

Playing Alongside Mushroom: Chasing Play in Human-Mycelium Encounters for More-than-Human Design

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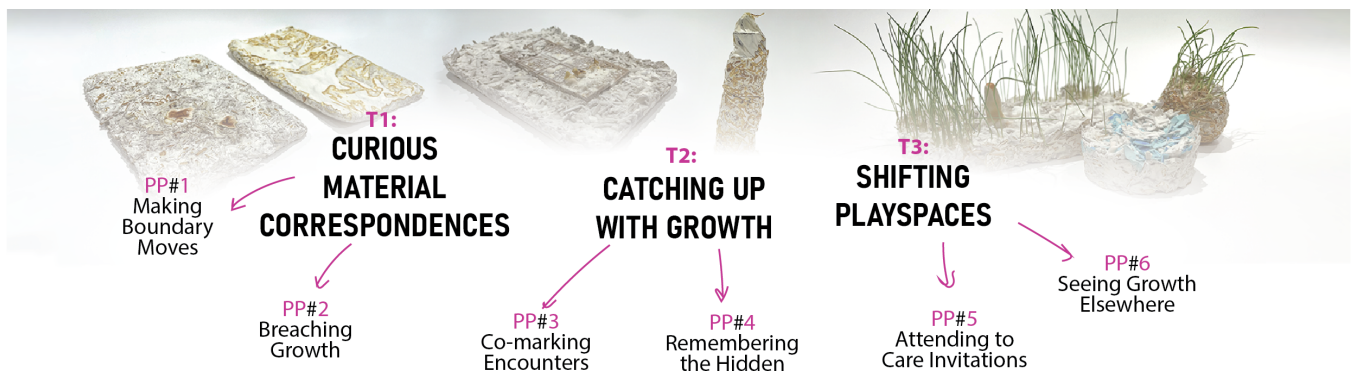


Figure 1: Themes (T) and Play Potentials (PP) formulated based on playing-alongside mushroom growth for two months.

Abstract

More-than-Human (MtH) design increasingly engages biomaterials such as fungi and algae through practices of noticing, care, and decentering beyond utilitarian framings. We extend this by examining play as a situated inquiry into MtH design. Through a two-month interspecies ethnography of attempting to play alongside fungal growth, and thematic analysis of our experiences, we formulated six *play potentials* (PPs) that surface playful practices such as *making play moves* and negotiating care with unpredictable playmates at the boundaries of growth, *breaching growth* and being surprised by how it's taken them up, *co-making funny, mysterious traces* to revisit their change in time, and taking up the challenge

of *remembering what growth has hidden*. Our work contributes (1) an empirical account of play as a situated way of knowing with biomaterials through joyful yet sometimes risky negotiations across temporalities, agencies, and entanglements, and (2) design directions for fostering playful, relational engagements with growing biomaterials.

CCS Concepts

• **Human-centered computing** → *Empirical studies in interaction design; Collaborative and social computing.*

Keywords

More-than-Human, Posthumanism, Play, Design, Mushroom

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1 Introduction

Design has long turned to living organisms for sustainable materials—fungi, algae, and bacteria increasingly appear in textiles, packaging, and architecture as so-called “biomaterials” [1]. In HCI and design research, these organisms are often examined through their affordances for designing interactive systems, for example, as sensors, actuators, or processors [36, 51]. While such works expand the design space with biomaterials, they risk reinforcing human-centred perspectives: living matter is treated primarily as a tool for human goals, flattening ecological relations and reproducing extractive practices [43].

More-than-Human (MtH) design takes a different approach and expands design beyond human needs and beyond being a solely human activity to include nonhuman beings in both design processes and everyday life [75]. In HCI research, this perspective has encouraged designers to develop new ways of working with nonhumans. These include practices for decentering human perspectives and exploring nonhuman temporalities [28, 54], noticing nonhuman participation in design processes [64], focusing on liminal, long-term, and proximal everyday engagements [76], and compiling these methods and approaches [52, 72]. More recently, these efforts have also explored how MtH designs themselves can enable others to engage with nonhumans in more relational ways, for example, by fostering care between humans and nonhumans in everyday life [77, 78]. While these efforts point to promising directions, MtH design remains a relatively young area. There is still a need for other accounts of how relational engagements with nonhumans can be explored in and supported through MtH design [34, 54].

In this paper, we examine *play* as one such mode of engagement for MtH design with biomaterials. Play activities are often described as open-ended, curious, and not bound to predefined goals or productive outcomes [23, 68]. Everyday playful moments—such as digging in soil to watch worms move, or pressing bread dough to feel air bubbles pop—are not oriented toward optimization, but toward sensing, responding, and exploring relations with others. Such moments show how play may resonate with MtH design: it is *deeply material*, unfolding through tactile and sensory intra-actions [12]; it is *non-utilitarian*, driven by curiosity rather than use [23, 68]; and it *can be critical*, opening space to redefine norms and reimagine relations [30, 53]. In these ways, play can help designers and other individuals joyfully notice and attune to MtH agencies and the ways to realise our interdependencies and to care in everyday lives. Yet, play also carries risks—it can *slip into harm, reinscribing human mastery instead of reciprocity* [55, 68]. Understanding play as a mode of MtH engagement, therefore, requires careful, situated attention.

Existing HCI research has explored play with living biomaterials in various ways. Video games have been used to simulate or represent nonhuman perspectives [31, 62], biotic games have rendered microbial processes visible and interactive [63], and embodied material explorations have highlighted moments of joy, care, and reciprocity [15, 58]. Yet, in much of this work, play is not studied in its own right: across these efforts, it is often representational strategy (e.g., in video games), a by-product of making (e.g., in material experiments [77]), or a technology-mediated mechanic that centres human (e.g., favouring one colony to terminate another

in biotic games [50]). As a result, we know little about how play actually unfolds in everyday engagements with biomaterial or what designers can learn from playing with biomaterials.

We address this gap *by studying play itself as it unfolds in everyday encounters with biomaterials, and by examining what such play can contribute to design*: We situated ourselves alongside mycelial growth and followed our desires to play with fungal life. As such, we treated play not as a tool or outcome, but as the central phenomenon through which relations with biomaterials were formed, negotiated, and questioned. We chose mycelial growth as it is a fertile context for MtH design, grounding our motivation in inquiries into how it invites other species into multispecies relations [45], drives design practice [47, 74], or facilitates forming new relations [35, 59].

Drawing on first-person, practice-based research method (multispecies ethnography [17] and situated play design [7]), we documented our encounters with mycelial growth through annotated timelines, diaries, and play provocations. Through reflexive thematic analysis (RTA) [19, 21] of these data, we formulated six *play potentials* (PPs)—situations in which play emerged as meaningful engagement and shaped our relation with mycelia. These are organized into three themes (Fig. 1), and each PP describes how play unfolded in our encounters and how they inform designers to create similar experiences:

Our findings suggest play helped us engage with agencies of mycelial growth through *Curious Material Correspondences* (Theme 1): practices such as negotiating care conditions of growth by *making moves on the growth containers*—e.g., loosening plastic wraps, or responding when mycelia pressed back—acted as play mechanics, positioning growth containers as interfaces of material negotiations of care (PP#1). In other moments, play unfolded when we introduced material *breaches* (e.g., flour, sugar, 3d printed inserts) *into growth* and attending to how growth accepted, resisted, or rerouted intervention as a way to attune to mycelial agencies (PP#2). Play also emerged as *making physical marks of encounters*—e.g., fingerprints, drawings—*and tracing them, or trying to remember objects hidden by growth* (PP#4) to attune to mycelia temporalities. Play also extended socially and culturally, as *care invitations circulated among people and institutions* (PP#5), or *as we compared our lived experiences of growth with representations of fungi elsewhere* (PP#6), allowing us to understand the entanglements that exceed physical engagements. Together, these PP show how play emerged not as a single activity, but as a set of situated, embodied ways of engaging with the growth of the living matter.

By uncovering these, this paper’s contribution is two-fold:

- **Contribution 1 (C1).** Our work demonstrates an *empirical account of playing alongside biomaterials as an inquiry into MtH design* by revealing how it acted as situated, fun, and sometimes risky ways of engagement across temporalities, agencies and entanglements.
- **Contribution 2 (C2).** Our PPs also constitute *generative design directions* that designers can translate into artifacts, systems, or situations that invite other individuals to play with biomaterials and foster relationalities of care, attunement among humans and biomaterial growth.

2 Background

2.1 More-than-Human (MtH) Design

Design unfolds amid ecological crisis, where human-centred narratives of efficiency and optimization have fueled environmental destruction and neglected other beings' ways of living [11]. More-than-Human (MtH) philosophies present alternatives to this human-centred world-view by proposing a relational perspective toward living, working, and becoming with MtH worlds: Feminist and posthumanist perspectives reject anthropocentrism by foregrounding humans and nonhumans as entangled entities. Haraway emphasises the blurred boundaries between human, machine, and nonhuman living, and non-living entities [39, 41], highlighting the need to transcend human exceptionalism and embrace the idea of mutual interdependence. Barad's notion of *intra-action* sharpens this view, describing how beings emerge through relations "that matter" rather than pre-existing individually [10]. Here, Tsing [73] reminds us how 'noticing' the MtH entanglements can occur through engagements and can challenge the dominant human control narratives. From these perspectives, existence is seen as distributed, relational, and material among MtH actors rather than being solely human-centred.

Drawing on these philosophies, MtH design focuses on shaping the world for living, working, and becoming with nonhumans, changing the human-centred agendas and roles in practicing design [33]. This involves embracing a shared authorship beyond human intention [75]. Designers attend to nonhuman participation, turning design into *designing with* nonhuman others [52, 75], and exploring how such participation unfolds in practice, e.g., [28, 61]. Such participation obliges designers to acknowledge nonhuman agencies with *humility*, accepting they cannot be fully understood or represented [75]. As such, MtH design shifts de-centers human needs, knowledges, intentionalities and dominance to account for a multispecies co-existence, nonhuman others' perspectives, agencies, and knowledges [54].

MtH design benefits from open-ended material engagements that foster attunement to nonhuman temporalities, foregrounding *everyday encounters* where humans, organisms, and places continually shape one another [34, 38]. For example, Wakkary et al.'s backyard design [76] shows how long-term engagements with plants and soil could shift human practices toward seasonal cycles and nonhuman agencies, while Tomico's plant studio [71] reveals MtH constituencies when plants demanded new arrangements of space and attention while moving together. To support such attunement to nonhuman temporalities and agencies, Oogjes and Desjardins propose attending to "Design Events"—brief, shared moments among human and/or nonhuman participants in design—through vocabularies such as transitions, pauses, temporal dissonances, and other-times [60]. In sum, MtH design foregrounds nonhuman participation in everyday encounters, focusing on the interdependence of human and nonhuman lives for the (re)enlivening of the world [8].

Building on these commitments and by foregrounding play as a mode of joyful and critical engagement in our human-mycelium encounters, our work aims to surface what playing can bring to MtH design.

2.2 Play within MtH Worlds

In this paper, we define *play* as an open-ended, embodied way of engaging with the world, driven by curiosity and joy rather than predefined goals or utilitarian outcomes. Indeed, play is often defined as an open-ended and relational mode of engagement that is not necessarily bounded by goals or tasks: While *games* typically present defined rules, objectives, and challenges to be overcome within clearly framed systems [67], *play* is often seen as the embodied engagement with those structures—players take up the rules and experiment within them, finding satisfaction, mastery, or joy in their traversal [67]. But play is not reducible to games. It can manifest outside formalized systems—as freeform expression, day-dreaming, or momentary improvisation with the mundane [24, 68]. Sicart describes play as "a way of being in the world" that can reimagine everyday settings through curiosity, care, and joy [68]. Haraway, in her book *When Species Meet* [40], takes a step forward and describes the moments during playing with her dog, Cayenne, where they co-create movements, and the joys of those as ways of "becoming with":

"We [Haraway and her dog] both know the tear in the fabric of our joined becoming when we rip apart into merely functional time and separate movement after the joy of inventive isopraxis. The taste of "becoming with" in play lures its apprentice stoics of both species back into the open of a vivid sensory present. That's why we do it. That's the answer to my question, Who are you, and so who are we?" [42, p.242]

It is no surprise that play is described through its embodied, sensory presence when acting in accordance with a nonhuman. This hints at its potential as a mode of attunement and responding to MtH worlds. We argue that playing as an activity holds potential for such MtH becoming: *Play is deeply material*. It unfolds through bodily action, sensory exploration, and physical intra-action. Bekker et al. [12] note how tactile and kinesthetic experiences during play root in bodies, environment, and matter. This tactile and experiential mode of play may bring joyful ways to understand bodies, environments, and things as co-constitutive, where meaning emerges through shared encounters with matter.

Play also often occurs in non-utilitarian contexts, driven by curiosity and exploration rather than purpose. Caillois [23] described play as free, uncertain, unproductive, and make-believe, while Sicart [68] called it a way of being that resists efficiency. Gaver's ludic design [32] hints at how play can be fostered by ambiguity and open interpretation, and HCI scholars demonstrate how such playful situations can foster designs that reframe the mundane as spaces for improvisation and relationality [3, 29]. This non-instrumental spirit aligns closely with MtH's modes of relation that value being-with over doing-for.

Finally, *play can also be critical and transformative* [30]: through reflection, where disruptions or slowdowns reframe values beyond the moment [53], and through transgression, where bending or recreating rules challenges norms and opens new relations [9]. The critical potential of play might provide an active engagement, driven by joy, in questioning the anthropocentric assumptions in human-biomaterial relationalities.

Play, however, is not only joyful or transformative but also *carries risks of harm*. As Sicart reminds us, “play is always on the verge of destruction, of itself and of its players” [68, p.3]. Moments of play can reinforce dominance and control rather than reciprocity, as shown by Nuñez et al. [55], where playful encounters with a robotic dog triggered hunting instincts and tensions between joy, care, and domination. These accounts caution that while play can foster attunement, it can also reinscribe human mastery or cause harm to others, underscoring the need for attentiveness when bringing play into Mth relations.

Taken together, these perspectives position play as a powerful yet ambivalent mode of Mth engagement: it can nurture embodied engagements, curiosity, and reciprocity across species through joy, while also carrying risks of reinforcing human dominance or harm. What remains less explored, however, is how play unfolds within lived, everyday encounters with biomaterials. Our work examines play in our encounters with mycelial growth, following its trajectories unpacked above to focus on curiosity and joy, rather than utilitarian goals, by not following guides to efficiently grow mycelia, engaging with growth in an embodied way and constantly reflecting on our experiences critically.

3 Related Work: Biodesign & Playing with Biomaterials

Design has long turned to living organisms for sustainable materials—fungi, algae, and bacteria are increasingly used as “biomaterials” appearing in everyday textiles, packaging, and architecture [1]. Yet, much mainstream work with biomaterials in HCI risks them being seen from a utilitarian lens—as resources to be scaled, optimized, and controlled for human ends. Living cells, viruses, and molecules are examined through their affordances for designing interactive systems by using them as, e.g., sensors, actuators, and processors [36, 51]. While these works demonstrate an expanding design space with living biological systems, such approaches may be criticized for reinforcing extractive logics, treating biological organisms primarily as a means for human use. These perspectives become problematic when they lead to neglecting the ecological consequences of optimization—overlooking how living systems can be destabilized, reduced in diversity, or stripped of their own rhythms when reduced to resources [43].

3.1 Designing with Biomaterials

Mth biodesign work shifts these perspectives, showing how humans, organisms, and places continually reshape one another through situated practices, e.g., in intimate bodily experiences: feminist posthumanist design positions care for one’s cycle as entangled with microbial and material others, for example, by designing menstrual products that return menstrual blood as fertilisers into soil [69]. Similarly, Microbiome interfaces such as μ Me surface our bodies as multispecies environments by tracing how physical activities (e.g., running, cycling) change microbial growth taken from the body [16]. Livingness is framed as a material quality that fosters ongoing care between humans and organisms [46, 77]: Zhu et al. [78] prototyped seed-embedded textiles that motivate care practices beyond the design studio, on their wearers’ bodies.

Care also extends across temporal horizons: Bio-digital calendar [14] helps humans attune to a yeast and bacteria culture (SCOBY) by displaying their changing health through abstract modalities, such as different tunes. “Caring through”, a concept introduced by Oktay et al. [59], emphasizes how care operates across temporalities, where care between mycelia and humans extends to soil when mycelia are placed on it. A taxonomy of microbial displays shows how canvassing, marking, or magnifying invite humans to notice microbial life on its own terms [49], while Chen et al. [26, 27] shifts designers’ utilitarian orientation in laboratory practice to humble stance of understanding and respecting biomaterial labour and agencies, where “not growing” becomes an assertion of agency rather than failure. Biodegradation is reframed as Mth unmaking, highlighting how breakdown processes decenter human timelines and foreground collaborative cycles of making and unmaking [13].

3.2 Video Games from Mth perspectives

Complementing the Mth design work with biomaterials, video games have been designed and studied from Mth design perspectives, simulating ecological and biological processes: LiverDefense [22] translates liver functions into a tower defence game. Gabrielaitis et al. [31] unpacked how Timberborn, a strategy game where the player builds a city from the perspective of beavers, positions players with beaver ways of relating to surrounding landscapes and systems. Pais [62] examines such games more broadly, noting how they can shift perspectives toward nonhumans and Mth entanglements [66]. Ruzanka’s Plant Play offers a provocation by connecting real Venus flytraps as co-players in a video game, Super Mario Bros, trying to eat Mario when the player moves towards the tubes in the video game. From an Mth perspective, the value of video games, whether they include physical presence of non-humans or not, lies in making nonhuman ways of living more imaginable, accessible, and experientially engaging. Yet they also carry limitations, as ecological processes are often simplified to fit game mechanics, nonhumans are portrayed in fictionalised ways to keep play enjoyable, and players typically succeed by managing or controlling ecosystems—reinforcing human mastery rather than reciprocity or care [62]. As such, video games offer valuable provocations but remain distant from embodied, co-present encounters with living matter.

3.3 Biotic Games

In terms of playing with actual biomaterials, biotic games have been widely explored in HCI (for an overview, see [63]), where living organisms and processes are integrated into gameplay. Riedel-Kruse et al. [65] introduced games that interfere with and visualize microbial processes through digital layers—such as pinball-like mechanics or yeast competitions mediated by smell. Kim et al. [50] extended this by streaming microbial growth on Twitch, where players could clone or kill colonies within a grid, later adapted into educational interfaces for biology learning [48]. While these games make microbial life visible and approachable, they are largely framed through technological mediation and game mechanics that simplify or instrumentalise living processes. From a Mth design perspective, this is problematic: they tend to reproduce narratives of control—prioritising one colony over another or killing cells for

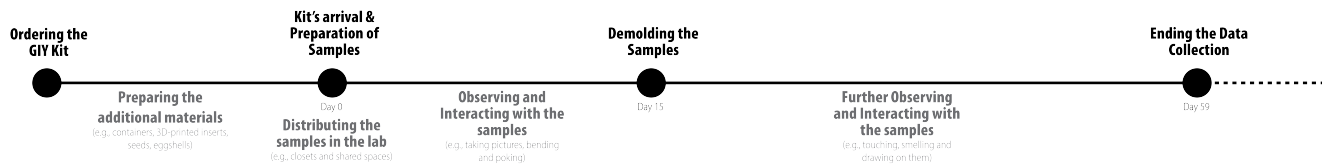


Figure 2: Simplified timeline of mycelial growth, highlighting, e.g., ordering, preparation, and removal from molds.

strategic advantage, e.g., in [50]—rather than attending to microbial agencies or relational care. As such, they leave underexplored what play might look like when humans and biomaterials share space in embodied, co-present ways, where values such as reciprocity, attentiveness, and care might take precedence over mastery or efficiency.

3.4 Embodied Play with Biomaterials

Pointing toward how embodied engagements with living matter might move beyond representation, Helms et al. [44] reimagine familiar toys and tools to invite children into MtH play in physical realms, proposing relations of care (mending leaves), attunement (listening to nocturnal life), reciprocity (answering bird calls), and noticing overlooked traces (slime trails, animal pee). Ofer et al. [58] explored playful interactions with bioluminescent algae through games such as checkers, ball play, and hopscotch, arguing from an organism-centred stance that such direct, kinetic engagements foreground the livingness of the nonhuman participant. Zhou et al. [77] showed how cyanobacteria artifacts that purify air invited playful care, as users took joy in keeping bacterial cultures “better” through their changing colors. Bell et al. [15], pointing to playful, curious, and joyful embodied encounters with biomaterials, describe their collection work as playgrounds. These works demonstrate the potential of play to foreground relational values such as joy, care, and reciprocity in embodied ways. However, they often report play as a byproduct or side-effect of MtH design, rather than the central focus of inquiry. This leaves open the question of what it means to study play itself in situated engagements with biomaterials.

Taken together, prior work demonstrates the promise of play for rethinking human–nonhuman relations: video games make ecological perspectives attainable, biotic games bring otherwise invisible microbial processes into perception, and embodied experiments with biomaterials highlight joy, care, and reciprocity. Yet across these efforts, play is often treated as a tool for representation (e.g., in video games), a design side-effect (e.g., embodied play with biomaterials), or a mechanic shaped by technological mediation that risks reinforcing human-centred narratives (e.g., biotic games). What remains underexplored is how play itself unfolds in everyday, co-present engagements with living matter—where humans and biomaterials grow, adapt, and respond together.

4 Methodology

We examined how play unfolds alongside mycelial growth by immersing ourselves in cultivation (Fig. 2) and treating joyful moments as sites for reflection and speculation. We combined Situated Play

Design (SPD) [7] with multispecies ethnography [17], documenting our encounters through collaborative timelines and individual diaries, and analysing them through reflexive thematic analysis (RTA) [19, 21] to articulate play potentials.

4.1 Methodological Orientations: Chasing Play through Multispecies Ethnographies

We drew on Situated Play Design (SPD) [7], which begins from *chasing play*: noticing and amplifying existing, situated *play potentials*—joyful, curious, or meaningful moments—rather than pre-imposing game structures. SPD helped us treat mycelial growth as a lived situation where play already emerges and can be followed as it develops, aligning with prior uses of SPD that foreground values such as joy, care, and wonder over efficiency [2, 4, 5].

To attend to mycelia as active participants, we also drew on multispecies ethnography [17], particularly strategies of noticing [73] and decentering [54]. We adopted a collaborative autoethnographic stance [25]: the first two authors immersed themselves in cultivation and documented how fungal agencies and material conditions shaped the unfolding encounters. Design provocations and speculative ideas were treated as part of the inquiry, helping us surface the potential moments as generative sites for play.

4.2 Positionalities

We outline how our backgrounds, experiences with biomaterials, and perspectives on MtH design shaped both our engagements with mycelial growth and our analysis.

The first two authors led the growth experiment and analysis. Linas is a doctoral researcher in design with backgrounds in media art and geology, and no prior experience in mushroom cultivation or biomaterials research. This unfamiliarity supported an open-ended, exploratory approach guided by curiosity and play. Çağlar is a design researcher with prior experience in hands-on engagements with biomaterials, including foraging, mushroom cultivation, and designing with mycelium (including earlier uses of the same GIY kit) in earlier research projects. These experiences shape his MtH design perspective: he finds care, joy, and surprise in growing and crafting with living materials, rather than approaching them primarily as resources.

The remaining authors acted as sounding boards throughout the study, contributing to contextualization and analysis. They are design researchers from Germany, Turkey, and Catalonia, with interests spanning feminist HCI (Velvet), everyday play (Ferran), and posthuman play (Oz). Collectively, the authors are united in viewing humans as part of MtH worlds and are enthusiastic about



Figure 3: Overview of mycelium samples with their illustrations and color-coded tags indicating additional materials (blue), containment during growth (green), and placement within the laboratory (orange).

MtH design's potential to foster kinship and relationality, while remaining cautious of its superficial adoption or use to justify further exploitation of human and nonhuman life.

4.3 Materials and Growth Processes

We conducted the work in a university laboratory using a Grow-it-Yourself (GIY) mycelium kit (Grown-bio; hemp substrate pre-inoculated with mycelium), FDM 3D printers, GrowLay biomaterial filament, and common labware (e.g., disinfectants, plastic containers). Using a GIY kit allowed us to bypass inoculation and focus on preparing and varying samples [18]. We 3D-printed GrowLay inserts due to their porous structure and cavities that can be colonized by mycelium [45], and also introduced seeds, eggshells, and sugar mixtures as additional materials into the growth.

The first two authors led cultivation (Fig. 2). Before the kit arrived, we prepared containers and printed inserts (some were intentionally altered, e.g., broken or sugar-dipped). After arrival, we broke down the substrate and added flour to stimulate growth (as suggested by the GIY instruction). We used broken-down substrates to prepare sixteen samples (Fig. 3), varying additional materials (3D prints, seeds, eggshells), containment (wrap vs. container), and

placement in the lab (e.g., hidden in closets vs. public in shared spaces). For the first 15 days, we observed and occasionally interacted with samples (e.g., bending, touching, poking droplets), then demolded them to enable direct sensory engagement (touch, smell, drawing). We continued periodic monitoring and interaction for approximately two months, placing some samples back into containers when mold emerged.

4.4 Data Collection

Data collection was done by the first two authors and consisted of two complementary practices: collaborative growth timelines and individual diaries.

Growth timelines. We created a shared Miro board combining a chronological timeline where both authors placed their entries (Fig. 4). The timeline began with ordering and branched into 16 sample-specific tracks after preparation. To record our entries on the timeline, we modified Altarriba et al's snapshot cards [6] that were empty cards with prompted topics designed to capture playful moments in forest encounters: *Anecdotes* (what happened), *Reflections* (feelings and interpretations), *Ideas* (design concepts), and *Expectations* (questions and anticipations). Entries also included

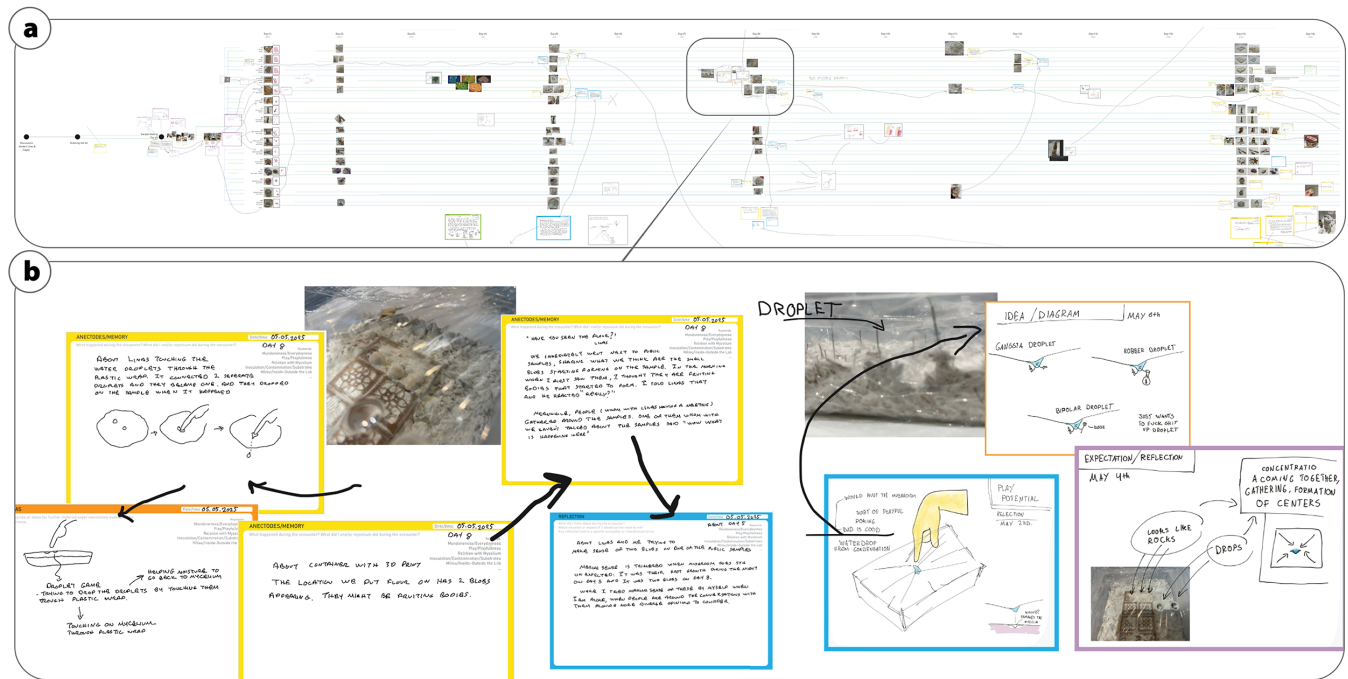


Figure 4: Growth timelines: (a) a portion of the growth timelines; (b) examples of images and snapshot cards [6] from the timeline.

notes, sketches, and photographs, and were linked to trace relationships across moments and samples.

Individual diaries. In parallel, the two lead researchers kept weekly diaries over two months, using prompts (e.g., “What stood out? Why? How did you feel?”) to reflect beyond single events. Diaries supported slower sense-making across time and connected mycelial encounters to everyday life.

4.5 Reflexive Thematic Analysis: Surfacing Play Potentials

We conducted reflexive thematic analysis (RTA) [19–21] to make sense of our encounters through the lens of play. First two authors analysed the growth timeline and diary entries inductively and reflexively (see Fig. 5), embracing their subjectivity and interpretations within the process [21]. Co-authors served as sounding boards throughout and helped with the framing of final play potentials.

Early meaning-making. Near the end of cultivation, we briefly went through the timeline and the excerpts selected on the spot, discussing what the first two authors found joyful, surprising, and/or frustrating together with the co-authors across two meetings. The first meeting with Ferran and Oz pushed us to specify what made particular moments playful. Velvet helped us reflect on how our positionalities shaped our approach (e.g., intentional knowing-by-doing rather than following standard procedures).

Familiarisation and coding. The first two authors revisited all timeline entries, diaries, and artefacts, marking moments that felt playful or affectively salient (e.g., joy, surprise, care, concern). We added further annotations and design provocations, then extracted and clustered excerpts on a new Miro board. We developed

codes that captured recurring dynamics (e.g., growth “climbing” 3D printed pieces, changes while humans were away) iteratively and collectively.

Developing and refining play potentials. Through iterative clustering of the codes and discussion, we developed candidate play potentials and reviewed them against the dataset, refining boundaries and wording. Co-authors reviewed the resulting articulations and examples; we iterated until consensus was reached on clarity and resonance.

5 Findings: Play Potentials

This section presents the Play Potentials (PPs) that we formulated through attempting to play alongside mycelium cultivation over two months (Fig. 1). The PPs are grounded in first-person lived-accounts of the first two researchers (referred to as “we” in the following sections). For each play potential, we structure the findings in two parts. First, we describe ethnographic moments that show how play unfolded in our inquiry. Second, we summarise the emergence of play (Contribution 1, C1) and, building on this, we present how these can constitute design directions (Contribution 2, C2), describing the design provocations we formulated throughout the cultivation and analysis process to concretise how design directions could be pursued to engage playfully with living biomaterials in similarly relational ways.

5.1 Theme 1: Curious material correspondence

This theme captures how play began as curiosity-led inquiry into how mycelia “answer back” through material change. Following the play to guide our actions, we resisted starting from tutorials.

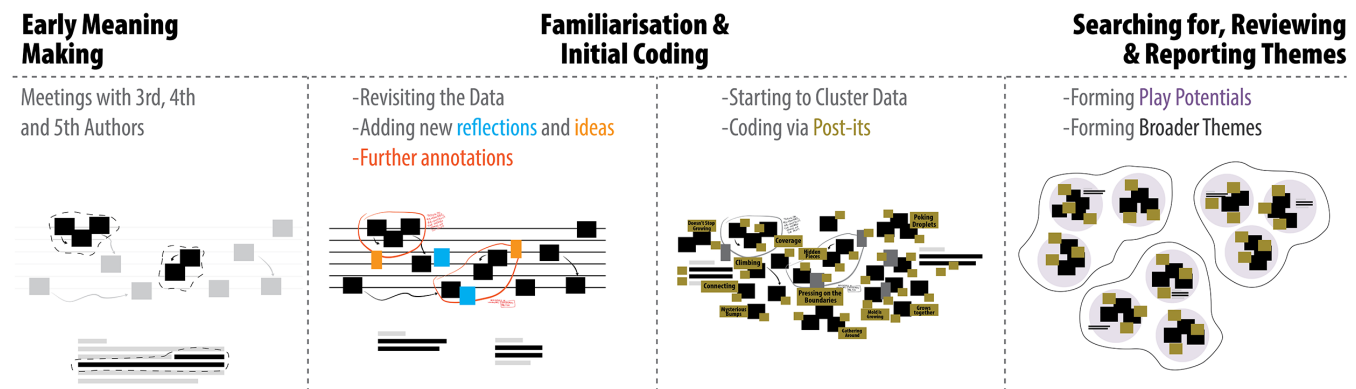


Figure 5: Steps of reflexive thematic analysis.

Instead, we took up a state of seeking knowledge through situated attempts to play with the mycelial growth. Yet, our playmate, the mycelium, was an unknown and unpredictable one. This unfamiliarity sparked curiosity about what might emerge next, which in turn drove our playful material correspondences. As Çağlar reflected, our engagements (such as putting things inside the growth) were driven by the “*curiosity about what’s gonna come next: Will they grow over 3D [printed] pieces and connect them? Will they cover the holes more or continue growing on the surfaces of the 3D prints?*”. At times, growth itself also sparked new questions—such as droplets forming on a container that prompted us to wonder, “*Will this cause harm?*” (Linus). Joy came from our sense of care and accomplishment in seeing mycelia thrive through material correspondence: e.g., “*being surprised or worried when something unexpected happens, happy when I saw more colonization, and frustrated when they don’t grow much. [...] There was the feeling of being proud when they grew more mycelium webs, thinking that we kept them healthy*” (Çağlar). As such, play here emerged through an ongoing back-and-forth of becoming curious, intervening, observing and responding to mycelial growth, where the fungi’s unpredictable and/or unknown material responses became part of the play rather than something for us to control.

5.1.1 PP#1: Making boundary moves. This PP centres on the joy of making moves on the protective edges of growth—boundaries such as plastic wraps, containers, and other enclosures. We initially placed these boundaries as purely functional barriers to prevent contamination. Gradually, however, they became a playful site of inquiry, where our small interventions were met with responses from the growth. For example, Linas noticed droplets condensing on the inside of the wrap (Fig. 6a). He found that “*the hanging droplet is intriguing,*” and could not resist poking one of them to watch two droplets join and fall. He later wrote that “*poking was fun*” but also wondered whether it might “*hurt the mushroom.*” Çağlar joined in such poking play—a bit more carefully though: he thought that “*poking might damage the growth by loosening the wrap and increasing contamination risk.*” We were not the only ones making such boundary moves: grass pierced through, and mycelia pushed and spread along the wrap (Fig. 6c). This, in turn, evoked responses in us, prompting questions about whether we had left enough space and what we owed the growing organism. Removing boundaries became our move to, as Çağlar wrote in his diary, “*free the mycelium.*” Yet, as we did so, we realised that unexpected molds emerged (Fig. 6b), and play shifted into unease: “*for a moment it was scary*” (Çağlar). This called for cautious responses such as re-wrapping, isolating, or retiring samples.

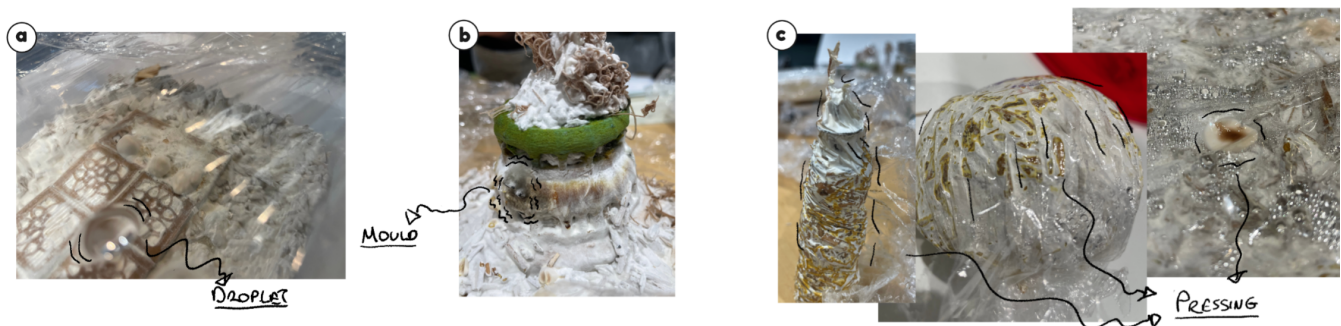


Figure 6: Photos of making boundary move encounters: (a) droplet condensed on the plastic wrap, (b) mould formed on mycelia, (c) mycelial growth along the plastic wraps.

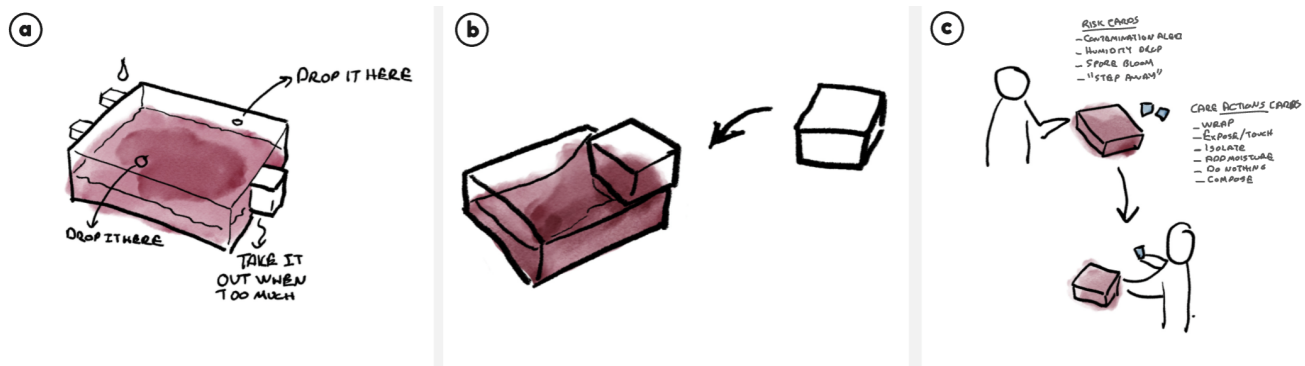


Figure 7: Play provocations: (a) “humidity-regulation container” lets players control the humidity of the container by poking droplets in or out, (b) “expandable container” allows players to expand the container when mycelium presses on, (c) “careful exposure” lets players take turns in making care moves on the boundaries.

Taken together, making boundary moves shows how play functioned as a relevant MTH engagement (C1): *for us, play took the form of negotiating care with mycelia as a play partner at boundaries of growth*. As we poked, exposed, and re-wrapped, and as mycelia condensed droplets, pressed, and spread, care became concrete and negotiable rather than something fixed in advance. As a design direction (C2), future designs can *focus on designing growth containers as boundaries for reciprocal play moves that make both human and mycelial actions—such as poking, exposing, pressing, spreading, or condensing—explicit and meaningful for playfully negotiating care*. Illustrative of how to pursue PP for design, for example, we imagined a *humidity-regulation container* (Fig. 7a), where droplets serve as health indicators of mycelia. Players could insert new droplets when they sense a need for more humidity, or poke the ones condensed on the flexible surfaces to release moisture when it feels excessive. We also envisioned an *Expandable Container* (Fig. 7b), in which extension pieces are gradually added as mycelia presses on its surfaces, offering more space to grow while giving humans “a (playful) tool to be attentive to the changing needs of mycelium” (Çağlar). Finally, we designed *Careful Exposure* (Fig. 7c), a slow, turn-based card game to be played alongside growth, where

each player selects a care action (e.g., Wrap, Expose/Touch, Isolate, Add Moisture, Do Nothing, Decompose) and pairs it with a risk card (e.g., Contamination Alert, Humidity Drop, Spore Bloom, Stay Away). As players pass on both cards and the sample, they accumulate a shared record of decisions and concerns.

5.1.2 PP#2: Breaching the growth. This PP centres on introducing breaches into mycelial growth to observe how mycelia comply with or disrupt our assumptions. As we introduced flour traces, sugar rims, seeds, and porous or broken 3D-prints, these interventions became sites of playful correspondence, where we attended to how growth responded by accepting, resisting, or rerouting. Joy came not only from moments when mycelia complied with our expectations of how they would respond to these breaches, but more strongly from the moments when they surprised us. For example, broken 3D-printed chess pieces, filled with substrate to see whether mycelium would connect them, were gradually “connected” by mycelial growth (Fig. 8d), collaborating with our play. Surprises also emerged in other ways. For example, growth at first seemed to follow piles of flour: “the piles of flour have blobs appearing” (Çağlar, see Fig. 8a). Yet later, similar blobs appeared elsewhere without flour. Sugar initially appeared to limit growth (Fig. 8b), but mycelium



Figure 8: Breaching into the growth process: (a) bumps formed where flour was placed on a 3D-printed insert, (b) mycelium extends toward a sugar-dipped 3D print, (c) white mycelial threads spread into the crevices of a failed 3D print, (d) mycelium fuses broken sections of a 3D-printed chess piece.

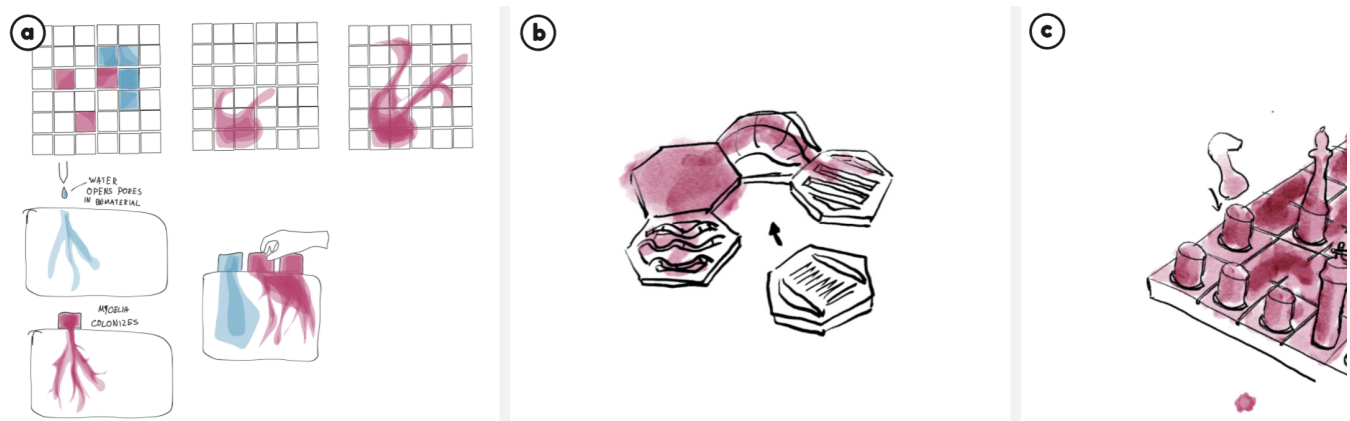


Figure 9: Play provocations: (a) “elemental growth” allowing players to introduce different elements such as flour, sugar or water; (b) “3D-printed tiles game” where players compete in finding best 3D-printed structure for mycelium growth; (c) “mending slow chess” where players collaborate with mycelial growth to connect pieces and the checkers on the board.

soon grew past the sugary ridges and continued climbing. Porous 3D-printed pieces became inhabited with “*mycelia fluff climbing up the layers*” (Linás), especially where the printer failed to connect layers (Fig. 8c). Reflecting across these instances while creating the play provocation “elemental growth” (see next paragraph), Linás articulated what made these breaches playful: the joy did not lie only in arranging conditions for growth, but in watching mycelia disturb the very systems we set up to organise it. As he put it, “[we gave in to] the joyful temptation to systematize and arrange mushroom growth on a grid, followed by a joyful disturbance of the grid system.”

These instances illustrate the value of play for M&H design (C1): *in our experience, play turned breaching from an attempt to steer growth into a joyful invitation for surprising response. By introducing small disturbances and attending to how mycelia accepted, resisted, or rerouted them, we came to value surprise not as failure, but as a way of learning how growth unfolds on its own terms.* Building on these, we suggest a design direction (C2) in which *play designs can foreground breaching as a playful probe, giving people options for small interventions to introduce and making compliance, resistance, or rerouting by living biomaterials meaningful parts of the play.* The following three design ideas (Fig. 9) illustrate how this design direction could be operationalised: *Elemental Growth* is a board game where players add flour, sugar, seeds, or water alongside mycelial cubes, introducing breaches that may attract, repel, or reroute growth. *3D-Printed Tiles* place designed inserts directly against a mycelial bulk, inviting players to observe whether growth accepts, incorporates, or rejects them over time. In *Mending Slow Chess*, breaching occurs through breaking and rejoining pieces via mycelial growth, allowing the board and pieces to change as growth partially connects them. Across these concepts, breaching is designed not as a means of control or optimization, but as a way for others to playfully engage with the limits of intervention—learning to notice refusal, partial collaboration, and the independent trajectories of living matter.

5.2 Theme 2: Catching up with the Growth

While Theme 1 focused on how play emerged through immediate material back-and-forth, this theme shifts to play under time gaps—weekends, holidays, and moments when growth continued without us. Here, play unfolded when we returned and tried to make sense of what had changed: we “caught up” with growth, reconstructed what happened in our absence, and used marks and memories as reference points. Across the play potentials, play became a way to live with temporal mismatch—making us attune to mycelial temporality without turning cultivation into constant monitoring.

5.2.1 PP#3: Co-marking Encounters. This PP captures the joy of leaving and following traces on mycelia as playful reference points for attuning to the temporalities of growth. These traces were not only practical markers that helped us notice change over time; they were also affectively engaging, making it fun to return to them because they appeared funny, mysterious, or evocative of our encounters with the mycelia. For example, the bumps that formed where we had placed flour (see Fig. 8a) became recurring points of attention and were often referred to by the funny name we gave them: “blobs”. Beyond simply looking amusing, they also drew us in because they remained somewhat mysterious: “are the

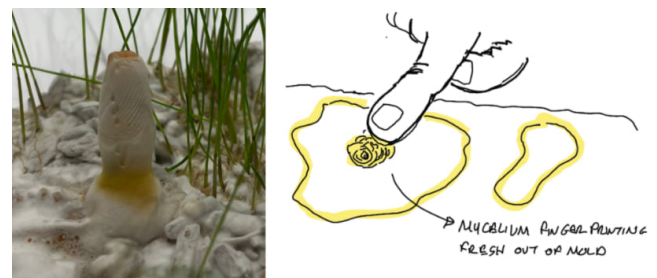


Figure 10: Fingerprint imprinted on a bump and Çağlar’s illustration about it on an anecdote card.

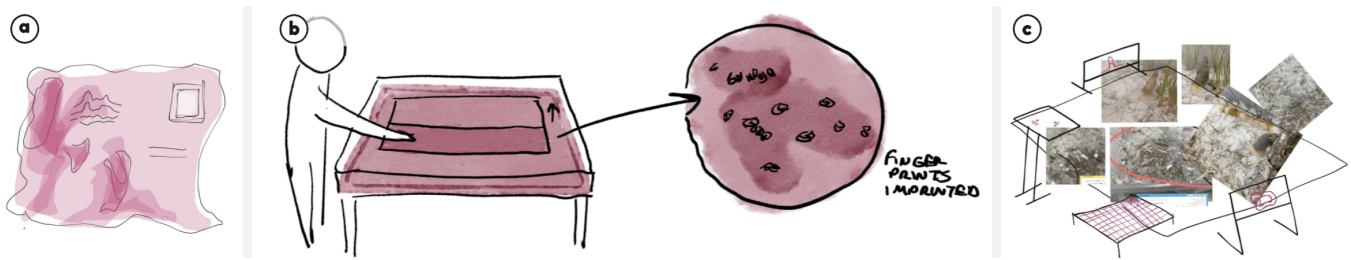


Figure 11: Play provocations: (a) the mycelium tablet of the “squiggle game”, altering what is drawn on it, (b) a meeting participant leaving fingerprints on the “mycelium table” through its opening along with other ones (on the right) (c) “micro-attention kit”—an imaginary toolkit with transparent sheets that helps documenting and tracing marks of encounters.

blobs the fruiting bodies?” (Çağlar). Because they became significant to us in this way, we repeatedly returned to them to “orient ourselves” (Linás), comparing their size, texture, and relation to nearby features to assemble a shared “landscape” (Çağlar) of how growth had progressed. Beyond mycelial marks alone, we noticed how our own encounters also left traces. When samples were first taken out of their containers, Çağlar remarked that “the fresh mushroom holds the fingerprints amazingly” (Fig. 10). Similarly, when Linás drew on a fresh piece to show something to Çağlar, the markings lingered but were gradually reshaped by fungal expansion, giving the impression that mycelia had joined in the drawing.

As such, *play unfolded as co-marking of encounters as a way of attuning to mycelial temporalities* (C1): the joy lay in leaving and revisiting traces with mycelia that became funny, mysterious, or memory-laden—not as fixed references to track, but as playful landmarks through which growth could be noticed and made sense over time. Building on this, we suggest a design direction (C2) in which *play designs can utilise co-marking as an affective way of engaging with growth temporalities*, scaffolding noticing and co-making traces that are meaningful enough to invite return, comparison, and reinterpretation as the marks changes over time. As an example, in the *Squiggle Game* (Fig. 11a), two people take turns drawing on a mycelial tablet; as mycelium grows, it reshapes their

lines into a shared, slow-forming composition. The *Mycelium Table* (Fig. 11b) extends this idea into a communal setting, where meeting participants touch the mycelium and leave fingerprints that are gradually transformed, turning the surface into a living record of encounters. The collage in Fig. 11c further expands this approach through an imagined *Micro-attention Kit*: a set of transparent sheets that invites people to shift viewing angles, bodily positions, and scales of attention when observing micro-growth. Together, these designs frame marks not as fixed indicators, but as playful, evolving landmarks that invite people to co-mark affectively engaging traces with mushrooms to return, compare, and wonder how living growth has reworked shared traces over time.

5.2.2 PP#4: Remembering the Hidden. This PP centres on the joy of returning to mycelial growth after absence and finding that time away had turned familiar things into playful puzzles. As Linás put it, the pleasure here was “not only joy of discovery, but re-discovery. By hiding and covering [mycelium] allows you to be surprised by the same thing many times.” For example, as mycelia slowly grew into 3D-printed parts—filling gaps, softening edges, and inventing new contours (see Fig. 12)—we found ourselves asking questions such as “what was it below, the 3D print?” (Çağlar). Returning after gaps became playful moments of challenge: we

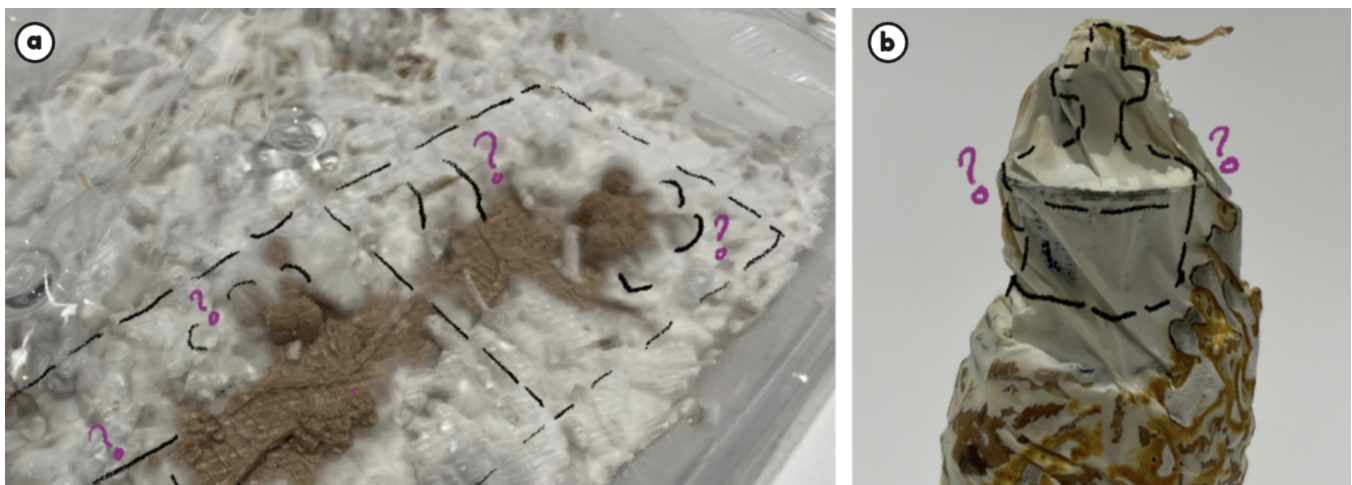


Figure 12: (a) Printed road pieces hidden by the growth, (b) growth over the chess piece, hiding and making its shape ambiguous.

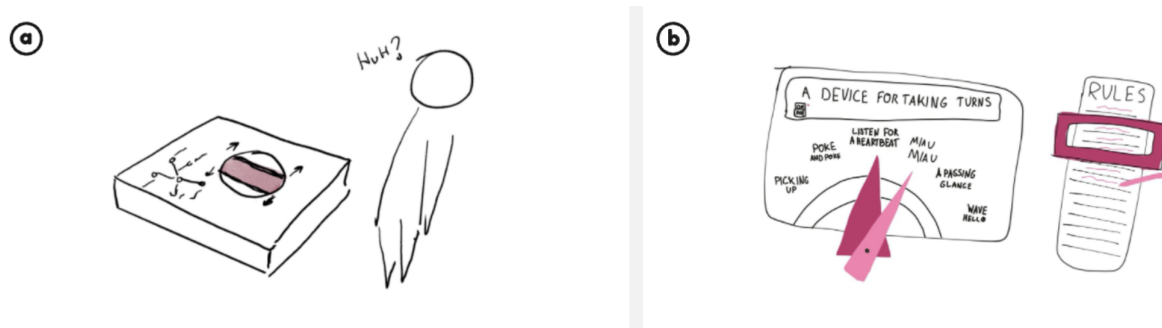


Figure 13: Play provocations: (a) “entangling Box”, opening up when detecting changes like a mould appearing, and new bumps, logging and showing engagement of others; (b) “devices for taking turns”, indicating playful actions like poking, listening, or waving and rules slider for deciding what to pay attention to.

tried to remember, imagine, and reconstruct what must have happened while we were away. We revisited the same sites repeatedly, comparing what we recalled with what we now saw, and taking pleasure in the surprise of forgetting. As Çağlar reflected, “*I remembered there was another 3D print in this sample. As it was completely covered with mycelium, I forgot about it*” (Çağlar).

As illustrated via instances, *play unfolded as the joyful challenge of re-discovering what growth had hidden or transformed (C1): rather than monitoring growth continuously or trying to manage it efficiently, we found pleasure in returning after absence and piecing together what had changed, letting forgetting, surprise, and imagination become part of how we engaged with fungal time.* As a design direction (C2), this PP suggests *designs can stage growth during absence as a play mechanic, allowing living materials to hide or transform familiar forms so that re-discovery, guessing, and reconstruction become joyful ways of engaging with long-term change.* As an illustrative example, we imagined a variation of Mending Slow Chess (PP#2, Fig. 9c), called *Forgetting Chess*, where the game unfolds over months or years, and mycelial growth gradually obscures chess pieces until they lose their recognizable forms (as in Fig. 12b). Players must rely on memory, inference, and collective negotiation to continue playing. Here, growth functions as a slow veil, and rediscovery becomes a designed mechanic that invites others to engage with absence, long-term change, and temporality mismatch as playful conditions rather than a problem to be solved.

5.3 Theme 3: Shifting playspaces

While Theme 2 centred on play across time gaps, this theme shifts to play across contexts. As growth progressed, play moved beyond our direct encounters with the samples and into wider playspaces—other people, institutions, and cultural representations of fungi. In our engagements, play unfolded through making visible the entanglements: care became distributed through invitations to other humans and nonhumans, entangling them in the growth. Moreover, our attention began to “travel,” outside of the immediate physical context of growth, prompting playful comparisons between lived growth and its portrayals elsewhere, and making us understand further entanglements in the growth

5.3.1 PP#5: Attending to Care Invitations. This PP centres on the joy of responding to care invitations—such as unexpected mycelial changes—that drew people into encounters and being part of gradually gathering a community around growth. These invitations not only fostered excitement between Linas and Çağlar, they rippled outward, prompting comments, concerns, and advice from others who encountered the mycelium. Among us as researchers, one thing we noticed early on was that, as Linas put it, “*sharing is fun.*” Whenever one of us noticed something new in the samples, it often quickly became something to call the other over to see. When blobs started to appear, for example, Linas called Çağlar: “*Have you seen the flour?*” Mycelia invited proximate researchers and passing strangers into the community of growth as well: seeing the sample in a well illuminated office kitchen, they left anonymous Post-it notes next to public samples with suggestions such as “*it should grow in the dark,*” offering their own interpretations of what the growth seemed to need. Likewise, an email exchange with university management fostered the involvement of other staff in care, with their suggestions for decomposing mycelium outside. The changes in the samples also reshaped roles between us as researchers. Early on, Çağlar focused on providing better growth conditions, while Linas embraced uncertainty, noting that “*knowing less about how to cultivate correctly allowed me to play in ways others might see as damaging to growth.*” As growth slowed and some samples developed moulds, raising concerns about toxicity, these positions shifted again. Çağlar reflected: “*Linas became more cautious, I took the role of being more courageous (maybe not a good strategy).*”

All in all, our encounters showed how play functioned as a mode of MtH engagement (C1): *play arose from the enjoyment of following and responding to care invitations as they circulated among humans, nonhumans, and institutions, making care a shared, fluid, and playful practice of calling others in, negotiating roles, and responding together rather than a predefined responsibility.* As a design direction (C2), this PP suggests that *designs can aid surfacing and circulating care invitations, so that changes in living growth become playful prompts for others (human or nonhuman) to call one another in, negotiate roles, and redistribute care as an evolving collective practice.* For example, to surface care invitations initiated by the growth, we imagined an *Entangling Box* (Fig. 13a) placed in a public space. When sensors detect a drastic change—such as

mold appearing or a new bump forming—the box opens to draw passersby in. It also logs engagements around the sample (human and nonhuman) and displays an evolving map of these entanglements. About the redistribution of care invitation, Fig.13b presents turn-taking devices for fluid care, aiming to support discussions about the changing roles among participants. It offers open-ended prompts to be exchanged among people for paying attention to growth—such as “observe in silence,” “respond to change,” or “poke only when curious”. A second device, a rule slider, allows players to collectively choose what to attend to at a given moment (e.g., when growth slows down, intensifies, or disappears), making shifts in care explicit and open to negotiation rather than fixed in advance.

5.3.2 PP#6: Seeing growth elsewhere. This PP captures the joy of noticing fungi beyond the immediate site of cultivation and playfully comparing those encounters with our lived experiences of mycelial growth. After spending time growing and caring for mycelia, our attention began to travel: fungi surfaced unexpectedly in media, games, conversations, and passing thoughts, even when we were away from the samples. These moments became playful because they invited us to spot unexpected connections, notice mismatches, and reframe familiar portrayals through what we had come to know in practice. For example, while worrying about the potential toxicity of inhaling spores, Linas joked, “Isn’t that how *The Last of Us* starts?” linking a moment of care-related concern to a familiar cultural trope. At other times, references to mushrooms in games or media. Linas noted, “*playing a video game can be a way of reflecting on the growth of mycelium. When I play video games, I encounter moments that remind me of ‘play sessions’ with mycelium.*” For example, when a mycologist was described as having an “*unglamorous job*” in a video game, the mismatch sparked surprise. Linas took a screenshot and added a question mark to the word “unglamorous” because it clashed with the joy, care, and curiosity we experienced in practice. In this way, play unfolded through spotting, juxtaposing, and reinterpreting representations of fungi across contexts.

As such, our experiences showed how *play unfolded through joyful re-encounters and comparisons across contexts (C1): fungi kept reappearing beyond cultivation as prompts for humor, surprise, and reinterpretation, inviting us to compare lived encounters with their portrayals elsewhere and rethink how mycelia are imagined and valued.* As a design direction (C2), this PP suggests that *designs can surface such playful re-encounters with fungi across contexts by making humor and comparison central to the play, bringing lived experiences of cultivation into conversation with representations in media, games, or everyday life.* For example, we imagined an *Mushroom News App*, which assembles all articles and media that mention mycelium. Through mixing different portrayals of mushrooms from the media, in combination with their fictional accounts, it aims to foster critical reflection with humor (e.g., a news title that says “scientist taught mycelia how to play piano,” or the app sends you a question “What did you teach your mushroom today?”). In this way, designs could extend more-than-human engagement beyond the cultivation site by making re-encounters with fungi elsewhere part of the play itself.

6 Discussion

In this section, we reflect on our work, which takes an empirical stance to studying *play* in human-biomaterial encounters by using our situated experiment of chasing play in mycelial growth. In what follows, we first discuss the play potentials, how they resonate with and expand prior MtH design work with biomaterials. By discussing the situatedness, tensions, and limitations of play in broader MtH design research, we present our understanding of what play might bring to MtH design research practices.

6.1 “Playing Along” as a way of “Situated Knowing” in MtH Design

In this section, we reflect on what playing along contributes to MtH design with biomaterials (C1), grounded in our empirical engagement with mycelium. Rather than approaching mycelium as a system to be optimized or understood through predefined metrics, we followed moments of curiosity, surprise, and joy as guides for inquiry. In doing so, we intentionally held back from readily available expert knowledge and cultivation tutorials, cultivating what A2 described as “*productive ignorance*.” This was not a rejection of knowledge, but a commitment to learning with mycelia through situated encounters, where knowing emerged as a multispecies accomplishment rather than a pre-given framework.

6.1.1 Playing along unfolded as non-utilitarian, open-ended, and embodied exploration. Similar to Haraway’s account of play as *inventive isopraxis* [40], we relied on what unfolded there and then between us and the growth, attending to the challenge of caring in ways that nurtured growth, feeling joy when we sensed that it did. The curiosity and challenges in understanding mycelial growth helped us stay engaged with its slow and ambiguous unfolding without reducing its temporalities to monitoring or management. In this sense, playing along resonates with work on slow technology [37] and slow games [56], which similarly foreground duration, waiting, and attentiveness as conditions for reflection and engagement. However, in our case, slowness was not a designed pacing mechanism to be calibrated, but emerged through the autonomous and unpredictable temporalities of living growth:

Waiting for changes to accumulate—for samples to whiten, spread, or unexpectedly transform over days—became part of the play itself, giving us time to make sense of the mycelia, ourselves, and our relationalities. Such play took shape through material engagements—poking droplets, pressing on wraps, adjusting wraps (PP#1), introducing breaches such as flour or 3D printed inserts (PP#2), and co-marking encounters on growth while attending to mycelial coverage for attuning temporalities (PP#3; PP#4). These engagements were not pursued to improve yield or ensure reliable outcomes, but to stay with what was happening, wait for and notice how mycelia responded. When mycelia pressed against boundaries, breached containers, or hid inserted forms, these moments became playful prompts for inquiry rather than problems to be fixed, raising questions such as “could we give them more space?” or “what happened while we were away?” Through such exploratory acts, learning emerged through correspondence rather than instruction: we came to know mycelial sensitivities, temporalities, and capacities by being affected by growth, uncertainty, and surprise.

6.1.2 Play supported an epistemic stance aligned with MtH design commitments to humility and paying attention to nonhuman agencies [75, 76]. Rather than centering control, or functional performance—as seen in biomaterial systems framed as sensors, actuators, or processors [36, 51]—playing along foregrounded responsiveness and attunement. Knowing was not abstracted from material engagement, but grew through doing, noticing, and adjusting alongside mycelia: humans and fungi co-constituted the conditions for action, and understanding remained provisional and situated.

Across our engagements, playing along also enacted MtH attunement through care, and decentering human intention. Our joy was grounded in being affected—not only by mycelia, but by the many presences entangled with their growth (e.g., concern when mould appeared -mentioned in PP#1-, or responding to proposals of care from others in PP#5). Playing humbly meant resituating decisions in response to what growth did: revising practices when conditions shifted, redistributing care through social and institutional invitations (PP#5), and accepting withdrawal from play as a legitimate outcome when risks or limits emerged. This playful stance became a way to design-with [70] by decentering human authority [54] and opening space for nonhuman participation [61]. For example, when mycelia gradually hid 3D-printed inserts (PP#4), our forgetting and attempts to remember became ways of attuning to slower temporalities rather than failures of attention.

6.1.3 Playing along contributed to uncovering joyful ways of attuning to mycelial temporalities and entanglements around the growth. While MtH design has long called for attentiveness to nonhuman temporalities [34, 60, 73], our findings show how play makes such attunement livable: Although we did not explicitly use the temporal vocabulary proposed by Oogjes and Desjardins [60] (e.g., encounters, pauses, and temporal dissonances) in our analysis, the instances of encounters we analysed were quite similar to with what Oogjes and Desjardins framed as “Design Events.” For example, across Theme 2, knowing emerged through design events similar to their construct, “waiting,” (e.g., overnight, in our case, for mycelia to grow and cover things) and temporal dissonances (e.g., mycelia not stopping growth when we were on vacation). Attending to such events allowed us to notice the playfulness of forgetting and remembering—catching up with growth—rather than expecting or forcing a synchronization with growth in our experiences. Measuring growth by “days” turned into co-making marks and observing how they change via growth, and gradual covering of the 3d printed pieces became anchors for understanding the temporality of growth (PP#3; PP#4). Moreover, similar to “encounters” as Oogjes and Desjardins would call them [60], we’ve had moments of gathering (e.g., people being called into care in P#5 or sudden appearance of a mushroom elsewhere in P#6) where we noticed what’s or who’s entangling with growth.

6.1.4 Playing along surfaced its risks. Play does not automatically guarantee reciprocity or care. As Sicart cautions, play is always on the verge of harm [68]. In our inquiry, playful urges—to poke, breach, or test limits (e.g., in Theme 1)—risked slipping into human mastery or displacing consequences onto nonhumans and unseen others. While we resisted yield optimization and positivist closure (e.g., declining strain testing), not-knowing itself can reproduce dominance by framing nonhumans primarily as respondents to

human curiosity. Moreover, many participants in these encounters remain partial or invisible—microbes, insects, and downstream ecologies affected by cultivation decisions—making care uneven and accountability incomplete. We therefore do not propose playing along as an innocent way of engagement by default. Rather, its value lies in making tensions visible: between curiosity and harm, responsiveness and control, engagement and withdrawal.

Like any ethical engagement in MtH design, we argue, play does not come with fixed rules about how to care better or moral purity. But it requires *situated judgment*—the willingness to slow down, to revise practices, and sometimes to stop playing altogether. Our design proposals suggest some ways playful tools might support such situated judgment. For example, play may be designed to explicitly foreground and reward attunement and care, as in the “humidity-regulation container,” or “expandable container” (see Fig. 7a and b), where the play is steered away from pursuing human goals towards noticing signs of growth and responding by adjusting humidity or making more space. Likewise, play may support situated judgment by offering moves that make withdrawal, restraint, or harm reduction possible—for instance, explicitly including actions such as retiring or decomposing the mycelium in “careful exposure” (Fig. 7c), or in “devices for taking turns” (see Fig. 13b). In this way, playing along can support MtH design not by resolving uncertainty, but by cultivating ways of staying with it—joyfully, critically, and with care.

6.2 Designing for Play with Growth

In contrast to prior work where play is not studied in its own right (e.g., [77] or [50]), our work offers empirically grounded design knowledge (play potentials) from our inquiry, where we focused on examining play in our mycelial growth encounters. As such, our PPs highlight a wide array of design directions where play can emerge in human–biomaterial relations and how designers might scaffold conditions for it. The design ideas presented in each PP illustrate examples of how designers could utilise them, rather than offering prescriptive or finalized artifacts. In what follows, we discuss how these resonate and expand prior work in informing future practitioners about enabling others to engage playfully and relationally with living biomaterials:

In contrast to video games and biotic games that make nonhuman processes playable through abstraction [31, 62] or human control [50], our PPs show how designers can stage *play as an ongoing negotiation with biomaterials*. Rather than asking how biomaterials can be made playable, the PPs ask how play *emerges through co-present intra-actions with growth itself*. For designers, this is most clearly articulated through *Curious Material Correspondence*. In *Making Boundary Moves* (PP#1), boundaries such as wraps and containers are not treated as neutral constraints to be optimized, but as playable zones where care is actively negotiated through actions such as loosening, extending, re-wrapping, pressing, piercing, and spreading. It suggests designing boundaries so they invite adjustment, hesitation, and response, rather than enforcing fixed conditions. Similarly, *Breaching the Growth* (PP#2) demonstrates how designers can frame breaches—often treated as failures or contamination risks—as playful probes. Introducing flour, sugar, or porous inserts was not aimed at steering outcomes, but at noticing

how growth accepted, resisted, or rerouted intervention. Unlike biotic games that reward management or elimination of colonies, these PPs show designers how to design for responsiveness rather than mastery, where refusal and unpredictability are meaningful play outcomes.

A second design knowledge concerns how designers can engage other humans with nonhuman temporalities without reducing them to data, dashboards, or constant oversight. Prior biomaterial work has often addressed temporal mismatch through visualization, signaling, or monitoring systems that help humans stay “in sync” with growth [14, 49]. Our PP instead demonstrates how play can make temporal attunement experiential and livable. Within *Catching Up with the Growth, Co-marking Encounters* (PP#3) and *Trying to Remember the Hidden* (PP#4) show how designers can leverage marks, absence, and forgetting as playful resources. For designers, the takeaway is not to better visualize growth, but to design situations where people return, compare, and reinterpret change over time. Compared to tracing or magnifying techniques [57], these PPs add imagination, memory, and comparison as core play mechanisms—offering alternatives to monitoring-heavy approaches that risk instrumentalizing care.

A third design contribution lies in engaging with and acting on entangled actors within growth processes that involve others (human or nonhuman), institutions, and representations. MtH design often operates in this domain, unpacking background relations and challenging norms: e.g., destabilising human/nature separations by surfacing how human body is already entangled with nonhuman worlds, e.g. with their biomes [16] or their menstrual blood feeding soil [69]. Our PPs, under *shifting playspaces*, suggest ways to make entanglements perceptible in practice through playing with mycelia: *Attending to Care Invitations* (PP#5) illustrates how play can be designed to foster communal care or joy in shifting responsibilities in care. The latter resonates with distributed, shared responsibility in joyful forest technologies [4]. Similarly, *Seeing Growth Elsewhere* (PP#6) shows how designers can scaffold playful comparison across contexts. By juxtaposing lived encounters with cultural portrayals of fungi, play can emerge through humor, surprise, and mismatch. Unlike video games that simulate nonhuman perspectives at a distance [65], this PP grounds reflection in participants’ own embodied experiences with biomaterials to contrast with its representations. The takeaway for designers is to design for comparison, using everyday media and representations as material for playful reflection.

Finally, while grounded in mycelial cultivation, the PP are intentionally expandable across growing biomaterials. For example, the way PP#1 articulates play with boundaries of growth containers or breaching the growth PP#2 can also be applied with other biomaterials. This may be taken up with SCOBY cultures [14] to design play experiences and games where the players reflect on the boundaries mediating multispecies encounters, and explore their design potentials for play and care. Likewise, potentials such as PPs under the theme of *shifting playspaces* may resonate with other biomaterials: a researcher designing with any living organism might take up the challenge of noticing how they invite care, or trying to see and reflect on their representations elsewhere. Even plants carry possibilities—marks of encounters, such as cuts on leaves, can become a playful way of catching up with plant temporalities

(PP#5). As such, we invite researchers and designers to take up our play potentials as inspirational resources to adapt them with different biomaterials, design games and play experiences for others to engage and explore. These explorations, we believe, extend the impact of this work to foster playful and caring relationalities with other living organisms, not just in MtH design research, but also in everyday lives.

7 Conclusion & Future Work

This paper examined what it means to *play along* with living biomaterials through a two-month collaborative ethnography of growing mycelium. Rather than approaching mycelium as a material system to be optimized or represented, we followed moments of curiosity, surprise, and joy as they emerged in everyday encounters with growth. From these engagements, we articulated six Play Potentials (PPs) that show how play unfolded in practice and how it can be designed for in MtH design with biomaterials.

Our first contribution (C1) is an empirical account of *playing along* as a mode of situated knowing in MtH design. Across our engagements, play unfolded through specific, hands-on practices with mycelium: poking condensed droplets and loosening plastic wraps to negotiate exposure and care (PP#1); placing flour, sugar, and porous or broken inserts into the substrate to probe how growth accepted, resisted, or rerouted intervention (PP#2); leaving fingerprints, drawings, and marks on fresh growth and returning to them after absence to notice how they had changed (PP#3); trying to remember and reconstruct forms that mycelium had gradually obscured or transformed (PP#4); responding to comments, concerns, and suggestions from others drawn into care through growth (PP#5); and playfully juxtaposing lived encounters with fungi against their representations in media, games, and fiction (PP#6). Together, these practices show how play enabled knowing with biomaterials—learning through correspondence, attunement, and being affected—rather than through control, optimization, or predefined metrics. In doing so, the work extends MtH design by demonstrating how play can operate as a primary epistemic stance for engaging living matter in everyday settings.

Our second contribution (C2) is the articulation of PPs as *design knowledge* that can be translates empirical instances into concrete design directions. Rather than offering prescriptive methods or finalized artifacts, the PPs identify recurring relational sites where designers can scaffold play in human-biomaterial encounters: framing growth containers as interfaces for humans and nonhumans negotiate care (PP#1), motivating experimentation by adding materials into growth to explore biomaterial agencies (PP#2), co-making traces on fungi, and trying to remember what’s hidden by the growth for attuning to mycelial temporalities (PP#3–4), amplifying and redistributing care invitations across people and institutions (PP#5), and supporting playful comparison between situated experienced with biomaterials and representations of them elsewhere (PP#6). Grounded in empirical practice and illustrated through speculative artifacts and situations, these potentials show how play can be designed as the central object of inquiry—rather than as representation, technological mechanic, or incidental outcome—offering designers actionable ways to enable relational, playful engagements with living biomaterials.

Looking forward, future work can extend this contribution in two directions. First, expanding the repertoire of play potentials through comparative engagements with different organisms may deepen understandings of how play can attune designers to diverse temporalities and agencies. Second, translating play potentials into designed artifacts, installations, or participatory experiences can create accessible invitations for others to encounter biomaterials playfully, not only as resources to be used but as companions to become-with. In both trajectories, play may help reconfigure Mth design as a practice of joyful, reciprocal, and sometimes uneasy co-flourishing—where knowing, caring, and designing emerge through open-ended acts of playing together.

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