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Botanical Fabrication: A research project at the intersection of design, botany and horticulture

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Abstract: 'Botanical Fabrication' is an on-going research initiative which investigates how an understanding of botany and horticultural techniques can challenge the design process and lead to alternative sustainable manufacturing or 'eco-facturing' tools. This paper presents different phases of the project, from an initial research workshop (2012), to an exhibition-based experiment (Botanical Factory, 2013) and includes current work in progress (Solar Gourd, 2015) so as to articulate a critical analysis of the work to date. In a context where we urgently need to devise new principles to live, manufacture and consume within the ecological capacity of our finite planet, the paper argues for the development of a new framework for slow manufacturing with plant systems. From Darwin's research into plant movements to our current understanding of plant physics and biomechanics, designers can begin to integrate botanical and horticultural knowledge to play with the environment of plant growth and envision production chains of a new type.

Keywords: Botany; Plant physics; Industrial design; Future manufacture; Sustainability.

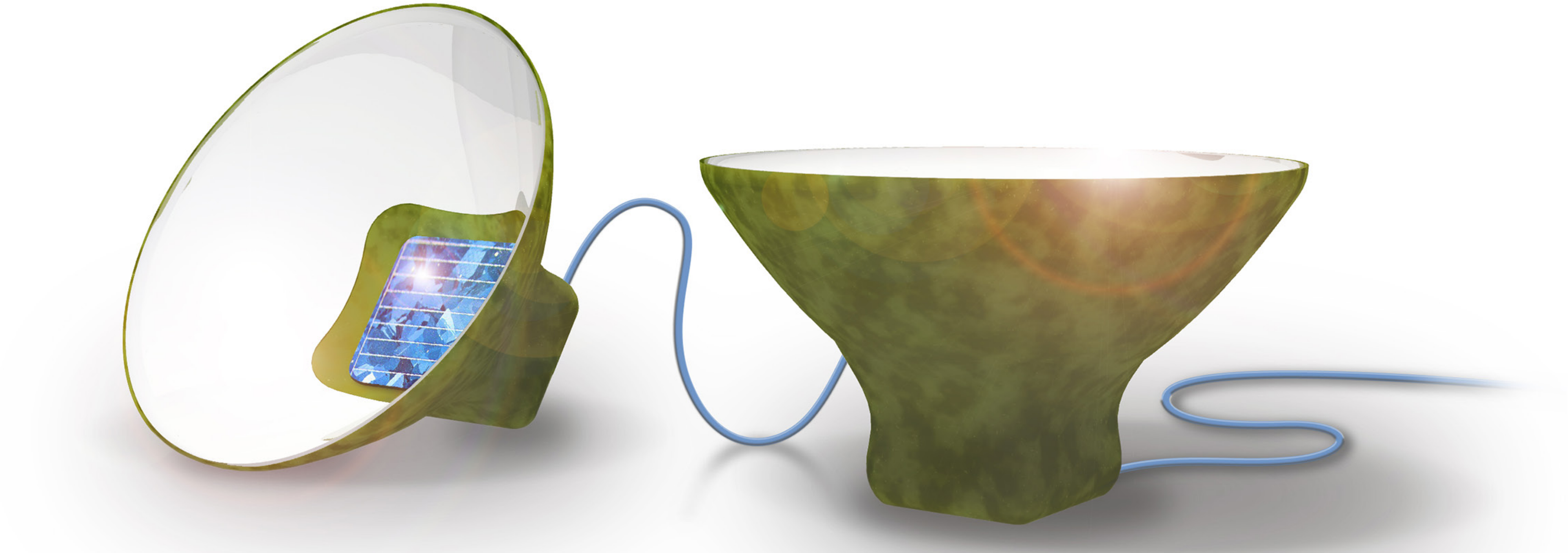

Figure 1: Growing a multiplug. Design Guillaume Jandin 2012

1 / Introduction

'Botanical Fabrication' is a research initiative which aims at investigating how an understanding of botany and horticultural techniques can challenge the design process and lead to alternative sustainable manufacturing and 'eco-facturing' tools. In a context where we urgently need to devise new principles to live, manufacture and consume within the ecological capacity of our finite planet, the paper argues for the development of a new framework for design and manufacture inspired by plant physics and biomechanics. A selection of design proposals that have emerged from a research workshop (2012), an exhibition-based experiment (Botanical Factory, 2013) and a current design project (Solar Gourd, 2015) are presented below so as to inform a critical analysis of the research to date. Each stage has led to explore both the imaginary and the practical realities of intersecting design thinking, plant physics and horticultural techniques and have contributed to develop a pertinent body of knowledge in relation to potential future botanical manufacturing. To date, the research has been limited to one-off small scale experiments and needs to move to larger production scales to test and validate the hypothesis. As such this paper relates to 'ways of making' and 'ways of knowing' and is a work in progress.

2 / Context

There are two key drivers for this project. The first is a quest for a paradigm shift in our manufacturing models to explore sustainable alternative modes of production. The project aims at exploring the intersection of botany and horticultural techniques to explore radically different means of production emerging from principles of sustaining life rather than from an abusive exploitation of natural resources. 'Today, humanity is in an ecological overshoot – requiring the equivalent of 1.5 planets to provide the renewable resources we use and to absorb our carbon waste' as argued by Moore and Rees (2013: 41) and we urgently need to reconsider our ways of making and consuming. Influenced by research in biomimicry where Nature is acknowledged as a model for sustainable fabrication, we wanted to explore ways to make a product using an ecosystem of plants, therefore relying on sun and water to 'fabricate' product components and engineered materials. How can we rethink a production model by transferring horticultural techniques to design and manufacturing? Can we design the environment of growth so that plants can be controlled to generate pre-conceived shapes and materials? Could this lead to manufacturing models of a new kind?

The second issue we wanted to address was in response to the emerging genetic engineering landscape arising from synthetic biology. The past four years have seen a fast increase in research towards computer-programmed new species, engineered to suit our needs. One leading argument is that to fabricate sustainably like nature does, we need to hack nature to re-appropriate some of its functions. Synthetic biologists claim that they will provide the next generation of sustainable substances and materials and this is endorsed by institutions such as the Royal Society and the OECD: 'Synthetic biology can help us address key challenges facing the planet and its population, such as food security, sustainable energy and health.' (OECD & Royal Society, 2010: 8). We believe that the current hype surrounding this new science, which is in effect a form of extreme genetic engineering, can lead to by-pass or overlook other alternative sustainable production models which can be accessible by all. With 'Botanical Fabrication', we propose to shape plants without genetic tinkering and to predict rather than to program plant forms. We want to treat plant as partners and/or providers of a service and we propose to follow nature's rhythm of production.

3 / The Botanical Design Process, a Research Workshop

So what could be the implications of interfacing botany, horticulture and design in terms of future production models? This research project started with a one week workshop conducted in July 2012 and designed to explore this question with a group of 24 industrial and textile designers. The co-investigators devised a set of creative briefs to challenge their design thinking and to incorporate botanical and horticultural knowledge within the design development.

To conceive new products, designers are usually educated to understand a wide range of mechanical and chemical manufacturing processes, from injection moulding to CNC milling, or 3D printing. The first objective of the workshop was to inspire a new approach to design by introducing key botanical facts and biological principles of life and growth. 'Plants constitute over 90% of the biomass on the planet' (Niklas 1992: 47) and they grow according to constraints set by their physical environment. Despite being sessile, they continually move: 'All the parts or organs in every plant whilst they continue to grow...are continually circumnutating' (Darwin: 477). As demonstrated by Darwin this form of growth is also constantly affected by external stimuli. So we chose to explore how the morphogenesis of plants can be affected by environmental factors and to investigate principles of biophysics such as phototropism, thigmomorphogenesis and gravitropism as a starting point. These tropisms directly affect the shape and structure of the plant's matrix which adapts its form to optimize its functions. 'This means that, in biology, it is natural to expect that form follows function: that the shape and structure of a biological entity ... is that which best equips the associated organism for survival' (Ball 2009:11). So here we find a parallel with design: the form of a plant is derived by its function, but can directly be affected by a range of tropisms. We know that plants have the ability to adapt by 'changing size, shape or geometry as they grow and develop' (Niklas & Spatz 2012: 26). What if we could engineer the environment of a plant to control the shape of its branches? For example, could we use positive and negative gravitopism to create a 90 degree angle on a branch and thus pre-form the branch of a tree for a section of furniture?

Since Darwin, the study of biomechanics in plants has established key measurable and controllable parameters that affect plant growth. This means that we have access to mathematical rules and algorithms that are embedded in the process of growth and we dedicated the first day of the workshop to explore how tropisms could be used to engineer plant forms without using direct mechanical interventions. This was the first step towards an understanding of the natural laws that govern living plant systems. Of course the field of horticulture has long established means to control plants morphology, reproduction and life cycle with direct interventions. Pruning for instance can be used to guide growth or to train a plant, whilst coppicing is used to help trees rejuvenate (Brickell & Joyce 2011: 13). However these are not techniques known to most designers, so we also introduced some basic principles of horticulture.

Figure 2. Research workshop, exploring plants physics, Central Saint Martins July 2012.

The workshop participants were then invited to develop a design methodology appropriate to this new potential production and cultivation framework. How can designers incorporate plant biomechanics in the conception of product components that can be grown by a plant as opposed to produced by a machine? Working in groups they were invited to speculate on a new production cycle in the form of a 'botanical factory'.

It is important to note here that the focus of the workshop was to shift the design thinking from designing for manufacture to designing for horticulture. The ideas generated at this stage were therefore very much exploratory and not solution driven.

Here we present the original design concepts which were selected for the second phase of the research initiative (see section 4). The two charts in figures 3 and 4 illustrate imaginary 'farm factories' where component parts for electronic products are grown. In this exercise, the designers began to question the timescale of growth, the interconnectedness of plant systems and the ecological value of such proposals. We could easily extrapolate further and imagine this factory to be part of an industrial ecological park, where the Co2 emissions of a neighbour factory could be fed to contribute to the growth of the plants. Such model has proven to be very efficient with crops such as tomatoes produced by Wissington in the UK. Tomatoes grow twice the usual rate when benefitting from the redirected Co2 and heat waste of and adjacent sugar refinery (Short. S et al 2014:7).

One idea involved using the rapid growth of Wisteria to produce the structure of a headphone. The Wisteria stem would be trained to grow around a starting frame, and would then be harvested at pruning time to be dried and assembled with the other components of a headphone. Wisteria shrubs grow very fast, and it is recommended to prune them twice a year to help the plant strengthen its roots and encourage flowering. This design concept therefore relies on a very simple principle of horticulture.

Next is an illustration of the process of growth:

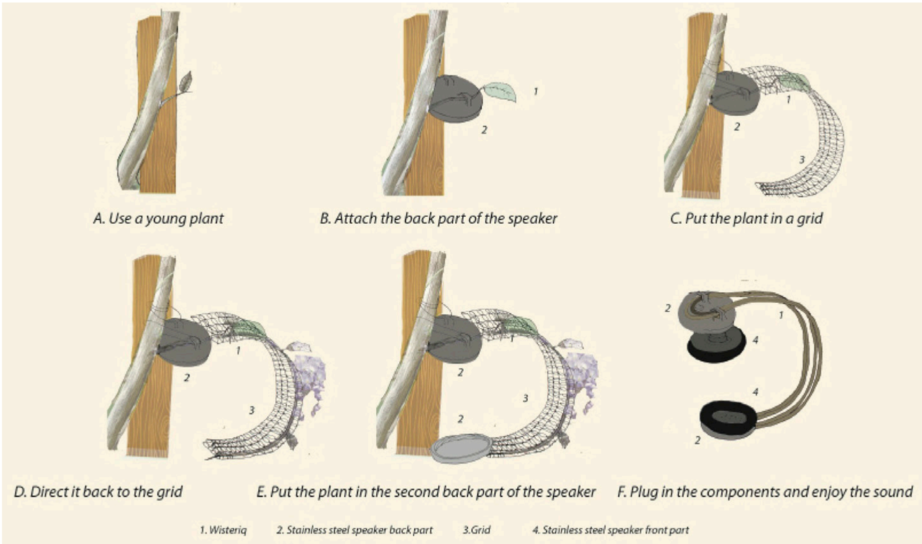

Figure 3. Design: Justine Andrieu, Gaétan Barbé & Raphaël Pluvinage 2012

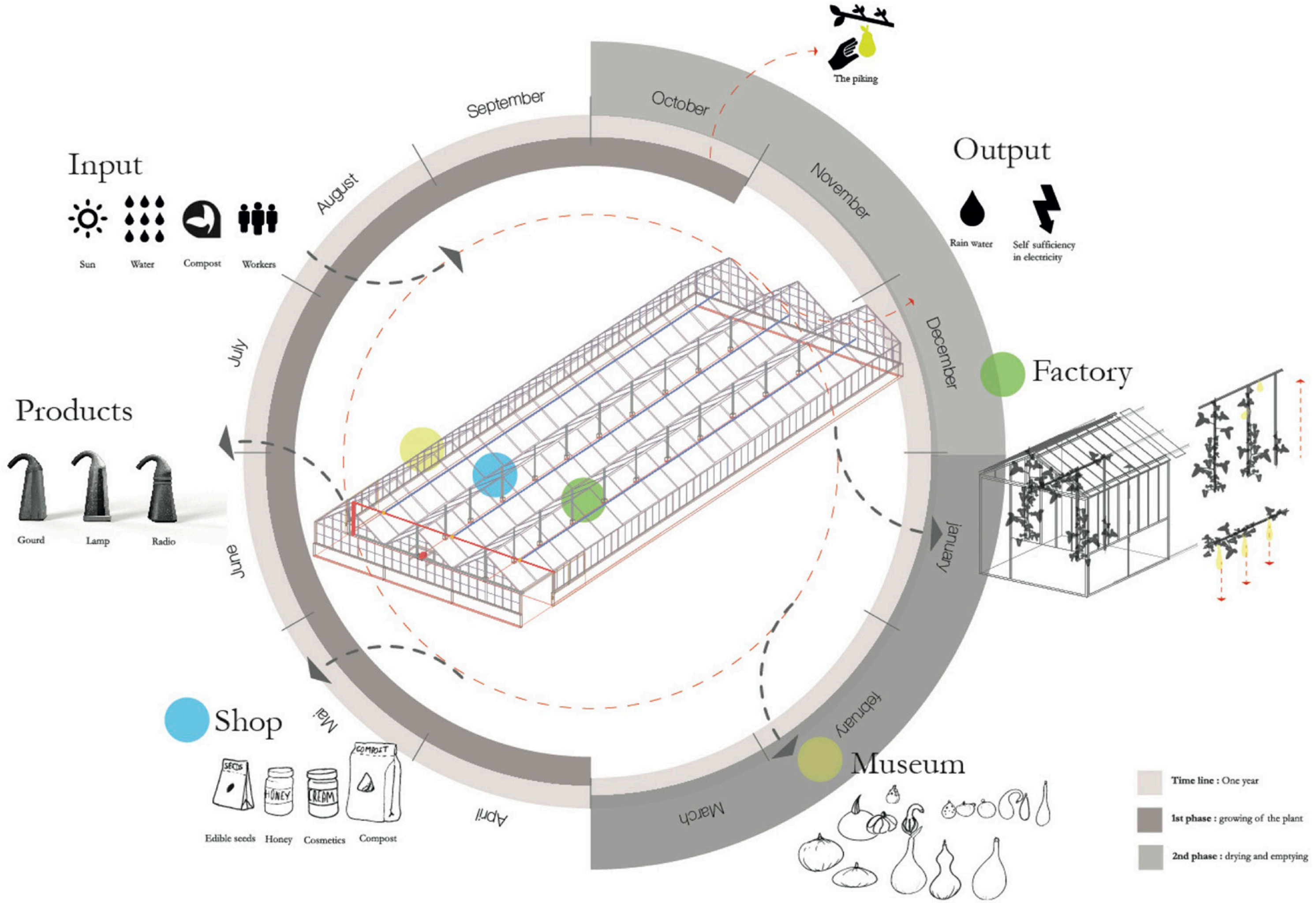

Figure 4. diagram of an imaginary farm-factory which would grow shell components for a portable radio. Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink 2012

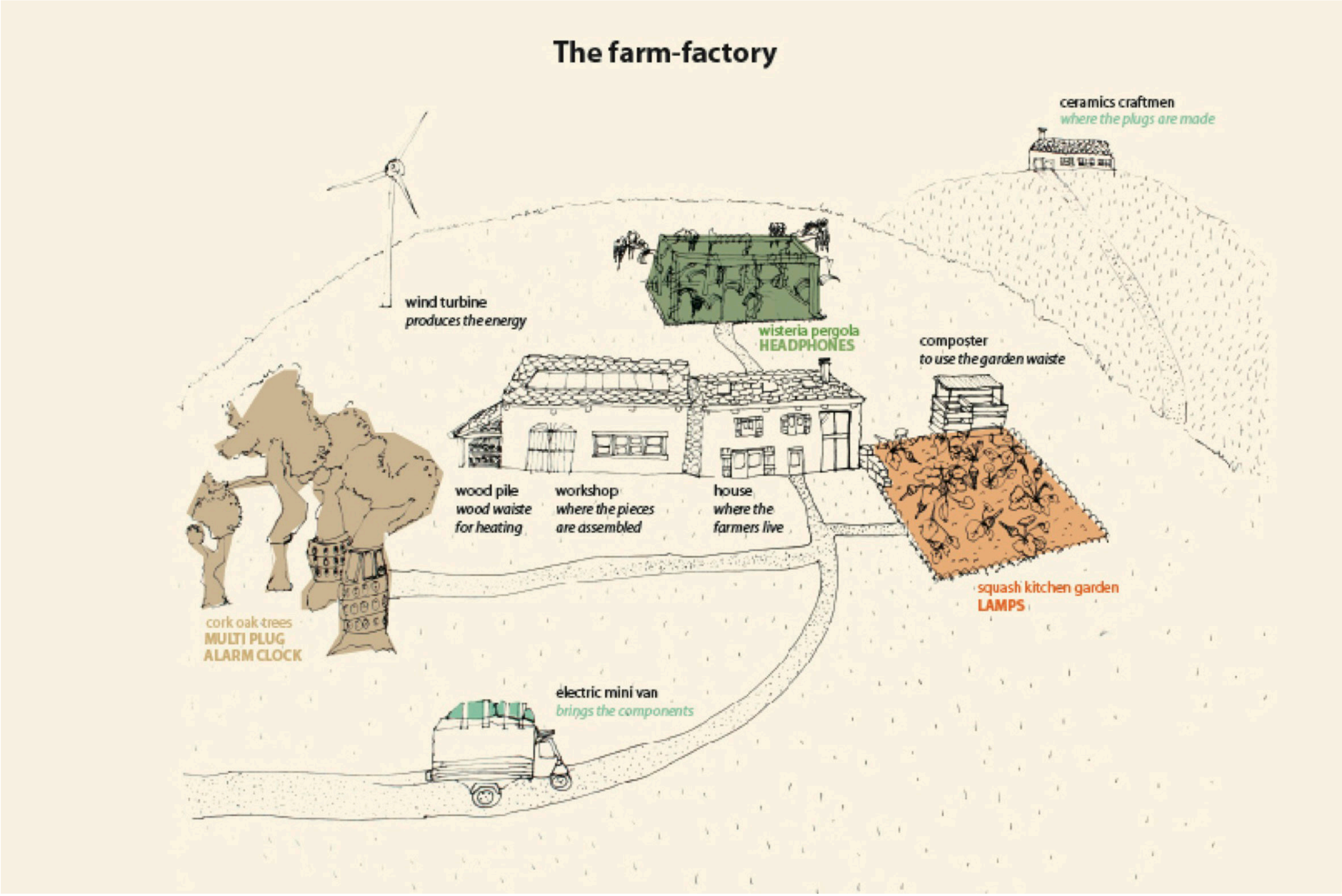

Figure 5. diagram of an imaginary farm-factory which would grow components for multi-plugs on Cork trees, and sections of headphones on Wisteria. Design: Justine Andrieu, Gaétan Barbé & Raphaël Pluvinage 2012

And the final wisteria headphone:

Figure 6. Design: Justine Andrieu, Gaétan Barbé & Raphaël Pluvinage 2012

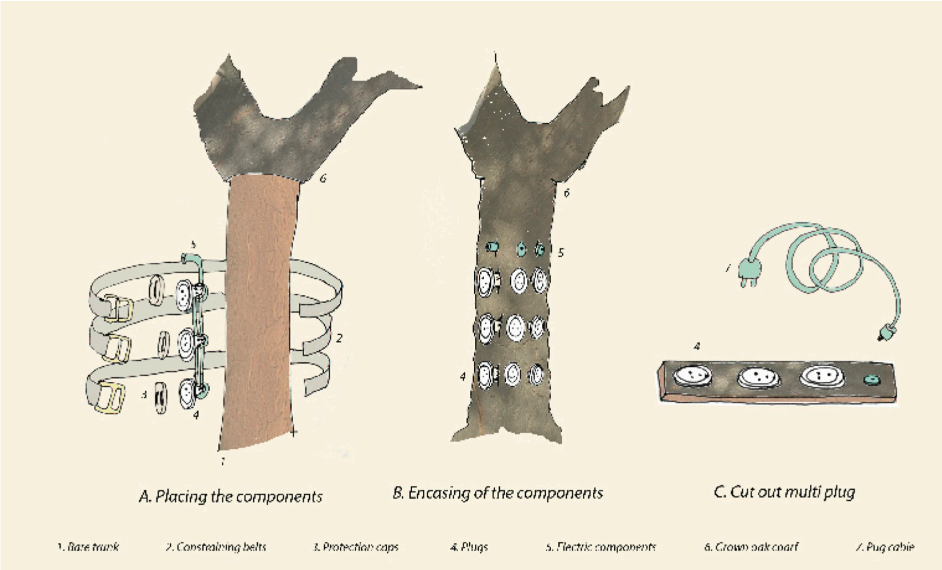

Figure 7. Internal components are inserted within the bark, to become slowly encased as the bark grows. Design: Justine Andrieu, Gaétan Barbé & Raphaël Pluvinage 2012

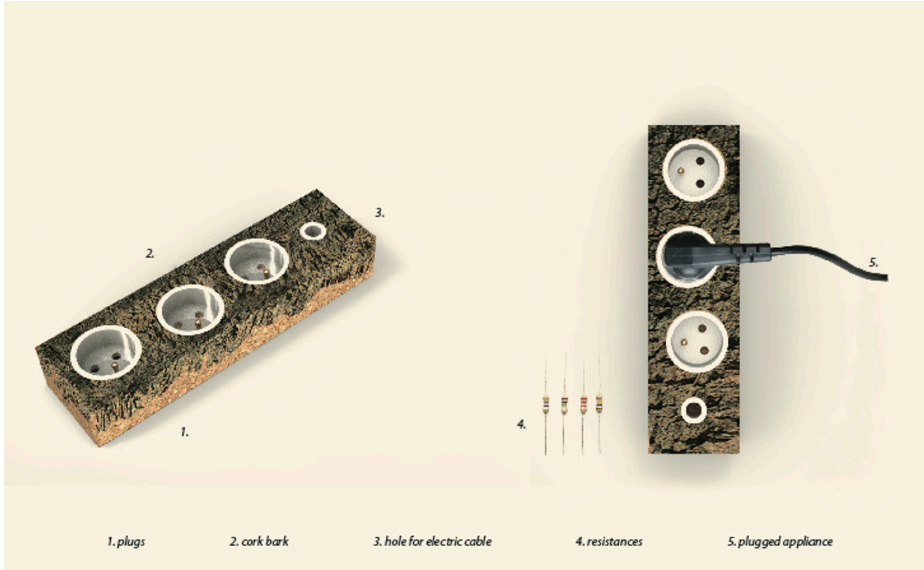

Figure 8. Design: Justine Andrieu, Gaétan Barbé & Raphaël Pluvinage 2012

By investigating how cork trees form a bark which can heal around an alien element, they also imagined slowly growing the external case of a multi-plug within the bark of a cork tree.

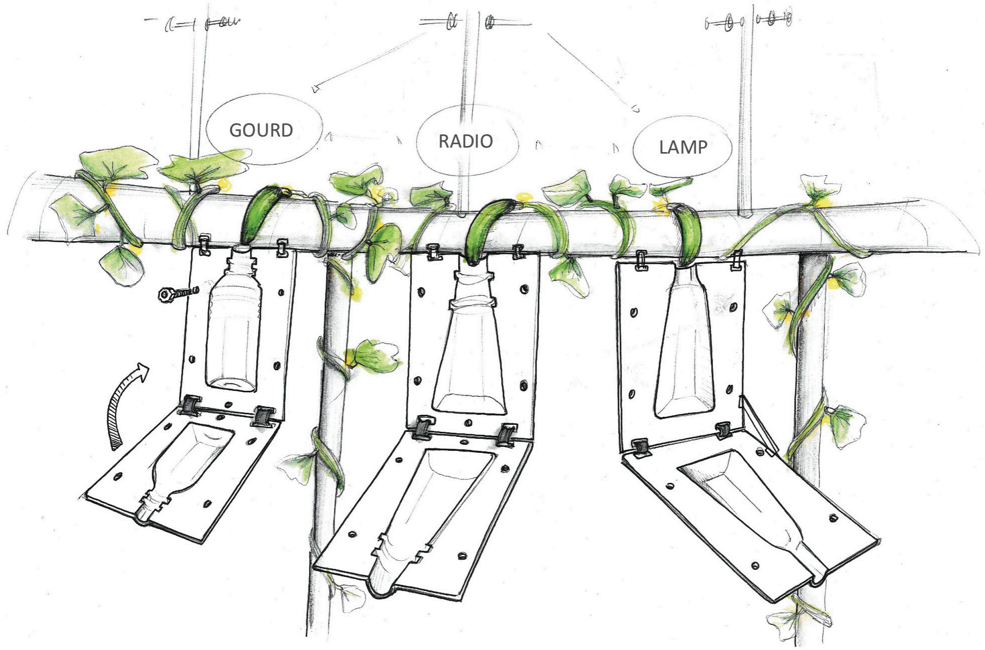

Figure 10: Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink 2012

Figure 9. Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink 2012

This project is a first step towards an imaginary of a new mode of design-led horticultural production rather than a set of concrete design solutions. Yet, this exercise was a mean to gain a different perspective on the idea of product manufacturing. Some of the projects were much more practical than others, but all integrated a notion of slow 'horticulturing' and of seasonal harvest thus challenging current production and consumption patterns.

Another key idea selected for the second phase of the research was to revisit the traditional craft of moulding gourds to grow the external skin of a radio or a lamp. Here designers are illustrating the pose of the moulds, when the gourds begin to grow just after blooming.

Figure 10 is an illustration of a 'gourd radio' once cut and assembled Gourds are warm season annuals and grow optimally in hot and humid climates, at temperatures ranging from 21–27°C but can be grown easily in a continental climate too. For moulding, the Lagenaria gourds are the most commonly used. The pose of the mould takes place as the gourd begins to grow and will not be removed until it is fully mature and the stem attaching the fruit to the vine begins to dry. Once harvested and left to dry over a few months, gourds naturally transform their outer skin into a hard shell comparable to wood. The process can take up to ten months in total. A wide range of products can be generated this way, whether the gourd if left to grow as it is, or whether a mould is applied around the gourd during its growth so as to create a specific shape or texture. Traditionally, such dried gourds are used as decorative containers, birdhouses, and even as the core of musical instruments. Below is an example of a snuff bottle produced by moulding a gourd and dated back to the 18th Century.

Could this very traditional craft be adapted to production chains of a new kind? This idea became the focus of the second phase of the research project as discussed below.

4 / Botanical Factory: a design-led horticultural experiment

Six designers selected from the workshop worked with the co-investigators to create a 'Botanical Factory' that would grow component parts for a multi-plug, a torch, a portable radio and a hair clipper. The actual cultivation of the gourds became a live design experiment exhibited in

Figure 11. China, Qing dynasty, Qianlong period, 1736-1795, Los Angeles County Museum of Art "www.lacma.org"

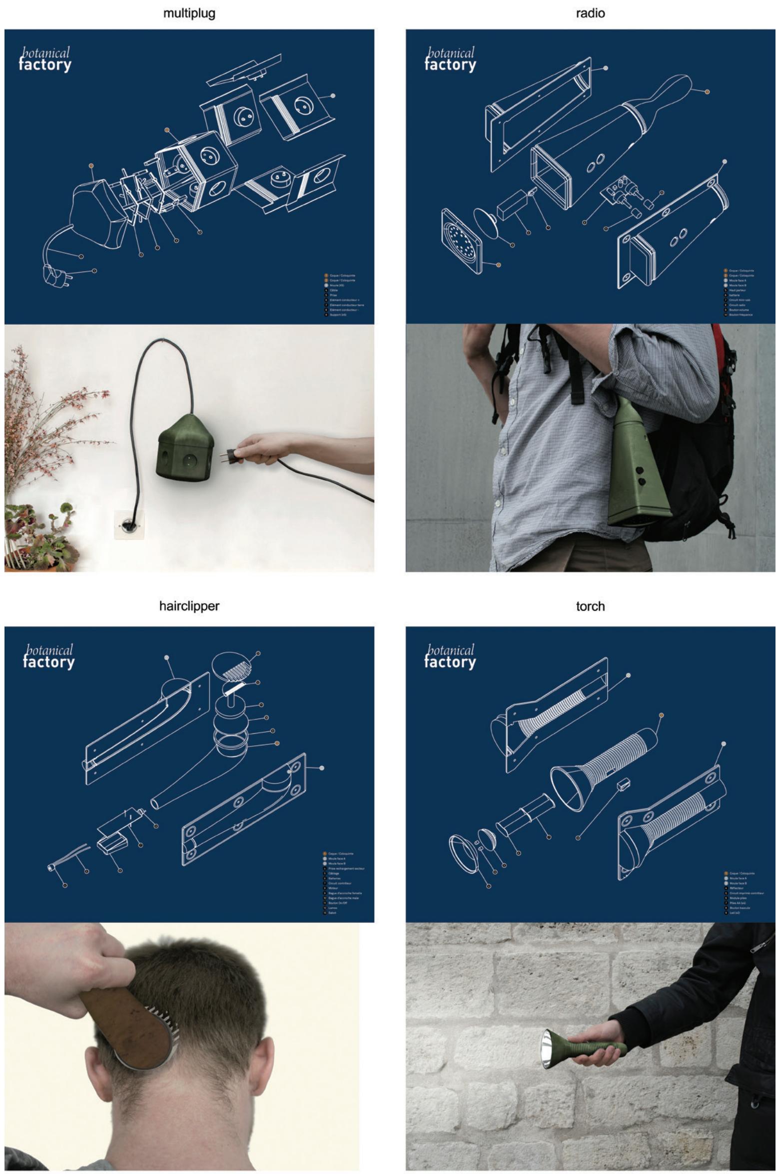

Figure 12. Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink, Justine Andrieu, Gaétan Barbé, Raphaël Pluvinage 2012

Figure 13. Detail of the multiplug and torch moulds applied to growing gourds with illustrations of the aimed results.Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink, Justine Andrieu, Gaétan Barbé, Raphaël Pluvinage 2012

Figure 14. Botanical Factory in the exhibition Alive, New Design Frontiers at the Espace Fondation EDF Paris.Design: Guillaume Jandin, Christopher Santerre, Arnaud Wink, Justine Andrieu, Gaétan Barbé, Raphaël Pluvinage 2012. Photography Laurent Lecat.

Alive, New Design Frontiers at the EDF Foundation in Paris from April to September 2013. Below are the four technical drawings and illustrations of the moulds which were thermoformed in plastic. Several techniques can be used, including plaster moulds, but we chose to produce reusable moulds. One of the challenge in the design process is to assess the potential final size of the gourd to ensure that the mould does not split as the gourd approaches maturity and reaches its final size. Equally if the mould is oversized, the gourd will not be fully constrained, and will be only partly formed. The gourd varieties grown for 'Botanical Factory' are Lagenaria 'apple' and Lagenaria 'birdhouse".

Unfortunately the conditions for growth in the exhibition were not optimum and the gourds did not reach full maturity, so we were unable to harvest the final products. Although this was a disappointment, we do know that moulding gourds is feasible as this is a long established craft. The key objective was to inspire designers to look beyond the current manufacturing model and to explore 'organic' and slow alternatives for industrial production. Here the gourd shells are designed specifically to replace the plastic components of ubiquitous electronic products. To date, the project has attracted a lot of interest, including the possibility to develop a pilot garden project for an eco-village where inhabitants could learn to use this craft to 'grow' their own day-to-day products.

5 / Solar Gourd

We acknowledge that many design iterations are needed to test the 'Botanical Factory' hypothesis further. The latest experiment is being developed for this paper and will be presented at the Research Through Design Conference 2015.

Here the main idea is to explore the cultivation of product components that could benefit emergent economies such as Africa where

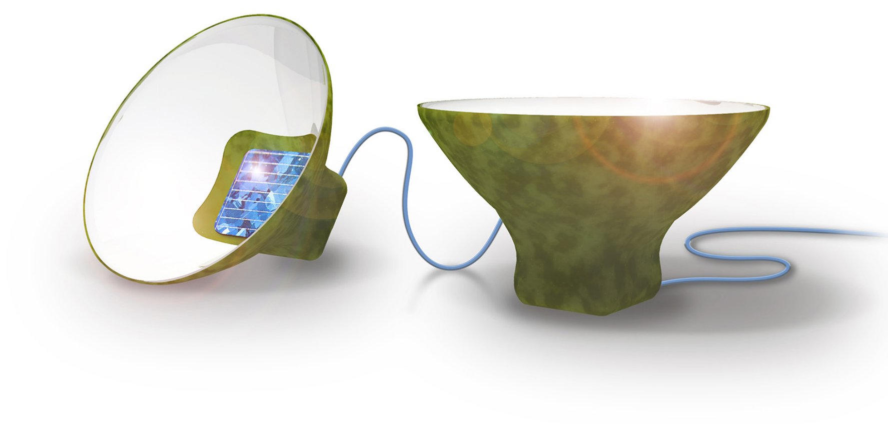

Figure 15. Solar Gourd: Concentrated parabolic solar collector. Design: Guillaume Foissac 2015.

Cucurbitaceae plants grow well. The mould is designed to fit either the Lagenaria 'apple gourd' or the Lagenaria 'birdhouse gourd'. Instead of a radical reshaping of the fruit, here the mould will help guide the curve of the gourd to follow a controlled parabolic shape so as to provide an optimum solar exposure for the photovoltaic cell. The top of the fruit will also be formed so as to allow for different standing positions. One of the key challenges is to investigate how to assemble grown and 'imperfect' components together with precisely manufactured metal or electronic parts. For this, we need to upscale the range and number of plant specimens used for cultivation so as to gather reliable data for optimum results. We are currently in discussion with potential horticultural partners to grow and test various moulding techniques on a larger crop.

6 / Rewilding design

Can we truly deviate from our current manufacturing model still largely relying on energy hungry machinery and oil-based chemistry? Can the above design and horticulture experiments begin to shift our industrial mindset? We believe that this way of thinking can lead to alternative paths, but there is a long way to go in refining the techniques and in establishing best design practice criteria. There has been a number of recent examples re-visiting the craft of gourd moulding and this is perhaps the most logical starting point to consider up-scaling this research initiative. However, if we are to explore the cultivation of product components, we cannot follow current conventional agricultural models that rely heavily on monocultures (to the detriment of our biodiversity) and on intense use of polluting pesticides and fertilisers. Aspiring models to explore include permaculture and industrial ecology principles. Permaculture is a model of agriculture based around the interconnectedness of species and designed to work in harmony with nature and a growing number of farms are now adopting this model. Industrial ecology was mentioned above and is in effect a means to transfer from conventional unsustainable manufacture to a cycle of economy of waste, where the waste of one producer, becomes useful to another (in the form of biofuel or Co2 for instance).

Another option is to use design-led horticulture to promote the merging of DIY and gardening activities together. In a context where 3D printers are predicted to enter our homes in the next decade, perhaps we can encourage people to contribute to greening their cities by growing day-to-day products. Instead of 3D printing, gardeners could rent moulds in local garden centres, and enjoy growing disposable and biodegradable artifacts for their communities alongside local food. This would mark a move towards slow design and slow consumption where the emotional gain is derived from the success of the crop rather than by the materialist drive to buy and own more and more products. Assadourian argues that ultimately, to continue to prosper on this planet, we need to re-engineer our current destructive consumer culture into cultures of sustainability so that' living sustainably feels as natural as living as a consumer does today' (Assadourian 2013:113). In this context, the idea of slow-growing versus rapid-manufacturing might become more appealing and help promote an emotionally-rich engagement with the making of day-to-day artifacts.

What matters to us is to 're-wild' design in the sense of reconnecting designers with the idea of producing in harmony with nature and to mark a break-through with the current economic model which takes nature for granted, as if we did not depend on it for our very own survival (Juniper 2013: iv). Yet, we do, and it is time to re-script our design processes.

7 / Conclusion

This research initiative is very much a work in progress and attempts to develop an alternative roadmap for manufacturing derived from horticulture and ultimately permaculture principles. We have began to engage with the imaginary of this new proposition but need to develop robust design principles which will require further research through practice and experiments before to be considered a viable option. We are very much hoping that through presenting this body of work, including freshly grown new products in the next RTD conference, we can outreach to the design community at large and encourage other designers to engage with this way of making.

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References

Assadourian, E. 2013. *State of the World 2013, is Sustainability Still Possible?* The Worldwatch Institute, Island Press.

Ball, P. 2009. *Shapes*. Oxford University Press.

Brickell, C, Joyce, D. 2011 The Royal Horticultural Society Pruning & Training, the definitive practical guide to pruning trees, shrubs and climbers. Dorling Kindersley.

Darwin, C. *The Power of Movement in Plants*. Tredition Classic. Reprint of original text dated 1880.

Juniper, T. 2013. *What Has Nature Ever Done For Us? How Does Money*

Really Grow On Trees. Profile Books.

Moore, J & Rees W.E. 2013. *State of the World 2013, is sustainability still possible?* The Worldwatch Institute, Island Press

Niklas K & Spatz H-C. Plant Physics, The Univeristy of Chicago Press, 2012.

Niklas K. 1992. *Plant Biomechanics, an engineering approach to plant form and function.* The Univeristy of Chicago Press.

Samuel W. Short, Nancy M.P. Bocken, Claire Y. Barlow, and Marian R. Chertow. 'From Refining Sugar to Growing Tomatoes'. *Journal of Industrial Ecology*, Volume 18, Issue 5, Article first published online: 29 AUG 2014 (accessed 20th of October 2014)

OECD & The Royal Society. (2010), Symposium on Opportunities and Challenges in the Emerging Field of Synthetic Biology, SYNTHESIS REPORT. Available at: http://www.oecd-ilibrary.org/science-and-technology/symposium-on-opportunities-and-challenges-in-the-emerging-field-of-synthetic-biology_9789264086265-en;jsessionid=1kwxknihjtlmr.delta. (Accessed 24-01-2014)

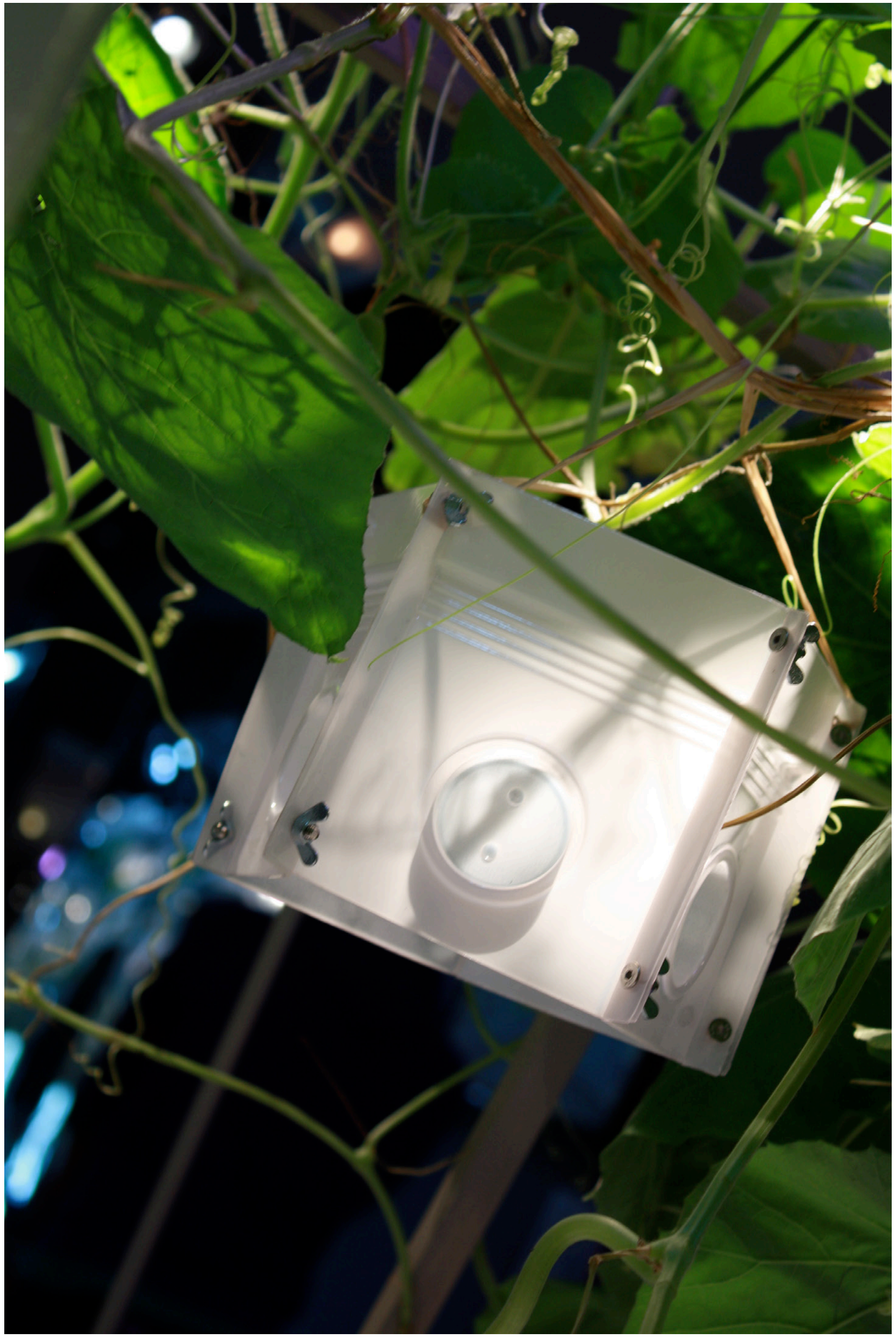

Figure 16. Detail of the Botanical Factory exhibit at Alive, New Design Frontiers, Espace EDF Foundation, Paris 2013.