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# Learning from plants to transform engineering, ethics and politics

## Introduction

Over the past decades the world of plants has attracted a renewed research attention focused on their capacities and performances. After the "animal turn" induced by cybernetics a,nd ethology in the twentieth century we now have a plant turn a thorough interest in plant performances that generates a radically new view of the plant kingdom.[1] As Teresa Castro notes research on plant motion has already been triggered by the emergence of graphic methods or imaging techniques, in particular cinema, and the study of plant communication was has also boosted bt the Cold War space programs.[2] in a new trend of research displays the performances of plants. While cybernetics focused on mobility and mimicked animal or human capacities in the making of automata, the focus on plants is on how their immobility generated the invention of specific capacities through biological evolution. What capacities they developed to face the fluctuations of their environment.

This revival of interest in plants is coming from various scholars. Barbara Mazzolai is a robotician, Coccia is a philosopher. Andre Oudenik is a geographer and writer. Olivier Hamant is a plant biologist, Paco Calvo from Murcia is a cognitive scientist.

This multidiscplinary approach broaden the spectrum of biomimetism. Like many trends in biomimicry it is driven by an ecological perspective. It is no longer a question of taking inspiration from organic forms in architecture or mimicking a few properties of plant tissues to design materials such as velcro or water repellent paints. Beyond the practical applications of plant roots research in soft robotics, plants turn out as models to develop critical perspectives not only on our current technological choices and practices (especially in the field of AI) but also on the societal and political system, and more broadly it is integral part of a deep paradigmatic shift in ontology. The Anthropocene demands that we see at the scale of the planet and consider new modes of representing our relation to other living creatures and develop new imaginaries for synergies.

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[1] Vinciane Desprets XXX. Wolfgand Schnaffer in Patric Ribault ed. XXX

[2] Teresa Castro The Mediated Plant https://www.e-flux.com/journal/102/283819/the-mediated-plant/

Focus on two authors Paco Calvo from Murcia and Olivier Hamant from Lyon - to outline the epistemic, metaphysical, political agendas underlying this new trends in biomimetism.

**Epistemic agenda**

Paying attention to plants can be seen as a revival of the natural history tradition and the culture of curiosity developed in the 17th and 18th century that blurred the boudaray between natural and artificial. Wonders in the order of nature. (Photo du livre de Daston)

Beyond this reminiscence, it is « learning to look differently » to the world. Promoting an alternative science, as Emanuele Coccia claims

> "Have you ever sat and watched a plant? The very idea itself might seem strange. We like to watch things that move, that do something. But in fact, plants are doing a great deal too - plants behave, as animals do - they are just doing it on a very different timescale."

This project may have been inspired by the 20th cent. ethologists who introduced radically new ways of observing the behaviour of animals. Instead of observing captive animals in zoos or submitting them to laboratory experiments, they developed slow science, a daily long-term observation of animal rhythms and habits.

Shirley Strum for instance investigated baboons in their milieu and insisted that the analysis of behaviours should try to identify what matters them. In a similar vein Thelma Rowell developed the art of creating experimental devices or dispositifs that give sheep the chance to become interesting (cf Vinciane Desprets : No sheeping sheep). Competition has been overemphasized by classical ethology on the basis of preassumptions.

After a few decades ethologists have that animal feeding behaviours globally aim at survival and not at competition as suggested by the observations conducted in artificial milieus where animals are dependent and protected by humans. Baboons for instance negotiate all actions with their fellows, they constantly interact to get food or to get females. Concerning birds social life, Vinciane Desprets insists that observation requires politeness. Through developing trans-species relation all animals reveal unexpected capacities, provided we try to understand their behaviour within their own horizon. It is an ecological approach in the sense that it is reminiscent of Aldo Leopold's famous injunction: "Thinking like a mountain". [3] Leopold advocated a holistic perspective on where one stands in an ecosystem. This approach does not prevent researchers from trying to understand the physical-chemical mechanisms and underlying general principles at work in animal or plant behaviour;

A major result of this ecological method of observation was that survival is what primarily matters for plants like for any animals. For instance, sunflowers turn to the sun as it tracks across the sky; mimosa plants close their leaves when they are touched so as to protect themselves against predators. Lacking locomotion, plants have developed new capacities to survive and adapt to changing environments.

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[3] Aldo Leopold *A Sand County Almanac,* section "Sketches Here and There"

> They cannot move about freely like animals do, so they grow into space instead and make new chemicals to interact with the species around them. Not only that, but what causes them to do these things, what drives this behaviour, is far more similar than we humans, with our speedy, animal-centric perceptions, have always assumed. If we learn to look differently, we might be amazed at what we find." (Coccia)

What we find is that plants have developed a strategy of adaptation through building tissues. They grow flexible materials in relation to the fluctuations of the environment and grow them in specific directions to access indispensable resources such as light or water. Through this continuous process of growth, they develop autonomy rather than automation. Whereas human robotics work on the basis of a binary logic, on/off digital logic, plants become autonomous through the silent continuous activity of growth.

What we find is that plants are capable of perception. Paco Calvo deliberately applies to plants the method developed by James Gibson to observe animal behaviour. Eco-psychology is a behavioural approach aimed at understanding how living organisms behave. Gibson claimed that perception and action are tightly coupled and. He named affordances the information collected and selected in the environment according to the needs of immediate action.

Calvo tries to first identify what plants look for and second how they work at the microlevel. The results are amazing. He demonstrates that

- Plants like animals have a direct perception of the surrounding through affordances, i.e. opportunities for action provided by the environment. they spot in the environment what is immediately useful for their survival. Indeed they will not provide an abstract physical description of what is out there. The environment is perceived based on how it relates to the plant's needs and actions, perception and action are intimately coupled.
- Plants are also capable of proprioception. They "can read their own shape"
- The process of adaptation is not merely a reflexive response to stimulus. Plants grow tips to actively explore their surroundings. For instance the tendrils of climbing vines have a helical movement of circumnutation to locate a support and then a rotational movement to turn around the support Calvo: "plants are as much in motion as any other living organism, and this movement is essential to their adaptive strategies".[4]

**Metaphysical agenda**

Most scientists involved in the study of plants behaviours are fond of writing semipopular books based on scientific literature where they feel free to develop the broad metaphysical views inspired by their research on plants. They all express the same feeling of seeing the world anew through plants. Their mission is to emancipate the audience from the prejudices that make us blind to plants performances, to awake them from the dogmatic slumber cerated by western metaphysics. Calvo for instance quotes William James to insist on our blindness to

[4] Calvo *Ecological, plant inspired soft growbotics* p. 4.

things around us:  “each of us literally choses, by his way of attending to things, what sort of universe he shall appear to himself to inhabit”. [5]

While biomimetic design is used to blurring the boundary between the natural and artificial, the current studies on plant behaviours converge to challenge the anthropocentrism of modern metaphysics. Three major metaphysical lessons stand out.

First, the activity of living beings usually characterized by their inaction. Against the prejudice expressed in the verb to vegetate that means to spend time in a dull, inactive, unchallenging way, plants are as active as any other being. They all assume that survival is the main driver of plants behaviours, thus echoing Spinoza’s metaphysical stance that all beings have a conatus to preserve themselves. As philosopher of technology Vincent Blok argues conativity is the central concept to develop an ecocentric notion of biomimetic technologies. Conative means self-assertive and self-perseverant. Plants should be treated as active subjects. They are active in spite of their apparent passivity. They dynamically interact with their environment and they use the information to guide their growth and action. Their activity is made visible thanks to instrumental techniques such as time-lapse photography condensing plant growth into visible movement or Alex Metcalf artistic recording of the noise of tree respiration. The evidence of plants’ activity challenges Cartesian dualism between passive objects and active mind. In the ecocentric perspective the subject/object dichotomy is obsolete: the unit is no longer the individual entity but the system formed by the organism and its environment.

The second lesson challenges the anthropocentric claim that intelligence belongs only to humans. Against conventional metaphysics inherited from Aristotle, Calvo and Hamant argue that plants behaviours are evidence of cognitive capacities. Not only do they exchange information as they communicate with one-another using chemical compounds or electrical signals to coordinate their response to the environment. They also have a memory embedded in their tissues. Plants who have been through previous droughts are capable of storing water more effectively than plants that have never endured droughts.

Calvo also argues that plants are capable of anticipation. They are “anticipatory engines” monitoring the environment to predict forthcoming environmental changes.  Like shoots in the air, roots navigate complex underground environment. They anticipate obstacles and make simili-decisions to avoid them on the basis of sensory information and internal regulatory mechanisms to minimize the metabolic cost of irreversible growth. The leaf laminas of *lavatera cretica* reorient during the night to face the sunrise in the morning. Calvo argues that plants.

In this respect plants behaviours converge with post-humanist claims that intelligence lies in material machines. Intelligence is a capacity linked to action, as Bergson and James famously argued. This pragmatist approach entails that cognition should be divorced from consciousness.  In this respect they comfort Michel Serres’s philosophy of communication. Serres grants objects knowledge capacities on the basis of the theory of information . Objects carry information because like all beings in the world they exist as negentropic pockets of information, counteracting the general decay of order. They are resisting decay and entropy.

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[5] Calvo *Planta Sapiens* intro chapter one.

Serres insisted that objects are subjects because they have the capacity to emit, receive, store and process information. Rocks, ice cores, shells and trees store the past and also climate changes in their texture. They record past events and inscribe them in their inner structure.

**Techno-political agenda**

In addition to this amodern, posthumanist ontology, the study of plant behaviour conveys a third, more specifically biomimetic lesson. Plants are models for an alternative to computational technology and challenges to rational design. Plants capacities of cognition and decision are developed without a central unit of control, like the brain. Calvo insists that the intelligence of plants is not based on information processing, as Serres assumes. Plants have no software, it is embedded in the material tissue of their body. Their mind is matter only. Their decision capacity does not follow the binary on/off logic displayed in artificial intelligence. It is a continuous process of growth at slow tempo based on the couple perception/action t provides immediate and actionable data that guide behavior in real time Calvo considers that this pragmatic processing of information challenges the GOFAI (Good-old-fashioned artificial intelligence). In contrast to AI based on algorithms and language models, that never related to the real world, ecological robotics based on the model pf plants' sensors and actuators has a direct link to the outside world.

While Calvo features plants as a model of intelligence and alternative robotics, Hamant broadens the scope, insisting that they provide a model of alternative technology, based on so called rational principles. In *La troisième voie du vivant* (2022) he stresses the contrasts between modern technology and plants technology. Rational design aims at efficiency while plants aim at robustness. Driven by a cult of performances, modern engineers and designers seek optimization whether it means higher, bigger, smaller, or faster. Hamant advocates sub-optimality on the model of plants. Although plant tissues may be capable of mechanical performances, they are sub-optimal because there is a lot redundances. They are above all capable of thermodynamical performance through fluctuations ensuring dynamic resilience. Resilience includes robustness, adaptability and transformability. A close look at the mechanism of photosynthesis instantiates this strategy of resilience through redundance, imperfection, and even incoherence.

Plants transform $CO_2$ into carbon fiber of cellulose or starch but they also release $CO_2$ through their respiration through the same pores named stomates. Stomates are multifunctional channels for water and $CO_2$. Once the $CO_2$ molecule is in, it is captured by an enzyme named RubisCO, responsible for the first step in the process of transformation into sugar molecule. However this enzyme, key actor of photosynthesis consumes and releases $CO_2$. RubisCO also captures oxygen molecules (photorespiration) thus producing $CO_2$. There is nevertheless a rationale in this incoherent behaviour because photorespiration is used for making nitrates, indispensable plant nutrients. The process of carbon metabolization in plants presents many incoherent loops that are inherent to the strategy of robustness.

Hamant insists that globally plant growth is an incoherent process. Cells grow by capturing water but the rigid molecules of cellulose slow down the growth of liquid cells. At the same time the rigid walls prevent the explosion of the cells. So plant cells reach a synergy between two antagonist continuous processes: compression (inside the cell) and tension on the membrane similar to the equilibrium reached in inflatable balloons. Metaphorically "plants

drive their growth with a handbrake on".[6] Although they are found in all living organisms incoherent loops have various vital functions in plants: shock absorbers (cushioning effect; they allow the system to return to equilibrium after a disturbance; they inhibit exponential amplification; they induce dynamic stability through oscillations. "Clearly, Hamant concludes, evolution has not selected an on-off switch type of process, but a mechanism incorporating incoherent loops, which allows a form of regulation to reach an equilibrium". [7]

Incoherence loops produce stable outcome, through oscillations that dampen external perturbations.This key strategy for robustness relies on a metaphysical assumption: living organisms are robust because there are traces of past traumatic events in their genes they are better equipped to operate in a fluctuating world. But it is also at work in technical systems such as suspension bridges: they balance the force of compression in the vertical piers and of tension in the deck cables.

**Political agenda**

Hamant does not hesitate to draw socio-political lessons from the incoherent loops implemented through biological evolution. He notes incoherent loops already at work to stabilize the social and political system, such as the balance of power with the implementation of counterpowers (parliament, independent journalism, associations)in democracy.

He strongly recommends incoherence as an actionable tool for decision makers. Incoherence provides an effective remedy to stop social violence and escalation due to unstoppable amplifying loops. Our over-optimized socio-technical system is vulnerable. We need a dose of defects and imperfections such as heterogeneity, inefficiency, slowness, errors, defects conflicts and randomness to face climate change and ecological crisis. It can be implemented through participatory approach to face climate crisis : instead of relying on competent experts, asking the opinion of non-experts (a citizen jury for instance) is an operational device to reduce polarized confrontation on hot topics. Idem for social justice replacing the egality pple by equity to stop the engrenage of economic growth increases the gap between poor and rich. Or the engrenage of the luddite textile workers destroying their means of work to save justice. Hence. accepting a dose of inequality to tend toward equity and social justice.

Upstream incoherence : power providing bonus or malus against the dogma of free competition or ensure a salary for life with a guarantee of promotion in the most arduous jobs, (p. 142Bernard Friot)

**In conclusion,**

Unveiling the adaptive capacities of plants has a transformative power. The new look on plants is integral part of the technoscientific agenda science driven by instrumental techniques and above all by action. Not new cf past episodes. From a ontological perspective it is integral part of the paradigm shift toward posthumanism challenging modern metaphysics categories

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[6] Hamant Anthropological Review, 2024, p. 5

[7] Hamant La troisième voie du vivant Paris, odile Jacob 2022, p. 102

cf Viveiros de Castro decolonizing thought by opening to other indigenous knowledge of plants. Finally it is triggered by the Anthropocene concern for survival in a damaged environment. Major shift that commands new techno practices based on bricolage and adaptabililty.  the context of the Anthropocene and the threats over the future of biodiversity, the concern with survival prevails and many scholars explore various strategies for survival. When survival becomes a priority the rapprochement between plants and the social order gains traction. For instance Anna Tsing *The Mushroom at the End of the World*. *On the possibility of life in Capitalist Ruins* connects plants, forests and survival in a damaged world.

Plants convey a political message against the famous neoliberal principle TINA. Plants suggest alternatives that better suit the political values of cooperation, equity, social justice. Just as Aesop and Jean de Lafontaine used animal characters to criticize their contemporary fellows' behaviours, plant characters could be used for telling moral or political fables, to face the disorders of the world.