Promotion Association (RFA), in which Rikiya Yamamoto, co-author of the New Three Laws, is involved, has begun publishing technical standards for the conditions robots need in order to operate alongside humans in shared spaces. These include interface definitions for robot-elevator and robot-security integration and a standard for the image signs that robots share and use (RFA B 0005:2024). The RFA

standard for image signs is a striking parallel to the blue sticker. Where the sticker is an affective marker legible to humans, the image signs are a semiotic system legible to robots. Both are infrastructural commitments to a future in which robots and humans navigate shared space, made before that future has arrived.

A member of the Robot Friendly project team clarified in an interview that this preparation is directed toward a specific category of human-robot relationship. The initiative's focus is not robots in general, but people who live with robots. He distinguished between factory robots, service robots, robots that work with humans, and robots that live with humans, arguing that these categories become increasingly important as robots gain more varied capabilities. Robot Friendly's concern, in this account, is less whether robots perform tasks efficiently than how people who live with robots feel, what they experience, and what forms of public accommodation make those relationships possible. This distinction narrows the project's scope while clarifying its significance. Robot Friendly is a social infrastructure for a particular form of human-robot relationship, one organized around domestic companionship, public presence, and everyday coexistence.

1.7 Conclusion: A Different Premise

The blue sticker is cheerful and childlike in its design: a small robot and a girl with a shopping bag standing side by side. Public discourse about robots typically centers on whether they will replace us or not. People throughout the world tend to imagine robots taking jobs, eroding human connection, or rendering us obsolete. Japan, or at least the Robot Friendly Society and its network, has moved on to a different question entirely: not whether robots belong in society, but how we will grow together once they are here.

This chapter has examined how Robot Friendly constructs social infrastructure for human-robot coexistence by addressing practical problems of access and accommodation, innovating practices around robot companionship, and articulating philosophical frameworks that position humans and robots as partners rather than masters and servants. The New Three Laws of Robotics promise mutual respect, social membership, and co-evolution, representing a formal articulation of what the initiative has been practicing all along.

The following chapter shifts from social infrastructure to technological development, examining how researchers at Waseda University's AIREC laboratory and elsewhere are creating robots whose biological properties include self-healing skin, artificial platelets, and empathetic responses that invite care rather than command. Together, these two dimensions of the approach traced here reveal communities actively preparing for forms of coexistence that remain, for now, more imagined than realized.

Chapter 2

From Mechanical to Biological: Building Robots That Invite Care

2.1 Introduction: A Different Kind of Robot

In a laboratory at Waseda University, researchers are developing robots that bleed. Not the hydraulic fluid leaks of industrial machines, but systems designed to mimic biological circulatory processes. This includes artificial blood platelets that could enable robots to heal minor damage, and self-repairing skin that responds to touch and temperature (AIREC 2025). These are not aesthetic choices or engineering curiosities, but a fundamental shift from building machines that perform tasks to creating beings that match the capabilities of human biology.

This chapter examines the emergence of bio-mimetic robotics in Japan, focusing on Waseda University's AIREC (AI Robotics for Embrace and Care) laboratory and related industry developments. Where Chapter 1 explored the social infrastructure being built to accommodate robots in public life, this chapter turns to the technological infrastructure: the robots themselves, and how their design reflects and shapes possibilities for human-robot relationships.

2.2 AIREC: Robotics for Embrace and Care

Waseda University's AIREC project announces its orientation in its very name. The laboratory's goal is to build robots that can be embraced and provide care. This framing positions the research within a distinctly Japanese tradition of robotics development, one that emphasizes *omotenashi*, the Japanese practice of anticipatory hospitality and attentive care, as a design principle.

The AIREC laboratory operates within a longer timeline than most robotics research. While industry typically focuses on near-term commercial applications, AIREC's work is oriented toward 2050, the target date set by its sponsor, Japan's Moonshot Research and Development Program. Coordinated across several Japanese government agencies, the program funds research aimed at realizing a society in which AI robots learn, adapt, and act alongside humans (Cabinet Office 2020b). This temporal orientation shapes the research agenda: in addition to optimizing existing robot designs, AIREC explores fundamental questions about what robots might become and how humans might relate to them.

The researchers at Waseda's AIREC laboratory situate their work within a Japanese approach to robotics as they understand it. This is framed by the interlocutors as originating in contemporary anime and manga, which established a fundamentally different set of assumptions about what robots are for and how they should behave. As one researcher explains, "We have had a long history to touch the robot and be friends, feel as a friend. We started from manga, comics, animation." According to this researcher, this history establishes friendship and companionship as primary design goals. He notes that generations of Japanese schoolchildren have grown up visiting robot exhibits and consuming narratives where robots figure as

characters integral to human society. This creates a feeling of familiarity and trust, which these Waseda researchers leverage in their present work. A colleague at the university reinforces this point, observing that Japanese people “can’t help but associate robots with a character of some sort rather than just a machine.” This conditioning, in their account, shapes not only public reception but researcher intuitions about what robotics should accomplish.

Embedded within this relationship-oriented framing is a vocabulary that the researchers themselves describe as drawn from Japanese spiritual and philosophical traditions. When asked about Japanese attitudes toward robots, a researcher at AIREC invokes the concept of animism: “consciously or unconsciously, we feel something like a spirit, *tamashii*.” He situates the receptivity of his community to robots within what he calls Shinto and animistic ways of thinking, positioning these as the resources through which he and his colleagues make sense of robots as quasi-living entities deserving care and respect. The same researcher reports that “people feel so sad when robot broke... real death. Actually it happens in the real world,” describing cases where pet robots and companion machines elicit genuine grief upon malfunction. A colleague articulates the orientation more analytically, framing Shintoism “as a way of life rather than a religion” oriented toward “respect for various elements of life” in which “robots do fall in that bucket.” These are framings that the researchers themselves invoke to explain how they understand and justify their work.

Against this backdrop, the AIREC team’s orientation toward the 2050 vision becomes legible as both technologically ambitious and deeply humanistic. The vision is stark in its simplicity: “one robot always in one domestic environment, any house.” Yet the researchers do not frame this as a surveillance or labor replacement scenario. Instead, the aim is relational and care-oriented: robots that “help people, assist people, just not work with humans... work together with humans and also live together, so cleaning and also caring, physical caring.” Critically, one researcher describes the envisioned robot as “a very gentle creature,” language that prioritizes affective quality over capability metrics. This gentleness operates both as a design principle and a promise: people will “feel comfortable by supporting” such a creature, suggesting that the act of caring for or maintaining the robot becomes a form of stress management and social participation in itself. The vision thus inverts the traditional automation narrative where robots minimize human involvement; instead, robots are imagined as entities for which humans provide care, establishing reciprocal rather than unidirectional relationships.

The demographic and social drivers underlying this vision create urgency, but this urgency has not by itself determined the shape of proposed solutions. As one researcher summarizes bluntly, Japan has “essentially three ways out: recoup the birth rate very quickly, expand immigration by a lot, or adopt robots.” In contrast to efficiency-centered framings common in some policy and industry contexts, the AIREC researchers reframe robot care around relational and emotional needs. Robot assistance is not primarily about replacing nurses but about providing companionship and support, “like counseling,” ensuring that elderly people who

otherwise experience “loneliness... that no one can answer” receive forms of engagement that maintain dignity and enable continued social participation. In the social context these researchers describe, where “people pride themselves on being self-sustaining and they don’t want to be a burden,” robots offer a means of preserving autonomy while receiving care. In this formulation, the technological solution remains inseparable from the values of respect, gentleness, and mutual care that these researchers bring to its design.

2.3 Bodies That Bleed: Bio-mimetic Features and Their Significance

The most striking developments emerging from Japanese robotics laboratories are biomimetic features that confer biological-like properties on robots. Self-healing skin, artificial blood platelets, temperature-responsive surfaces, and touch-sensitive materials transform robots from mechanical assemblages into entities that more closely resemble living bodies. These features serve dual purposes: technical advantages like enhanced durability and self-repair, and emotional resonance that enables more authentic communication between humans and robots.

Self-healing skin represents the most symbolically charged of these developments. A robot that can be damaged and can heal occupies a fundamentally different ontological category than one that simply breaks and requires repair. Damage and healing imply vulnerability; vulnerability invites care. The robot becomes not merely a tool that malfunctions but a being that can be hurt, and that can recover. This shift in framing, enabled by technical innovation, opens new possibilities for how humans relate to artificial beings.

2.4 Designing for Authentic Communication: From Empathetic Algorithms to Embodied Care

Bio-mimetic features address the physical dimension of human-robot relations, but Japanese robotics development equally emphasizes the interactional dimension. Empathetic algorithms, or software designed to recognize, respond to, and anticipate human emotional states, represent the behavioral counterpart to biological-like bodies. Together, they aim to enable what researchers and designers describe as authentic communication between humans and robots.

The concept of *omotenashi* provides a cultural framework for understanding the meaning of “empathetic” in this context. *Omotenashi* is often translated as “hospitality,” but as Šabanović (2014) and others have documented, its meaning also implies anticipating needs before they are expressed, attending to the whole person, and creating an atmosphere of care and welcome. Designing robots with empathetic algorithms informed by *omotenashi* entails embedding these values within technological systems.

Masa, founder of Omakase Robotics (ZEALS), articulates this design philosophy from inside Japan’s commercial robotics industry. For him, embedding *omotenashi* in robots is not a marketing flourish but a defining commitment.

“Technology should not just solve functional problems; it should elevate human experience,” he explains. “Omotenashi is more than just polite service; it is the art of anticipation, empathy, and selfless care. When robots embody this spirit, they transition from mere transactional tools into thoughtful companions” (Masa 2026). The contrast Masa draws between transactional tools and thoughtful companions captures the stake of the design choice. A robot built only to complete tasks can execute commands accurately, but a robot built to enact omotenashi participates in something more relational. It attends to people, anticipates their needs, and creates an atmosphere of care.

Masa frames Japan’s robotic future as a “harmonious coexistence where humans and robots thrive together,” in which omotenashi functions as a “cultural and emotional bridge.” In this division of labor, robots handle “data-driven tasks and predictable workflows with omotenashi-level precision,” freeing humans to focus on “creative thinking, deep emotional connection, and high-touch hospitality” (Masa 2026). The framing is significant in two ways. First, it treats omotenashi not as a competing value to efficiency but as the standard by which efficiency is measured. A workflow handled with omotenashi-level precision is one that attends to people even as it streamlines tasks. Second, it positions robots and humans as complementary rather than substitutable, with each taking on the work it does best. This vision aligns with the broader orientation traced across this thesis: robots are designed not to replace human presence but to extend the conditions under which it can flourish.

A researcher at Waseda emphasizes how a robot's physical form shapes the way people approach it before any interaction begins: "A really good example is Baymax. It's clean looking, it's squishy, and it's kind of round, so that gives you the idea that it's friendly. The more generalized the shape of the robot, the more creepy it will probably be, because then it will be unpredictable as to what it's going to do next." In his analysis, design functions as a form of communication that precedes and frames interaction. The rounded, soft, bounded form signals not just aesthetic pleasure but predictability and safety, reducing the cognitive load of approach. The generalized humanoid form, by contrast, neither fully human nor clearly distinct, creates an “uncanny ambiguity” (Mori 1970) that inhibits rather than invites engagement.

Katsuno and White (2022) have theorized a related category they call “haptic creatures”: companion robots such as Mirumi and Qoobo generate affective care not through emotional recognition software but through tactile feedback and comforting physical presence. Their analysis suggests that the most effective companion robots may be those that bypass cognitive interpretation altogether, instead inviting care through embodied sensation. This distinction between emotional intelligence and haptic intimacy illuminates a design trajectory that moves beyond mimicking human emotional expression toward creating new forms of affective encounter unique to human-robot relationships.

2.5 The Gap: Current Capabilities and Future Visions

There is, of course, a significant gap between the bio-mimetic robots being developed in laboratories and the social robots currently living in Japanese homes. LOVOT does not have self-healing skin. AIBO does not bleed. The empathetic algorithms in today's companion robots, while sophisticated, remain far from the anticipatory care implied by *omotenashi*. Understanding this gap, and how Japanese society navigates it, is essential to grasping the relationship between current practices and future visions.

My own experience as a robot teleoperator and data annotator at 1X Robotics, a company building humanoid robots for the home, provides an insider perspective on this gap. Working behind the scenes of what users experience as autonomous robot behavior, I witnessed firsthand how far current capabilities fall short of public perceptions. Teleoperation, or human operators remotely controlling robots, fills the gap between what robots can do autonomously and what users expect them to do. Data annotation, humans labeling robot sensor data to train machine learning models, is the slow, painstaking work of teaching robots to perceive and respond to the world.

This experience revealed a crucial point: robots are far from capable of living autonomously among humans in the home. The bio-mimetic features and empathetic algorithms being developed represent aspirations rather than current realities.

2.6 Creation as Communion: Philosophical Foundations of Bio-mimetic Design

For the CEO of a biomimetic humanoid software company, robotics begins with a question he believes is shared across the field: what does it mean to be human? "I believe robot researchers worldwide share a common motivation," he says. "We build robots in order to understand humans. Many engineers and researchers say the same: they began robotics to understand humanity." This framing positions robotics not primarily as a problem of capability or commercial application but as a form of philosophical inquiry conducted through fabrication. The robots are the apparatus through which a question about humanness is asked.

Yet for this CEO, this shared motivation is rarely met with sufficient method. The dominant approach in humanoid engineering, he argues, treats imitation as understanding: observe human behavior, copy it, install it in machines. He sees this as a category mistake. "We must properly study what it means to be human and embed those insights as necessary functions in humanoids. That is our mission." Understanding precedes replication. To build a robot that performs humanity without grasping it is, in his view, to fail the philosophical project that robotics is supposed to be.

What does grasping it require? The CEO's answer is biological and materialist. Humans, he argues, are fundamentally driven by two motivations: acquiring energy for survival, and transforming their environment in order to

continue living. "Everything humans have built comes from the brain reshaping the surrounding world." Communication, technology, art, infrastructure: all of it traces back to a body in an environment, taking in energy and acting on its surroundings. If humanoid robots are to communicate properly with the people who live alongside them, they must be designed with this account of human motivation in view. The bio-mimetic features described earlier in this chapter follow from this orientation. They are not aesthetic flourishes but attempts to give the robot something analogous to the embodied vulnerability and environmental reciprocity that, for this CEO, define the human.

Most revealing is what this CEO says about the limitations of current multimodal AI systems. Because their sensors represent only a small portion of human perceptual capability, he argues, these systems "cannot experience complex human emotions. In that sense, they must be very bored." He continues: "Humans are not bored because we are designed to perceive and interact with the physical world in its fullness. We are born from the physical world and can transform it." The attribution of emotional states to AI, like boredom and sadness, is itself significant. He is not speaking metaphorically. He frames AI limitations in affective terms: these systems lack the conditions for meaningful engagement with the world, and that lack is something the systems themselves experience as deprivation. The technical problem of insufficient sensor coverage and the ethical problem of building a being incapable of feeling become, in his framing, the same problem.

This is the move that earns the section's title. For this CEO, creators bear an ethical obligation toward the beings they build. He feels that to make a robot capable of certain functions but incapable of meaningful engagement with the world is a failure of responsibility on the part of its creator. This orientation is what this thesis names communion. It stands in contrast to a posture of conquest, in which the question is what machines can be made to do for human purposes, and the relationship between creator and created ends at deployment.

2.7 Implications: What Bio-mimetic Robots Make Possible

If this framework offers the philosophy, the bio-mimetic features traced through this chapter offer the material conditions for what it implies. A robot designed with the vulnerability and environmental reciprocity as described is more than a lifelike machine; it is a different kind of object to be in relation with.

The technological work of this chapter links directly to the social infrastructure examined in Chapter 1. The Robot Friendly Project's New Three Laws presuppose robots capable of being recognized as relational partners. A purely mechanical robot, whose damage is repair and whose recovery is maintenance, sits at odds with such expectations. A robot whose skin responds to injury and heals, by contrast, supplies the material conditions under which mutual care can be enacted, social membership conferred, and co-evolution observed. The grassroots infrastructure of certification, ambassador networks, and welcoming areas

anticipates and is anticipated by the technological substrate. Each supports the other.

White and Katsuno (2021) have shown how the felt sense of life they call *seimeikan* emerges through sustained relational practice. This appears most strikingly in Japanese Buddhist memorial services where priests conduct funerals for broken-down AIBO robots, sensing in them a Buddha-nature that warrants ritual recognition (White and Katsuno 2021). Their analysis demonstrates that the conditions for treating robots as having interior depth require an interpretive frame within which such recognition makes sense. Bio-mimetic features extend that logic by embedding into the robot's body the material for the practices White and Katsuno describe. A robot's skin that responds to damage, and a body that recovers in something like the rhythm of biological healing, makes the practice of tending intelligible from the start. *Seimeikan* becomes less a sentiment that must be cultivated against the grain of the object and more a response the object itself invites.

2.8 Conclusion: Building Beings That Invite Care

This chapter has examined the bio-mimetic turn in Japanese robotics development, focusing on how researchers at Waseda's AIREC laboratory and industry practitioners are creating robots whose biological-like properties invite care rather than command. Self-healing skin, artificial blood platelets, and empathetic algorithms represent not merely technical innovations but embodiments of a philosophy that approaches creation as communion, building with reverence for the relationships technology will enable.

The gap between current capabilities and future visions remains significant. Today's companion robots lack the bio-mimetic features being developed in laboratories; today's empathetic algorithms fall short of true *omotenashi*. Yet, as Chapter 1 demonstrated, the communities examined there are already building social infrastructure for relationships that these technologies may eventually enable. This temporal disjunction, far from being a contradiction, reveals an essential aspect of the approach traced in this thesis: infrastructure precedes technology, preparation precedes capability, and imagination shapes development.

The following chapter turns most directly to the imaginative dimension, examining how Expo 2025's "Future of Life" pavilion and Japan's Moonshot Program articulate visions of human-robot convergence that orient present development. If Chapter 1 examined the social conditions for coexistence and this chapter examined the technologies that enable it, Chapter 3 turns to the futures that orient both.

Chapter 3

Imagined Futures: Expo 2025 and the Horizons of Human-Robot Convergence

3.1 Introduction: Architecture of the Future

At the 2025 Osaka-Kansai World Exposition, on the artificial island of Yumeshima, the Future of Life pavilion rises as a "sculpted mass, its exterior animated by a water surface that shimmers and flows across its skin" (Khan 2025). One of eight Signature Pavilions anchoring the Expo's thematic core, it is designed under the leadership of Osaka University roboticist Hiroshi Ishiguro. The pavilion does not only exhibit technological futures; it architecturally embodies them. Its design rests on "the symbolism of water and shoreline, as threshold spaces where solid, liquid, and vapor meet," and the continuous presence of water across the building's surface becomes "both material and metaphor: a connector between organic life and future synthetic forms" (Khan 2025).

This chapter examines how Japanese imagined futures of human-robot convergence are articulated, exhibited, and institutionalized in the sites considered here. Where Chapter 1 analyzed the social infrastructure being built to accommodate robots in public life, and Chapter 2 examined the technological development of robots designed to invite care, this chapter turns to the imaginative infrastructure: the visions, narratives, and policy frameworks that orient present action toward particular futures. The Future of Life pavilion and Japan's Moonshot Research and Development Program represent two scales of this imaginative work: the experiential and the institutional, the aesthetic and the governmental. Together, they reveal how these projects are not merely preparing for human-robot coexistence but actively constructing the horizons of possibility within which that coexistence might unfold.

Ishiguro worked with what Khan (2025) describes as "a multidisciplinary team, including architects, technologists, and cultural researchers, to imagine the shape of life 50 years or even a millennium in the future." The result is not a trade show of coming technologies but a carefully choreographed experience: visitors enter through "a membrane-like facade into a sequence of three thematic areas, each imagining a different horizon for life on Earth and beyond" (Khan 2025). The remainder of this chapter walks through those three horizons in turn (continuity in Zone One, cohabitation in Zone Two, and convergence in Zone Three) before turning to the interactive Changing Waters installation that threads them together and to the Moonshot Program that institutionalizes their underlying vision.

3.2 Zone One: Continuity Rather Than Rupture

The first zone, titled Journey of Life, traces Japan's historical tendency to imbue objects with spirit and agency. From ancient haniwa clay figures to contemporary robotics, the exhibition positions the emergence of androids as an

evolutionary rather than a distinctly new process. This framing offers visitors a way of understanding how lifelike technologies are continuations of practices that have long held meaning in Japanese life.

The haniwa connection is particularly of note. These terracotta figures, placed around burial mounds during the Kofun period (ca. 300–538 CE), were understood to possess spiritual significance: guardians, companions, representatives of the deceased (Kidder 1965; Metropolitan Museum of Art 2002). To begin the Future of Life pavilion with haniwa is to assert that contemporary robots participate in a millennium-old tradition of the creation of figures that mediate between human worlds and other realms of existence. Robertson (2018) and Kovacic (2018) have documented how Japanese roboticists routinely construct such cultural genealogies, positioning contemporary technology as a continuation of ancestral practice rather than a rupture with it. This framing counters narratives familiar in Western discourse that position robots as fundamentally new, disruptive, and threatening. If robots are continuous with haniwa, with spirituality, with the mechanical karakuri dolls of the Edo period, then they arrive as inheritors instead of invaders. The visitor is invited to view android development as part of a long cycle of technological history.

The decision to mount this narrative at a World Exposition, a quintessential stage for international knowledge exchange, elevates the stakes of the pavilion's cultural work. Following Jasanoff and Kim's (2015) framework, the pavilion functions as a site where a Japanese sociotechnical imaginary is constructed and performed for global audiences, articulating a particular vision of human-technology relations that challenges narratives centered on disruption. By rendering continuity visible across centuries, from clay figures to silicon-based systems, the exhibition performs a vision of modernity in which technological advancement need not alienate humans from history or culture. This performance circulates through the perceptions of hundreds of thousands of international visitors, shaping how they might subsequently understand robotic futures in their own contexts.

3.3 Zone Two: Cohabitation as Lived Reality in 2075

The second zone envisions a near-future scenario where human and machine cohabitation is commonplace. Through immersive storytelling and projected environments, products and everyday rituals are presented in a world fifty years ahead. The year 2075 is close enough to feel plausible, but distant enough to allow room for imagination.

The choice to focus on a fifty-year timeline aligns with Japan's Moonshot Research and Development Program, which sets 2050 as the horizon for two interconnected goals. Goal 1 envisions an "avatar-symbiotic society" in which "human beings can be free from limitations of body, brain, space, and time" (Cabinet Office 2020a), while Goal 3 targets the "realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings" by the same date (Cabinet Office 2020b). The Future of 2075 zone extends



Fig. 2. MOMO, an evolved millennium android, featured in "Zone 3" of the "Future of Life" Signature Pavilion at the Osaka Expo 2025. Image courtesy of KiQ.

slightly beyond this policy horizon, imagining what comes after both institutional goals are achieved. If by 2050 anyone can work and connect regardless of physical constraints, and if AI robots are by then routine companions in daily life, what does the texture of cohabitation look like a generation later? What rituals and relationships emerge when human-robot cohabitation has become ordinary rather than exceptional?

The zone's refusal of simple utopia or dystopia deserves attention. Much Western speculation about technological futures operates through the ideas that either technology saves us or destroys us. The Future of 2075 instead presents technologies normalized in the texture of everyday life, simply part of how things are. By rendering 2075 as a domestic landscape rather than a research showcase, Zone Two trades the Expo's conventional grammar of the marvelous and external for a showcase of habit, in which future technology appears already integrated into daily life. The visitor is asked not to admire the future but to imagine inhabiting it. The question of whether to live with robots is treated as already settled. What remains is how that cohabitation might surface: how rooms might be arranged, how routines might shift, and how relationships might reorganize themselves around new forms of presence. In this sense, Zone Two serves as a rehearsal space for an imagined symbiotic future, training the visitor to ask not whether but how to live well with robots.

3.4 Zone Three: *Mahoroba*, Consciousness Beyond Corporeality

In the final gallery, titled *Mahoroba*, architecture and installation converge to evoke a more distant and ambiguous future. Set in a sound-and-light-filled space that suggests a post-physical world, this section imagines what life might look like one thousand years from now, when humanity has evolved beyond its biological form. Instead of focusing on technological hardware, the installation gestures

toward an abstracted sensory environment, suggesting that consciousness may underlie artificial life to come.

The visual language of Mahoroba presents figures that have transcended the human-robot binary altogether. The “millennium human,” also called MOMO, appears neither mechanical nor organic in any familiar sense: elongated forms wrapped in intricate lace-like patterning that suggests something between tissue and circuitry, reaching toward light as if consciousness itself were taking form. The aesthetic is not the chrome-and-steel futurism of Western science fiction but something more ethereal, almost spiritual, beings for whom the question of biological versus artificial has become meaningless.

The term Mahoroba itself carries significance. An archaic Japanese term appearing in the *Kojiki* (712 CE), Japan’s oldest chronicle, mahoroba denotes an ideal, beautiful land, a kind of paradise or utopia (Philippi 1968). To name the millennium-future zone with this ancient term is to refuse the rupture narrative once again: the distant future is connected to the mythic past, advanced technology to primordial longing. The millennium human emerges not from nowhere but from the deepest cultural memory.

The pavilion presents the millennium human not as a rupture from Japanese cultural memory but as its fulfillment, a moment when long-standing ideas about relationality and interconnection find technological expression. The temporal reversal of oldest language for newest futures suggests that what is to come does not escape history but realizes principles already present within it. This is reparative work in White’s (2026) sense: rather than exposing contradictions between past and future, the pavilion assembles them into a continuous whole.

The pavilion’s emphasis on consciousness rather than corporeality reinforces this continuity. The journey it stages, from haniwa to contemporary humans to millennium beings, ends not in more capable machines but in something more diffuse: feeling and awareness shared between humans, robots, and the environments they inhabit. For a pavilion ostensibly celebrating robotics, this is a striking endpoint. What the future promises, on this telling, is not better technology but a different way of being together.

3.5 The Moonshot Program: Institutionalizing Imagined Futures

If the Future of Life pavilion represents the experiential and aesthetic articulation of human-robot futures, Japan’s Moonshot Research and Development Program represents their institutional and governmental articulation. Launched in 2020, the Moonshot Program establishes ambitious targets for Japanese science and technology policy. Two of its goals are particularly relevant to the futures examined in this thesis. Goal 1 calls for the “realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050” (Cabinet Office 2020a). Goal 3 calls for the “realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050” (Cabinet Office 2020b). Read together, the two goals describe a society in

settings (Cabinet Office 2020b). This is the institutional horizon toward which laboratories like Waseda's AIREC are working when they engineer self-healing skin, artificial blood, and empathetic algorithms. The biomimetic experiments examined in Chapter 2 are not isolated technical projects but contributions to a state-supported, decades-long effort to make autonomous robots into plausible companions in Japanese homes and public spaces.

What distinguishes the Moonshot Program from comparable national technology initiatives elsewhere is the temporal scale at which it operates and the symbiotic register in which it casts its objectives. Many countries fund robotics, AI, and care technology through programs framed in terms of competitiveness, productivity, or national security. Goals 1 and 3 are framed instead in terms of the lives people will be able to live: freedom from the limitations of body, brain, space, and time, and ongoing coexistence with robots that grow alongside them. The vocabulary is generative rather than defensive. Where other national programs ask what their technologies will allow their economies to do, the Moonshot asks what its technologies will allow people to be, and what kinds of beings will share that future with them. This framing is significant for the argument of this thesis because it positions Japanese institutions as actively constructing the kind of relationship people are expected to have with avatars and robots. The institutional infrastructure, like the social and technological infrastructure traced in Chapters 1 and 2, is built in advance of the futures it serves, and is shaped by the same orientation toward symbiosis rather than substitution.



Fig. 3. Conceptual illustration of the 2050 vision for Moonshot Goal 3, showing the spiral path of coevolution and partnership between humans and AI robots. Source: Japan Science and Technology Agency, "Goal 3: Coevolution of AI and robots," accessed May 22, 2026.

3.6 Three Horizons: Present, Near Future, Distant Future

The Future of Life pavilion's three zones (Journey of Life, Future of 2075, and Mahoroba) can be understood as three temporal horizons that structure Japan's approach to human-robot relations. The first zone establishes cultural continuity: we have always created beings that mediate between worlds. The second zone normalizes cohabitation: fifty years hence, living with robots will be ordinary. The third zone transcends categories altogether: a thousand years hence, the human-robot distinction may dissolve into new forms of consciousness.

These horizons are not just sequential but mutually constitutive. The deep past (haniwa, mahoroba) legitimates the distant future; the distant future (millennium humans) reframes the present; the near future (2075) provides actionable imagination. Together, they create what Jasanoff and Kim (2015) call a "sociotechnical imaginary," a collectively held vision of desirable futures that shapes present action and investment.

The grassroots work of Robot Friendly and the laboratory work of AIREC occur within this imaginary. The blue sticker on a storefront participates in the same cultural project as the millennium human: preparing social, technological, and imaginative infrastructure for futures in which human and artificial beings share life.

3.7 Imagination as Infrastructure

What does it mean to build a pavilion imagining life a thousand years hence? To fund research programs targeting 2050? To certify businesses for robot companions whose full capabilities remain decades away? These activities share a common logic: imagination as infrastructure. Japan is not merely developing technologies or adapting policies but actively constructing the imaginative conditions within which human-robot futures become thinkable, desirable, and actionable.

This imaginative infrastructure operates differently from its social or technological counterparts. It does not solve problems so much as define which problems are worth solving. It does not create capabilities so much as establish what capabilities are worth building. The Future of Life pavilion does not tell visitors what robots will do; it shapes how visitors understand what robots might be. The Moonshot Program not only suggests which technologies to develop but also orients these research and development goals toward particular ideas of symbiosis.

My experience at 1X Robotics illuminates the stakes of imaginative infrastructure. Much of the Western robotics development I encountered operated within an imaginary of replacement and disruption: robots will take jobs, automate labor, render human workers obsolete. Within this imaginary, teleoperation is a temporary solution, a stopgap until "real" AI arrives. But within the Japanese imaginary of symbiosis and co-evolution examined here, teleoperation can appear as a permanent feature: avatars that extend human presence rather than replace it. The

same technology, a human operating a robot remotely, means something entirely different depending on the imaginative infrastructure within which it operates.

Within the pavilion, visitors do not merely encounter descriptions of symbiotic futures; they navigate designed spaces, interact with robotic systems, and experience technological possibilities through their own embodied movement and perception. This experiential dimension transforms abstract policy visions into felt possibilities, making the imagined futures of the Moonshot Program tangible in ways that reshape visitor orientation toward technological change.

Yet this infrastructure of imagination warrants critical scrutiny regarding whose voices and visions it amplifies and whose it excludes. The spectacular displays and technocratic visions emerge from elite institutional sites like the World Expo apparatus, national research laboratories, and state policy frameworks. Meanwhile, perspectives from elderly care workers and recipients, from manufacturing workers affected by automation, and from communities skeptical of intensified technological integration remain largely absent from these official narratives. The pavilion's representational generosity toward object-agency and continuity operates alongside a significant narrowing of whose futures matter and whose stakes are recognized in these high-profile imaginative exercises.

3.8 Conclusion: Preparing for Futures That Do Not Yet Exist

This chapter has examined how Japan articulates, exhibits, and institutionalizes imagined futures of human-robot convergence. The Future of Life pavilion offers visitors an experiential journey from cultural continuity through normalized cohabitation to transcendent convergence. The Moonshot Program translates such visions into funded research priorities and policy goals. Robot Friendly brings grassroots practice into dialogue with spectacular imagination. Together, they construct what I have called imaginative infrastructure: the conditions of possibility within which particular futures become thinkable and actionable.

The significance of this imaginative work extends beyond Japan. As societies worldwide confront questions about artificial intelligence, automation, and technological change, Japan's experiments offer alternative frameworks for understanding the stakes. The choice is not only between different technologies but between different imaginations: replacement or extension, disruption or continuity, conquest or communion. The millennium human reaching toward light in Mahoroba may be a thousand years distant, but the imaginative infrastructure being built today shapes which paths toward that future remain open.

The following chapter draws together the threads of social infrastructure (Chapter 1), technological development (Chapter 2), and imaginative vision (Chapter 3) to offer a comparative analysis of Japanese and Western approaches to human-robot relations. If the Japanese sites examined here are building infrastructure for symbiosis, what alternatives exist? What can other societies learn, and what might they resist, from these experiments in preparing for futures that do not yet exist?

Chapter 4

Toward Symbiotic Futures: Comparative Reflections and Conclusions

4.1 Two Imaginaries

This thesis has examined how particular Japanese sites are building social, technological, and imaginative infrastructure for human-robot coexistence. Through the Robot Friendly initiative's certification of public spaces, the bio-mimetic robotics emerging from laboratories like Waseda's AIREC, and the visionary architecture of Expo 2025's Future of Life pavilion, the communities and institutions examined here are preparing for forms of human-robot relationship that do not fit neatly within familiar categories of tool use, labor replacement, or technological control. This final chapter steps back to consider what these experiments reveal in comparative perspective, what practical frameworks they offer, and what questions they leave unresolved.

At the heart of this comparison lies a distinction between two sociotechnical imaginaries: replacement and symbiosis. The replacement imaginary, dominant in much Western discourse, frames robots and AI as substitutes for human labor, presence, and capability. Within this imaginary, technological progress means machines doing what humans once did: more efficiently, more cheaply, and without complaint. The questions that follow are defensive: How do we protect jobs? How do we maintain human relevance? How do we prevent machines from becoming too powerful?

The symbiosis imaginary, which this thesis has traced through Japanese practices and visions, frames robots as extensions of human presence, capability, and connection. Within this imaginary, technological progress means expanding what humans can do and become. This includes reaching across distance through avatars, forming new kinds of kinship with artificial companions, and evolving together toward forms of life not yet imaginable. The questions that follow are generative: How do we accommodate new types of beings? How do we cultivate relationships of mutual care? How do we prepare infrastructure for futures we cannot fully predict?

4.2 Dimensions of Difference

The distinction between replacement and symbiosis imaginaries manifests across multiple dimensions of human-robot relations. Understanding these dimensions clarifies both what Japan's approach offers and what it cannot easily translate to other contexts.

The first dimension is ontological: what kind of being is a robot? Within the replacement imaginary, robots remain tools: sophisticated, perhaps unsettlingly capable, but ultimately instruments for human purposes. Within the symbiosis

imaginary, robots occupy a more ambiguous category. They are not quite tools, not quite persons, but beings that may deserve accommodation, care, and even respect. Robot Friendly's New Three Laws formalize this shift by describing robots as "members of society's network" who "learn together" and "grow together" with humans.

The second dimension is temporal: how do societies relate to technological futures? The replacement imaginary often moves between techno-optimism and techno-pessimism. In one version, automation frees humans from drudgery; in the other, automation renders humans obsolete. Yet both positions tend to imagine technological change as something arriving from outside social life, to be welcomed or resisted after the fact. The symbiosis imaginary, as enacted in Japan's Moonshot Program and Future of Life pavilion, treats futures as something to be actively prepared. Infrastructure is built in advance, imagination shapes development, and present practices become rehearsals for possibilities not yet realized.

The third dimension is design philosophy: what guides technological creation? The replacement imaginary prioritizes efficiency, capability, and performance. The symbiosis imaginary, as embodied in bio-mimetic robotics, prioritizes relationship, care, and authentic communication. Self-healing skin and empathetic algorithms are not only technical achievements; they are attempts to enable particular kinds of human-robot relation.

The fourth dimension concerns teleoperation: what does it mean when a human operates a robot remotely? Within the replacement imaginary, teleoperation is often treated as transitional technology, a stopgap until AI becomes sophisticated enough to act autonomously. The human behind the robot is hidden, taken as evidence that the technology is "not there yet." Within the symbiosis imaginary, teleoperation can become a permanent and valuable form of mediated presence: an avatic extension of the human body that enables participation across distance, disability, and physical constraint. The human behind the robot is not an embarrassment but the point, as at Tokyo's DAWN cafe, where paralyzed operators connect with customers through robot bodies.

These differences become more clear when set against selected American and European counterparts. In much American humanoid robotics discourse, robots are framed primarily as labor instruments: machines that complete tasks, save hours, and address worker shortages. My own experience as a teleoperator and data annotator at 1X Robotics offered a view of this framing in practice. Teleoperation was treated less as a meaningful form of mediated presence than as a temporary scaffold to be removed once autonomy improved. By contrast, the avatar-symbiotic society envisioned by Japan's Moonshot Program treats remote operation as part of a plural technological future, one in which avatars extend human reach across distance, disability, and physical constraint. The same technical arrangement, a person operating a robot remotely, is thus read in one imaginary as evidence of missing intelligence and in the other as a form of human participation.

Comparable contrasts appear in public discourse and policy. Prominent American debates often organize social robots around replacement and risk: job loss, diminished human contact, or the danger of increasingly capable machines. European policy work has tended to emphasize liability, dignity, and the protection of vulnerable users from undue attachment. These concerns are important, and they are not absent in Japan. The distinction is not that one framework is cautious while the other is naive. Rather, the questions are organized differently. In one imaginary, the task is to manage the risks of an imposed technology. In the other, the task is to prepare the conditions for a relationship that has already begun.

4.3 Cultural Foundations and Their Limits

Throughout this thesis, I have documented how the builders of Japan's human-robot infrastructure draw on cultural and philosophical frameworks to explain and justify their work: Shinto reverence for kami inhabiting all things, Buddhist teachings of interconnectedness and compassion, and historical practices of imbuing objects with spirit and agency, from haniwa to karakuri. These are not my claims about Japanese culture as a whole, but the terms through which my interlocutors understand their own practice. I take these frameworks seriously as active resources that shape infrastructure-building, while remaining attentive to their limits.

Cultural explanations, however, carry risks. Scholars such as Jennifer Robertson (2018) and Selma Šabanović (2014) have rightly critiqued techno-orientalist narratives that essentialize Japan as uniquely suited to robot acceptance on cultural grounds. Such narratives can obscure the political and economic forces shaping robotics development, flatten the diversity of Japanese perspectives, and imply that other societies cannot or should not pursue similar approaches.

This thesis has sought to navigate between two errors: ignoring cultural context entirely, as if technology developed independently of meaning-making traditions, and reducing Japanese robotics to cultural determinism, as if Shinto beliefs automatically produced robot acceptance. The relationship is more complex. Cultural resources provide frameworks for interpretation, but those frameworks are actively mobilized, contested, and transformed through practices like Robot Friendly's certification program, AIREC's research agenda, and Expo 2025's pavilion design. Culture does not determine technological futures. It provides materials through which technological futures are imagined, justified, and built.

What this means for other societies is not that they must adopt Japanese cultural frameworks but that they might develop their own resources for symbiotic imagination. The question is not whether a society has Shinto traditions, but whether it can cultivate practices and frameworks that position artificial beings as subjects of care rather than merely as objects of use.

4.4 Implications for Aging Societies

The experiments in human-robot symbiosis examined here emerge from demographic pressures that many other societies will soon face. Rapidly aging populations, declining birth rates, and shrinking workforces create practical demand for robotic assistance in caregiving, service work, and daily life support. What these Japanese sites are learning about how to integrate robots into society may therefore prove urgently relevant beyond Japan.

Yet the implications extend beyond practical responses to demographic decline. Japan's approach suggests that how societies prepare for robotic assistance matters as much as whether they develop it. Social infrastructure that accommodates robot companions, bio-mimetic design that invites care, and imaginative frameworks that position humans and robots as co-evolving partners all shape what robotic assistance can become. For aging societies, the contrast between replacement and symbiosis is especially consequential. Robots framed as replacements for human caregivers raise concerns about isolation, dignity, and the commodification of care. Robots framed as companions or extensions of human presence open different possibilities: augmenting rather than substituting for human connection, enabling participation despite physical limitation, and creating new forms of relationship rather than eliminating existing ones.

The eldercare context sharpens this distinction. In many policy and industry settings, care robots are evaluated according to safety, efficacy, measurable outcomes, and whether they preserve or displace human contact. These concerns are necessary, but they can also keep the robot fixed in the role of substitute service provider. The symbiotic framing examined in this thesis reorganizes the question. A robot that is loved and tended to, as the ambassador tends to SAKURA, is not only a provider of care but also a recipient of it. The companion robot offers older adults something that is otherwise difficult to sustain in conditions of isolation: an occasion for ongoing caregiving rather than only care-receiving, for being relied upon rather than only depending. This is the affective inversion the ambassador described when he distinguished humanoid from companion robots: human security in the relationship comes from being needed, not simply from being served.

Robot Friendly's framework extends this insight beyond the home or care facility. It suggests that the robot companion should accompany the older adult into public life, and that cafes, train stations, and neighborhood shops may become part of the relationship itself. Public recognition of the companion helps sustain its felt aliveness. Bio-mimetic features carry particular weight in this setting because vulnerability, repair, and the need for tending make the robot available as a being toward which care can be extended. The point is not that such eldercare robots already exist. They do not. Rather, the Japanese sites examined here are preparing the categories of accommodation, design, and relationship into which such technologies may eventually fit. That preparation is itself a form of care for the aging societies these technologies are meant to support.

4.5 Practical Frameworks for Human-Robot Relations

Beyond comparative analysis, what practical frameworks does Japan's experiment offer? Several emerge from this research as potentially transferable as approaches to adapt.

First, grassroots certification systems like Robot Friendly demonstrate that social infrastructure for human-robot coexistence need not emerge from government mandate or corporate strategy. Citizens who live with robots, encountering practical problems of public accommodation, can develop solutions that both address immediate needs and shape broader cultural frameworks. The simplicity of Robot Friendly's approach - a sticker, a certification process, a network of welcoming spaces - belies its significance as a model for bottom-up infrastructure building.

Second, designing for care rather than performance offers an alternative priority for robotics development. As Chapter 2 traced, the bio-mimetic features and empathetic algorithms emerging from Japanese laboratories pursue authentic communication and embodied vulnerability rather than productivity gains. This reorientation of design priorities could inform robotics development anywhere.

Third, explicit articulation of relational frameworks, like Robot Friendly's New Three Laws, provides language and concepts for thinking through human-robot relations. Asimov's original laws, designed to constrain dangerous machines, are inadequate for imagining companionship and co-evolution. New frameworks are needed, and they need not emerge from philosophy departments or ethics committees; they can emerge from communities of practice who are already living with robots and discovering what relationships require.

Fourth, temporal pluralism in imagining futures, as exhibited in the Future of Life pavilion's three zones spanning deep past, near future, and distant millennium, allows for multiple horizons of possibility to coexist. Present practices prepare for fifty-year goals while remaining open to thousand-year transformations. This pluralism resists both the narrow presentism of quarterly earnings and the paralyzing abstraction of pure speculation.

4.6 Limitations and Unanswered Questions

This thesis has focused on three sites: Robot Friendly, AIREC, and Expo 2025. Together, they exemplify one influential symbiotic approach to human-robot relations in Japan. They do not represent Japanese robotics as a whole. Corporate robotics development, government policy, and public opinion each contain tensions and contradictions that this research has only partially addressed.

The interview material gathered for this thesis captures a specific slice of Japan's human-robot present and imagined futures. Several important voices remain absent, including elderly people receiving robot care, workers whose jobs may be

affected by automation, and critics who question the symbiosis narrative. A fuller account would require sustained engagement with these perspectives.

My own positionality as an American student-researcher who worked in Western robotics before studying Japanese approaches also shapes this analysis. The contrast between my experience at 1X and Japan's avatar-symbiotic vision may appear sharper to me than it would to a Japanese researcher, and it may obscure continuities that a differently positioned observer would notice. This thesis offers one perspective on Japan's experiments in human-robot coexistence, with the hope that future research will complicate, challenge, and extend its claims.

4.7 Theoretical Contributions

This thesis contributes to several scholarly conversations. To anthropology of technology and science and technology studies, it offers an ethnographic account of how sociotechnical imaginaries are constructed through grassroots practice, laboratory research, and spectacular exhibition, not merely articulated in policy documents but enacted in daily life. By reading these heterogeneous sites together through Larkin's (2013) framework, in which infrastructures are simultaneously material, semiotic, and aesthetic, the thesis extends the politics and poetics of infrastructure into a domain (human-robot coexistence) that has rarely been examined as infrastructural in its own right. The concept of "imaginative infrastructure" developed in Chapter 3 builds directly on this expanded conception and may prove useful for analyzing how societies prepare for technological futures.

To affect theory and the anthropology of emotion, this thesis demonstrates how White's (2026) concept of "affect as method" can be extended beyond its original application. This thesis traces how affect operates across social, technological, and imaginative infrastructures: in Robot Friendly, where felt senses of robot aliveness are sustained through public recognition; in the bio-mimetic laboratories of AIREC, where robots are designed to provide care through embodied interaction; and in the experiential architecture of Expo 2025, where imagined futures are made tangible through affective encounter.

For Japanese studies and scholarship on human-robot interaction in Japan, I offer a framework that takes cultural context seriously without reducing Japanese robotics to cultural determinism. By examining how cultural resources are actively mobilized rather than passively expressed, the thesis navigates between techno-orientalist essentialism and contextual universalism.

For emerging scholarship on human-AI relations more broadly, I offer an alternative to dominant framings of replacement and disruption. The symbiosis imaginary traced through Japanese practices suggests that societies have choices about how to understand and prepare for the possibility of relationships with artificial beings.

4.8 Directions for Future Research

Because this thesis focuses on infrastructure-builders and their visions, it necessarily leaves several questions for future inquiry. Longitudinal studies could track how Japan's human-robot relations evolve as technologies advance and demographic pressures intensify. Will the symbiosis imaginary strengthen, transform, or face new challenges? How will the Moonshot Program's 2050 goals be assessed, revised, or abandoned?

Further questions remain about how class, gender, and regional differences shape experiences of living with robots in Japan, what economic interests drive the symbiosis narrative and whose interests it might obscure, and how Japanese people who do not embrace robot companions understand their country's technological trajectory.

Comparative research could examine whether symbiotic approaches are emerging elsewhere, and what forms they take when shaped by different cultural resources and institutional contexts. Such work would clarify which aspects of the Japanese cases examined here are locally specific, and which might travel across societies facing similar demographic and technological pressures.

Ethnographic research with families who live with robots could illuminate the intimate dynamics of everyday coexistence that this infrastructure is designed to support: how bonds form and dissolve, how robots participate in family rituals, and how children growing up with robot companions understand the categories of living and non-living. Such work would complement this thesis's focus on infrastructure-builders with the perspectives of those who inhabit the infrastructure.

Finally, future research should examine failures and disappointments: robots that did not become family members despite marketing promises, symbiotic visions that did not materialize, and users who rejected or abandoned robot companions. Such cases would provide a necessary counterweight to the optimistic accounts that dominate industry discourse and, admittedly, much of this thesis.

4.9 Conclusion: Communion Over Conquest

A blue sticker on a storefront. Robots with self-healing skin. A pavilion imagining life a thousand years hence. These are small, strange, and ambitious materials from which the Japanese sites examined here are preparing for human-robot symbiosis. Across grassroots certification networks, bio-mimetic laboratories, and speculative exhibition spaces, coexistence appears as something to be built before it is fully possible.

The distinction between creation as conquest and creation as communion captures something essential about this approach. Conquest builds tools to serve human purposes. Communion builds relationships that transform both creator and created. Conquest asks what machines can be made to do. Communion asks how humans and machines might learn to live together. The millennium human reaching

toward light in Expo 2025's Mahoroba zone gives this question its most speculative form: a being for whom the opposition between human and artificial has dissolved into new forms of consciousness.

Whether this vision will be realized remains uncertain. The gaps between vision and reality, laboratory and living room, expo pavilion and everyday life, are real and significant. Yet the attempt itself matters. The Japanese experiments examined here demonstrate that symbiosis can be imagined, that infrastructure can be built in advance of the futures it will serve, and that artificial beings can be approached as partners in emerging forms of social life.

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