Harold Wager and the Photography of Plants

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Abstract

The recent surge of interest in the sensory, cognitive and communicative strategies of plant life and the development of neurobotany and phyto-philosophy resumes a debate that briefly flourished in the early twentieth century. Francis Darwin and Gottlieb Haberland then proposed that plants possessed vision and memory, a position rapidly abandoned until its recent revival. A striking contribution to the earlier debate was botanist Harold Wagner's showing of a series of photographs purported to have been taken using lens extracted from plant leaf epidermis. The article will reflect on the status of this photographic practice, in which plants are posed as the photographing subject rather than photographed object, and consider its wider implications for non-human photographic practices.

Keywords

Photography, Plant, botany, vision, microscopic photography, organic lenses

The grammatical properties of the double genetive permit a phrase like 'the photography of plants' to refer both to photographs *of* plants and photographs *by* plants. The former practice - the photographic capture of images of plant life - is almost as old as pjotography itself. Plate VII of Henry Fox Talbot's (1800-1877) *The*

*Pencil of Nature (*1844*)* is the contact print 'Leaf of a Plant' while the Muybridge of the plant, Wilhelm Pfeiffer (1845-1920), pioneered time lapse photography in the late 1880s in order photographically to capture the process of plant growth. Later Edward Weston (1886-1958) and Karl Blossfeld (1865-1932) brought plant life into proximity with surrealism while Robert Mapplethorpe's flower studies (1946-1989) would form a large and distinct sub-genre in his work. However, the other side of the double genetive - photography *by* plants - has had few advocates, among whom the most significant was the botanist, cytologist and mycologist Harold Wager FRS (1862-1929) His challenge to the ways in which we understand and limit photography by examining plant visual perception was quickly compromised by claims from his critics that he was attributing photographic subjectivity to the plant. [1]

Wager's photographic intervention following the 1908 Annual Conference of the British Association for the Advancement of Science held in Dublin was forgotten for over a century by the histories of science and photography. This neglect was due to his being on the wrong side - that of Charles and Francis Darwin and their followers - in a late Victorian debate on plant sensibility and intelligence. However, there has recently been a return to this debate and the rescue of some of its positions from the archive. This return to these debates of a century ago is an aspect of a revolution in botany over the last decade that has been described by one its major participants and advocates - Stefano Mancuso, a researcher in neuro-botany at Florence University - as a Copernican Revolution of the Plant.[2] In his

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[1]The desire for a plant photographic subjectivity was by no means exhausted by the fanciful responses to Wager's work. As recently as October 2019 researchers at London Zoo's Rainforest Life exhibit could claim - however ironically - that a plant they call Pete had taken a 'selfie'. The declared objective of their experiment was to harness the power of microbial fuel cells to power cameras in ecological settings for conservation research. This project was largely successful, but the plant - a maidenhead fern - also seemed to be taking selfies of itself once every twenty seconds.

[2] 'we could say that in biology we're still in a period which we could define as Aristotelian-Ptolemaic. Before the Copernican Revolution, people still believed that Earth was at the centreo f the universe and that all celestial bodies revoleved around it - a totally anthropcentric vision which Galileo endeavoured to subvert and which took centuries to disappear from popular opinion. Well, we could say that biology finds itself in a more or less pre-Copernican situation. The reigning idea is that humans are the most important living beings and everything revolves around us: because we've imposed ourselves upon the others we're the absolute lords of nature. An intriguing and consoling vision…if only it were true!' Mancuso 2013, 39-40. For another genial statement of the Copernican Revolution see Michael Pollin's *The Botany of Desire.*

books *Brilliant Green* (with Alessandra Viola) (2013) and *The Revolutionary Genius of Plants: A New Understanding of Plant Intelligence and Behaviour (2017)* he literally revolutionises our estimation of the place of plant life on this planet, an achievement complemented by Daniel Chamovitz *What A Plant Knows (2012 & 2017)*.[3] and Barbara Mazzolai's theoretical reflection on plant robotics and plant AI in *La natura geniale (2019).* Evidence of a similar shift in the broader cultural understanding of plants is provided by the Pulitzer Prize winning novel by Richard Powers, *The Overstory* - which tries to extend the imaginative possibilities of human plant interactions - as well as by the unprecedented impact of Peter Wohlleben's *The Hidden Life of Trees* (2017) . This revolution in botany is complemented by the emergence of the field of phyto- or plant philosophy that has begun the process of reflecting on the implications of recent findings that plants - beyond comprising 80% of the planetary biomass compared to the 0.01% contributed by the entire population of human beings - have at least 13 sophisticated senses including sight, are capable of memory and can communicate between themselves and with other species through the mycorhizal network of the 'Wood-Wide-Web'.[4] The 'Copernican Revolution of the Plant' is forcing us to acknowledge, slowly but surely, that plants do not passively surround us as our 'environment' or *Umwelt,* but that we represent, in Mancuso'a words, a 'trace element' of plant life; they do orbit us as we would like to believe but we them, completely dependent on plants for energy, for oxygen and for other less tangible benefits, pleasures and threats.

The Copernican revolution in botany traces its lineage back to Charles Darwin's extensive researches in botany after *The Origin of Species* - a project he shared with his son Frances and elegantly decribed recently by Ken Thompson in his *Darwin's Most Wonderful Plants: Darwin's Botany Today (2018)*.[5] Frances took

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[3] The changes across the two editions of of Chamovitz's book testify to the tremendous changes being carrried through in this field of study.

[4] See the pioneering studies by Michael Marder *Plant Thinking: A Philosophy of Vegetal Life (2013) ,* Emmanuele Coccia *The Life of Plants* 2017 and Jeffrey T. Nealon, *Plant Theory: Biopower and Vegetal Life* (2016)

[5] 'Darwin showed that plants were able to perceive a stimulus, which then caused a different part of the plant to react with a specific and clearly adaptive way. The parallel with animals was clear to Darwin…The seed of the idea that plants can *think* had been sown.' (Thompson 2018, p.76

many of his father's ideas on the motion of plants to their logical if humanistically unacceptable conclusions. The Darwins moved towards the conclusion that a form of plant intelligence underlay the regularities of plant motion. The recent Copernican revolution in botany regards the derisive reaction to Francis Darwin's Presidential address to the Annual Conference of the British Association of the Advancement of Science in Dublin of Autumn 1908 in which he claimed plants have intelligence and are capable of memory and, following the Austrian botanist Gottlieb Haberlandt (1854-1945), that they were capable of vision as marking a century long interruption of a line of research that it is only now possible to resume. That fateful conference was subsequently rocked by another scandalous claim by the ally of Darwin and sympathetic critic of Haberland, Harold Wager (1862-1929) who showed that plants are capable not only of vision but also of photography. The context in which Wager made this claim needs careful reconstruction, but it was immediately relayed to the public as the sensational claim that plants were active photographic subjects. Wager we shall see did play with this claim, but his intervention in the 1908 debate was not intended to reduce the scope of plant photography to its human uses, quite the contrary: Wager believed that meticulous study the photography of plants potentially revolutionised not only our understanding of plants, but also of photography and perhaps even ourselves and our place in planetary life.

Harold Wager's supportive intervention following Darwin's address to the 1908 conference was but one of many distinguished contributions to botany that had earlier earnt him a Fellowship of the Royal Society in 1904. He was a distinguished mycologist - student of funghi - a specialist in cytology or the cellular anatomy and physiology of plants and - central to all his research - a leading pioneer in the the use of microscopic photography as a tool for botanic research and divulgation. This was noted in his scientific obituary published in Nature in 1929 which remarked on his 'almost uncanny *flair* for microscopic manipulation' noting that 'His photographs through the lenses of the leaf epidermis were as beautiful a demonstration of the capacity these cell wall structures showed to focus objects, as his experiments were to show that Haberlandt's views as to the function of the

'Ocelli' needed revision.' This delicate reference to the plant photography of 1908 was immediately followed in the obituary by a reference to 'his numerous observations upon the leaf pigments and other plant pigments, many of which, probably, have never been fully embodied in his published writings.'[6] There is a close relationship between the photographs taken through the lenses of the leaf epidermis and Wager's extended research into the photographic properties of leaf pigments. Some appreciation of the latter inquiries is vital for understanding the radical character of Wager's views on photographic thought and practice. Fortunately, the usually authoritative *Nature* obituary was mistaken about the unpublished work on vegetal pigments: his thoughts on leaf and plant pigments were published in a 1914 paper 'The Action of Light on Chlorophyll' in the *Philosophical Transactions of the Royal Society.* This important article can serve to orient Wager both in the history of scientific photography and in the bitter debates on the issue of plant sensibility and thought.

The 1914 article begins by evoking the phenomenon of plant photosynthesis: 'The chemical changes brought about by light in the green leaf leading to the production of sugars and starch from carbon dioxide and water are still far from being clearly understood.'[7] Informing the reported detail of Wager's elegant experiments and reasoning is his use of photography as a model for understanding photosynthesis. Both photo*graphy* and photo*synthesis* are of course allied terms describing chemical reactions provoked by the action of light. But before discussing these further Wager's article cites from three works by Sir John Herschel 'who in a series of papers published more than 60 years ago described many interesting experiments on the action of the rays of the solar spectrum on the vegetable colours expressed from the petals and leaves of plants.'[8] He refers specifically in a footnote to two articles in the Philosophical Transactions of 1840 and 1842 'On the Chemical Action of the Rays of the Solar Spectrum on Preparations of Silver and other Substances, both metallic and and on some Photographic Processes' and 'On the Action of the Rays of the Solar Spectrum on Vegetable colours, and on

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[6] *Nature* December 21, 1929, 954
[7] Wager 1914, p. 386
[8] *Wager* 1914, p. 386

some new Photographic Processes' usually cited in the quite different context of pioneering developments in photographic technology, especially in the making of photographic prints. He cites Herschel's estimation that 'photographic pictures may be taken on such papers, half an hour in good sun sufficing; but the glairy nature of the juices prevents their being evenly tinted , and spoils their beauty', adding the critical observation that Herschel 'did not experiment with chlorophyl in a state of purity, owing to the nicety required in its preparation' [9] (of which Wager was himself an acknowledged master). Wager observes that Herschel's experiment - dedicated to fixing the mark making properties of light - regarded the photographic mark as the trace of a destructive act, a wound or a cut that was destructive of the living vegetal cell and its constituents. Wager proposed instead a cycle of cellular photo-destruction allied with its reconstitution or synthesis: 'under the influence of light, the chlorophyl in a living cell is constantly being destroyed [the condition of photography], but under normal conditions the leaves remain green, the chlorophyl being reconstructed as quickly as it is destroyed.' [10] Wager, in other words, is suggesting that the difference between photography and photosynthesis is not one of kind, but of degree - both draw with light, the one destructively on the very matter of the vegetal cell and the other synthetically; both however are understood as complementary actions of the same chemical effect of exposure to light.

Nevertheless, in spite of the distinction between the destructive and reconstructive effects of light, the experiments reported in Wager's paper forcus almost exclusively on the decomposition or destruction of chlorophyll to the near exclusion of any consideration of its recomposition. This meant that all of the experiments reported in this paper are exclusively photo*graphic* in interest, involving the chromatic marks left on prepared papers by diverse preparations of chlorophyl exposed to different frequencies and intensities of light. Wager sees himself as continuing Herschel's proto-photographic researches by setting out to explain - by means of photography - the marks left by the exposure of a cellular substance (chlorophyl) to light thus focusing on its destructive and mark-making properties at the level of the plant cell.

[9] Wager 1914, pp. 386-7
[10] Wager 1914, p. 387

Here, as just one example of his use of a photographic methodology learnt from Herschel, is Wager's description of the first of many experiements reported in the article: 'Experiment 1. A piece of paper, tinged with alcoholic solution of chlorophyl, was arranged so that one half of it was exposed to good light, the other being kept dark. The half exposed to light became bleached, and when placed in Schiff's solution the exposed portion developed a beautiful pink, the unexposed half remaining green with no pink coloration.' [11] This and subsequent experiments show that the destruction of chlorophyl is attended by a process of oxidisation - and thus for Wager , the fact that there is photography, or traces of the decomposition of chlorophyl by oxygen - suggests that photosynthesis or that 'the production of sugars and starch in the green leaf may be intitiated by the photo-oxidation of chlorophyl and the subsequent polymerisation of the aldehyde thus formed, rather than by the direct photosysnthesis of carbon dioxide and water.' [12] The reference to photo-oxidisation connects this line of argument with Wager's work in public health on oxygen and clean air.

This quite ingenious use of photographic methodology to prove a physiological process involving light and proceeding through a scrutiny of the traces left by the effects of light was also important for Wager's practice of microscopic photography.

This is evident in an earlier 1903 paper 'The Cell Structure of Cyanphycae' also published in the *Philosophical Transactions.* This was an exercise in cytology reporting on the investigation of cell structure in an algae like plant - the cyanphycae - interesting to botanists as a plant historically involved in the evolutionary transition from sea to land plants and to us for the insight it gives into Wager's methodology when working photographically with the microscopically small plant cell. The article addresses a then twenty year controversy concerning the presence or otherwise of a nucleus in these plant cells - the very important question of whether this form of life was pro- or eukaryotic. The suspected nuclei are too small to see unaided - and Wager notes: 'The investigation of the cytology of these

[11] *Wager* 1914, p. 390
[12] Wager 1914, p. 407

organisms is certainly not an easy one, and it is not astonishing that so many different interpretations are given of the facts observed. But it seems to me as if it is not an impossible task…' [13] To achieve the almost impossible he will call on the aid of photography, but in two senses, for 'In attacking the problem it is necessary that the methods should be as refined as apparatus and re-agents will allow.' It is important to note the reference to both apparatus and re-agents — a pair corresponding to two discrete photographic acts. By 'apparatus' Wager refers to a hook-up of microscopic and photographic technology, 'that not only the highest possible powers of the microscope should be used, but that the illumination should be as perfect as possible' in order to capture an image of the cell. [14]The second - the reagents - concern the preparation of the cell for photographic capture: 'As regards the preparation and staining of these plants, the ordinary methods used in connection with cytological investigations are sufficient, but special care is required in their application, especially in the matter of staining and washing out.' [15] The chemical solutions basically produce a contact print of the cell - staining it chemically (compromising its cellular structure) and exposing it to light, thus making the photographic result available for further photographic capture - photographing the photographable - a technique that allowed Wager in a *tour de force* not only to prove the existence of a nucleus, but also to describe some of its unusual and unsuspected properties.

It's against this backdrop that we can move from Wager's photography of plant cells to his remarkable contribution following the 1908 Presidential Address where it seems to be the plant cells that are doing the photography, or at least supplying the lenses… Here is how it was reported in the New York Times, in the same week that the newspaper announced the Wright brothers progress towards human flight - as humans become birds plants become cameras. On the front page of the September 8th 1908 editor a special cable reports 'Plants have eyes, Botanist shows: Professor Wager finds outer skins of leaves are lens much like Eyes of Insects - Photographs with them - and pictures of persons and landscapes thus

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[13] *Wager* 1903, p. 401
[14] Wager 1903, p. 401
[15] Wager 19903, p. 401

secured are remarkable clearly defined'. And given Wager's work with chromatic pigments, it will come as no surprise that 'coloured photographs were exhibited' during Wager's presentation at the conference. The article begins with Francis Darwin's Presidential address and its claims that plants can remember before moving to the further claim - attributed to Wager - that plants not only can form clear images of surrounding objects through the outer skin of leaves but also have a brain. [16] This is definitely not Wager's claim - he is in fact even more radical in proposing a quite different understanding of vision in terms of the chemical activation of cellular particles by light - one closer to our understanding of the pixelisation of light. The New York Times is correct in reporting the claim that plants can see, but Wager never claimed that they have a brain or that their vision consisted in images. In terms of the Copernican Revolution, plants do not resemble humans but humans resemble plants, albeit presenting a specialist application of the general chemical physiology of vision evident in plant kingdom. What is perhaps most interesting in all of this is how Wager assembles light, vision and memory in the space of photography. The New York Times article also notes that one of Wager's photographs was a plant's eye photograph of a pjhotograph of Darwin himself, one that unfortunately Wager does not seem to have published. [17]

A Version of the 1908 paper was subsequently published a year later in the *Annals of Botany* of 1909. In it Wager extends and criticises an earlier account of plant sensibility reported by the Austrian botanist Gottlieb Haberlandt in his 1901 *Sinnesorgane im Pflanzenreich* (*Sensory Organs in the Plant Kingdom*). [18] Wager

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[16] 'The interest aroused by the contention made by Francis Darwin, so of the uthor of the 'The Origin of Species' in his presidential address befoer the British Association in Dublin last week, that plants can remember and can develop habits, has been increased by a paper read today by Prof Harold Wager, the well known botanist. Prof Wager declared that plants possess an organism correspondong to the brain in animals and further demonstrated that they have eyes with which they can see and se well.' New York Times, September 8, 1908

[17] 'These lenses are so good and focus the light that falls on them so carefully that photographs can be taken by means of them. Prof. Wager has taken a great many such photographs, and he showed some of the most remarkable. These included reproducitons of a photograph of Darwin, in which the features were distinct and unmistakeable, as well as direct photographs of landscapes and people. Even coloured photographs were exhibited and, like the rest, they are remarkably cleraly defined.' New York Times, September 8, 1908

[18] For a review of the significance of Haberlandt's work, especially his pioneering techniques in microscopy that would been of interest to Wafger, see see Laimer & Ruecker, 2003.

questions Haberlandt's explanation of the phenomenon of heliotropism that intrigued the Darwins in a 1905 article '*Lichtsinnesorgane im Laubblatter*' (Sense Organs for Light in Foliage Leaves) terms of light experting pressure on cell walls by investigating the differential effects of different frequencies of light on the individual chlorophyl grains in a cell. Referring to Charles and Francis Darwin's account in their 1880 *Power of Movement in Plants* Wager asks 'by what means does the leaf-blade, or the plant for that matter, perceive that it is or is not in the most advantageous position for the incident rays? '[19] Although Wager did not have the vocabulary to describe his thought, his vision of an ensemble of cellular lenses each containing individual grains of chlorophyl reacting to different light frequencies is similar to an array of pixels. While both Haberland and Wager depart from the strange property of leaf epidermal cells containing no chlorophyl and being shaped like lens whose configuration can be altered by changing levels of moisture participating in what botanists now call an antenna/response reaction, and while both emphasise the movement of the surface of the leaves in order to maximise the benefit of light conditions for photosynthesis, their explanations are quite diverse. Haberlandt emphasises the plasticity of the epidermal cell wall while Wager shows how these cells function by comparing them to a photographic apparatus. [20]

He first describes the photographic set-up that permitted him not only to photograph plant cells, but also to use epidermal plant cells as photographic lenses:
'By appropriate manipulation with the microscope and the Gordon photo-micrographic apparatus made by Messrs. Beck, it has been found possible to obtain photographs of a variety of objects through cells both of the upper and lower epidermis of leaves of many species of plants. Among these are portraits from life, reproductions of photographs of various kinds, flowers and other objects direct, and it has even been found possible to photograph trees, houses, and landscapes, and to reproduce simple

[19] Wager 2008, p. 459
[20] Wager notes that Haberlandt saw clear and distinct images through the cell lenses and also obtained 'a somewhat indistinct photograph of a microscope stand' (Wager 1908, p. 262; but if Haberlandt could claim priority for the first plant cell lens photograph, Wager developed and extended the technique.

diagrams in colour on the autochrome plates of Messrs. Lumiere.[21]

After this description of his microscope and camera set-up he infers from the quality of the images he obtained that ‘the epidermal cells are capable of functioning as very efficient lenses. But it is not probable that the plant is capable of perceiving images, nor is such a supposition necessary to Haberlandt's hypothesis.’ [22] What Wager hopes to show is less that plants see like us, but that our vision is a special case, a specific evolutionary development, of a physiology of vision exemplified by the plant:. Still following Haberlandt, he observes ‘if we reserve the term ' eye' only for those organs which bring about an image perception, then the foliage leaves and many animals are eyeless. But if the term is extended to include organs capable of perceiving a difference in the intensity of light, then plants must be said to possess eyes.’ [23] Wager proposes that we view image perception allied with the cerebral manipulation of visual data as a special case of the management of vision. He follows Darwin in tying plant perception to memory, in this case a photographic memory in which vision leaves traces - enduring marks made by the light - at the level of the cell that enable habitual movement, claiming ‘It is clear that the orientation of the leaf with respect to the light has for its main purpose the more efficient illumination of the chlorophyll grains ; and this must be taken into account in considering the lens function of the epidermal cells.’ [24] and continuing ‘Light is able to bring about an orientation of the chloroplasts in many foliage leaves and in some Algae.’ [25] and that this points to the conclusion that .‘chemical changes taking place in the chlorophyll would afford a more satisfactory explanation of the origin of the stimulus than [Haberland’s hypothesis] of the pressure of light upon the cytoplasm.’ [26] Far from claiming plants to have a brain, he in fact maintains that the chemical action of light induces patterns in the shape and distribution of the chlorophyll - first destroying them and then optimising their re-creation. They are chemical reactions not generically distinct from the chemical reactions that

[21] Wager 1908, p.462
[22] Wager 1908, p.464
[23] Wager 1908, p. 464
[24] Wager 1908, p. 478
[25] Wager 1908, p.481
[26] Wager 1908, p.488

underlies our image based vision; both involve energy transfers through chemical reactions provoked by different frequencies and intensities of light.

Wager sets out to show how these differences of intensity correspond to what we translate as images - but most of his photographs are directed to showing these differentials in energy and not their composition into images. Indeed his showing of images through the plant lens such as this face, this photograph, houses perhaps provoked the misunderstanding of his claim. It was not that plants take photographs but but that plant photography provides the basis for our more limited and specialised practices of vision and photography.

When we examine the photographs Wager took by his method - placing himself behind the lens of the plant - we can detect an uncanny ambivalence in his images. In some cases he adapts the plant lens to the camera lens of human based image photography. With this he seems to suggest that plants not only see and photograph, but they see and photograph the human world. Which according to Wager they in a sense do, but not by means of an image constructed out of electro-chemical signals transmitted from the array of rods and cones in the animal retina to the optic nerve. Wager set out to offer photographic proof of the visual and retentive powers of plants by playing out the subjective and objective genetive of the photography of plants as a visual supplement to his scientific argument. Carefully framed in terms of equipment used and technique followed, he proposed photographs of the human world seen literally through the plant lenses extracted from leaf epidermis and concluding with the photography through the plant lens not of objects but of intensities.

In the group of images of the human world, Wager lent particular attention to the photography of existing photographs through the plant lens. His circular mphotographs double as images of the array of plant lens seen under a microscope lens and of the image perceived through them. His comment on fig. 1 describes the photograph as a ‘Reproduction of a photograph taken through the upper epidermal cells of Tradecescalia Fiumiiunsis. Some of the cells are in much better

focus than others.'[27] The array of epidermal lens seen under the microcope is shown in the act of capturing the image of a portrait photograph. Figure 12 also reproduces a photograph in the same way but showing the double lens of the outer and inner lens cells: 'Zabrina pendula. Image of a cabinet photograph, taken through the papillate projection on the outer cell-wall, and focused very nearly on the basal wall in each cell.'[28] In this case it seems as if the photograph is captured by one lens and then projected onto another, producing a complex microscopic image that corresponds to the steering of light through the epidermal to the internal chlorophyll cells. Figure 3 is photographed through 'special cells on the underside of the leaf of *M. Cordifolium ' and* shows a distorted view of a distant house while figure 22 shows 'the figure of a pipe focused on or near the basal walls' [29] Wager seems to use these images of the human world and geometrical figures - such as the image of a cross in figure 24 - in order to create the illusion of plant *image* photography, but it is one in which he insists the image is only present for the human viewer - the plant will see no difference between the differential intensities of light that for us correspond to images and others that seem to us to be abstract and not image based.

Most of Wager's plant photographs do not involve images but show the effects of light as applied to the lens. The main interest is not so much the object of vision as the array of cells that constitute the visual apparatus of the plant. Figure 16 shows the 'Basal walls of the cells in the same preparation when light fals obliquely upon the outer walls. Half of each basal wall is in the light and half in darkness.' [30] His figure 17 is an especially interesting photograph of the 'Upper epidermis of *Eranthis kyemalis'* that shows 'the irregular light areas below the basal walls of the epidermal cells whenallowed to fall on the curved outer walls through a small diaphram opening. Here and there in the light areas in each cell are to be observed clearer circular disks of light, due to the more pronounced curvature of the cells. Each one of these is capable of forming an image of an object near it.'[31] Figure

[27] Wager 1908, p.488
[28] Wager 1908, p. 488
[29] Wager 1908, p. 489
[30] Wager 1908, p. 489
[31] Wager 1908, p. 489

18 of the petals of Phlox provides a clearer example of this formation of image centres ‘showing a clear disk of light in the centre of each cell’ [32] These circular disks visible within the cells offer sight of the potential for image capture on the part of the plant, they are photographs of the plant’s capacity to capture and register differentials in external light, which is to say, to photograph.

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In *The Revolutionary Genius of Plants* Stefano Mancuso reproduced Wager’s photographs to accompany his discussion of Haberlandt and Wager’s anticipation of recent directions of research on the visual capacity of simple organisms. And when he returned to the Wager and Haberland’s work in a 2016 article ‘Vision in Plants via Plant Specific Occeli’ in the journal *Trends in Plant Science* - exploring the properties of some plants to camouflage themselves by imitating their surroundings - he reported that the 1908 debate provoked a century of silence that is only now lifting. But from the standpoint of the Copernican Revolutiom of the plant and the development of digital photography out of stellar spectography and AI, Mancuso was able to see a new relevance in this debate, one capable of shifting not only botany but also photography away from exclusively understanding the drawing of light in terms of the specialised image making of the 0.01% of the planetary biomass to the way light is worked by majority life, the 80% of the biomass represented by plant life and enigmatic 12% of funghal life. In this light Wager’s work remains a pioneering episode in the theory and practice of an non-human, non image based photography.

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[32] Wager 1908, p.289

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