

Received: 6 January 2020 | Revised: 30 June 2020 | Accepted: 3 July 2020

DOI: 10.1002/ppp3.10133

RESEARCH ARTICLE



The Global Garden project: Imagining plant science

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Funding information

Biotechnology and Biological Sciences Research Council, Grant/Award Number: BB/L014130/1 and BBS/E/J/000PR9790; John Innes Foundation

Social Impact Statement

Plants are rich sources of drugs and other high-value chemicals that are used by humans. Many of the plant species that produce important molecules grow in remote locations and have extensive histories of indigenous use. Global concerns about sustainable supply have in some cases led to the development of alternative methods for production using biotechnological approaches. Consideration of responsible stewardship and use of the world's plants and associated traditional knowledge for the greater human good are at the heart of the Convention on Biological Diversity and the recently implemented Nagoya Protocol. The development of fora that enable open discussion and exploration of issues relating to these aspects will be critical in endeavors to protect and preserve both the environment and present and future generations.

Summary: Here, we investigate the application of cross-disciplinary approaches to explore societal perceptions of plants and their uses, focusing on high-value chemicals. The Global Garden project engages the public, researchers, and regulators in day-long workshops that combine science, poetry, and visual arts practice to foster participants' skill in imagining and re-imagining relationships between high-value plant products, biotechnology, and social and ethical aspects of these. The project represents an intervention into discussions of science communications and public engagement, addressing the uses and benefits of arts-based approaches to foster imaginative engagement with plant science. The workshop reported here began with real plant case studies and a discussion of the aims of scientists using them. Participants were invited to respond to the issues of relationships among plants, chemicals, and people raised by the case studies through poetry and visual artwork. The poems and artwork that were produced show variation in the participants' imaginings of plant science. They present distinctive visions of research and innovation and of the associated ethical and social implications. This type of forum, based on creative immersion, opens up opportunities for engaging with and exploring complex relations between plant biotechnology, society, and ethics. This article offers a reflection on the uses, challenges, and implications of arts-based approaches to

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research communications and public engagement that disrupts traditional knowledge transfer structures. In doing so, we frame the project within science communication pedagogies and consider public engagement a form of pedagogy.

KEYWORDS

biotechnology, drugs, flavorings, high-value biorenewables, imagination, sweeteners, synthetic biology

1 | INTRODUCTION

The Global Garden project offers a new perspective on public engagement in plant science. It translates over 10 years experience of work with children, conducted by the Science, Art and Writing Trust (www.sawtrust.org) (Osbourn, 2009), into workshops for groups of adults who have a professional or personal interest in plant science. It brings gardeners, biotechnology regulators, researchers, and artists together to re-imagine plant science and its ethical and social implications using art/science discourses. The core purpose of the Global Garden project is to use poetry and visual art as means for adult participants to develop their understanding of plant science, and to foster their imagination about this topic and the host of social and ethical issues its application implies through creative means. The approach creates workshop environments that stimulate a diversity of 'bio-social imaginations' (Lee & Motzkau, 2012). In what follows, we describe our approach and our practice and present some early findings from the first of our ongoing workshop series.

2 | SCIENCE AND PUBLIC ENGAGEMENT: FACTS, VALUES, AND IMAGINATION

Communication is a crucial element of scientific research, informing lay audiences such as journalists, policy makers, stakeholders, institutions, and scholars. Indeed, the urgency of the need for effective science communications has become more pertinent in the age of climate crisis, particularly in places where confusion and skepticism over climate change prevail (Somerville & Hassol, 2011). The communication of scientific research, in this case, tangibly impacts people's lives and their interactions with the environment. Critiques of a so-called 'deficit model' of public interaction with science, in which scientists combat perceived gaps in public knowledge attributed to basic ignorance, have resulted in the development of approaches in which 'the scientific community ... reflexively engage the public in a genuine dialogue' (Jones, 2011).

Still, the deficit model persists: Hallerman and Grabau (2016) argue that there is an urgent need to secure global public acceptance of agricultural biotechnology. They call for education to counter public misconceptions about the risks of genetically engineered crops and fears about the power of multinational corporations. On this view the public need to learn facts from

experts. Esvelt (2016) works on gene-drive systems that are capable of spreading engineered traits through wild populations of organisms. The possible benefits of deploying any gene-drive system will involve ecological change and risks that will affect communities outside the laboratory. In contrast to Hallerman and Grabau (2016), rather than seeking to educate against public misconceptions, Esvelt proposes a model of 'responsive science' in which research plans are made available to the communities they are likely to affect from the earliest stages of their development, to seek their preferences. In this scheme, while the public need to learn facts and plans from researchers, researchers, for their part, need to learn about and respond to public preferences. Thus, responsive science sets limits, realistic or otherwise, on expectations of the public's capabilities. The public is credited with the possession of values but little else. This resonates with Jones' view, developed through engagement with nanotechnology communication, that public engagement is and should be 'part of an explicit process of democratizing science, in which research priorities and the trajectory of technologies are steered with reference to public values' (Jones, 2011).

The strength of the deficit model and of the strategy of positioning the public as bearers of 'value' lies in the ability of scientists to present science as a set of established facts that will not be altered by their encounter with the public's values. This way of relating fact and value and researchers and the public has surface validity, even if it risks reproducing the 'deficit model' view that researchers are the expert teachers and the public is the, more or less compliant, learners. The Global Garden project, however, emphasizes 'imagination' over the familiar duo of 'facts' and 'values'. While facts may be known and values may be contested, the relationships among plant science research practices, commercial production, and use of plant-derived chemicals, and matters of power and of social and economic justice remain open to being imagined, re-imagined, and ultimately re-cast in the form of future research practice, business practice, and the institutional and social frameworks that support them. Thus, the Global Garden approaches science communication as an opportunity to foster the capacities of researchers, policy makers, and the public to imagine plant science in terms not only of facts and values, but of the existing and potential social and material relationships it can help to build, within or without the logic of capital accumulation that informs so much decision making about people, plants, and production (Isaacman, 1997). Global Gardens certainly avoids the deficit model and is thus better understood as a dialogical form of public

engagement with science than as an exercise in the public understanding of science. Furthermore, as Davies, McCallie, Simonsson, Lehr, and Duensing (2009) make clear, while there are examples of dialogic public engagement that aim directly at informing policy, there are others, like Global Gardens, that use relatively symmetrical relationships between participants from scientific and other backgrounds to foster small-scale learning through social processes.

3 | IMAGINATION AND PLANT SCIENCE

Like Surridge (2017) and Hoffman and Furcht (2014), the Global Garden sees imagination as a positive resource for making sense of the practice, ethics, and social implications of plant science. As the educationalist Montessori argued, imagination is quite distinct from fantasy because of its intimate connection with practical activity (O'Donnell, 2007). While fantasy offers escape from reality, imagination is a site for developing capacities creatively to engage with the material world. We acknowledge that the ways in which plant science is currently imagined are shaped by a historical legacy of associations (Haraway, 2016; Nerlich & Clarke, 1999), but we also suppose that they remain open to being reshaped. The public's responses to innovative plant biotechnology often focus, for example, on the question of what is 'natural' and what is 'artificial' (Blanke, 2015). This distinction informs some responses to genetically modified crops (Ribeiro, Barone, & Behrens, 2016) and to synthetic biology (Avellaneda & Hagen, 2016). The distinction itself is not a matter of fact, however, but is an element of a particular imaginative repertoire that has its origins in the Western philosophical tradition, in particular, Aristotle's 'Physics' (Aristotle, 2008).

Seeing imagination as open to diversity and to change is important today, as human activity and non-human global processes are combining to create the conditions of the new geological era of the 'Anthropocene' (Crutzen, 2002) and as 'synthetic biology' (Freemont & Kitney, 2012) and 'artificial life' (Venter, 2013) have become thriving research fields. In these fields, natural processes and human activities are becoming hybridized across a range of scales. This is happening alongside rapid technological developments in genome editing (Bortesi & Fischer, 2015) and increasing environmental stress on plants and people. This suggests that one tool of imagination at least, the natural/artificial distinction, may be losing its practical value as a guide to assessing plant science. As we have argued elsewhere, there is a need today to foster new 'biosocial imaginations' (Lee & Motzkau, 2012) that can re-draw links between life processes, technologies, societies, and ethics. A greater diversity of imaginations in this context could broaden the range of culturally available ways of responding emotionally and intellectually to emerging challenges and opportunities and to the application of plant science in doing so. Global Garden workshops are opportunities to build the diversity of imagination regarding plant science for individuals and, potentially, for wider society.

In the following section we will present our rationale for the methods we adopted in designing the workshop, but we can now state the key questions that we wanted to answer:

- Can an arts-based approach to science communication be used to foster rich imaginative responses to case studies of plant science?
- Can an arts-based workshop enable participants to produce diverse ways of imagining and evaluating plant science and its many material and social relations?
- Can an arts-based approach help to add an emphasis on imagination in science communication practice?

4 | ARTS-BASED RESEARCH METHODOLOGY

Arts-Based Research (ABR) is a broad set of research practices in which creative, expressive, or artistic elements are utilized within the research process. For the purposes of this project, which blends science research, communication, and pedagogy, we follow Barone and Eisner's broad but useful definition: 'Arts based research is a process that uses the expressive qualities of form to convey meaning' (Barone & Eisner, 2011). The workshop emphasized shared, creative experiences over the exchange of representations of facts or viewpoints reflecting ABR's setting aside of the pursuit of 'knowledge claims or achieving validity and reliability' (Barone, 2008). This follows a tradition of arts-based approaches to both research and pedagogy and represents an intervention into what might be referred to as traditional science communication.

ABR emerged in the 1990s as an aspect of wider civil rights challenges to assumptions about the value of different kinds of knowledge. It notes the high social and funding status of empirical science and the relatively low status of the arts. Taking account of the power dynamics at work in knowledge production (Haraway, 1988; Leavy, 2015)—including gender, ethnicity, and, not least, the deficit model of the non-expert public—arts-based approaches challenge academic conventions that present the kinds of knowledge that consist of factual, empirical truths as the sole standard of validity. Arts-based approaches center 'aesthetic knowing' (Eisner, 2005; Leavy, 2015) or modes in which knowledge is 'revealed within aesthetic experiences' (Viega, 2016). The purpose of this is not to deny the value of empirical facts, but to present the exercise of imagination and creativity as valuable aspects of knowledge production whether they take place in communities that self-define as scientific researchers or among diverse publics or, as in the Global Garden, in meetings of researchers and the public.

Arts-based approaches have contributed to natural and experimental sciences in the past. Sullivan's 'Notes from a Marine Biologist's Daughter' (Sullivan, 2011) takes the form of poetry and stanzaic prose to meditate on experiences of marine biology, Kamen explores natural sciences through sculpture (Kamen, 2017), and the Science, Art and Writing (SAW Trust) (see Osbourn, 2006, 2009) has engaged young learners for over a decade. Drawing connections between art and scientific practice can challenge a tendency for reductive, quantitative science to limit attention to its own social implications or to place ethical questions and empathic responses outside the bounds of proper scientific

enquiry. The plant scientists Econopouly and Jones (2018) follow the associations that are made within a painting by Jean-Michel Basquiat among Darwin, Huxley, and Mendel as the founders of evolutionary and genetic science, and capitalist and colonialist exploitation of both human lives and plant genomes. Following Basquiat's presentation of these associations, their discussion is able to go beyond a critique of racist pseudoscience to consider the intimate and abiding relationships among plant science, the horrors of slavery, and international trade and profit that were struck in US cotton plantations. They present the question of how to reintegrate scientific practice with empathy and an inclusive ethical imagination to avoid scientific complicity with injustice in today's circumstances, where exaggerated claims for technology's

ability to end suffering remain accompanied by the strict elimination of emotional responses from conventional scientific practice. Arts-based approaches have also helped articulate the affective qualities of humankind's relationship with the environment, as has been elaborated through the recent affective turn in ecocriticism (Bladow & Ladino, 2018; Davidson, Park, & Shields, 2013; González-Hidalgo & Zografos, 2020; Kemkes & Akerman, 2019). Such approaches involve what Eisner refers to as the 'imaginative transformation of images,' a process underscored by the ability of imagination to provide images of what is possible as a platform for seeing the actual from new perspectives, allowing us to 'try things out' (Eisner, 2002). Arts-based research is less about hypothesizing, answering concrete questions, or offering a sense of certainty



FIGURE 1 Case studies used in the Global Garden workshop. (a) Madagascan periwinkle; (b) sweet wormwood; (c) vanilla orchid; and (d) sweetleaf. The sources of the images are as follows: (a) Madagascan periwinkle plant, Sarah O'Connor and Andrew Davis, John Innes Centre; vinblastine molecular model, Marina Vladivostok (commons.wikimedia.org/wiki/File:Vinblastine_ball-and-stick.png); MALDI-imaged leaves, Lorenzo Caputi, John Innes Centre; (b) sweet wormwood plant, Scamperdale (https://www.flickr.com/photos/36517976@N06/3521581244); artemisinin molecular model, BromothymolAMB (commons.wikimedia.org/w/index.php?curid = 53,313,214); liver stage of rodent malaria parasite *Plasmodium berghei*, Paul Christian Burda (commons.wikimedia.org/w/index.php?curid = 39,791,388); (c) vanilla orchid, Everglades National Park (commons.wikimedia.org/wiki/File:Vanilla_planifolia_1.jpg); vanillin molecular model, AbcdKolya (commons.wikimedia.org/w/index.php?curid = 27,791,744); vanillin crystals, Photon 400 750 (commons.wikimedia.org/wiki/File:04_Vanillin_crystals.jpg); (d) sweetleaf plant, Robert Lynch (commons.wikimedia.org/wiki/File:Stevia_plant.jpg); scanning electron micrograph of the surface of a human tongue, Omrikon/Science Photo Library (www.sciencephoto.com/media/309378/view); steviolide molecular model, Michael Stephenson, John Innes Centre

(Eisner, 2008; Irwin, 2010), but is rather a process of 'living inquiry' over time (Irwin, 2008). Its outputs have been referred to as 'messy texts' (Finley, 2008) that do not neatly fit within the categories of fact and value, objective, and subjective that more normally give form to science communication. We consider the poems and art produced within the workshop as 'messy texts' in this sense. For this reason we are wary of a tendency to treat artistic outputs primarily as expressions of individual subjectivity rather than as moments in a collective conversation. For us, the value of these messy texts is not to be determined by further exegesis from their authors. The purpose of ABR is to raise questions and stimulate conversation, an outcome of the Global Garden project that was very much realized.

5 | WORKSHOP ACTIVITIES AND PARTICIPANTS

The workshop first introduced participants to some plant case studies, including the stevioside-producing plant sweetleaf (*Stevia rebaudiana*); Madagascan periwinkle (*Catharanthus roseus*), which makes the anti-cancer drug vinblastine; sweet wormwood (*Artemisia annua*), which produces artemisinin, a drug used in the treatment of malaria; and the vanilla orchid (*Vanilla planifolia*), source of vanilla food flavoring (Figure 1). These case studies were selected as examples of politically charged or contested applications of plant science. Participants were first given laboratory experience of extracting pigmented chemicals from plants. Next, they learned how to extract DNA from strawberries. After extracting DNA, they re-visited the plant case studies to consider how having access to the DNA instruction manuals of plants impacted on their views about access and benefit sharing, and responsible stewardship of the Plant Kingdom and

associated resources. Following their practical science experiences (Figure 2), the participants then took part in two more sessions, one led by a poet and another by an artist, in which they were supported in sharing their creative responses to the relationship among plants, chemicals, and people. The workshop was advertised in the regional newspaper and through other local outlets. There were 25 self-selected participants including a photographer, food writer, therapist and a retired local government administrator, plant science researchers, and a UK government biodiversity manager. At the end of the workshop we gained the participants' written consent to reproduce their anonymous poems and artwork here. Following the workshop, we carried out detailed textual analysis on these messy texts to discern how the participants' imagine and assess the relationships that the application of plant science might form.

There is a wealth of artistic genres and formats from which to draw in arts-based approaches to research and pedagogy. We opted for poetry and painting for distinct reasons. Poetic inquiry addresses arts-based approaches' querying of logical, discursive writing as the solve conveyor of content. Poetry challenges the fact-fiction dichotomy and is itself a hybridized vehicle of expression, merging word, and lyrical invocation to form a 'feeling-picture' (Leavy, 2015) and making room within research for emotive contributions. Poetry 'invites us to experiment with language, to create, to know, to engage creatively and imaginatively with experience', and 'invites interactive responses—intellectual, emotional, spiritual, and aesthetic responses' (Leggo, 2008). This made it particularly useful as a means through which the Global Garden participants could imagine plant science.

Poems can be interpreted in multiple ways, but this does not imply that all readings are equally valid. The purpose of the readings we offer below is to first to render explicit the connections between our key questions and the poems that participants' produced. First, we pose questions about the writing choices participants have made and refer back to specific lines and words from each poem in attempts to answer those questions. Second, we do not look for a self-consistent position or message from each poem. Where we cannot resolve our questions, we note the specific ambiguity that remains. In what follows we have selected poems to analyze and report on that most clearly address these concerns.

Working with images is particularly well suited to participatory research methods (Leavy, 2015). Visual art production via painting was chosen to set the participatory tone for the workshop in which participants could feel safe to explore and able to be creative. Participants were provided with a set of art materials and given clear instructions about how to build a picture. They were initially guided in this by our art practitioner's instructions and comments, but soon conversation and comparison began to take place between participants. The images that we have included indicate that participants with different levels of artistic skill were equally able to create images. Indeed, within participatory visual inquiry, the issue of aesthetics is generally sidelined in favor of attending to the expressive qualities of the image: 'although produced by amateurs, the visual art produced by research participants can still be quite powerful with respect to conveying emotion and the multiple meanings articulated via the art' (Leavy, 2015).

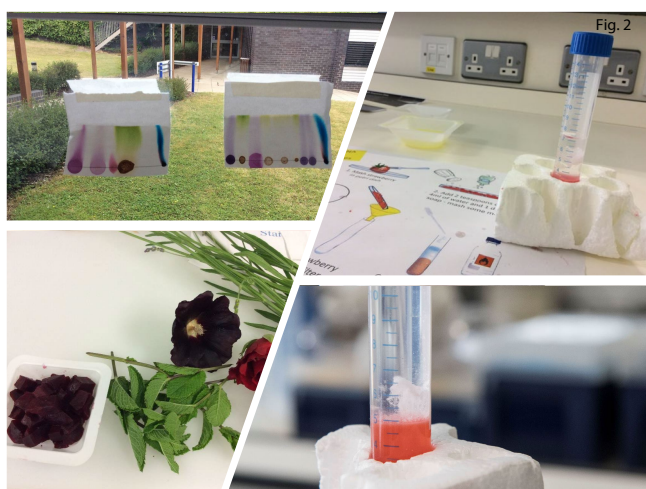


FIGURE 2 Practical science activities. Clockwise from bottom left: Plant material used for pigment extraction, including beetroot, mint, rose, hollyhock, and grass; thin layer paper chromatograms of plant extracts; extraction of DNA from strawberries; close up of DNA precipitating in a tube

6 | GLOBAL GARDEN POEMS

Having described our purposes and practices we can now turn to the poems that were produced in the workshop. Our first poem reads as a reflection on the workshop itself and on the nature of co-learning:

A recipe for success

*A room of strangers
A pinch of questions
Throw in a picture or two.
Mix well, stand back
Allow to mature.
Will we combine or separate?
Strands of thought
Rise above, deep from inner consciousness.
Will ideas be formulaic
New strains.*

This presents the workshop as a culinary experiment in the combination of 'strangers' and of 'strands of thought' that is guided by curiosity. If any recipe is involved it has an improvised feel to it. Baking aside, recipes can, of course, be successfully improvised. The experiment has two potential outcomes. First, it may well yield 'formulaic' ideas. To say that something is formulaic is to suggest that the result is no different than what could be achieved with a familiar recipe. Predictability has its value, but it might not satisfy the experiment's guiding curiosity. Second, is the idea of 'New strains' that closes the poem. The metaphor of 'strain' suggests that just as there are variations between 'strains' within a given biological species—differences in function and structure that can amount to different kinds of risk (think of viral pathogens) and of practical value (think of genetically engineered strains of rice)—so, given the right conditions, new strains of idea can emerge. This is, perhaps, the 'success' of the recipe.

Just one room, one pinch, one or two pictures and time to mature in the hope of novelty. This experiment is not about recording what already exists in the way of fact and value, what the 'strangers' already know and feel. Nor does it much take account of their existing identities. We are not told whether they are researchers or members of the public. Presented as 'strangers', participants' identities are effaced, or at least set to one side for a time. The recipe is a small scale and tentative intervention in the variety of available imagination. It is an attempt to foster the spontaneous ('stand back') recombination of available ingredients. It asks what can happen when a tight hold on identities – that might underlie formulaic separation – is temporarily allowed to relax in one room with a few people and connections between strands given time to mature.

The next two poems draw links among high-value plant products, contemporary plant research, and issues of ownership and benefit.

The conflicting taste of the everyday vanilla

*A pretty pink whorl, surrounded by green,
an organism living, potential unseen.
From traditional knowledge*

*to a global dream.
the biological message, coded onto a screen.
A poison, a medicine, a life-saving drug
from the genome mined, from the earth dug.*

The 'global dream' at the core of this poem is also ambiguous but seems to relate to the undertaking of contemporary plant research. The links made to a 'living organism' and 'traditional knowledge' might indicate a troubling relationship to the global dream, which has connotations of capitalistic achievement (along the lines of 'American dream') within a globalized market context. In this, both the organism with hidden potential and the traditional knowledge are used as a means to this end. The poem is likewise ambivalent toward the outcome: it could be poison or medicine, pointing toward issues of human responsibility for the use of resources. The organism, previously a 'pretty pink whorl, surrounded by green,' is reduced to a 'biological message, coded onto a screen,' as if something were lost in this process. The final line of the poem uses the evocative term 'mined' and 'dug,' both of which indicate an invasive interaction of humans upon the earth (that, as the poem also highlights, can provide the benefit of life-saving medicine and drugs). Here, we see ethical themes emerging through emotive language, although the poem is structurally predictable through its use of rhyme—there is nonetheless a sense that these practices are commonplace in their predictability.

A periodic table of colour and taste

1. lavender	2. purple	3. vanilla	4. knowledge
roses	hollyhock	sweetleaf	locked
beetroot	blue	wormwood	knowledge
and mint	mint and	periwinkle	owned
	lavender		knowledge
lav	green	flavour	shared
ender	rose and	taste	knowledge
rose	rose	medicine	thrown
and beet		drug	
	madder		
root and		shaman	
mint		writer	
rose and		scientist	
lavender		wise man	
wash and		knowledge	
tie		learning	
peg and		and use	
dye			
rise and			
seed			
root and			
die			

This poem addresses plant-derived colors and flavors. It also presents a puzzle: to what extent can this periodic table encompass

relations among plants, chemicals, people, and knowledge? The periodic table motif together with the many lists the poem offers suggests that each word or phrase could be considered as isolated units that might, if the reader chose, be paired with one another, as might individual elements of the periodic table of elements. A periodic table reflects the valencies of elements, so not all combinations have the same kind of outcome. Pair two elements that share a period, say sodium and potassium, and the result is an alloy of two metals with, perhaps, some novel physical characteristics. Pair sodium with fluorine, however, and a highly energetic reaction will generate sodium fluoride, a compound that has distinctive physical and chemical properties. Thus, when 'lavender roses beetroot and mint' meets 'wash and tie peg and dye' we can imagine a change in the color of cloth. Our attention is directed to the creation of value in the processing of raw materials, perhaps using the technologies of bucket and washing line. When 'lavender roses beetroot and mint' meets 'knowledge owned' a different order of transformation is involved and one that, perhaps, involves more of the energy of controversy. It raises the question of whether and how the technological abstraction and reshaping of plant chemical pathways should lead to exclusive rights to the ownership and licensing of those novel pathways.

Step back, forwards, sideways, out

*sometimes the thing itself - nature -
DISAPPOINTS, ON ANALYSIS, DECONSTRUCTION
THE SUM of the PARTS, though perfection,
the COMPOUND, is of little INTEREST to us
It may be TOO FUSSY - needs its own
personal assistant or DEMANDS specific CONDITIONS
TO GROW like a diva popstar before performing.*

*Step back to the precursor -
a lower form more NAÏVE before combination,
may be more amenable to our probing.*

*Move sideways to something SIMILAR
where we can tap what we want,
produce a rather like flower*

*Perhaps yeast may be a guest bed
suitable for bacterial insertion,
with the right conditions
to get them in the mood.*

*Sometimes EVEN OIL, expensive to SUCK from the GROUND
with an invention forever looming, maybe the answer,
alternative USES for the need to be found.*

*JUST AS LONG AS WE CAN CIRCUMVENT THE RULES TO CALL IT
NATURAL.*

This poem takes us away from thinking the 'natural' as a stable moral category and toward a more complex milieu of seduction in which satisfaction and exploitation are closely linked. It begins with the arresting statement that 'nature' can be disappointing. This counters a long history of nature writing that emphasizes nature's beauty or sublimity (Morton, 2009). Like much nature writing, however, it is committed first to the view that nature exists to serve human needs and second it deploys a patriarchal metaphorical repertoire that associates nature with women. Disappointing 'nature' can be too fussy and demanding, wanting conditions to be just right before giving up the 'performance' required of it. Nature as a 'diva' here—a term for a female deity that describes notable female performers while suggesting that their off-stage behavior is problematic.

Returning to the theme of disappointment, even though the sum of nature's parts may be 'perfection', on analysis, it still manages to disappoint 'us' when its compounds yield little interest. Here, 'compound' is both 'the sum of parts' and 'compound interest' the growth of a financial holding. Nature's growth, despite 'perfection', can disappoint us when compared with the performance of other assets. Even 'perfection'—perhaps a hint of beauty and sublimity popping up here—when reframed in terms of more clearly defined financial interest shows up to 'us' as lacking.

Having established disappointment with this diva, a series of alternative ways to deal with 'nature' are then sketched. Each arises from the ability to analyze and recombine the 'parts' of plants. Some come across as manipulative and exploitative. Others carry the moral ambiguity of seduction. If the diva is too fussy, why not locate a more 'naïve' proxy to probe? Or make a sideways shift to produce something that is 'rather like' the diva but that will give us what we want. Maybe we should turn on the charm, preparing a suitable bed to change the diva's mood. So, does disappointment with perfection lead the poem to a simple celebration of a mindset that identifies nature with women and justifies the exploitation of both? Maybe not. All of that rests on the condition that 'rules' can be circumvented so that we can 'call it natural'. The question of where these 'rules' come from is not settled within the poem. They are not 'laws' though so we are not in the realm of breaking 'natural law'. This would seem to be about negotiating rules as conventions, artifice open to circumvention with no need for dramatic breakage.

Noting, but not entirely sharing, disappointment with 'the thing itself', the poem moves past the natural/artifice divide and has little use for it as a way of grounding decisions and preferences. At one level the poem presents 'nature' as a matter of conventional cultural ascription. In this sense the poem is writing 'after nature' (Purdy, 2018). The poem then redirects our ethical attention away from the clarity of a nature/artificial divide and toward ambiguous mixtures of seduction and exploitation.

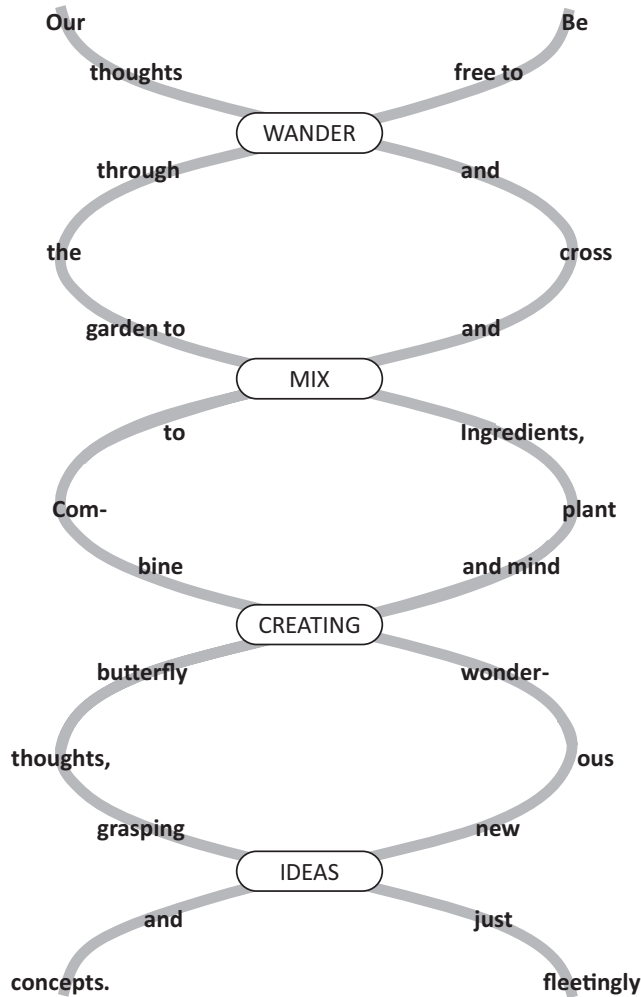


FIGURE 3 A concrete poem

Untitled

one world
open our minds
open our borders
the secrets of nature
share our resources
share our knowledge.
Benefits have no boundaries.

From the global biosphere to single strands
knowledge is the key
unlocking the secrets of nature.
What lies within the single leaf?
More than the pigment that meets the eye.
Benefits have no boundaries.

This poem posits a reality of 'one world', through which, if we 'open' and 'share', then 'benefits' will be able to spread without hindrance. The things that need to be opened are 'minds' and 'borders', properties of

individuals, states, and research disciplines, perhaps? 'Resources' and 'knowledge' are to be shared. Is 'nature' properly part of the 'one world' that is posited here? If there were to be an opening of 'nature', it would appear that this poem finds that operation a little more complicated. 'Nature' has secrets that stand in need of 'unlocking' for benefits to spread. For 'nature' to join that 'one world' something more than a determination to open and share would be required. No full account of how to unlock nature's secrets is offered, but there is a hint. The key is 'knowledge' and this is to be gained by looking beyond what meets the eye and into what 'lies within'. The poem leaves us with a question. Is it only 'nature' that has secrets in this way? Do humans and human organizations and communities not have them too? The poem makes us wonder whether and how it is legitimate for people to keep secrets until they can be persuaded to share, perhaps with the promise of benefit. Alternatively, should the promise of unbounded benefit oblige all people, regardless of their position to share and share all? If the suppositions of the poem were born out, then indigenous people holding knowledge of local plants might lose some of the bargaining position afforded them by the Nagoya Protocol. Would the unbounded sharing of the benefits of knowledge cause a collapse in research and innovation activity or could it stimulate the creation of business models less reliant on, say, patent law?

We conclude our analyses with a poem that works with form as well as words (Figure 3). The drawn lines suggest a double helix with resonances of recombination and self-assembly. The lines, however, join at four points that would seem to be obligatory waymarks for anyone following the poem. As long as the lines are followed and contact made with one or more obligatory points, the poem can be read as any combination of gathered words. For example, starting at the top left and heading back to the top of the page after we had met 'wander', we found 'our thoughts wander free to be'. By starting at top left and treating each obligatory point as a crossing opportunity, we found 'be free to wander through the garden to mix ingredients plant and mind creating butterfly thoughts grasping ideas just fleetingly'.

This poem clearly involves the reader in actively deciding what path/s to follow to compose a reading. It is, then, an open but delimited space for making choices and it invites exploration. This is certainly one way of thinking about plant biotechnology. The readers' choices can be made moment-by-moment, but they can also involve the reader in deciding the rules they will follow to generate their pathway. Are obligatory points to be treated as opportunities to cross the page or not? Can the lines be followed to the top of the page as well as the bottom? Is there a preferred starting point? Should we try to end up creating a particular message and adjust the application of our rules as we go to do so? Each junction and line is an opportunity to choose, but the outcomes of each choice are not clear until the resulting pathway is completed and read back as a whole. At that moment, the reader can decide whether they are pleased, on an aesthetic basis, with that outcome and whether to try again. The poem, we would suggest, engages readers as active explorers and creators of pathways in a delimited space who are guided by aesthetic preferences and who have the time to choose and choose again. If this poem presents a vision of plant biotechnology it is an inspiring and hopeful one.

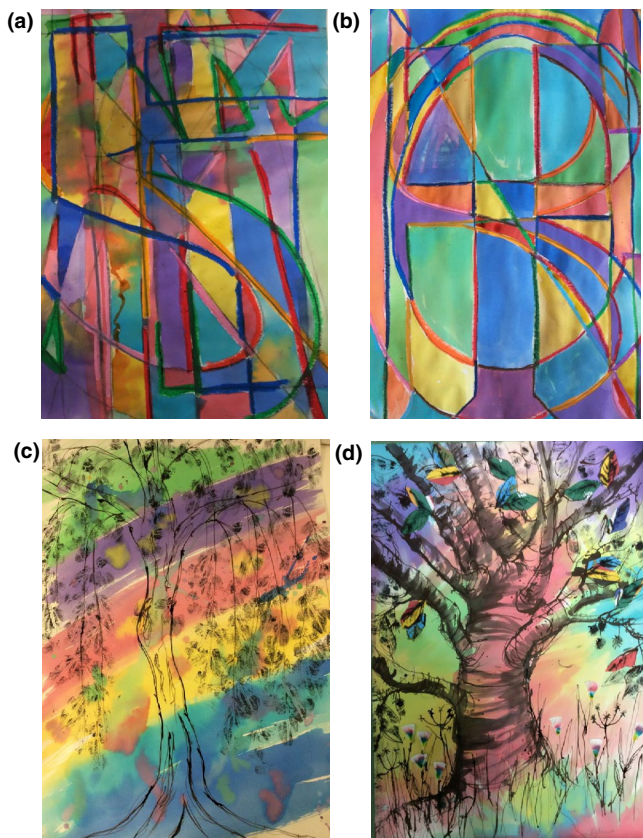


FIGURE 4 Examples of Global Garden artwork. (a, b) Artwork inspired by Jasper Johns' painting '0 through 9'; (c, d) Global Garden trees

7 | GLOBAL GARDEN ARTWORK

Unlike the poetry, where the participants had an open brief to write about anything connected to the science activities and/or the subsequent discussions, the art session that followed was rather more prescriptive in that the participants were given a specific brief. Despite this, however, the resulting images were all very different and individual.

The brief had two separate elements. The first was based on Jasper Johns iconic painting '0 through 9', an expressionistic oil painting where all of the numbers from 0 – 9 are superimposed and blended over each other. Known for iconic paintings of maps and flags, Johns' art is associated with abstract expressionism and pop art. The piece is one of a series of images carried out using different media depicting the numbers 0 to 9.

Johns' work has been consistently concerned with the underlying themes of form, perception, and the 'material and non-material layers of meaning' of a painting (Osterwold, 2003), clearly present in *0 through 9*. The piece is literally a multi-layered, multiple image with multiplicitous meaning depending on the viewer's perspective. It is possible to contemplate the piece several times and each time focus on a new set of marks representing a distinct number. On the other hand, one can view the painting as a series of labyrinthine jumbled lines that evoke new meanings. *Zero through 9* offered an entry point for participants into the ways in which visual images create meaning.

Bearing in mind the specificities of the piece, Johns' work links thematically to the rationale behind the workshop, in which multiple perceptions are queried and different, ambiguous meanings are embraced.

Participants were asked to choose a word – either the name of a plant or from their poems – and subject the word to the same treatment as the Johns painting. Words, letters, and numbers on a printed page are by nature two dimensional. By superimposing the letters of a word, the word takes on a three-dimensional abstracted character that removes it from the literal quality of being a denotative word and opens the image to interpretation.

Examples are shown in Figure 4a,b. The image shown in Figure 4a has a strong expressive structure. The lines are broken up into different colors, which leads to spatial ambiguity, and the way that the flat colors have been positioned across the format gives this image a powerful composition. It has the feeling of being able to 'see through' in places, only to be denied walking through by the myriad of intersecting lines. Because of this, it is reminiscent of a sculpture made up of geometric, man-made elements, similar to some of Frank Stella's monumental relief works. The image shown in Figure 4b is less busy and has *mise-en-abyme*-like qualities, an oval within a rectangle, again pointing the viewer toward a perception of depth and questioning. Intersecting lines in the image evoke a motif of windows allowing the viewer to 'look into' the piece through meditative, perceptive activity. This gives the image a very different spatial quality to that of Figure 4a. Again, the lines are broken up into a variety of colors, but the individual letters are easier to read. Unlike Figure 4a, there is more intentionality behind the lines and no trace of pencil, suggesting a feeling of finality that somewhat counteracts the exploration of perception offered by the window shapes. It has a very clear structure combining curves with horizontals and verticals, and the colors have been carefully placed to make a strong relationship, which adds to the overall clarity of the composition. Nonetheless, there are moments within individual segments of the piece in which colors blend and bleed into each other, perhaps directing the viewer toward hidden depths. The picture appears to have a calm, spiritual quality, an image that could take the spectator on a journey.

In the second part of the brief, participants were asked to draw their interpretation of a tree using ink and a wooden kebab stick. The tree was chosen as an image because of the importance of trees within the Plant Kingdom. As a leaf is a microcosm of a tree in structure and shape, the trees were printed with a variety of different shaped leaves. Participants were given small prints of world flags to cut leaf shapes from and use as collage, again relating to the global context of the workshop and channeling Johns' motifs. Finally, they added flowers in the foreground made from make-up pads decorated with felt tip pens. Some participants also used a wash of rainbow colors across the whole image, to create an added symbolism, a bridge of hope for the future. Examples are shown in Figure 4c,d. The tree shown in Figure 4c has a delicate quality similar to a Chinese ink drawing. Minimal marks have been made to the trunk of the tree to describe its form. The cascading branches and printed leaves are reminiscent of weeping willow. The tree appears to have a sheltering, protective nature as well as a

figurative look to the structure of the trunk and branches, rather like a female dancer frozen in time. The diagonal areas of color, similar to those of a rainbow, detract from the upward movement of the tree. It almost appears as if this tree could walk, run, or dance off the page. Unlike the first tree, the tree shown in Figure 4d is a monumental, powerful, and expressive tree that is firmly rooted to the spot. It has multiple large branches that seem to flail about, giving rise to the idea that it may be angry. Its sheer physicality is emphasized by its pot-bellied trunk, which leans back, and the shaded lines that give it form and weight. The tree almost shouts, and this noise and anger appear related to its red color. In contrast, the delicate little flowers around the base of the tree look like Lilliputians surrounding a giant.

8 | DISCUSSION OF OUTCOMES AND PARTICIPANTS' EXPERIENCE

Feedback was received from nine participants through a questionnaire administered at the end of the workshop. Along with questions about the design of the event, the questionnaire also included questions that have direct bearing on the concerns of this study: 'What did you like/dislike about the event?'; 'What was the most interesting thing you discovered in the workshop?'; 'What was your favourite part of the workshop?'; and 'What difference do you think the workshop might have made to you?' Feedback was overall positive. Eight participants rated their experience four of a possible five, and one three five, for satisfaction with the workshop, and all indicated that they would recommend it to a friend. The combination of laboratory activities, poetry, and visual art was enjoyed by all, giving some the novel experience of DNA as a substance and others the unusual experience of creative writing. The following participants' comments indicate that the event made a difference to them:

'Changed my view of plants.'

'Broadened my experience, giving greater awareness of complexity by discussion'

'Will leave thinking and questioning. Would like to discuss more!'

'Deepened my curiosity in the topic and future potential for studying plant based remedies.'

This indicates that the design of the workshop was successful in engaging the participants through its distinctive combination of scientific and artistic activities that left them feeling informed, curious, and confident to continue to an engagement with plant science. It also highlights the value of esthetic experiences in science communication. Complexities were accessed through the activities in the workshop that might not otherwise have come to light in more traditional pedagogical and academic settings.

The poems that were produced by individuals, following shared experiences and discussion, were closely engaged with plant science and richly imaginative in their use of metaphor and poetic form. Even as they presented distinctive visions and assessments of plant

science in social and ethical contexts, they explicitly framed some questions, and provoked others that have clear implications for plant science (e.g., in the contexts of natural/artificial distinctions, the gendered assumptions attached to nature and technology, the forms of desire and need that justify plant science applications while also complexifying the ethics of their delivery, the distribution of costs and benefits, and the institutional and ethical frameworks underlying these). Five participants were clear that the visual art session was a favorite part of the workshop and there is evidence that the responses to the two briefs were diverse and imaginative. Compared to the poetry, it is difficult to evidence substantial links between the artwork produced and ethical and social implications of plant science, although in-depth exploration of this overall aspect may prove to be a fertile area for further investigation.

9 | ASSESSING THE WORKSHOP

In line with Barone's quality outlines for ABR, the work produced through the workshop was as follows: a) an imaginative reconfiguration of experiences into a plausible virtual world that resonates with experiences; b) intellectually and creatively compelling, and c) made to move people into a particular virtual world in order to consider wider contexts that might shape and be shaped by these experiences (Barone, 2008). The aim of ABR is not to replace traditional science research models but to complexify discussions, enable conversation, and to involve the public, all of which were facilitated in the workshop. Turning to our initial key questions, it is clear that the Global Garden's innovative approach to science communication fostered rich imaginative responses to case studies of plant science, and that these ways of imagining and evaluating plant science and its many material and social relations were diverse. Finally, by fostering diverse imaginative responses that raised issues of direct relevance to plant science, the Global Garden approach ensured that in this workshop fact, value, and – crucially – imagination each had a role to play.

As noted above, this workshop was the first attempt to transfer techniques from the established Science, Art and Writing Trust (www.sawtrust.org) (Osborn, 2009) approach to science education and outreach, so far used mainly in primary schools settings, for use in science communication research among the adult public. Moving from educational to research goals presented some new challenges around the recruitment of participants and the status of the outputs as sites of evidential value. Since the call for interest was posted in a regional newspaper and similar outlets, participants stemmed from more or less the same geographical locality (which, in turn, has implications regarding socio-economic standing). The majority of the participants were older, retired people (the workshop took place during the day so this was to be expected), and more women participated than men. While arts-based approaches are not designed to produce generalizable, standardized outputs, but rather to enable conversation and dialogue, these recruitment biases will need to be addressed in ongoing iterations of the Global Garden project, given the opportunities for constructive dialogue between diverse publics

that, no doubt, exist. In Global Garden research, poems and artwork both have intrinsic value to facilitators and participants and value as evidence within our ABR approach. In the present methodology and analysis, there were clearer links to be made between the poetry outputs and key research questions than for the visual art outputs. It may be that it is appropriate for the visual sessions mainly to add quality of experience to the day-long workshop. However, in future workshops there is scope to explore whether more detailed feedback and commentary from participants on links between their artwork and the workshop as a whole might reveal aspects of imaginative engagement that are as yet unrecognized.

As Eisner and Powell have it, 'the art in science inspires, motivates, and enriches the pursuit of inquiry; indeed, for good work to be done, artistry appears inevitable' (Eisner & Powell, 2002). In this workshop, the Global Garden blended approaches from science disciplines, educational research, creative writing, and visual arts to provide a unique exploratory experience that can be drawn from and developed for further research.

ACKNOWLEDGMENTS

This work was supported by Biological Sciences Research Council (BBSRC)-funded OpenPlant Synthetic Biology Research Centre grant (BB/L014130/1), BBSRC Institute Strategic Programme Grant 'Molecules from Nature' (BB/P012523/1), and the John Innes Foundation.

AUTHOR CONTRIBUTIONS

NML, JR, and AO designed the Global Garden workshop. HH, SS, MK, and CM developed the case studies. JR, CH, and MO'D planned and delivered the science, art, and poetry sessions, respectively. NML analyzed the output. NML and AO drafted the manuscript. All authors helped revise and finalize the manuscript.

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How to cite this article: Lee NM, Hodgson HE, Hann C, et al. The Global Garden project: Imagining plant science. *Plants, People, Planet*. 2020;2:602–613. <https://doi.org/10.1002/ppp3.10133>