Sun-Catchers, Sensors, Shape-Shifters: Reclaiming the Intelligence of Plants
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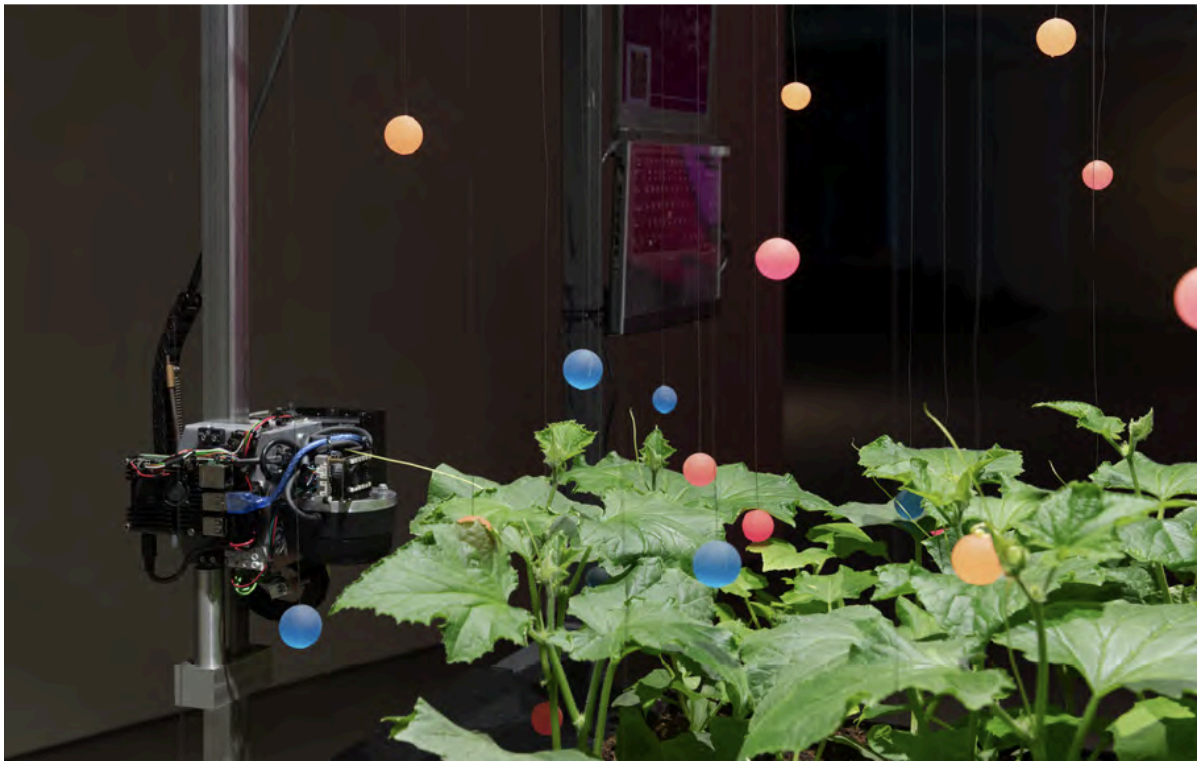

Fig. 1: Špela Petrič, *PL'AI*, 2020. Photo: Franz Wamhof, 2025.

Red and blue spheres gently bobbing up and down, suspended on wires. A tall robot with reels to pull these wires. Plants whose tendrils probe the space like feelers, clinging to the wires and balls. An AI that makes the movements of the plants resonate with the wires and balls, and vice versa. A dance of spheres, wires, leaves and tendrils. An enigmatic game.

Špela Petrič's installation *PL'AI* (2020) (Fig. 1–3) stages the spatial proximity of cucumber plants and machines as an encounter, a process of shared becoming and aesthetic play. For the duration of a cucumber's life cycle, over the course of a summer, plants and machines can grow, learn and play together. The audience is invited to share in this process by learning to see what we rarely (want to) see: plants and machines in motion, in reciprocal relation. The cucumber, like all plants, is a highly sensitive being that responds in a nuanced way to the presence of the wires, the movements of the balls and even their colours – the plant's optical receptors are able to distinguish red and blue. Perhaps there are other signals that it detects and responds to – acoustically, olfactorily, electrochemically, mechanically, or by means of

root secretions and volatile organic compounds (VOC). As the time-lapse video presented alongside the work shows clearly, the plant's stems, tendrils and leaves are in constant motion, exploring and extending their reach. While the stems and leaves need light and grow towards it, the thin tendrils seek out stems, wires and balls to cling to for support. The robot, too, is responsive. Programmed as a sensory being, the robot moves the wires and balls, but stops as soon as a tendril makes contact and attaches to it.

Plasticity as Agency

The installation's aesthetic play between plants and machines reflects a situation that plants constantly face: they are rooted in a specific place and want to keep growing. In the course of their evolution, they have developed unique strategies to cope with their immobility. One such strategy is their high density of sensory cells, allowing them to perceive their environment in a highly differentiated way. But unlike animals, whose sense of perception is concentrated in a few organs, in plants it is distributed throughout their entire body. For example, they can detect acoustic signals with the tiny hairs found all over their surface, which resemble those found in the inner ear of humans and other animals.

Another remarkable ability is the phenotypic plasticity of a plant: its adaptation to environmental conditions during its lifetime.[1] The fact that a plant grows towards the light and away from the shade to ensure photosynthesis, that its roots can hear water in the soil and grow towards it, that it grows large on rich soils and small on poor ones; and that here, in this installation, it recognizes and tests the moving balls and wires as potential supports: all of this is due to the plant's extraordinary ability to design its own body according to the situation it finds itself in. Plasticity gives it scope for play and agency. Animals also have phenotypic plasticity, but to a more limited extent. Because plants are modular, they can grow certain body parts while letting others wither, radically changing their shape over time. This ability is based on the plant's sensory perception of its environment, which it interprets to trigger an appropriate response. Plants must be able to process information, which is an act of cognition. According to Michael Marder and André Geremia Parise cognition can be defined as »the ongoing process whereby organisms perceive, process, and use information to keep their homeostasis in balance and increase their chances of survival«. [2] It is a case of plant intelligence. The experiments conducted by Monica Gagliano, Stefano Mancuso, Paco Calvo, Katja Tielbörger and others have shown that plants are capable of learning, that they have memory, anticipate events and make decisions.[3]

The extraordinary adaptability, creativity and agency of plants is not simply an expression of a passive stimulus-response mechanism, but an active cognitive and, as I will explain later, aesthetic act of information processing. It is rooted in the material conditions of the

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[1] This refers to differences in morphological expression of the same genetic type, as opposed to evolutionary biological plasticity, which encompasses transgenerational mutations (breeding).

[2]Michael Marder and André Geremia Parise, „Extending cognition: A vegetal rejoinder to extensionless thought and to extended cognition», *Plant Signaling & Behavior* 19/1, 2024. https://doi.org/10.1080/15592324.2024.2345984, 10.02.2025.

[3] Stefano Mancuso and Alessandra Viola, *Brilliant Green*, Washington DC, 2015; Monica Gagliano, *Thus Spoke the Plant: A Remarkable Journey of Groundbreaking Scientific Discoveries and Personal Encounters with Plants*, Berkeley 2018; Katja Tielbörger and Robert Koller, »Intelligente Pflanzen: Quicklebendig und ganz schön raffiniert«, *Planet Wissen*, SWR/WDR, 25.03.2021, https://www1.wdr.de/mediathek/video-intelligente-pflanzen--quicklebendig-und-ganz-schoen-raffiniert-100.html,17.03.2025; Paco Calvo, *Planta sapiens: Unmasking Plant Intelligence*, London 2022.

respective situation and recourse to experience. Plants are sensory beings – a fact that few would dispute, and yet it is constantly overlooked. Plants are sun-catchers, energy converters, shape-shifters, transformers. Moreover, they are smart beings that can compute in their own way. The Venus flytrap, for example, »counts« the number of rhythmic contractions to ensure that an insect has been trapped before it snaps shut. Acknowledging plant intelligence means to fully recognize the following: First, that there are »brainless«, »natural« forms of intelligence. Second, that these forms of intelligence are ancient. Third, that we are fighting a culture war in which natural intelligence is introduced as a strategic concept to counter the dominant thinking, making it clear that animals, plants, fungi, and lichens have long developed cognitive agency.

The discourse of »plant intelligence« has been conducted on the margins of botany, neuroscience, and philosophy for about twenty years now – and it has also been criticized: Some argue that there are too many different concepts of intelligence circulating, and many consider it too problematic to call »brainless« non-human beings intelligent. The supporting experiments are inevitably carried out in the natural sciences, but these are poorly equipped for philosophical discourses on subjectivity. After all, the ultimate question is to whom and on the basis of what criteria we ascribe agency and subjectivity. Women, animals, slaves and people of colour were in some contexts denied any form of mind nor recognized as possessing rights until well into the twentieth century. Now the time has come to ask whether we may have underestimated plants as well. Just because we don't understand them, even though we eat and digest them every day, doesn't mean that they cannot make connections within their own system of reference. Their sense and sensors are simply different, specifically embodied in their physicality and environment to an extent that goes beyond the kind of embodiment we find in animal sense perception.

But there are also evolutionary parallels between plant and animal senses: plant cells, for example, take on many of the functions that in humans are the responsibility of the central nervous system. Signal transformation in plants likewise relies on electrical impulses; however, these so-called action potentials occur via cells and not via neurons. And while the globally dominant narrative is built on emphasizing differences, there are cultural currents that cultivate an awareness of our close relationship to plants: children, mystics, witches, healers or Indigenous people connect with plants and honour them. Plants are our predecessors, companions, future. We would not be here without them. This is probably why for Zoë Schlanger, the topic of plant intelligence is also a social issue that must be negotiated within society.[4] Negotiation, however, is also the terrain of art and culture: art discovers or invents forms for accepting – or rejecting – the unfamiliar. In this sense, it is also political.

What is Plant Intelligence?

The question of what can be considered intelligent remains fiercely debated. The penetration of many spheres of our life by AI, including self-driving cars and more, forces us to become more open to engaging with non-human forms of intelligence and to account for differences. What is the difference between ChatGPT and a rain forest? The question posed by the curators of this exhibition suggests the possibility that in both cases we might be dealing with non-human forms of intelligence – artificial and natural intelligences that may even be structurally similar. This is a perspective I share, although first we need to carefully reconsider the conditions that frame it. ChatGPT and Co. represent economic interests poised

[4] Thanks to Kathrin Meyer for pointing this out to me. See also: Kathrin Meyer, »Mit Pflanzen im Museum: Ein Gesprächsmitschnitt«, in: Kathrin Meyer and Yvonne Volkart, (eds.), *Unter Pflanzen*, exh. cat. Museum Sinclair-Haus, Bad Homburg, 2025, p. 112.

to exploit culturally entrenched hierarchies. The word »intelligent« is already part of the verbal marketing of AI. But why should such language machines, based solely on digital data volumes and brute force methods, be considered intelligent, while the physical interactions of plants with concrete spherical and terrestrial conditions is dismissed as a purely chemical or physical stimulus-response mechanism? Why should digital intelligence[5] be valued more highly more than physical intelligence? An obvious conclusion is that recognizing the intelligence of machines, previously marketed as dumb, now has tangible financial benefits: they are intended to substitute human intelligence. As Špela Petrič points out, in the context of agricultural technology even plant self-determination (intelligence) is now being replaced by precision agriculture and smart farming – algorithmic surveillance in greenhouses is deemed »necessary«. To increase yields, a hybrid system of smart control and chemical technologies determines the type of growth.[6]

The intelligence of plants has (as yet) no recognizable use value; under capitalism, the rainforest is currently only of interest as biomass, as a resource for humans and machines to extract from. To answer the curatorial question: the difference between ChatGPT and the rainforest is also that the rainforest keeps ChatGPT running, while ChatGPT consumes the rainforest to function. Plants create and regenerate life; technologies are designed to foster expendable consumption, like AI, destroy it. Even so-called »green« technologies do nothing to change this dynamic for the time being, because capitalism keeps inventing new technologies not to replace old (fossil) ones but to add to them.[7] It is also based on a hierarchical relationship with nature.[8] This logic reaches a new level with the current capitalist appropriation of artificial intelligence.

Hierarchical, exploitative relationships with nature were normalized in modernity through the impact of Cartesianism. This philosophical system defines the human condition as that of a thinking subject, an »I« defined by its ability to reason: »Cogito, ergo sum«. This seminal statement, articulated by René Descartes in the mid-seventeenth century, was deeply influential on the body-mind split that continues to characterize much of Western thought to this day. »I think, therefore I am« posits thinking as the precondition of being. This was taken to imply that »ergo«, all other beings, those who do not say »I, human«, do not think. Ergo: machines and plants do not think. The fact that machine intelligence is so highly praised may be due to the hope that it originated in human brains and therefore remains controlled by them. After all, few people appear to share the radical idea that machines can truly think. In cybernetics, however, parallels have been drawn between humans and non-humans in terms of information and language processing since the mid-twentieth century, defined in explicitly

[5] For Paco Calvo, the essential difference between AI and plant intelligence is that the latter is based on material sensory data, while AI relies on purely digital training data. See: Paco Calvo, »For Plant Intelligence«, Keynote and Workshop, Mesh-Festival, HGK Basel FHNW, 18–19.10.2024. Birgit Schneider also argues along these lines, see her essay »Pflanzenkognition und KI im Vergleich. Ein Gedankenspiel«, in: Meyer and Volkart, 2025, pp. 52–53.
[6] Špela Petrič, »PL'AI« in: *Biomedia* exh. cat. ZKM, Karlsruhe, 2025.
[7] Marcel Hänggi, »Wissen, Nichtwissen und trotzdem handeln«, *WoZ* (14.11.2024, https://www.woz.ch/2446/festrede/wissen-nichtwissen-und-trotzdem-handeln/!FP2PHF7PJDGY, 10.02.2025.
[8] Nancy Fraser, *Cannibal Capitalism: How Our System is Devouring Democracy, Care and the Planet and What We Can Do About It*, London 2013; Jason Moore, *Capitalism in the Web of Life*. *Ecology and the Accumulation of Capital*, London Verso, 2015; Maria Mies, »The Subsistence Perspective«, transcription of a video by Oliver Ressler, Cologne, 26 min, 2005, https://transversal.at/transversal/0805/mies/en, 20.03.2023.

machinic terms. In this context, the human being was conceived not only as an integrated part of overarching information-processing feedback loops, but also as such a loop itself. [9]

Biophysicist Hans-Günther Döbereiner summarizes this thinking as follows: »Intelligence in humans is nothing more than data processing in the present against the background of lessons learned from the past. The better the learning algorithm and the better the data interpretation, the more intelligent you are«. For him, the most meaningful and most general definition of intelligence is the ability to solve complex problems«.[10] This is an ability his research subjects, slime moulds, share with humans, machines and plants. Problem-solving strategies, intentional behaviour, decision-making and flexibility are generally considered characteristics of cognition and thus intelligence,[11] as well as being specifically mentioned as characteristics of plant intelligence.[12] Paco Calvo describes intelligence as »any kind of intentional and adaptive behaviour that helps the organism to achieve its goal«.[13] Plants not only respond sensitively to individual stimuli, they also orchestrate several signals with each other and in a targeted manner; they anticipate possible events and trigger their reactions in advance. For example, when attacked by a predator, the lower leaves use scents as signals to warn the upper leaves as well as neighbouring related or unrelated plants.[14] So what can plants do that other intelligences cannot?

»A simple definition of plant intelligence can be coined as *adaptively variable growth and development during the lifetime of the individual*«, writes molecular biologist Anthony Trewavas.[15] He was one of the first to scientifically study the communication behaviour of plants and to advocate the concept of plant intelligence. For this purpose, he reformulated an existing definition by David Stenhouse, who described animal intelligence as »adaptively variable behaviour during the lifetime of the individual«. [16] The term »behavior« is replaced by »growth«, which is an expression of intelligence in plants. Growth is accomplished through cellular interactions. At first glance, this may not seem spectacular – it is simply what plants do. But, as touched on above, it is also a characteristic of typically vegetal phenotypic plasticity: the response or »decision« of a plant to extend its own body in space and time in a very specific way and not any other, expanding it into new dimensions. For a being that cannot move from its place, this ability is fundamental and quite different from that of animals with legs and stable body plans—the plant simply builds up or breaks down its body in a modular way. However, this capacity also differs from that of slime moulds and similar organisms, which unlike plants shape themselves only horizontally, i.e. in two rather than three dimensions.[17]

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[9] Donna Haraway, »A Cyborg Manifesto«, in: *Manifestly Haraway*, Minneapolis 2016; Katherine N. Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, Chicago 1999.
[10] Hans-Günther Döbereiner, email to the author, 25.08.2019.
[11] Katherine N. Hayles, *Unthought: The Power of the Cognitive Nonconscious*, Chicago 2017.
[12] Trewavas 2003; Mancuso / Viola, 2015; Hayles 2017; Marder / Parise 2024.
[13] Paco Calvo, cited in Jennifer Khattar, Paco Calvo et. al., »Understanding interdisciplinary perspectives of plant intelligence. Is it a matter of science, language, or subjectivity?«, in: *Journal of Ethnobiology and Ethnomedicine* 18/41, 2022, p. 2.
[14] Florianne Koechlin, *Verwoben und verflochten: Was Mikroben, Tiere und Pflanzen eint und wie sie uns ernähren,* Basel 2025; Consuelo De Moraes in conversation with Kathrin Meyer, »Von Hummeln, die in Blätter beissen«, in: Meyer / Volkart, 2025, pp. 72–73.
[15] Anthony Trewavas, »Aspects of Plant Intelligence«, *Annals of Botany* 92, 2003, p. 1. This is a seminal text to which our research partner, botanist Katja Tielbörger, also refers to.
[16] David Stenhouse, 1974, cited in Trewavas 2003, p. 1.
[17] Marder / Parise, 2024, p. 5.

For Michael Marder and André Geremia Parise, plant perception, signalling and spatiotemporal organization are an expression of »extended and extend*ing*« plant cognition. They coined this term on the one hand to reference the so-called 4E model of post-cognitivist theory, according to which cognition is always embodied, embedded, enacted and extended. On the other hand, they challenge the Cartesian body-mind hierarchy. They argue that a (plant-) body registering the quality of the soil, the air and the presence of other beings, and responding to these perceptions creatively, is always engaged in a cognitive process – even with no head involved.[18] As Marder emphasizes, plants continuously extend into their environment, forming an inseparable connection between their body and their milieu that makes any clear demarcation between plant and environment fundamentally meaningless.[19] Plant intelligence must therefore be located precisely in this constant process of extending and connecting.

To this one might add that the boundaries between humans and environment – and, consequently, the establishment of human individuality and autonomous subjectivity—are themselves conceptual constructs stemming from Cartesian thinking. In humans, seemingly purely rational decisions are controlled by hormonal messengers such as oestrogen or testosterone, as well as by the gut microbiome, which is itself embedded in an environment – moving for example from a cow's gut to the meadow, from there through milk to humans and back to the cow. The boundaries between inside and outside, self and others, mental and physical acts are fluid. As post-cognitivist theory and the work of N. Katherine Hayles make clear, the act of thinking is physical and context-dependent in humans too.[20] As the installation *PL'AI* shows us, plants in turn are not only perceptive beings, but – quite unlike AI, for example—they are experts at reading various contexts and responding to them. Their survival depends on it.

[18] Marder / Parise, 2024, p. 1; Hayles, 1999.
[19] Michael Marder in conversation with Yvonne Volkart: »Denken ohne den Kopf«, Meyer /Volkart, 2025, pp. 62–63.
[20] Hayles, 2017.

Fig. 2: Špela Petrič, *PL'AI*, 2020. Photo: Franz Wamhof, 2025.

The Aesthetic Creativity of Plants

»I am getting very much amused by my tendrils«, Paco Calvo quotes Charles Darwin, who was confined to bed for several weeks in 1862 due to illness and thus had the opportunity not only to observe the cucumber plants he had sown and potted for the purpose of study, but also to share their experience of time.[21] »He really wanted to *see them*«, says Calvo, summing up how one might begin to understand a plant's otherwise seemingly unremarkable way of life. In order to record the movements of the tendrils with mathematical precision, Darwin developed a topographical mapping system and published an essay on the behaviour of climbing plants.[22] Viewed in this context, *PL'AI*, especially with the time-lapse technique used in the accompanying video documentation, reads like a re-enactment of Darwin's attempt to study, calculate and appreciate the mobility – the intelligence – of plants.

But *PL'AI* also performs the next step, which historically followed such calculations: cybernetic interconnection, in which technical systems are used to model biological ones and vice versa. For example, certain parts of a machine may perform functions analogous to those of plants. In this case the wires, equipped with touch sensors, provide the AI with a physical component corresponding to the plant's tendrils. Each time the cucumber's tendrils begin to wrap around the wire or the balls, they stop moving. This interaction is made possible by a lidar scanner that captures the surface of the leaves while six cameras record the respective positions of the tendrils from different perspectives. The AI uses this information to calculate and predict plant behaviour, anticipating and adjusting its patterns of movement using neural networks. In other words, the programming of the robot and the AI controlling it is open-ended, but oriented toward plant behaviour in order to enable interaction. The plant has

[21] Calvo 2022, chapter 2.
[22] Charles Darwin, »On the movements and habits of climbing plants«, *Botanical Journal of the Linnean Society*, 9/33–34, 1865, pp. 1–118.

a certain degree of »freedom«, but ultimately it must arrange its shape within the constraints of its biological and chronological determinants – just as the robot's scope of action is determined by laws of physics and mechanics.

When it comes to aesthetic behaviour, it is the cucumber plant's incredible creative capacity that is decisive, while the technology seems to take a back seat.[23] This is also indicated by its programming as a plant-centered robot with the goal of »entering the temporality of the plant and playing with it«.[24] Fundamentally, it appears that the given framework provides both the plant and the robot with space for development, allowing them to adaptively vary their behaviour and growth. They are both agents engaging in free play. The open-ended game merely traces what plants do anyway: establish relationships, claim space, shape their bodies and their environment. It is an interplay of perception and creation, of *aisthesis* in its original sense of »perception«. The plants and the machine are the aesthetic agents – the artists. They perform nothing but their own life: their sensing, touching, failing, not failing, trying again. Vegetal life means wanting to survive, by expanding and connecting with others. It is adaptation, »survival of the fittest« in its original, unadulterated sense: not as the survival of the strongest, but of the best-adapted. Those who correctly assess the situation, try things out, adapt accordingly and are lucky enough that this can be achieved within the given biological and chronological determinants, survive. Survival, as *PL'AI* suggests, is aesthetic creation, experimentation, learning – in short, »playing« – and therefore an expression of plant cognition, plant intelligence. If, however, the cucumbers, whose natural habitat is the open field in summer, should wither in the dark, uncultivated exhibition space, we shouldn't consider them bad players, and therefore unintelligent. The more likely culprit in this scenario would be the impossible premises of the game itself. *Game over*. *Restart*. Perhaps in ten thousand or a hundred thousand years there will be a species of cucumber whose ancestors played so excessively and diversely over time that their genes eventually adapted to the media art space – thriving precisely in this most cucumber-hostile environment of all.

In-Formation

Plant cognition and intelligence appears to be the basis of all existence, generating and shaping what constitutes life on earth. It is material and relational – an interplay of sensual events and physical relationships. Aesthetic and artistic practices, settings and rites raise awareness of this. They allow people to engage with the intelligent and aesthetic strategies of plants and to experience their own being as part of it. They reveal that forms of intelligence have always existed in the material world – it's just that they were deliberately not recognized as such. In doing so, these practices help to reclaim the characteristics of vegetal »good living« (*buen vivir*) that have been coopted by neoliberal and cognitive capitalism – such as growing, staying open and adapting to the environment – for ways of life that do not merely conform to the economic dictates of optimization and performance.

Plant intelligence both builds upon and redefines the Cartesian, language-based concept of intelligence found in information theory. As early as the mid-twentieth century, the Turing test suggested that verbal language games between humans and computers are increasingly the arena where intelligence is performed and evaluated.[25] We recall: If the subject cannot determine whether they are talking to a human or a machine, this serves as proof that the

[23] Apparently, the lidar scanner can only scan the leaves and not even the delicate tendrils, since these are below the sensor's perception threshold. But this imperfection and lack of knowledge, especially by the technology, is part of the concept. Špela Petrič, email to the author, 28.01.2025.

[24] Špela Petrič in the making-of video.

[25] Hayles 1999, p. xi.

machine is thinking. Indeed, we have now reached this point. Unlike a conversation with ChatGPT, talking to the rainforest does not raise questions of attribution.

Insisting on the intelligence of plants means taking a step back in time and showing that, in contrast to the cybernetic conception of information processing, the vegetal processing of information occurs without a brain, while being profoundly embodied. In the etymological sense of the Latin word *informatio*, it is literal: in-formation – becoming form, expanding, connecting. This is what plants do, what they must do. In a traditional and political sense, these concepts also apply to art, whose sphere is the aesthetic, the sensory, or rather the »distribution of the sensible«.[26] Reclaiming plant intelligence is therefore also about revaluing it – celebrating the diversity, openness, and abundance of embodied, contextual, extended and creative thinking. The aesthetic, supra-individual growth of plants could teach us to conceive and live a vegetal aesthetic – one that, with an unfiltered gaze at reality, connects with others and transforms the world that surrounds us in an adaptive, variable way. Intelligently.

[26] Jacques Rancière, *The Politics of Aesthetics: The Distribution of the Sensible*, London/New York 2004.

Fig. 3: Špela Petrič, *PL'AI*, 2020. Photo: Franz Wamhof, 2025.

Translated by Kate Whitebread.