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Why Look at Plants?

Patrick Blanc – The Beauty of Being Plant / Anthony Trewavas – Aspects of Plant Intelligence / Lucy Davies – In the Company of Trees / Ackroyd and Harvey – Beuys' Acorns / Renny Pritikin – Futurfarmers / Pil and Galia Kollective – Asparagus: *an Horticultural Ballet / Renee McGarry – Familiar Contact: Plant sculpture in Mexica (Atzec) Stone Sculpture / Janaina Tschäpe –* Botanica / Lauren Berkowitz – Manna

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The Journal of Nature in Visual Culture

Front Cover Image: Giovanni Aloi, from the *Plant Revolution* series, sketch, 2010 © Giovanni Aloi

EDITORIAL

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Look around. Whether you are now in your office, house or in a public space, it will not take long before something green will fall in your field of vision. Plants are around us more frequently than animals, in fact they usually then to hide them and in doing so, they fill our everyday lives with their silent but indispensable presence. *Why look at plants?* What is there to see, one may ask - an entire world, or nothing at all, one might answer; this entirely depends on your predisposition, just as much as to someone a mouse can be a pest and to someone else a pet.

To this point, plants have been silent witnesses of the animal revolution. Frequently studied for their medical properties and consistently exploited for their aesthetic qualities, plants have played a defining role in the historical and cultural development of humankind. But just as this role comes increasingly into focus, the botanical world is seriously threatened by industrialization and climate change. Forests are razed at an alarming rate as large seed banks scramble to preserve genetic material of the world's flora before it is too late.

The proposal this issue of *Antennae* puts forward is a daring one and it involves taking a few imaginative leaps in the attempt of outlining new avenues in the experimental research of new fields. What about plants as companion species, for instance? Would there be productive opportunities in attempting to understand plants from different perspectives, just as the field of human-animal studies has proved possible with animals? What contributions to our understanding of animals could a focus on plants make? Could we even envisage that, in a near future, we may have a field of human-plant studies?

Times may be ripe for this opportunity to be considered. After all, on what grounds could we so insistently provide evidence of the relevance animals bear in our everyday lives and simultaneously decide to be blind to plants? The visual arts have embraced "plants as a subject" in a very similar way that they have already embraced animals. The first ever exhibition to present plants as subjects was the memorable 1936 display of genetically modified delphiniums by Edward Steichen staged at the Museum of Modern Art in New York. Steichen bred his plants over twenty-six years through a combination of traditional methods of selective breeding and the use of a chemical that altered the plants' genetic make up. This effectively constituted the dawn of what today is called bio-art, a strand of controversial artistic practice that is very well known to the field of human-animal studies.

It was then George Gessert to bring plants back in the gallery space in 1988, staging a selection of irises that summoned viewers' memories and fears of eugenics. Today, a multitude of artists engage with tissue culture and transgenic engineering with both, animals and plants. But as the present and the next issue of Antennae will aim to show, plants are not only present in bio-art but have appeared in many disparate artistic contexts already.

It is also on the scientific front that perspectives on the botanical world are rapidly changing. The *Laboratorio Internazionale di Neurobiologia Vegetale* (the International Laboratory of Plant Neurobiology) founded in 2005 in Florence, has contributed new key evidence on plants' cognitive and sentient qualities continuing the line of enquiry initiated by Charles and Francis Darwin who conducted a series of experiments on plants between 1850 and 1882 documented in the book *Power of Movements in Plants*.

As a result, recent advances in plant molecular biology, cellular biology, electrophysiology and ecology, have unmasked plants as sensory and communicative organisms, characterized by active, problem-solving behavior. Plants are not the passive, *ultimate automata* which conveniently many like to think. What are the challenges posed by these new awareness?

This issue of *Antennae* was co-edited by Australian artist Gregory Prior, currently lecturing at the School of Communication and the Arts at Edith Cowan University (Perth, Australia). From a background in painting, Gregory Pryor's practice has evolved into many different areas, which include drawing, video, performance and object based work. After many years traveling to and making work about his experiences in Europe and Asia, he moved from Melbourne to Perth in 2003 and began to explore the visual language of the country he was born in. His interest in plants has led to the creation of a number of challenging works of art, including the ominous *Balck Solander* (2005). We will begin our enquiry by posing

the question: "what is it like to be a plant?" through an adaptation of a book titled *The Beauty of Being Plant* (yet to become available in English) written by Patrick Blanc, a French botanist who invented the now more and more popular "green walls". His bittersweet narrative is counterpointed by an essay titled *Aspects of plants intelligence (2003)* by Professor Anthony Trewavas. The essay, a straight scientific offering, bravely addresses the concept of *intelligence* in plants and goes on to argue that, that not only are plants intelligent beings, but that they are also capable of learning through memory – plenty of food for thought.

Lucy Davis looks at *Tree Duet*—a performance series by Singapore theatre company spell#7 (Paul Rae and Kaylene Tan)—through a series of explorations of trees in modern and contemporary visual art works from Singapore and colonial Malaya. Heather Ackroyd and Dan Harvey follow the footsteps of Joseph Beuys and travel to Germany in order to collect acorns from one of his original piece in order to create theirs. The issue then explores the work of *Futurefarmers* a group of artists whose work challenges current social, political and economic systems.

Pil and Galia Kollectiv brings to us a very unusual performative experience involving asparagus, whilst Renee McGarry's explores a small subset of Mexica stone sculpture that used materials and technique to naturalistically represent plants. In a curious botanical milieu peopled with costumed creatures born from myths and folktales, Janaina Tschäpe produces extremely fascinating works of art employing diverse media such as painting, video and photography. This issue closes with a look at Lauren Berkowitz's complex and multifaceted practice concerns issues of humanism, contemporary feminism and the environment, explored through the binary lenses of order and chaos.

Our hope of course is that you will find this issue as interesting as challenging and that above all, upon looking around you, you may begin to see plants in a different way. But in order to prevent any relapse into the older "mode of looking" we have already prepared another plant-dedicated issue that will be available at the end of summer. Spread the green word!

Giovanni Aloi
Editor in Chief of Antennae Project

Edward Steichen with delphiniums (c. 1938), Umpawaug House (Redding, Connecticut). Photo by Dana Steichen. Gelatin silver print. Edward Steichen Archive, VII. The Museum of Modern Art Archives

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THE BEAUTY OF BEING PLANT

Have you ever wondered what being a plant may be like? A book by internationally renowned botanist and inventor of the vertical garden, Patrick Blanc attempts to give us an idea and in the process it accidentally questions everything about life and otherness.
Extracts from Le Bonheur d'Être Plante by Patrick Blanc, translated and adapted into a short story by Giovanni Aloi

I grow, therefore I am. I am destined to continuously generate new leaves without, however, feeling any fear of losing them because they may become old or because a greedy animal may come to eat them. Even bad weather can take away my leaves. But what does it matter if I lose them anyway considering that it is in my nature to produce leaves without ever keeping count. However I do count, I count a lot. In my humid undergrowth of the tropical forest where I live sheltered by the shade, I take it easy and only grow a leaf every two or three months. I have to admit that my leaves live a long life here in the shadow: I keep them for three or four years, whilst the exuberant bush nearby, at the fringes of the forest, exposed to full light, will keep them only for a year, just like the tree up there that shelters me. Sometimes I become jealous of plants that are lazier than me, like that uprooted *Caucciu'* for instance which, eradicated from its Indian forest, now vegetates in the corner of a flat; it will only produce one or two leaves a year that will however live more than ten: what a difference from the life on the low branches of the trees on the rivers of its original habitat where it used to grow like me, or even a little faster.

My life on a little rock in the Malaysian forest is very, very tranquil. […] If I am beautiful it is only because my morphology is developed in response to the resources available in my habitat. No living being is ugly as long as it is in harmony with its environment. Proof of this is the fact that the beautiful seems to unite the true and the good. Disharmony is manifested when conditions change abruptly, whether this unbalance is caused by overabundance or a drastic reduction of resources. In too much shadow, a plant that loves light will inevitably perish. In too much sun, a plant that loves shade will produce yellow and shriveled leaves, or will sprawl in an exuberant and unordered growth. A *Camelia* perfectly stretches its branches in the shade of the Japanese brushwood from which it originates, whilst in sunny city gardens it produces a horrible blunder of upright branches and contorted leaves.

There is no such thing as weeds, there only are plants that grow where they want to grow, instead of those that humans choose for their gardens or fields and that usually do not match the resources offered by these sites. "Aesthetic errors" remain rare amongst animals as these either adapt to the availability of resources or disappear entirely. And people find it very hard to adapt indeed: insufficient food will make them emaciated and ill. But today's men have become particularly talented at modifying to their advantage all landscapes on earth and then they become surprised at the fact that the earth is tired of their demands. They have mistaken the request of an individual with that of its invasive society. The main issue lies in their inability to resize their so-called necessities, whilst I can enter a phase of regressive adaptation if needed. Humans are like this and I am willing to forgive their bulimic egoism, but how long will it take them to realize that it is best to stabilize their use of resources to then scale it down step by step over generations? How long will it take them to recklessly consume everything. Why not? But they are so many that it is impossible for our planet to house them all.

Here on my rocks they have not seen me but it has been a completely different story for my friends who live a few kilometres away. They, too, were ignored when humans cut the forest down to replace it with plantations of rubber trees and palms for oil. Humans did not know that some of

the plants were unique and that they only existed there, but even if they had known, they would have still cut those trees down. We plants have developed the most complex and successful survival strategies, but there is very little we can do against men. […]

I find their thinking extremely surprising for they relentlessly apply double standards to themselves and the world around them. Today's men, or at least large part of Westerners, believe that the future lays in the opportunities offered by crossbreeding; this would enhance the beauty of the descendance. The crossover of cultural and technological exchanges would in theory result the essence of knowledge and creativity. Fine, why not? They only seem to be able to apply Darwinian theories to their own species. In this case, why do they persistently attempt to preserve the integrity of the genetic material of animals and plants in the wild as well as in the case of flowers, fruit and animals they have patiently selected?

I really find hard to understand how they can, on one side, campaign to maintain biodiversity in the wild and, on the other side, reap the benefits of crossbreeding in farming and agriculture. All they care about is world-domination and their God's (especially if they have been reduced to one) aid this approach.

Well, what they do with their species is their problem, but I would very much like not to find myself on the outside of one of those reserve-areas in which some plants gain protection. […] After all men like to see us and to see us flourish in their gardens and on their streets. They all have different ways in relating to us. There are those who lose interest as soon as we don't live up to their expectations. They buy a beautiful pot with a magnificently looking plant grown in a greenhouse and pumped with fertilisers. Obviously, after a few weeks outside this environment, the plant becomes unable to produce its rich foliage and the excess of flowers which motivated the acquisition in the first place. Then, in the light of the evident delusion, the plant is thrown away.

As a simple object of consumerism, this plant really only exists in her root which is endlessly multiplied in the greenhouse. Been thrown in the trash is the equivalent of a large leaf from a big tree falling onto a plant in the wild. In the dark the plant will die. But other men are much more keen on giving us a happy life. Even if we drop blooms and our leaves become increasingly smaller, since we have no choice but to trigger a regressive adaptation, they continue to love us and to move us from one place to the other in order to find the best spot, the brightest location but away from direct sunlight. Then they are happy to see us grow. These men really love life. The fact that some of us have been climatised and survive in their homes still does not justify the fact that we should become another vulgar object in their homes. We are companions and as such live with them. Because they have taken us away from our natural habitat they also have an obligation to take care of us. Whoever multiplies us in the greenhouses has no merit as to them we only are a source of money. By contrast, whoever is successful in making us feel loved in their homes is laudable. It is through this relationship that we cease to be mass-produced objects and become companions.

In all honesty, I would have actually liked it if one or two hundred years ago, someone would have picked up one of my stems to take it with care from my Malaysian homeland to a European greenhouse where it would have been multiplied to no end. But because I'm rare and only live on the rocks of a deep valley, I went unnoticed – a pity, as I would have travelled from home to home. However, men do know me, although I am only kept in the form of dry branches in a herbarium of some scientific institution where they have given me a Latin name. This is the only way I exist for them.

[…] This may, in any case, be better than the destiny of those plants grown in the gardens of the cities because of their adaptability, rapid growth and abundant flowering. They, too, are considered like decorative objects and can be changed, effectively killed and replaced by other plants with the change of season. It is strange that trees in general are much more respected as if the mere difference of their size would grant them a more noble aura. A demonstration of this double standard is offered whenever people demonstrate against the cutting of trees but do not even take note of *Impatiens* and *Salvia* being ripped up and thrown away once their flowering season is over. Man's sense of respect for plants is proportional to their size: ripping up *Forsythia* or *Roses* would be more shocking than the elimination of small plants, but much less so than the cutting of a tree. And even amongst trees, a big *Oak* will be considered more valuable than *Hazelnut.* Even when it comes to animals, man's sensibility is related to size: a whale will be respected much more than a sardine, and of course the argument would be based on the fact that there are millions of sardines in the sea, whilst whales are rare. But things are slowly changing. Or are they? Humans have not yet realised that the right to live belongs to big and small alike; men

have simply become more aware that anything potentially relevant to biotechnology should be treated with care in light of the potential usefulness of its genetic heritage. But I'd like to be an optimist: could it instead be that humans are beginning to accept the fact that every form of life as the unconfutable right to live on this planet?

By the way, I haven't introduced myself: I'm a *Sonerila.*

Patrick Blanc (born June 3, 1953 in Paris) is a botanist, working at the French National Centre for Scientific Research, where he specializes in plants from tropical forests. He has invented the concept of a vertical garden. Since 1982, he has studied the many ways plants adapt to extreme conditions. He has worked with Jean Nouvel, Andree Putman, Francis Soler, Edouard Francois, Jacqueline et Henri Boiffils, Herzog et de Meuron, Marc Newson, Saguez et Partners, and many others. He has received numerous awards including the French 1993 Science Society, Botany, 1999 Innovation Contest, Ministere de la Recherche, and Talent d'or 2002 du Sommet du Luxe et de la Creation award.

The book ***Le Bonheur d'Être Plante*** is available in French (Maren Sell Editeurs, 2005) and Italian (translated by Lucia Airoldi, 2008, part of the series 'Oltre i Giardini', published by Bollati Boringhieri). This adaptation has been published with permission of the author and original publisher.

P. de Pannemaeker

Melastomatacee - Sonerila, from: *Revue de l'horticulture belge et étrangère* by Frédéric Burvenich, Oswald de Kerchove de Denterchem, Édouard Pynaert, August van Geert & Hubert J. van Hulle (editors). Gand [Gent], Bureau de la Revue, 1887, volume 13, plate 15. Chromolithograph (sheet 332 x 253 mm with fold). © free image

ASPECTS OF PLANT INTELLIGENCE

Intelligence is not a term commonly used when plants are discussed. However, I believe that this is an omission based not on a true assessment of the ability of plants to compute complex aspects of their environment, but solely on a reflection of a sessile lifestyle. This article, which is admittedly controversial, attempts to raise many issues surrounding this area. To commence use of the term intelligence with regard to plant behaviour will lead to a better understanding of the complexity of plant signal transduction, the discrimination and sensitivity with which plants construct images of their environment. It will also raise critical questions about how plants compute responses at the whole plant level. Approaches to investigating learning and memory in plants will also be considered.
Text by **Anthony Trewavas**

INTRODUCTION.

Intelligence is a term fraught with difficulties in definition. In part, the problems arise because of the human slant placed on the use and meaning of the word. However, it is also unlikely that intelligence as a biological property originated only with *Homo sapiens*. There should therefore be aspects of intelligent behaviour in lower organisms from which our superlative capabilities are but the latest evolutionary expression.

Stenhouse (1973) examined the evolution of intelligence in animals and described intelligence as "[a]daptively variable behaviour within the lifetime of the individual." The more intelligent the organism, the greater the degree of individual adaptively-variable behaviour there will be. Because this is a definition which was used to describe intelligence in organisms other than humans, it is a definition useful for investigating the question in plants. Do plants exhibit intelligent behaviour? The use of the term "vegetable" to describe unthinking or brain-dead human beings indicates perhaps the general attitude.

In animal terms behaviour is equated with movement, and since plants exhibit little, if any, form of movement, plant intelligence on that these are exceptions rather than common-place. *Mimosa* captures our attention because it operates on a time scale similar to our own and it is the difference in time scales that frequently makes plants seem unmoving. The use of time-lapse facilities has indeed indicated that plants operate on very much slower time scales than our own, but once observed in this way, movement is quite clear.

Also the majority of higher plants, including macroalgae, are sessile, the result of a decision several billion years back to gather energy and reduce potential via photosynthesis. Light being freely available, movement has never been particularly critical to plant survival. Such movement as has been observed is usually limited to less complex plants such as blue green algae. Rejection of that (photosynthetic) decision by the primordial animal eucaryotic cell ensured that movement became critical to find food and mates. Once animals started to prey upon each other, the development of highly-differentiated sensory systems and specialised nerve cells to convey information rapidly between sensory tissues and organs of movement was an

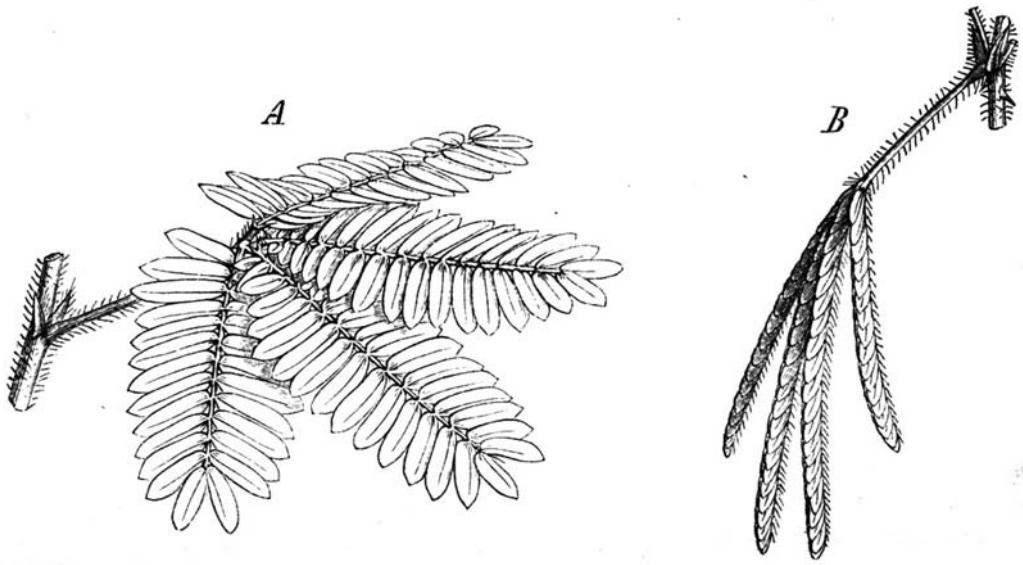

Fig. 41. *Mimosa pudica* L. *A* im ungereizten Zustande (Tagstellung); *B* nach einer Erschütterung (auch Nachtstellung) (1/2). (Nach Sachs.)

Paul Hermann Wilhelm Taubert
Mimosa pudica. in Engelmann (ed.): *Natürliche Pflanzenfamilien. Vol. III, 3, 1891* © free image

inevitable consequence. The predator-prey relationship has acted as a positive feedback loop to accelerate complex development and equally complex organ differentiation in animal evolution (Trewavas, 1986b).

Movement is the expression of intelligence; it is not intelligence itself. Stenhouse (1973) regarded the early expressions of intelligence in animals as resulting from delays in the transfer of information between the sensory system and the motor tissues acting upon the signals. The delay enabled assessment of the information and modification of information in the light of prior experience. It was that assessment which formed the basis of intelligence. The key difference between plants and animals in the Stenhouse (1974) definition is in the word behaviour. Silvertown and Gordon (1989) have defined plant behaviour as the response to internal and external signals. In plant terms these are familiar growth and development phenomena like, de-etiolation, flower induction, wind sway response, regeneration, induced bud break/germination, tropic bending etc. Thus a simple definition of plant intelligence can be coined as *adaptively variable growth and development during the lifetime of the individual.* To add significance to this definition, time lapse shows that virtually all plant movements are indeed the result of growth and development.

It may be argued that animals also grow and develop, but there are important qualitative differences. The sessile plant requires a morphological and developmental pattern that cycle and is necessarily plastic if proper exploitation and growth are to be achieved. Plasticity is from all examinations adaptive (Sultan, 2000), by its nature variable between individuals in different environments, and therefore must involve an element of computation if it is to succeed. Since all plants exhibit adaptive plasticity within the lifetime of the individual (Bradshaw and Hardwick 1989), they must all exhibit intelligent behaviour according to the definition above. In contrast, much animal development and differentiation is confined to a uterus or egg, is minimal in the adult form, and is often described as unitary as a consequence. Plant development is clearly modular, highly polarised through tip growth, and often exhibits complex branching patterns to enable proper resource exploitation that continues throughout the life cycle.

It is crucial to appreciate that all intelligent behaviour in both animals and plants has evolved to optimise fitness. Plants must then have access to an internal memory that specifies the optimal ecological niche in which maximal fitness, usually regarded as greatest numbers of viable seeds, can be achieved. When the niche is sub-optimal, plasticity in growth and development intervenes to counterbalance and to attempt to recover, as far as possible, the benefits of the optimal niche. The sub-optimal niche can then, in some way, be compared to the optimal niche to specify the necessary extent of plasticity in growth and development.

This article considers various aspects of enables exploitation of local minerals, light and

water. Since the environment is a variable and often unpredictable quantity for any individual plant intelligence and attempts to answer some of the inevitable criticisms that will come with the notion of the intelligent plant. The major problems are a mind-set, common in plant scientists, that regards plants basically as automatons. The reasons for this mind-set will be examined later and counter-evidence provided. The article is necessarily long as it must be when trying to justify a change in attitude. Other aspects such as learning, memory, individuality, and plasticity in plants will be reviewed and the article will finish with some interesting examples of intelligence in action which ecologists are beginning to uncover.

SOME IMPORTANT CONSEQUENCES OF A DEFINITION OF PLANT INTELLIGENCE.

Intelligent behaviour is regarded as a property of the whole individual plant or animal. Although there is discussion from population ecologists as to whether the plant should be regarded as the genet or as an individual ramet, due to the modular character and a certain degree of independence of behaviour of individual meristems (White 1973), I shall assume that the individual is the genet. A consequence of a repetitive modular structure is that the individual ramets might be regarded as like parallel processors contributing different experiences resulting from different ages to present day decisions.

Learning and memory are the two emergent (holistic) properties of neural networks that involve large numbers of neural cells acting in communication with each other. But both properties originate from signal transduction processes in individual neural cells. Quite remarkably, the suite of molecules used in signal transduction are entirely similar between nerve cells (Kandel, 2001) and plant cells (Gilroy and Trewavas, 2001; Trewavas, 2000). Most decisions made by plants about growth and development do seem to involve communication between all parts of the plant but with prominence in the decision given to meristems local to the signal. In *Aplysia*, and probably all animal neural systems, learning and memory are inter-twined. Learning results from the formation of new dendrites and memory lasts as long as the newly formed dendrites themselves (Kandel, 2001). The neural network is phenotypically plastic and intelligent behaviour requires that plastic potential. Plant development is plastic too and is not irreversible; many mature plants can be reduced to a single bud and root and regenerate to a new plant with a different structure determined by the new environmental circumstances.

Adaptively-variable behaviour in animals is commonly secured by coordinating different groups of muscles. Individuality in cell and tissue behaviour in plants can underpin behaviours of different, but equal, varieties in individual plants and will be considered later.

Do plants work by rote incapable of anything but reflexive responses?

The animal reflex arc is invariant under all conditions and a common attitude sees plant behaviour as analogous and likewise automaton, rote and invariant. There are probably at least four bases for this mistaken perception.

- **(1). The use of statistics to simplify complex individual behaviour.** Statistics originated as a method to test whether two populations differed significantly as a result of their environmental treatments. However the wholesale summary of physiological responses through means, averages or medians simply eliminates individual variation on the common but incorrect assumption that such variation is only experimental error (Trewavas, 1998). Individual behaviour, as required in the definition of intelligence, is ignored and behaviour thus over-simplified. Quite critically the mean or average does not usually reflect the behaviour of any individual and is simply a composite population response with meaning only to those who wish to study the behaviour of whole populations. But the behaviour of the mean is commonly assumed to reflect the behaviour of each individual in the whole population, particularly when describing mechanisms. Statistical averaging can seriously mislead as to actual mechanisms in individual plants.

Gravitropic responses illustrate the difficulty. Ishikawa et al., (1991) imposed a gravitational stimulus on young growing roots to produce, some 5-6 hours later, the textbook picture of recovery to vertical growth. However the trajectory of individual roots back to the vertical was far from simple and Ishikawa et al., (1991) properly recognised five approximate classes of response. Zeischang and Sievers (1991) found the trajectories of individual gravi-responding roots of *Phleum pratense* too complex to summarise as statistical means. Gravi-responding hypocotyls or coleoptiles can likewise show enormous variations in trajectory back to the vertical (Macleod et al.,

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Phleum pratense, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

1987). Red light, calcium, touch, moisture, oxygen, temperature, ethylene, and auxin have all been reported to modify gravitropic bending illustrating the common observation that physiological phenomena are integrated responses resulting from many environmental influences (Trewavas, 1992). But variations in individual seedling sensitivity to each of these factors increase the variety of individual response. Rich and Smith (1986) noted similar complexity in initiation time in phototropism with individual hypocotyls requiring anywhere from 5 to 40 minutes to initiate response to the same blue light signal. They discuss the problems that averaging incurs in deciding on transduction mechanisms to this signal. Integration of many different environmental influences together to produce a final integrated response is a particular feature of the intelligent animal.

- (2). Controlled environments during experimentation. Because the effects of the numerous environmental factors on plant growth and development can be complex, students are taught to examine such complexity by keeping all environmental factors constant except one which is varied sufficiently strongly to obtain a response. Again the response is usually summarised statistically. These experimental approaches, which are again perfectly valid for asking questions about population behaviour, predispose towards assumptions that responses are reflexive because the signal is imposed until a response is obvious. A good example is water deprivation in which water is withheld until a response is achieved. However, in the wild, a multiplicity of factors affect the response to water deprivation and the imposition of the stimulus takes place in a constantly-changing environmental framework on plants of different age, different genotypes, and very different circumstances. Experimentally depriving an animal of water or nutrient for several days and then exposing them to sources of either, would give rise to an apparently reproducible response (particularly when summarised statistically), but no one would regard such responses as indicating lack of intelligence; far from it.

- (3). The capacity to navigate a maze. One of the hallmarks of intelligent behaviour in the laboratory is the capacity of animals to run successfully through mazes and to receive an eventual reward. But the capacity of plants to grow through an environmental maze is not commonly assumed to represent intelligent behaviour and attracts little attention. Individual branches growing through gaps towards sources of light are an obvious example (Trewavas,1986b). Numerous studies on rhizomes suggest that higher plants must be able to construct a three-dimensional perspective of their local space and optimise their growth patterns to exploit resources, thus receiving rewards for successful behaviour. To any wild plant the environment represents a continual maze that must be successfully navigated.

Dia-gravitropic rhizomes can certainly sense vertical environmental vectors either from being buried or from receipt of light near the surface with vertical growth then being adjusted (Bennet-Clerk and Ball, 1951; Maun and Lapierre, 1984). Consistent control of rhizome horizontal direction has been observed, particularly in heterogeneous soil environments, which are extremely common (Farley and Fitter, 1999). Rich soil patches are exploited by increased branching and growth; poor ones are either directly avoided, or the rhizome thins to conserve resource use and growth is accelerated to speed the detection of new richer patches (Aphalo and Ballare, 1995; Evans and Cain, 1995; Klejihn and Groenendael, 1999; McDonald and Leiffers, 1993; Salzmann, 1985; Wijesighe and Hutchings, 1999). Evans and Cain, (1995) report that *Hydrocotyle* rhizomes veer away from patches of grass, and thus, from competition.

Roots are able to sense humidity gradients and thus also construct a three-dimensional environmental perspective (Takahashi and Scott, 1993). Increased root branching in patches rich in nitrate or phosphate indicate a similar ability in environmental perception (Drew and Saker 1973). Roots will also take avoidance action when near others (Aphalo and Ballare, 1995). These data and others have led to the concept that plants actively forage resources from their environment (Hutchings and Kroon, 1993) using assessment mechanisms similar to those of animals.

Both plants and animals use exploratory behaviour to enhance the chances of survival by optimising the gathering of food resources. In this way, they maximise both the potential for reproduction and the selfish passage of genes into the next generation.

- (4). Intelligent behaviour in animals requires the right environmental context for it to be expressed. A simple (sometimes-controversial) way to detect

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Hydrocotyle vulgaris, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

intelligent behaviour in humans is to impose an IQ test. These two factors, context and organism, are both essential in detection and examination of intelligent behaviour. Just as obvious intelligent behaviour is not so easy to detect in caged animals in zoos, it will not be readily observed in laboratory grown plants. This is, in part, because the necessary competitive and variable circumstances to elicit intelligent responses are not present. Intelligence requires both the organism able to compute and the right environmental circumstances to elicit that computation. On that basis, it is not surprising that most observations supporting the concept of plant intelligence come from ecologists studying plant behaviour under conditions more nearly mimicking those of plants in the wild. The observations of Darwin or Von Sachs that suggested similarities between animal behaviour, nervous systems, and the behaviour of plants (quotations are to be found in Trewavas, 1999) could represent the lack of controlled growth and laboratory facilities in the 19th century and thus the likely observation of plants growing under less-controlled and far more realistic circumstances eliciting intelligent behaviour.

THE BASIS OF INTELLIGENT BEHAVIOUR.

Learning involves goals and error assessment mechanisms.

At its simplest level, whole organism learning requires two things: **(1)** A goal, usually set in advance, and **(2)** an error-indicating mechanism that quantifies how close newly-changed behaviour approaches that goal. For those who prefer a familiar human example with a short-term goal, learning to ride a bike is a good model. The process of learning requires a continual exchange of information and feedback from the goal to the current behaviour in order to correct current behaviour and direct future behaviour more closely towards achieving the goal.

Wild plants need trial-and-error learning because the environmental circumstances in which signals arrive can be so variable. That is, the starting point can be indeterminate and rote behaviour would be insufficient to ensure successful progress towards the goal. Whereas the eventual fitness goal may always be the same, the life trajectories attempting to achieve that goal must be learnt. Indications of trial-and-error learning can be deduced from the presence of damped or even robust oscillations in behaviour as the organism continually assesses and makes further corrections to behaviour. The reason that plants respond to gravity, for example, is primarily one of nutrition (shoots to light-roots to minerals and water) leading to better growth and eventual reproduction. But roots and shoots may find themselves at any angle to the final desired position and thus must learn progressively how to approach the internally-specified optimal angle if conditions allow. However the final branch angle adopted depends on a congruence of environmental assessments with internally specified information which can be accessed as a default position when conditions are optimal.

There are numerous plant learning examples and a few indicate the point.

- Oscillations and overshoot in the approach of seedling shoots or roots to the vertical after horizontal displacement were reported, for example, by Ishikawa et al., (1991); Heathcote and Aston, (1970); Johnsson and Israelsson, (1968); and Shen Miller, (1973). Johnsson (1979) lists a further 23 earlier references that report this behaviour. Bennet-Clerk and Ball, (1951) detail the gravitropic behaviour of many individual rhizomes and report overshoot, undershoot, growth initially in the wrong direction and sustained oscillations. These latter authors specifically note that averaging tends to eliminate detection of individual behaviour because individuals are rarely in synchrony with each other. Clifford et al., (1982) reported that deliberate bending of *Taraxacum* shoots with release, causes over-compensatory growth in the other direction, again indicating error correction with a goal (or set point).

- Bose, (1924) used continuous recording to report that the behaviour of petioles, roots, styles, and *Mimosa* leaflets to thermal, mechanical and light stimuli often oscillated in their approach to a new state of growth.

- When leaves are deprived of water, stomata reduce aperture size, but the tendency to overshoot and oscillations in the new steady state have both been reported (Stalfelt, (1929) quoted in Raschke, (1979)). Raschke, (1970) detected oscillations of the average stomatal aperture determined by porometry in different regions of maize leaves. Johnsson, (1976)

Prof. Dr. Otto Wilhelm Thomé

Taraxacum officinale, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

concluded that both feedback and feed forward mechanisms are involved in error correction and optimising stomatal aperture.

- On mild water stress there is often a period of compensatory growth after rewatering, indicating an error correction mechanism (Stocker, 1960). Trees can abscind sufficient leaves to adjust numbers to current water supplies. Some trial and error mechanism must determine when sufficient leaves are dropped (Addicott, 1982). Similar mechanisms must be present for all phenotypically plastic processes. Thus, for example, stem thickening in response to wind sway must be able to access the goal of optimal wind sway and a trial-and-error assessment of how far the individual is from that goal.

- Resistance to drought or cold can be enhanced by prior treatment to milder conditions of water stress or low temperature (for example, Kacperska and Kuleza, 1987; Kramer, 1980; Griffith and McIntyre, 1993). Such well-known behaviour (acclimation), requiring physiological and metabolic changes, is analogous to animal learning.

Similarities in avoidance responses by plants and animals.

A single stimulus in the marine snail, *Aplysia*, designed to produce avoidance responses (the goal in this case) may only initiate short term memory changes lasting a few minutes (Kandel, 2001). The intracellular mechanisms involve the second messengers Ca^{2+} and cyclic nucleotides, and a limited number of protein kinases that phosphorylate ion channels that serve as temporary memory (Greengard, 2001). Repetition of the stimulus or increasing its intensity modifies protein synthesis in neurones and the formation of new dendrites (neural connections). The transduction of these avoidance stimuli involves MAP kinases, control of gene expression by cyclic nucleotide binding elements (CREB), and the ubiquitin pathway to dispose of protein kinase A-regulatory proteins. Increasing the size of the stimulus again greatly enhances further dendrite formation and a strengthening and increased effectiveness of dendrites already present in the chosen pathway of communication by adhesion mechanisms that may involve integrins. Additional growth factors are now involved, including EF1α, a protein with similar functions in both animals and plants. The new dendrites in this animal represent memory and as they disappear so the memory disappears.

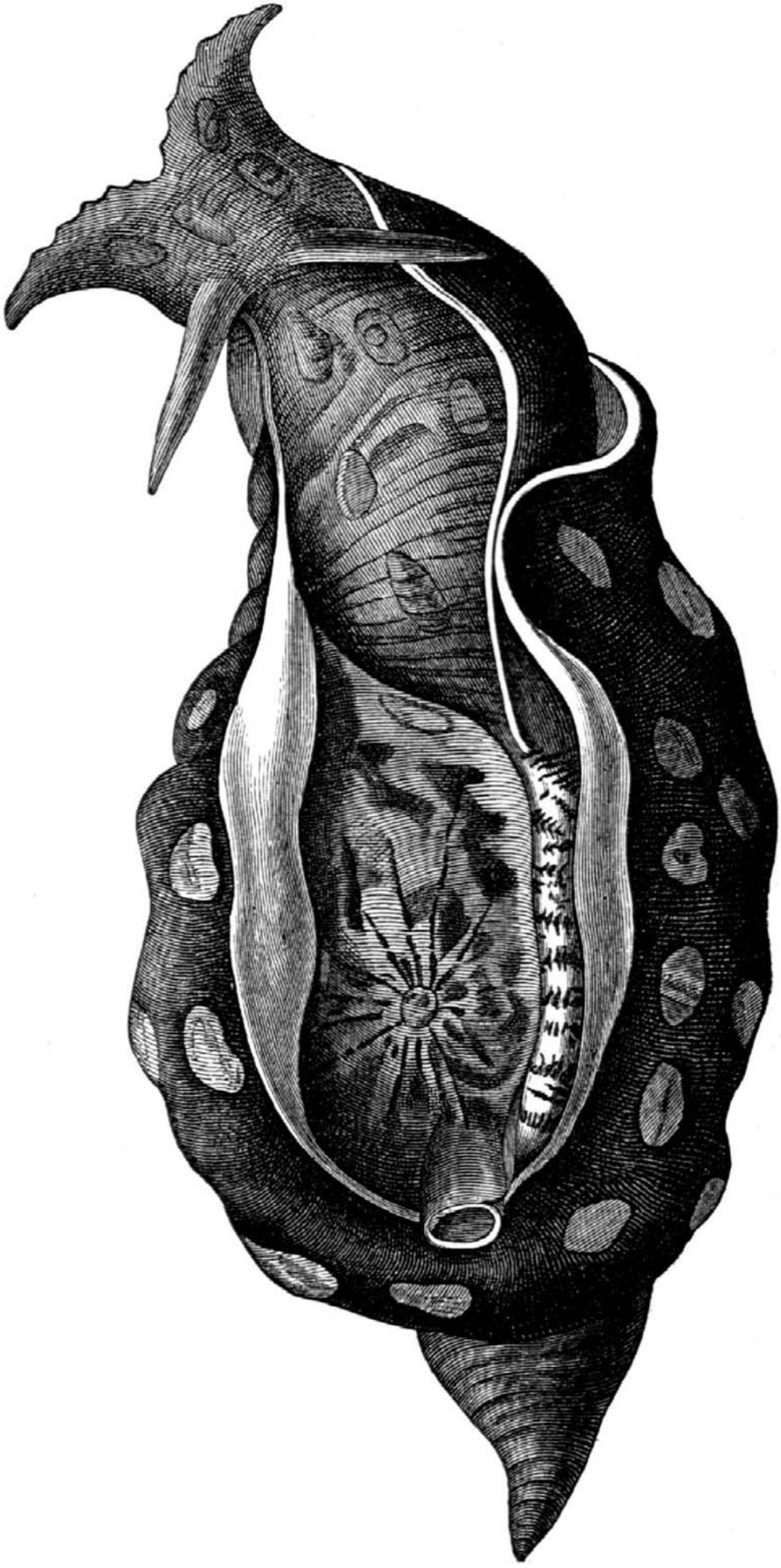
Drought avoidance behaviour by plants is well established. Slight variations in water availability incur equally slight, but temporary reductions only in cell growth rate. These probably involve changes in second messengers, particularly [Ca^{2+}], and phosphorylation changes in turgor-generating ATPases and associated ion channels (Begg, 1980; Hanson and Trewavas, 1982; Palmgren, 2001). More intense stress signals initiate changes in protein and wall synthesis, cuticle thickness, stomatal conductance and limited morphological reductions of leaf area (Hsaio et al., 1976; Kramer, 1980). Each of these processes seems to have a discrete water potential threshold at which it is initiated. Perhaps progressive reductions in plasma membrane wall adhesion are responsible, initiating transduction mechanisms and modifying plasmodesmatal functioning. The transduction mechanisms include those mentioned above and MAP kinases and other protein kinases modifying transcription factors (Hetherington, 2001; Jonak et al., 2001).

With more severe water stress, the root/shoot ratio increases, and, in wild plants, can vary up to twenty fold (Chapin, 1980). In developing leaves, internal mesophyll surface area is reduced and stomatal density modified, producing a xeromorphic-type morphology (Stocker, 1960). Increased hairiness, early flowering and a modified vascular system are induced later, indicative of memory of the initial droughting signal (Kramer, 1980; Stocker, 1960).

All of the above responses, whether physiological or morphological, must be initiated and transduced by mechanisms that can assess the current supply of water against a notional optimal supply. The plant learns by trial and error when sufficient changes have taken place so that further stress and injury is minimised and some seed production can be achieved. The responses to water stress are modified by interaction and integration with other environmental variables, mineral nutrition, temperature, humidity, age, previous plant history, disease, and probably with all external environmental influences. They are not, therefore, reflexive responses. Clearly decisions are made by the whole plant.

The similarities between avoidance responses in neural circuitry and plant water stress are:

1. A graded response in both cases according to strength of stimulus.
2. Similar transduction mechanisms with the different strengths of stimuli.



Alfred Brehm

Aplysia, from: Alfred Brehm's Animal Life / Lower Animals / The group of mollusks / Fourth Order: Hinterkiemer (Opistobranchia) / I. Deckkiemer / 4 Family Group: lumpfish (Aplysia) / Common lumpfish (Aplysia depilans) lumpfish (Aplysia depilans).

3. Morphological changes in nerve cells and plants induced only by the stronger stimuli.
4. The result of neural learning is to coordinate the behaviour of different muscles together to enable an avoidance response by movement. The result of plant learning is to coordinate the developmental behaviour of different tissues together to produce an avoidance response by phenotypic plasticity. Muscles are as constrained in their behaviour as any plant tissue; there are just many of them that can be coordinated together to generate great varieties of behaviour.
5. Animal learning lays down additional pathways of communication. Plant learning increases vasculature and increased communication between cells through plasmodesmata (see below).
6. Both organisms integrate together the present organismal state to modify the response to further signals.

Morphological changes in plants do act like long term memory, because they will influence subsequent behaviour by the individual plant when other environmental signals are imposed. It can be objected that long-term animal memory is reversible in the absence of further stimulation, whereas morphological changes are not. However, this is not the case. In the short term, stomata usually open again within a few days when water stress is still imposed. "Xeromorphic" leaves are often the first to be abscised after re-watering and new leaves are formed by bud break. There is root turnover and death (Bazzaz, 1996) enabling some recovery of root/shoot ratios.

Do seedlings learn about their environment?

The seedling stage is the most vulnerable for any higher plant with chaotic fluctuations at the soil surface in temperature, moisture, carbon dioxide, light, patchy nutrient dispersal, and the common but variable enemies of disease and predation. There is also a stochastic character to seed dispersal, dormancy breakage, degree of phenotypic individuality (Bradford and Trewavas, 1994), and thus indications that the behaviour of every seed will differ from others in certain aspects of behaviour (Bazzaz, 1996). The integrated environment can be viewed as a continually changing in shape topological surface that is directly mapped onto the signal transduction network in sensitive cells and tissues in mirror image, eliciting responses to navigate the environmental maze (Trewavas, 2000). Each seedling must experience a unique spatial and temporal environmental surface. Bazzaz (1996, page 168) illustrates topological surfaces constructed from the interaction of two environmental variables on different genotypes.

It is recognised that signal transduction mechanisms can be represented as a network. The implication may be that pathways of information flow between the signal and response may not be invariant between different individuals (Csete and Doyle, 2002; Elowitz et al., 2002; Guet et al., 2002; Levsky et al., 2002; McAdams and Arkin,1999). What is suggested is that when a seedling first receives a signal, a weak response is constructed using the signal transduction constituents to hand and with the signal information finding various channels through which it can flow. Further signalling reinforces this information channel by synthesis of particular signal transduction constituents, much as increased numbers of dendrites improve information flow rates during neural network learning. The signal transduction network thus learns (Trewavas, 2001). Seedlings that fail to learn adequately or quickly die off. It is already known that Ca^{2+} dependent and independent processes can be separately invoked to induce identical physiological processes (Allan et al., 1994) and that the synthesis of many constituents concerned with calcium signal transduction are synthesised following signalling (Trewavas, 1999; Trewavas, 2001).

COMMUNICATION TO CONSTRUCT INTELLIGENT NETWORKS.

Intelligence requires a network of elements capable of adaptively variable information flow to underpin intelligent behaviour. In animals, nerve cells are specifically adapted by structure to enable rapid phenotypic adjustments and computation. But critically a network requires communication between the elements.

Communication in neural systems.

Much early work in the last century hinged on the notion that communication across nerve synapses and throughout the brain was purely electrical. Action potentials jumped across the synaptic divide propagating further action potentials downstream. A contrasting view suggested that communication between nerve cells was performed solely by chemicals, although these in turn would generate action potentials down the long axon. Neurotransmitters

were released by fusion of secretory vesicles with the plasma membrane. Specific neurotransmitter receptors across the synapse induced a new action potential by modifying ligand-operated ion channel function. The chemical messenger theory is correct. 99% of all communication in the brain is chemical (Greengard, 2001). Action potentials are used primarily to speed communication down the long nerve cell axons.

Two kinds of chemical transmission are recognised. Fast transmission, completed in milliseconds, uses the neurotransmitter glutamate and glutamate receptors. Fast inhibition uses γ-aminobutyric acid (GABA). Slow transmission can take many minutes and is enormously more complex involving at least 100 different chemicals falling into four classes: biogenic amines, peptides, amino acids, and nitric oxide (Greengard, 2001). Quite remarkably, glutamate has recently been found to influence cytosolic $[Ca^{2+}]_i$ in plant cells, and nitric oxide is a recognised second messenger in plant cells (Dennison and Spalding, 2000).

Communication between and within plant tissues.

The fact that the various parts of plants communicate with each other has been established by many experiments. Various surgical treatments (such as removal of root or shoot or leaves mimicking predation or other damage), resource stress (lack of light or water or minerals), or exposure of one part of a plant to varying resource levels give rise to specific changes in growth and development elsewhere in the plant, indicating communication of the stimulus. Such phenomena have been called correlations. In these above cases, development is usually adjusted to try and recover a balance between root and shoot or to ensure a better balance of basic resources. (Note again the presence of a goal (set point) and an error-correcting (learning) mechanism). Flowering, tuberisation, bud break, enhanced root growth, and branching can follow selective exposure of leaves to particular light periods. Signals are thus transmitted from the leaf to other tissues (Trewavas, 1986b).

A shortage of specific resources leads to accelerated growth of the tissue either as elongation, weight, or branching that normally collects the resource. In contrast, abundance of all resources leads to increased branching, or if the resource is localised, often local branching. When shaded, shade-intolerant species show substantial elongation of the primary stem (at the expense of lateral stem growth), increased leaf area, and a disproportionate reduction in the growth of fine roots (Bloom et al., 1985). A shortage of water leads to enhanced root growth and particular proliferation when an abundance of resources are located. Lake et al., (2001), observed that high CO_2 levels reduce stomatal frequencies, but the CO_2 signals are sensed by mature leaves and the information conveyed to developing leaves which cannot respond to high CO_2. Communication of aphid attack between plants has recently been shown to involve other volatiles (Petterson et al., 1999).

By use of a microbeam of red light, Nick et al., (1993) provided convincing evidence for cell to cell communication between cotyledon cells with long range inhibition of gene expression in un-irradiated cotyledon cells at some distance from the irradiated patch. Moreover the cell regions responding were, in turn, specifically determined by the region irradiated, suggesting selective communication only between certain cells in the cotyledon.

The information that is being communicated between tissues and cells is now known to be extraordinarily complex. Communication involves nucleic acids, oligonucleotides, proteins and peptides, minerals, oxidative signals, gases, hydraulic and other mechanical signals, electrical signals, lipids, wall fragments (oligosaccharides), growth regulators, some amino acids, secondary products of many kinds, minerals, and simple sugars (Bose, 1924; Brownlee, 2002; Gilroy and Trewavas 1990, 2001; Haywood et al., 2002; Jorgensen et al., 1998; Kim et al., 2001; Mott and Buckley, 2000; Nakajima et al., 2001; Sessions et al., 2000; Sheen et al., 1999; Takayama and Sakagami, 2002; Voinnet, 2002; references on growth regulators in Quatrano et al., 2002). Transcripts can move even between graft unions (Kim et al., 2001). From the current rate of progress it looks as though plant communication is likely to be as complex as within a brain. The demonstration of macromolecule movement between cells is of considerable significance because it enables substantial amounts of information to be built into the signal if needed; thus, complex information can be encoded in the signal.

Plasmodesmata controlling information flow.

Plasmodesmatal connections enable movement of proteins and nucleic acids as well as smaller

molecules between plant cells (Zambryski and Crawford, 2000). Movement of transcription factors and nucleic acids have the potential to activate or repress genes in cells remote from the source by activation of DNA methylation or by mRNA translation. Oligonucleotides with specific sequences can silence genes. To create a complex, cellular network capable of computation also requires particular cellular locales for specific receptors remote from the source of the signal. Alternatively, substantive variation in sensitivity to the same signal between individual cells might achieve the same end.

Furthermore just as synaptic connections (dendrites) can be increased to amplify particular pathways of communication during learning, individual cells can modulate the extent of plasmodesmatal transport. Physiological alterations of plasmodesmatal transport result from anaerobic and osmotic stress, changes in $[Ca^{2+}]_i$, or inositol phosphates (Ding et al., 1999). I expect this list to increase. Even slight changes in growing conditions have been observed to modify signal transmission (Zambryski and Crawford, 2000). Quantitative and qualitative changes in plasmodesmatal number occur during development and secondary plasmodesmata can be formed in the absence of cell division and can even branch rather like the synthesis of new dendrites.

Plasmodesmatal connections seem to be limited to adjacent cells. Whether plasmodesmatal strength, analogous to synaptic strength, could be increased is not clear, but, intriguingly, one of the proteins that binds plasmodesmatal proteins is pectin methylesterase (Jackson,2000). Such observations might imply that connections between plasmodesmata and the wall can be altered and that mechanical constraints alter plasmodesmatal function leading to a modified flux of information. In this case, wall interactions could control the ability of plasmodesmata to act like an information valve, changing flux rates according to mechanical stresses imposed either by the environment or resulting from mechanical stresses induced by growth.

Communication within cells.

Communication within cells is equally complex and stable, and transient transduction complexes are known to be used to interpret new information (Gilroy and Trewavas, 2001). Cytosolic Ca^{2+}, $[Ca^{2+}]_i$, in particular, seems to act as a cellular second messenger with ubiquitous roles in signal transduction and intra-cellular communication. $[Ca^{2+}]_i$ has very limited cytoplasmic mobility and enhanced entry through channels following signalling. It activates Ca^{2+} binding proteins within the microdomain in which channels are clustered (Trewavas, 2002a). Localised intracellular distributions, and particular control properties of channels and ATPases that pump Ca^{2+} back into subcellular compartments or walls, result in Ca^{2+} waves and oscillations (Mahlo et al., 1998; Schroeder et al., 2001), a rich source of information and specific communication. Rapidly moving Ca^{2+} waves have been observed in a number of cell types, and thus can act to coordinate parts of the recipient cell towards a behavioural objective (Sanders et al., 2002). The wave moves on the surface of cellular membranes, most probably the ER and inner plasma membrane surface. The wave itself is a movement of Ca^{2+}-induced-Ca^{2+} release and not a physical transmission of Ca^{2+} ions. Topological similarities between Ca^{2+} waves and simple neural circuits, enabling aspects of computation to be understood, have already been drawn (Trewavas, 1999).

Many different environmental signals (e.g. touch, wind, cold, disease, gravity, etc.) modify $[Ca^{2+}]_i$ and are responsible for generating phenotypic plasticity. How can a single ion mediate such response variety? The reality is that $[Ca^{2+}]_i$ is just one of a large number of signals that operate in signal transduction, but one which acts as a nodal point in a robust transduction network. Complexity in $[Ca^{2+}]_i$ signalling is increased by contributions from various organelles such as the nucleus, ER, or chloroplast (Van der Luit et al., 1999). The nucleus is thought to have its own Ca^{2+} mobilising system, and mitochondria and chloroplasts have internal Ca^{2+} control. The ER and the vacuole modify cytoplasmic signals (Sanders et al., 2002). Different closing signals in guard cells elicit Ca^{2+} responses from different compartments (Gilroy and Trewavas, 2001). The amplitude and kinetics of the Ca^{2+} transient (wave), and different regions of the transient, can also initiate discrete transduction sequences. Changes in $[Ca^{2+}]_i$ can be extremely rapid (within the 100 millisecond range) and can initiate selective changes in gene expression. Changes in $[Ca^{2+}]_i$ are essential to communication and learning within nerve cells (Greengard, 2001).

PLANT MEMORY AND INFORMATION RETRIEVAL.

In nervous systems, new connections (dendrites) between nerve cells may form the basis of memory (Kandel, 2001), and loss of the dendrite

coincides with loss of memory. What is required for memory is an ability to access past experience so that new responses incorporate relevant information from the past. Many different forms of plant memory can be envisaged, all of which modify signal transduction from the current chemistry and enzymology of membranes (Gilroy and Trewavas, 2001) or wall characteristics (Trewavas, 1999) to a prior expression of particular genes. It is also clear that the history of stimulation modifies subsequent transduction (Ingolis and Murray, 2002) and, in plants, interpretation through $[Ca^{2+}]_i$ is likewise modified by previous signalling, ensuring another form of memory is present (Trewavas, 1999). All these forms of memory can be recognised by the ability to interact with and modify the transduction pathways to new signals. The only requirement is merely that the memory can be accessed and influence the response to the current signal. A more complex form of memory requires information storage of previous signalling with the ability to retrieve the information at a much later time. Both forms occur in plants.

Memory of developmental status.

It is obvious that the present state of development acts as memory for any individual plant because the same signal can have different effects determined by when the plant, tissue, or cell receives it. The effects of blue or red light signals are good examples, having different effects dependent on the stage of development. Thus red light can affect leaf movement, stem elongation, or germination. Furthermore photoperiodic plants can be exposed to one or two inductive photoperiods and then returned to a non-inductive light/dark schedule where they will continue to flower. Some long-lived memory has obviously been instituted. Plants which are vernalised by three weeks, low temperature or appropriate imbibed dormant seeds given 3-4 weeks low temperature, retain the memory of that treatment and either flower or germinate when the inductive schedule is no longer imposed. Lloyd, (1980), suggested that flowering consist of a series of reassessment points in which adjustments to the final number of flowers could be made dependent on nutritional availability in a form of learning and memory. If seed imbibition takes place in conditions that are inimical to germination, then a more prolonged state of dormancy, secondary dormancy, can be entered into, lasting many years (Trewavas, 1986a). Some dormant imbibed seeds can show annual flushes in germination rates, often in the form of damped oscillations in numbers, germinating over successive years. Many aspects of dormancy are analogous to nervous memory; there are short and long-term versions. Dormancy can be reinforced or over-ridden. A variety of environmental facets inter-play to modify germination and dormancy. Even the molecular basis of long term dormancy may be similar to animal memory (Trewavas, 1986a). Apolar *Fucus* zygotes can be polarised by a one-second flash of intense directional blue light, and so on. Examples abound.

In the whole plant, there are many examples where prior signals modify the response to rapid subsequent signals, thus indicating memory of the previous signal. Dostal, (1967) describes many such examples produced by his own work. For example, exposure of de-etiolated flax seedlings to white or red light generally has no influence on cotyledonary bud growth. But if the main stem above the cotyledons of flax seedling is removed, both cotyledonary buds grow out. When Dostal removed one cotyledon and the main stem from flax seedlings and placed the truncated seedling in white light, only the axillary bud subtended by the remaining cotyledon grew. But when placed in red light, the opposite bud grew out. Both buds retrieved information concerning the presence or absence of the apex and received signals to grow. But retrieval of that information could be subsequently over-ridden for either bud by other later signals arising from light exposure, the wavelength of light, and the presence or absence of the cotyledon.

In *Schrophularia nodosa*, information retrieval by dormant buds is evidently modified by the state of development (Dostal, 1967). This plant has square shaped stems, dichotamous branching, and thus known vascular arrangements. Cuttings were made from pieces of stem containing two opposite leaves and thus two axillary buds. If kept moist, both axillary buds broke dormancy and grew; adventitious roots formed on all four sides of the base of the cut stem. If the leaves were mature, removal of one of the leaves inhibited the growth of the subtended axillary bud whilst permitting the other bud to grow out. Adventitious roots then formed only on the side of the amputated leaf. If the leaf left behind was not fully mature, inhibition of axillary bud growth was still evident, but the roots now developed on the opposite side underneath the remaining leaf. If the leaf left behind was developmentally very young, both the axillary bud and roots grew out only on the leaf side.

Prof. Dr. Otto Wilhelm Thomé

Schropularia nodosa, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

There was a complex interplay between the age of leaves, leaf removal, bud outgrowth and root formation that modified the original excision signal, but the memory of that signal remained in the activity of the buds.

Retrieval of information after a delay.

Similar experimental approaches in *Bidens pilosa* have shown that the initial signal can be separated from its effects by many days. Removal of the growing apex from young seedlings again results in outgrowth of cotyledonary buds (Desbiez et al., 1991). Puncturing one cotyledon of non-decapitated plants had no effect on the cotyledonary buds which remained quiescent. But if one cotyledon was pricked with a needle, both cotyledons then removed within five minutes and the seedling then decapitated several days later. In this case, the bud opposite to the pricked cotyledon started to grow much faster than the other. An asymmetric state had been achieved, but usually only in about half of the seedlings. The response is clearly an example of individuality. The recall of information about the original needle damage required the seedling to be in the appropriate state. Various environmental treatments such as cold or warm temperatures could override the retrieval of information that specified asymmetry. It was thought that a wave of depolarisation was the signal conveyed to the bud from the puncture signal on the cotyledon. The overriding environmental treatments are all known to modify $[Ca^{2+}]_i$.

Ca^{2+} controls the accessible memory of environmental signals involved in the induction of flax epidermal meristems (Verdus et al., 1997). These hypocotyl meristems could be induced by drought or wind signals that are also known to increase $[Ca^{2+}]_i$ transiently. But induction required a depletion of seedling Ca^{2+} of about one day in length before the effects of drought and wind could be detected. Using this system, memory of the previous drought and wind signals could be stored and accessed for at least 8 days, unabated, before expression was finally elicited by a Ca^{2+} depletion. The mechanism is unknown but changes in gene expression, or protein kinase activity, resulting from drought and wind signals might be responsible.

Further examples of shorter term memory involving $[Ca^{2+}]_i$ have emerged. Exposure of etiolated cereal leaves to red light results in unrolling. However sections of leaves will not unroll in red light if Ca^{2+} is removed from the medium (Viner et al., 1988). But if leaf sections are exposed first to red light, Ca^{2+} can be added back to the medium to induce unrolling up to four hours later. Some excited state of the cells is induced by red light and maintained for at least four hours. Administration of an hyper-osmotic shock normally induces a $[Ca^{2+}]_i$ transient of short duration (Takahashi et al., 1997). But if the shock is administered in the absence of extracellular Ca^{2+}, the transient fails to appear until extracellular Ca^{2+} is returned to the medium. The separation of shock and return of extracellular Ca^{2+} can last as long as 20 minutes.

Accessing of internal information; is the niche an accessible memory?

It is perhaps no accident that optimal fitness is the overall goal of any individual animal, and intelligent behaviour contributes to that goal (Wright,1932; Dawkins,1976). Wright produced a visual representation of fitness, in terms of a landscape, in which individuals represent hills or mountains, with the most fit being the highest.

The operational life cycle goal to which all individual plants aspire is also optimal fitness. However fitness is indissolubly linked with the local environment in which the individual finds itself and grows. Maximal fitness can be achieved when the plant grows in its optimal (fundamental) ecological niche. The niche is difficult to characterise (Bazzaz, 1996 and see below), and with competition for resources in wild plants, is limited to the realized niche. But measurements show that the niche is individual to the genotype, not the species. On that basis, it is likely that each individual plant will possess a unique niche memory to which it will attempt to match growth and development. The important feature is that information, which describes the fundamental niche, is present in the organism and can be accessed, thus representing a long-term (life cycle) memory. How information about the fundamental niche can be inherited, when it is rarely realised (Hunt and Lloyd, 1987), is not understood.

Theoretical and experimental work suggests that species must have different resource requirements for them to coexist in a community; they must occupy different niches with only a minimum of overlap. Furthermore recognition must be present, that is information encoded in the individual, that indicates when the niche conditions are met and when they are not. Since all plants require minerals, water, and light, niche differentiation is considered more difficult to define in plants than animals where the concept first arose (Bazzaz, 1996). However if the

concept is useful it should inform upon the subject matter of this essay.

Phenotypic (and physiological) plasticity represents part or all of the error-correcting mechanisms that individual plants use in an attempt to achieve optimal fitness in the realised niche. Phenotypically-plastic mechanisms are not reflex responses (see below), but depend on an ability to assess not only what tissues should alter (with the assessment influencing very early tissue development), but an ability to stop plasticity when sufficient change towards the optimal goal has been made. However to have to resort to phenotypic plasticity implies that optimal fitness may not be achieved. Individual plants that express plasticity will more nearly approach the fitness objective than individuals that do not. But the error-correcting mechanism must involve complex negative feedback mechanisms with versions of trial and error; that is, learning.

Inherently all descriptions of niche must basically concern the interaction of the plant with its environment, that is the position of the individual in both space and time. Moreover niche can be different for plants grown in the laboratory to those in the wild. Uniform stands of some plants such as wild wheat, *Phragmites,* and *Spartina* are known to exist and may even be genetically identical. But most plants exist in complex communities implying discrimination by the individual plants amongst the numerous factors in the environment. It is known that wild populations contain enormous genetic diversity (Burdon, 1980) and it is thought that this reflects, in large part, environmental diversity which must be correspondingly complex (Antonovics, 1971).

Many plants do show different (non-equitable) physiological and morphological responses along gradients of any of the primary resources, and it seems unlikely that many or indeed any of these resource axes act independently of each other (Bazzaz, 1996; Tilman, 1982). Some resources like N or K can act synergistically, but others can be incongruent; an increase in sunlight can institute moisture stress, for example. If there are about 15 environmental factors acting in differing degrees and affecting the perception of each other, then the combination of possible environments in which any individual can find itself, and to which it must respond, is enormous. Thus exists the necessity for learning rather than rote behaviour. Moreover long and short-term responses to environmental variables will be different. The response of an individual along a resource gradient is very strongly influenced by its neighbours. While negative interactions through competition for the basic resources of space, light, minerals, and water and interactions through allelopathy are well established (e.g.Turkington 1983; Turkington and Harper 1979; Zangerl and Bazzaz, 1984), co-operative, positive interactions are clearly evident through mycorrhizal spread, symbiotic relations with bacteria, releasing nitrogen to other plants, remediation of local stressful environments (Salzman and Parker, 1985), or semio-chemicals warning other plants of predatory attack (Petterson et al., 1999).

Time may be an additional critical factor in defining niche. Continued growth generates new environments for both root and shoot and responses of both tissues to the environment change ontogenetically. In low vegetation, above-ground patchiness may be imposed by the spatial arrangement of dwarf shrubs and persistent clumps of perennial herbs, and modified by microtopography and grazing. Hartgerink and Bazzaz, (1984), observed that the imprint of a footprint on the soil or a stone placed nearby could accelerate germination rates but substantially reduce final biomass and seed number nearly three fold. Such results suggest a remarkably fine definition of the environment by the individual plant. Soil resources can be patchily distributed or may be continuous (Farley and Fitter, 1999).

Individual genotypes of *Polygonum* expressed unique norms of reaction in physiological, allocational and morphological characters (including fitness) when nutrient and light environments were modified (Bazzaz, 1996, [note response surface on page 168]; Sultan, 1996, 2000; Sultan et al., 1998; Zangerl and Bazzaz, 1984). Thus at each setting of the environment, the individual plant can access information that it can use to construct a response and to ensure that overall, maximal fitness will be achieved. The implication is that the difference between the optimal niche/phenotype and the present environment and present phenotype can be measured. A counterbalancing response is then constructed that directs the individual into a new trajectory of development. Once again a goal is specified, even though that goal might be heritable, and an error-correcting mechanism is in place to try and achieve the goal. Constant monitoring of the new phenotype as it develops and continuous control are exerted to ensure that the new phase of development is optimal and consistent with long term evolutionary objectives. Information about the individual genotype can be accessed as permanent memory and

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Phragmites communis, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

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Polygonum bistorta, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

interpretation follows from interaction with the complex network that underpins signal transduction processes. Until we understand better the properties of signal transduction networks, we will not be in a position to understand how plants achieve their fitness goals.

INCREASING THE VARIETY OF RESPONSE

Control circuitry and individuality.

The genetic analysis of flowering time in *Arabidopsis* will probably provide a paradigm for the genetic control circuitry that underpins other timing processes such as bud and seed dormancy breakage in plant development. Although the precise molecular details are still being uncovered, some very broad outlines of control circuitry are now indicated (Simpson and Dean, 2002). Robust control circuits involve both feed forward and feed back regulation, and obvious signals that attempt to propel the system forward or hold it back are obviously present in the flowering time circuitry. Integration of different signals is achieved, it is thought, by protein/protein interaction from different input signals on the promoters of integrator genes. Redundancy in the circuitry is also evident, providing for fail safe mechanisms. Plasticity in flowering time results from quantitative variations in overlapping pathways. Further investigation may reveal the extent to which controls consist of modular groups of proteins which can be changed *en bloc*, as it were, and which overlap with each other providing reliability (Hartwell et al., 1999). Hierarchical organisation of modularity has already been detailed in metabolic networks (Ravasz et al., 2002). However these basic elements in control circuitry are what might be expected to control plasticity.

While genetics is a powerful investigative tool, we are not dealing with bacteria in which mutation affects only the cell in which it expressed. Instead the individual plant is a complex, multi-cellular and multi-tissue organism in which development is continuous and in which communication is paramount. Flowering time, an aspect of plasticity and behaviour, is a composite response involving all parts of the organism including its life cycle. Mutations, the normal means of identifying relevant genes that modify any character, are often present throughout the whole life cycle. Knock-on consequences from some mutations may then only indirectly affect later processes such as flowering time. Intelligent behaviour is a holistic quantity reflecting in turn the whole organism but some of the circuit control indicated above for flowering should be present at a whole plant level.

The problems of resource gathering and predation for a sessile organism seem to be the major evolutionary pressures that have generated minimal tissue specialisation, the branched structure, and modular development. All higher plants are constructed from repetitions of the same basic modular structure: leaf plus bud and below ground root meristems, repeated many times, with an enormously varying number. Since a plant can be regenerated from a single meristem, redundancy in development is self-evident. Furthermore, growth regulators often overlap in their effects. This is organisational plasticity we simply do not understand. But plants can be best viewed as more like a democratic confederation in their control structure than an autocracy as occurs in animals, underpinned by an all-embracing nervous system. With a spatial and temporal mosaic of resources that surround the plant, some latitude must be present to allow local growing areas to optimally exploit rich sources. Our understanding of plant intelligence must therefore accommodate these properties and answer some very basic questions. How many varieties of behaviour can be constructed with a limited number of tissues? Does partial independence of growing parts change a holistic view of plant intelligence?

Individuality is used to describe situations in which morphologically or anatomically identical cells, tissues, or plants show non-similar responses to signals (Gilroy and Trewavas, 2001; Trewavas, 1998). The example of rhizome gravitropism quoted above (Bennet-Clark and Ball, 1951) details individual variations. Individuality receives little or no investigation in plant science despite being a widespread phenomenon. As if to counteract the paucity of different tissues in the normal vegetative plant, continued embryogenic development by meristems results in tissues and cells with enormous varieties of individual behaviour. A reservoir of different cell behaviours becomes available to enable the construction of a variety of tissue and plant behaviours to exploit the resource mosaic. Individuality of the kind commonly observed in plants might be unique. A mechanism for individuality has been proposed as originating from stochastic variation in distribution between daughter cells of tiny numbers of critical proteins controlling cell and tissue development (Federoff and Fontana, 2002;Gilroy and Trewavas, 2001).

Recognition of individuality can easily be

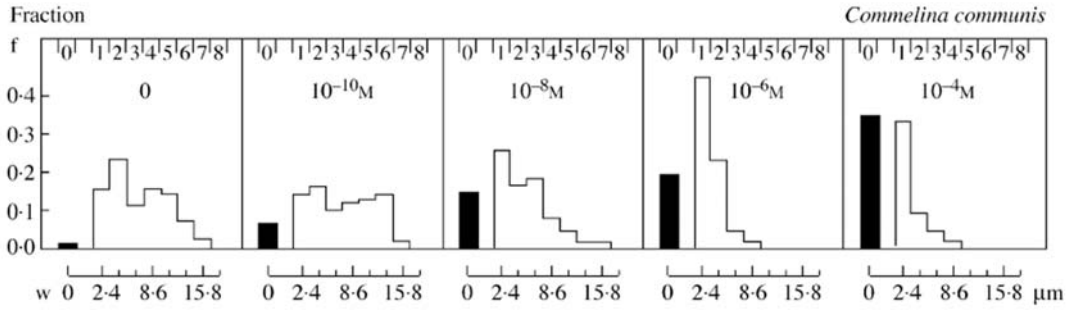


FIG. 1. Frequency distribution of stomatal apertures in illuminated strips from the lower epidermis of leaves of *Commelina communis*, floating on 80 mM KCl, plus the indicated concentrations of (±)-ABA. f, Fraction of stomata in a particular aperture class; w, stomatal aperture. The upper scale represents aperture-class numbers and shaded columns represent the fraction of closed stomata. Reproduced with permission from Raschke (1988).

seen from dose response curves. If the responses are all-or-none (e.g. germination [the seed does or does not germinate], root formation, abscission, flowering, dormancy, senescence etc.), then a dose response curve simply reflects population variation in sensitivity to the inducing stimulus (Bradford and Trewavas, 1994;Trewavas, 1991). Such dose response data can vary over three to five orders of magnitude change in the strength of the inducing stimulus, thus describing the degree of individual variation (Trewavas, 1981). Nissen (1985, 1988a and b,) compiled much information on this point using growth regulators as the controlling stimulus.

Individuality in Guard cells.

Because the behaviour of individual guard cells can be easily examined, I have used them as an illustration. **Figure 1**, published in Raschke, (1988), quantifies the response of stomatal apertures in *Commelina* to increasing abscisic acid (ABA) concentration. The concentration range spans six orders of magnitude but even then some guard cells have still not completely closed. Yet at each concentration, an increasing number of stomata close, suggesting that the individual dose response range can be much narrower than the whole population. The population response is thus made up of differential sensitivity amongst individual guard cells to abscisic acid. Furthermore, by quantifying chlorophyll 'a' fluorescence (Raschke 1988), temporal variation in the rate at which individual guard cells closed in the intact leaf was detected. After ABA treatment, patchiness in closure rates was observed. Further information is summarised in Mott and Buckley (1998, 2000).

Many signals have been described as regulating guard cell closure (Willmer and Fricker, 1996). If there is equivalent individual cell variation for each of these signals as described for ABA, then enormous potential exists to construct many kinds of leaf water relation behaviours under a variety of environmental conditions. Each novel behaviour is constructed by putting together unique collectives of guard cells in both space and time. Such behaviour can be regarded as adaptively variable and thus coinciding with the definition of intelligence in foraging for carbon dioxide.

Mott and Buckley, (2000) indicate that guard cell collectives (recognised as patches during closure) can behave coherently, chaotically, and may oscillate in total aperture and vary in size and character as predicted from above. Crucially, patch behaviour is underpinned by definite evidence of communication across whole areas of leaf and between individual guard and epidermal cells. Such communication may result from hydraulic interactions but will need much further investigation to distinguish other anticipated mechanisms, such as electrical and chemical communication. Detection of oscillations in transpiration rate may result from this dynamic (Johnsson, 1976).

In the whole leaf, the most sensitive guard cells could potentiate the response of other local, but less sensitive guard cells to closing signals by modifications of **(1)** internal humidity; **(2)** abscisic acid sequestration; **(3)** carbon dioxide; **(4)** wall pH; **(5)** wall potassium and calcium levels; **(6)** the osmotic behaviour of subsidiary and other guard cells (Mott and Buckley, 2000; Willmer and Fricker, 1996) – all of which are factors known to modify aperture. The most sensitive cells might then act as critical elements in the propagation of information relating to aperture throughout local regions of the leaf, acting perhaps like relays in an excitable tissue. Sensitive guard cells could then be regarded as analogous to motor cells (organising centres as described by Winfree, 1987), generating focal points that organise stomatal patch formation by influencing the behaviour of other guard cells. The rate of patch formation and its longevity

would then be dependent on the local density of the most sensitive (motor) guard cells. Is intelligent behaviour to be sought in the network composed of the most sensitive cells?

Support for this possibility comes from observations by (Rascher et al., 2001). They showed that variations in CAM in leaves are the result of localised but initially independent oscillators that eventually co-operate together to produce the whole leaf circadian CAM response, in an analogous fashion to guard cell communication. Oscillators are characteristic of motor cell initiation and control (Winfree, 1987), and oscillations in activity are common in neural networks.

Other examples of individuality.

Other cellular examples of individuality have been reported in gibberellin-dependent amylase production by aleurone protoplasts and in pericycle cells sensitive to auxin (Gilroy and Trewavas, 2001). Further observation of individuality have been made in cotyledon cells, in anthocyanin synthesis responsive to red light, and in cytoskeletal structure responsive to blue light (Nick et al., 1993; Nick et al., 1992). Tissue examples can found in fruit ripening and abscission (Trewavas, 1998).

If individual guard cell behaviour is a paradigm for other cells in other tissues, then the following can be suggested. Individuality in aleurone cell amylase production enables potential optimisation of amylase production within the variety of environmental states experienced by cereal seedlings. A computational network can form slowly or quickly, but sugars, amino acids and fatty acids will be some of the information transmitted between individual aleurone cells (Trewavas, 1988). Pericycle cells more sensitive to auxin, or other factors, will act as foci for the formation of branch roots. The different sensitivities of individual pericycle cells act to provide a broad range of lateral root production in different root environments. Using a microbeam of red light, Nick et al., (1993) observed great heterogeneity in the formation of red light-induced anthocyanins between individual cotyledon cells, as described earlier. They reported patchy formation of the pigment and indicated that there was substantial variation in the sensitivity of individual cells. Furthermore, not all cells that likewise synthesised chalcone synthase mRNA in response to red light also synthesised anthocyanin, and long range suppression of one group of cells by another was observed. Communication is clearly happening, but the mechanism of communication has not been established. But again anthocyanin formation can be optimised to fit the environmental requirements and improve overall fitness.

The benefits of individuality are to be found in the much greater variety of response provided to the individual plant. Williams, (1958) provided an interesting way of assessing the variation in populations. (see **Box 1**)

THE INTELLECTUAL RESPONSE. PHENOTYPIC PLASTICITY AS FORESIGHT.

The characteristics of phenotypic plasticity

Plasticity is the degree to which the organism can be changed in response to environmental signals and, as indicated earlier, a clear example of plant intelligence. Plasticity can be expressed in both physiology and morphology. Guard cell plasticity, or more exactly plasticity in transpiration, is clearly physiological plasticity. Other physiological examples are to be found in carbon assimilation (photosynthesis rates) and dry matter partitioning (Bell and Sultan, 1999; Bloom et al., 1985; Korner, 1991). Karban and Baldwin, (1997) indicate that herbivory and pest defence mechanisms can generate enormous numbers of physiologically-distinguishable individuals arising from the moving target model. This model suggests that pest attack results in effectively random resistance responses in identical tissues such as leaves. Indeed, data provided by them indicates that on a single tree every leaf was observed to be at a different stage of pest resistance.

Morphological or phenotypic plasticity has been studied for many years, largely by population geneticists, because of its relevance to evolutionary studies (see **Box 2**). Phenotypic plasticity generated by environmental variation is commonly expressed in growth habit and size, morphology and anatomy of vegetative and reproductive structures, in absolute and relative biomass accumulation, growth rates, functional cleistogamy, variable sex expression, and offspring developmental patterns (Ackerley et al., 2000; Bazzaz, 1996; Bradshaw, 1965; Diggle,1994; Pigliucci, 1997; Schlichting and Pigliucci, 1998; Sultan, 2000). Variations are also common in stomatal frequency, hairiness on leaves, palisade, as against spongy mesophyll, modifications in vascular tissues, cuticular thickness, and sclerenchyma. Even the number of petals on a flower can change after leaf

removal (Tooke and Battey, 2000). Maryland Mammoth tobacco (Taiz and Zeiger,1998), and the ability of gardeners to grow outsize, giant vegetables, indicate the extent to which variation is possible if the right growth conditions are provided. The record pumpkin for example is 481kg (Guiness Book of Records, 1998). How giant fruits and vegetables can be grown without the apparent selection of particular genotypes in the first place is indicative of the extent to which epigenetic phenomena must contribute to the final phenotype. It is generally accepted that genotype determines whether the individual phenotype or character can be plastic in the first place. Expression and extent of that plasticity is environmentally regulated.

The timing of many developmental processes is certainly subject to plastic modification (Bradford and Trewavas 1994). Even environmental influences on the parent can be detected in the resulting seedlings, certainly to one or more generations (Mazer and Gorchov, 1996), and in certain cases, much longer (Durrant, 1962). Phenotypic plasticity is generally not all-or-none, but usually varies quantitatively, a phenomenon described as the norm of reaction (Schlichting and Pigliucci, 1998). Plasticity is adaptive. That has recently been made clear (Ackerley et al., 2000), and thus phenotypic plasticity fulfils the requirement for intelligent behaviour. Phenotypic plasticity is a visible witness to the complex computational capability plants can bring to bear to finely scrutinise the local environment and act upon it.

However, plasticity can be limited to certain characteristics in plant development with others remaining stable. When grown under low and high fertility, *Polypogon* exhibited a 100 fold variation in the numbers of spikelets/panicle, while glume and seed size varied by only 10% (Bradshaw 1965). In the well known Clausen et al., (1940) experiments (see diagrams in Schlichting and Pigliucci, 1998). Plasticity was observed in the size of vegetative parts, numbers of shoots, leaves and flowers, elongation of stems, and hairiness. But pinnate leaf shape, leaf margin serration, shape of inflorescence, and floral characters remained stable within limits, at least under the conditions investigated.

The presence of morphological plasticity for specific traits is genotype dependent (e.g. Sultan and Bazzaz, 1993 a-c), and thus individual in character as required by the definition of plant intelligence. But many life history characters such as mortality, growth rate, and fecundity, all important components of fitness, are more dependent on the environment than the genotype (Antonovics and Primack, 1982). Thus the perception of the genotype is changing from a blueprint that describes a single fixed outcome to a constrained repertoire of environmentally contingent and intelligent processes. The phenotype ultimately is constructed from synergistic developmental systems in which genes and gene products interact in complex fashion with signal transduction networks, which are then in turn directly responsive to numerous and constantly changing environmental factors (Trewavas and Mahlo, 1997).

Phenotypic plasticity enables individuals or genotypes to assume obviously different phenotypes during the life cycle (Schlichting, 1986; Sultan, 2000). Moreover, given the variety of environmental parameters and the different orders and combinations in which they occur in the wild, the potential number of distinguishable phenotypes must be enormous. Phenotypic variation can even cause substantial problems in taxonomic classification. Just as animal behaviour is constrained by genetic capabilities, so too will ultimate genetic constraints on phenotypic change in plants be present. But with plants refining their discrimination to local conditions, perhaps the enormous numbers of distinguishable phenotypes corresponds well with the number of behavioural variations available to any animal.

But plasticity indicates foresight. For plants that experience, for example, either periods of water stress or shading, morphological adaptations in the leaves improve fitness. This, however, comes at a cost that would not be experienced by other individuals that received adequate water or light. It is here that the capacity for intelligent behaviour must be paramount. Just as any animal will assess the totality of its sensory environment and respond, a plant will carry out the same assessment of all conditions and adjust growth and development from that assessment. Furthermore, faced with new patterns of environmental variation, plasticity enables the individual to come up with some sort of solution the first time. Those individuals that have the best behavioural solution will survive better and go on to reproduce. Further, improvement by selection can be expected if the new environment remains. Repetitive and reproducible changes in the environment easily lead, in turn, to genetically-proscribed behaviour by natural selection if the new environmental constraint is permanent.

Phenotypic plasticity is much more readily obvious in plants than in animals. Development continues throughout the plant life cycle and is thus subject to environmental influences to a

greater extent. Theoretically every plant body would contain its environmental history if that could be read.

A Darwinian mechanism for phenotypic plasticity

In mammalian brains phenotypic plasticity underpins the process of learning and memory. Except in early development, neural cell numbers do not increase, and changes in function are provided, as already described by changes in either dendrite connections numbers or synaptic adhesions that form the adaptive neural networks essential for intelligent behaviour. It is the ability to create new computational networks that either direct the flow of information into different channels or reference previously-held memories that is crucial. Once new dendrites form or decay, the neural cell becomes effectively a cell with different functions. In early development, new cells with new dendrites, and thus connections arising from mitosis, obviously contribute, although memory may perhaps be more easily retained in non-dividing cells.

Because plants lack an obvious specific tissue for computation, and cell division/development continues throughout the life cycle, new mechanisms for computation may be required. What is suggested here is: (1) the basic elements of computation are individual cells in tissues; (2) computational cellular networks are formed as the tissue develops, best fitted for the environmental state of the time; (3) each individual plant (genet) accumulates tissues (ramets) with different computational capabilities, so reflecting the history of experience. Just as the process of learning in a brain could be represented as a time series, a set of snapshots of developing brain connections, in plants each snapshot may possibly be represented by developing plasmodesmatal connections, or equally, successive new tissues. So instead of changing dendrite connections, plants form new networks by creating new tissues, a series of developing brains as it were, that can act like parallel processors, each with slightly different computational capabilities. In this way the successive plant tissues act as repositories of memory of environmental states which if such information can be conveyed elsewhere contributes to the whole plant assessment. Evidence for this view is very limited but plants do abscise leaves as conditions change and can form new and obviously different leaves in the new conditions (Addicott, 1982). It is also known that as leaves can age, stomatal function weakens, thus there are leaves with varying potential on any one individual plant (Willmer and Fricker, 1996).

But how do different tissues arise from the same growing meristem, or are apical meristems identical throughout their life? Progressive changes in successive leaves are known to occur in certain plants under constant conditions of growth (Steeves and Sussex, 1972), and bud dormancy can vary according to the age and position of the bud (Gregory and Veale, 1957). Rooting of branches from some trees (e.g. *Taxus*) results in plants with maintenance of the same plagio-gravitropic angle of shoot growth. In others, such as *Hevea*, cuttings only form adventitious roots, and the main tap root is not regenerated. But to explain how phenotypic plasticity arises from what is often assumed to be an identical meristem, we can borrow from an idea by Edelman, (1993). He summarised evidence that indicated that connections in the brain were often very variable, even though behaviour might be similar, suggesting that prespecified point-to-point wiring did not occur. Neural territories and maps are often unique to each individual, for example. He suggested that experience selected out certain groups of neurones by chance whose original connections constructed a weak response. These networks were then reinforced by increased synaptic adhesion with additional signalling. Channels of information flow were thus deepened, improving the quality of the response. The final neural network constructed depended therefore initially on a kind of Neural Darwinism.

The suggestion here is that the true meristem produces cells that are anatomically indistinguishable, but differ in molecular and physiological capabilities. During development, as cells leave the true meristem, environmental conditions will result in the proponderant replication of certain cells with particular physiological patterns over others which in due course give rise to phenotypic plasticity, a kind of cloning (Steves and Sussex, 1972). Perhaps cells in the transition region between division and expansion are where selection occurs in roots (Barlow and Baluska, 2000). In the apical meristem, larger leaves might originate as the environmental conditions select cells capable of expanding longer or larger in their final size. Maybe these cells would differ in sensitivity to auxin or kinin. Self evidently, only young, developing tissues in plants, can express morphological plasticity. Examples of responses of very young tissues to ABA and cold treatment

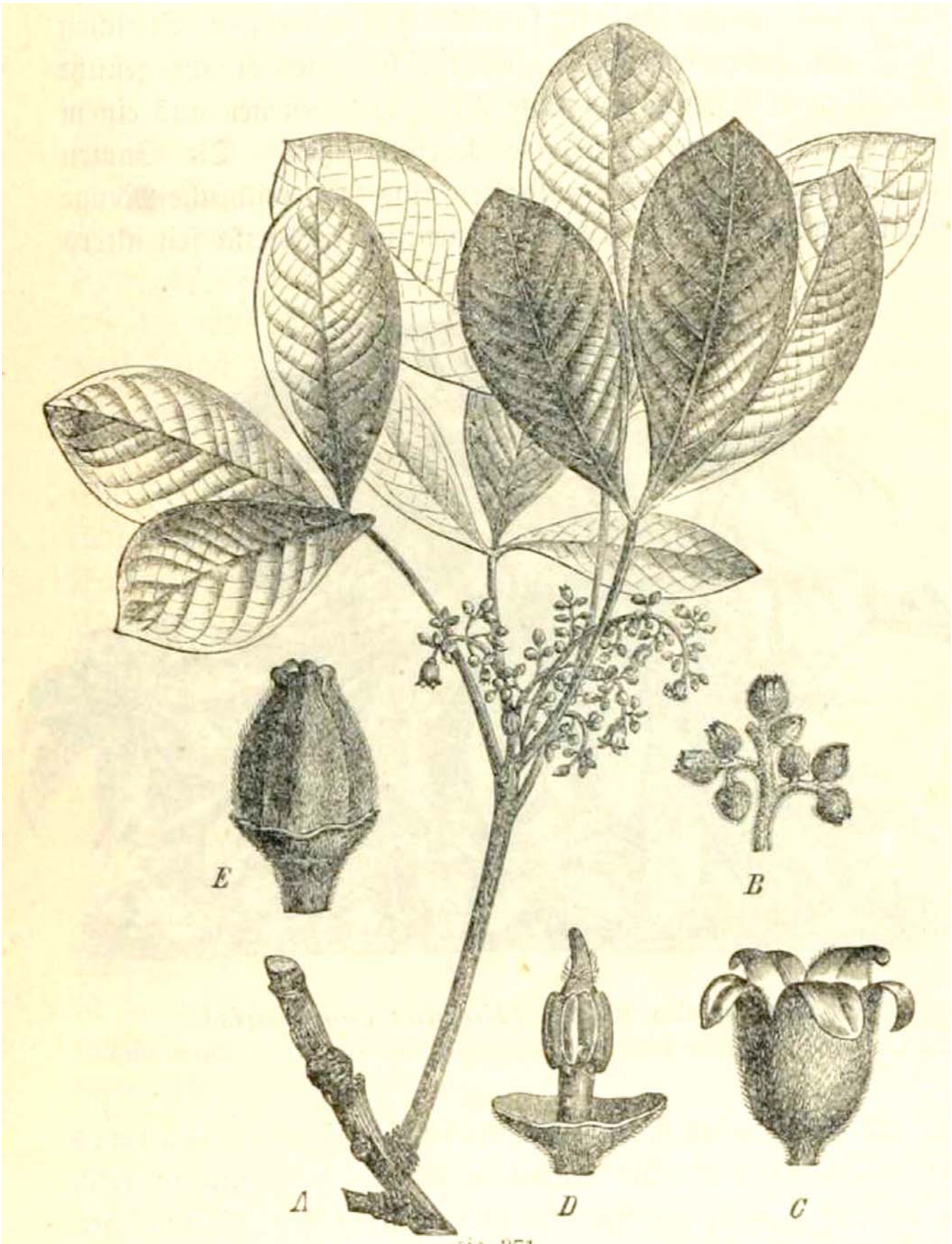


Fig. 371.

Brasilianischer Kautschukbaum *(Hevea Brasiliensis).*

A Blühender Zweig. *B* Teil eines Blütenstandes. *C* Blüte. *D* Geschlechtsapparat. (Nach Engler-Prantl.)

Ernst Gilg and Karl Shumann

Hevea brasiliensis, from: *Das Pflanzenreich Hausschatz des Wissens*, 1900

leading to different morphologies and tissues (*Spirodela turions*) are to be found in Smart and Trewavas, (1983). Also morphological data provided by Milthorpe (1956) indicates that young XXXXX leaves of a certain age only respond to cold treatments.

INDICATIONS OF INTELLIGENT CHOICE, INTENTION AND BEHAVIOUR.

Intelligent behaviour is designed to maximise fitness, but only in circumstances which challenge the survival of the organism and test its capability for intention (within an evolutionarily determined end point) and choice. Ecological investigators are starting to construct circumstances in which intention and choice are tested.

Foraging for food resources is an essential activity for both plants and animals. Consequently, most aspects of intelligent behaviour are exemplified in foraging for nutrients. Little is left to chance or plasticity in reproductive behaviour. For a similar reason, much plant taxonomy relies on flower structure in which plasticity is minimised. For land plants, resources appear as a complex spatial and temporal mosaic (Hutchings and deKroon, 1994), in part reflecting patchy distribution of soil materials and neighbour competition (Salzman and Parker, 1985; Turkington and Harper, 1979). Competition is certainly one environmental circumstance rarely provided in laboratory experiments. In a resource mosaic, intelligent behaviour is essential if resource collection is to be optimised in the face of competition. Foraging is a term now used much more frequently in plant ecological literature and is a proper description of the way plants behave when gathering growth resources.

Dodders (*Cuscuta* sp) are parasitical plants which have lost almost all photosynthetic capability (Kuijt, 1969). Responding to an initial touch stimulus, growing shoots take several days to coil around suitable hosts. *Haustorial primordia* and *haustoria* then differentiate and nutrient resources commence transfer from the host in about 4 days (Kelly, 1990). In Dodder it is thus possible to dissociate active choice from the subsequent passive effects of acquired resources on growth that can complicate other situations. By tying suitable stem explants of Dodder to touch the host, Kelly (1992) observed that 60% of individuals rejected suitable hosts within several hours. Rejection was reduced to about 25% if the host was given a pre-treatment with nitrate. Active choice was thus influenced by the anticipated reward. By using a range of hosts of different reward value, and measuring the length of coils and the biomass subsequently accumulated after 28 days, it was shown that the length of coiling was linearly related to subsequent reward /unit of energy invested. These data fit a simple marginal value model of resource use, applicable also to grazing animals. They also indicated plasticity in the length of coiling. Just as animals intelligently feed, so do plants. Seed set was correlated with the size of the parasite, indicating that host selection was adaptive and fitness of the parasite improved. It was suggested that rapid transfer of chemical information through the initial touch contact determined host selection and final length of coiling.

The uneven distribution of light to which wild plants are exposed is a critical factor controlling subsequent fitness. Light is critical to the acquisition of carbon resources and energy for other cellular processes. But many plants (often called sun plants to distinguish them from shade plants) do not react passively to the light mosaic in a canopy, simply accumulating dry weight when the light is strong enough. The quality and quantity of light is actively perceived (through R/FR ratios) and the position of likely future competitive neighbours mapped (Gilroy and Trewavas, 2001). Avoiding action is taken by accelerating the growth of the stem which becomes thinner (Aphalo and Ballare, 1995; Ballare et al., 1990), or by an acceleration of the branch growth into light of higher intensity (Trewavas, 1986b). Thus the resource acquiring structure(s), the stem plus leaves, is projected at speed into the resource-rich patch away from competition. Root growth is also altered, indicating communication of light perception to other parts of the organism (Aphalo and Ballare, 1995). New leaves are then specially positioned free from competitive light interruption (Ackerley and Bazzaz, 1995).

The stilt palm (Allen 1977) is constructed from a stem raised on prop roots. When competitive neighbours approach, avoidance action is taken by moving the whole plant back into full sunlight. Such obvious "walking" is accomplished by growing new prop roots in the direction of movement while those behind die off. That this is intentional behaviour is very clear.

Other equally dramatic light-foraging mechanisms are to be found in tropical climbers, particularly *Syngonium*. On reaching the top of a tree, the growing point descends progressively, changing its morphology and leaf structure, eventually assuming a very thin filiform shape with only scale leaves on the soil. Using skototropism (movement towards darkness), the filiform stem

explores, locates and recognises a new trunk and reverses the growth pattern. As it climbs, the internode becomes progressively thicker and leaves progressively redevelop to full size (Ray, 1987; Ray, 1992; Strong and Ray, 1975). But the behaviour is analogous to animals that climb trees to forage and intelligently descend and climb the next tree when food is exhausted or competition severe.

Experiments with rhizomatous clonal herbs have shown that when provided with deliberate choice, the new growth of rhizomes and associated shoots is highly selective and directed with much higher probability into favourable microhabitats. The new territories that are exploited may consist of freedom from other competitors (Evans and Cain, 1995; Kleijn and Van Groenendael, 1999) or unshaded and warmer temperatures (MacDonald and Lieffers, 1993; or weaker salinity (Salzman, 1985; Salzman and Parker, 1985). When resources become abundant, dormant buds are induced to grow as shoots rather than new rhizomes (Hutchings and de Kroon, 1994). Rhizomes that penetrate the poorer environments are generally thinner, and the internodes longer and more rapidly growing, where possible. The dispersal of any new shoots from the parent plant is thus greatly increased, and new territory is actively searched for new resource-rich patches. Limited growth resources are thus efficiently used to cover maximum ground with minimum investment. Directing the majority of rhizomes to exploit rich resources, whilst allowing others to search for new resources, suggests optimal strategies are in place to maximise return and increase fitness. When resources are scarce, growth materials are invested in the organ through which scarce resources are normally sequestered. If minerals or water are scarce, enhanced root growth occurs. If light is scarce, stem growth is enhanced at the expense of the root.

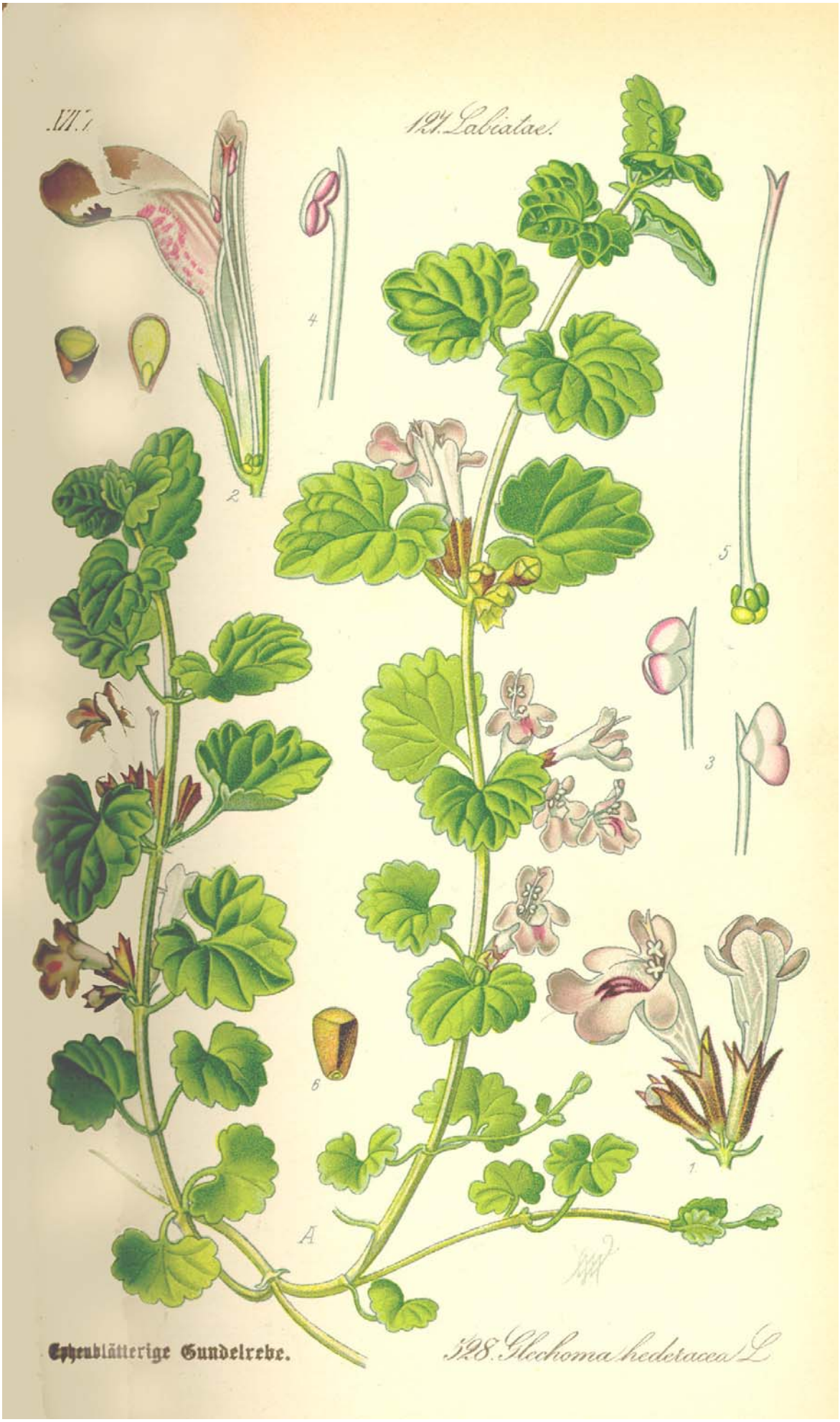
But the growth of clonal herbs responds directly to the uneven distribution of resources in the soil. When grown on soil in which resources are distributed in patches rather than uniformly, overall biomass accumulation could be up to seven fold higher (Wijensinghe and Hutchings, 1997, 1999). Not only could *Glechoma* discriminate an optimal patch size, but it could also discriminate the strength of gradients across the boundary of the patch, showing several fold better growth when the gradient was greatest. How the parameters of patch size and gradient strength lead to enhanced growth is not understood. It is difficult to avoid the conclusion of intention and intelligent choice and the ability to select conducive habitats in which to place and grow organs of resource exploitation. Perhaps the most surprising observations come from Evans and Cain, (1995). They tested whether the clonal herb *Hydrocotyle*, which grows on sand dunes, could preferentially locate good patches or avoid bad patches in a heterogeneous environment. They reported that rhizomes veered away from patches of grass and thus obvious competition. Intentional choice of habitat is clear.

Individual roots can track humidity and mineral gradients in soil (see summary of references in Takahashi and Scott, 1993), just as shoots can track local light sources (Trewavas 1986b). Roots can change their branching patterns (architecture) radically when resource rich patches are found (from herring bone structure to a highly branched motif, (Fitter, 1986)), and change uptake rates so that no particular resource limits growth but all remain in approximate balance. And to avoid detrimental competition, roots (like shoots) take deliberate avoidance action to prevent contact when approached by roots of other species (Mahall and Calloway, 1991).

CONCLUSIONS

A major difficulty in studying any plant behaviour is the problem of differing time scales from those in animals. Whereas human beings operate in seconds, plants usually operate in weeks and months. Even though bamboos can grow at a centimetre an hour, without some sort of recording device it would be extremely difficult for any human to observe this phenomenon. Plant behaviour in the wild is usually unrecorded and much uncommon behaviour must simply be missed as a consequence. Time lapse photography is at least a start, but how many plant physiologists with time lapse facilities study and experiment on wild plants where real intelligent behaviour is to be expected? There is no doubt this is a serious omission in the scientific literature. There are so many crucial questions to pose. Why is it that one wild seedling survives and others do not when apparently shed at the same time from the parent plant and in the same soil? There is so little information on the actual preliminary struggle for existence recorded in real time.

To the well-informed physiological reader not much of the information above will be particularly new. However the particular combination that I have presented here of



Prof. Dr. Otto Wilhelm Thomé

Glechoma hederacea, from: Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

intelligence, learning, memory, and fitness should place some facets in a different light. Higher plants do represent about 99% of the eucaryotic biomass of the planet. Their sessile lifestyle is clearly successful and individuals must then possess a fine ability to adjust and optimally exploit the local environment. How well they map the local environment and the extent of computation (with good estimates of computational skill) clearly still requires significant investigation in real, not artificial, environments.

Undoubtedly, one of the problems that botanists have with using the phrase "plant intelligence" is the incorrect assumptions about animal intelligence, which is then often equated with human intelligence, and suppositions of complete freedom of choice (if they exist). Much animal behaviour is strongly heritable (for example, reproductive or early feeding behaviour is probably innate) and indeed has to be. So in the same way there are aspects of plant behaviour which are rarely phenotypically plastic. The structure of the flower, or the square shaped stems of the Labiatae, are two good examples among many.

Apart from the fact that the major form of expression of animal intelligence is movement rather than growth and development as defined here for plants, I find there is little to distinguish between the two groups of organisms once adjustments are made for the time differences noted above. As regards movement, the computer that beat Kasparov at chess (surely an excellent example of intelligence in action regardless of the human requirement to programme) certainly required human intervention to move the pieces. We have already described the necessity for the right environment to elicit intelligent behaviour and the Kasparov chess computer is again an excellent example. Good at chess, it wasn't any good at assessing economics statistics until reprogrammed. Chess games were the right environment to elicit intelligent responses.

In fact chess provides a further and important illustration of how ignoring individual behaviour and simply averaging behaviour can confuse understanding. Each chess game represents a unique and highly individual trajectory recording intelligent behaviour between two properly matched opponents. Suppose instead that we now averaged 1000 chess games, much as physiologists average responses, and then looked for meaningful variations. The averaging process would reveal that pawns had a very high probability (and a narrow standard error) of being moved right at the beginning, and the king had a high probability of being irreversibly confined (mated) at the end, although with greater variability. Knights and bishops would have a high probability of being moved early on, although the probability mean would be lower than pawns and the standard deviation broader. Castles (rooks) and Queens would be later still, and with much more spread in the standard deviation and so on. In fact averaging any one large set of chess games would look very similar to any other large averaged set, and we would conclude that the chess game on this basis was rote, started with a clock, of little interest, and certainly nothing to do with intelligence. And in an attempt to understand what was going on, we might experimentally knock out pieces only to find that, yes, they were necessary and you lose if they go, just as we currently knock out cells, chemicals, genes or signal transduction molecules in an attempt to understand what is going on. Another crucial point is surely that very simple rules govern chess but the order in which events take place (i.e. the trajectory) can be unique to each game. This may represent a paradigm for signal transduction. We are so used to thinking of intelligence as a property of the human individual that we fail to recognise the necessity of applying that rule to plants as well.

Perhaps a more critical question is, does it matter? Does it matter whether intelligence is used to describe plant behaviour. If intelligent behaviour is an accurate description of what plants are capable of, then why not use the term? But having used it, the next question is how such intelligence is accomplished in the absence of a brain. I have called this phenomenon "Mindless Mastery" (Trewavas, 2002) and can only suggest that intelligent behaviour is indeed an emergent property that results from cellular interactions just as it is in the brains of animals. Whatever the mechanism, the end result usually comes from the distinctive behaviour of meristems. There must then be important conduits of proper information flow, as distinct from nutrients, from the rest of the plant into meristems.

Hopefully this article can indicate more clearly the kinds of investigations needed to fill in the gaps. Undoubtedly we need much more information on cellular and tissue communication, and the distribution of receptors for all those signals that have been uncovered recently. We need many more studies on individual wild plant behaviour. Questions about tissue-to-tissue interactions need reformulating. How much information is conveyed between

tissues and what exactly is the sum total of its nature? Although the classic growth regulators are often assumed to carry out such communication, the uncertainty that still surrounds much of these notions is remarkable. Molecular studies can improve this situation and some answers may arise from skilled use of the inducible expression of tissue and cell specific critical synthetic enzymes. Others will arise from creative construction of particular environments in which plants can demonstrate their undoubted behavioural potential.

Although we understand much more about signal transduction processes in plants than we did 20 years ago, there is a long road yet to travel to jump the gap between cell, tissue, and whole organism. In this article I have travelled Robert Frost's "less travelled road." My hope is that in future this may become a more major highway.

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BOX 1

MEASUREMENTS OF INDIVIDUALITY.

Williams (1958) approached biochemical individuality in an interesting way. He examined whether it was possible for a single uniform drug dose to be prescribed for the whole human population and concluded it could not be. Williams assumed that any individual trait could be considered to be normal if it lay within 95% (probability = 0.95) of the distribution around the mean. The probability that an individual is normal for two traits is 0.95^2. For 100 traits, the probability of normality of any individual for all traits is 0.005, and for 1000 different traits the probability is vanishingly small. Ergo, we are all deviant in certain characteristics.

There are at least 15 distinguishable environmental signals (water, five primary minerals, light, gravity, soil structure, neighbour competition, herbivory, disease, allelopathy, wind, and gases (Trewavas, 2000)) to which individual plants are sensitive, many observable traits which can be distinguished, and there may be as many as the number of distinguishable genes. On that basis, it is likely that every individual plant, at least in the wild, is unique in one or more traits.

Williams (1958) also describes anatomical and biochemical individuality in normal reproducing human beings and lists the variations that he could find in the literature for apparently normal healthy, reproducing, human beings. The variations described are enormous given the necessity for producing such a complex organism. It would be useful if an equivalent catalogue of plant variation could be compiled, if that were possible. However the modular character to plant growth and development and plasticity might make this a difficult task.

But the biochemical observations measuring variations in vital constituents could equally apply to plants although I have never seen it compiled. No doubt metabolite profiling is going to indicate this in greater detail. The Handbook of Biological Data does contain some information about plants showing variation in dry weights, protein, secondary metabolites, ions, and other metabolites. Elsasser, (1988) regarded the data compiled by Williams, (1958) to represent the primary difficulty in the instructionist view of life that regards the genome as merely a computer tape (full of information) and the cell as a computer following instructions which should always result in exact replicas (clones) of the genome. Thus organisms survive perfectly well despite huge variations in constituents, and the notion of being simply complex machines (which require precision and reproducibility in structure and composition) is untenable.

BOX 2.

PHENOTYPIC PLASTICITY AND EVOLUTION.

Phenotypic plasticity has long been investigated by those interested in evolutionary studies. Certainly, around the turn of the 20th century, Darwinian views were opposed by some botanists because of phenotypic plasticity. Henslow, (1898) provides a number of examples, such as two kinds of *Ampelopsis*; one of which forms suckers on mechanical stimulation; the other which forms them regardless of stimulation. Henslow (1898) supported Lamarckian views to explain these data, but genetic assimilation is a much more likely hypothesis. That is, the original character is the result of temporary adaptation, and natural selection increases the numbers of individuals more able to optimise the character before finally simple mutations ensure the character

becomes fixed.

Suggestions that genetic assimilation is a major mechanism in evolution have recurred from time to time. Baldwin, (1896) called this organic selection and may have been the first to suggest the possibility. Waddington, (1957) supported genetic assimilation using several examples. The most prominent example was the well-known callosities in the ostrich, which occurs where the bird lies down. It might be thought that these would be an adaptive feature, but they are clearly visible on the embryo inside the egg to support genetic assimilation mechanisms. The important feature in genetic assimilation is the persistence of the environmental situation so that the novel initially-adaptive behaviour persists. With time, genes and gene combinations originate which allow the strategy to develop with greater rapidity, higher probability, or lower cost (Bateson, 1963). Eventually mutations appear that fix the trait regardless of environmental signalling. Thus, in these cases, natural selection merely ratifies an adaptation that has already been developed and tested.

The molecular origin of genetic assimilation must occur in signal transduction processes. However, genetic assimilation enables the evolutionary process to move forward more quickly and efficiently, avoiding the tedious trial and error process that would involve the alternative view; the random production of such characters complete. Further discussion of this important aspect of phenotypic plasticity can be found in Bazzaz, (1996); Bradshaw, (1965); Bradshaw and Hardwick (1989); Schlichting and Pigliucci (1998); Sultan (2000), and references therein.

References

Ackerly DD, Bazzaz FA. 1995. Seedling crown orientation and interception of diffuse radiation in tropical forest gaps. *Ecology* **76**: 1134-1146.

Ackerley DD, Dudley SA, Sultan S, Schmitt J, Coleman JS, Linder CR, Sandquist DR, Geber MA, Evans AS, Dawson TE, Lechowicz MJ. 2000. The evolution of eco-physiological traits: recent advances and future directions. *Bioscience* **50**: 979-995.

Addicott FT. 1982. *Abscission*. California: University of California Press.

Allan AC, Fricker MD, Ward JL, Beale M, Trewavas AJ. 1994. Two transduction pathways mediate rapid effects of abscisic acid in *Commelina* guard cells. *The Plant Cell* **6**: 1319-1328.

Allen PH. 1977. *The Rain Forests of Golfo Dulce.* Stanford University Press, Stanford, CA. **Antonovics J. 1971**. The effects of a heterogeneous environment on the genetics of natural populations. *American Scientist* **59**: 592-599.

Antonovics J. Primack RB. 1982. Experimental ecological genetics in *Plantago*. *Journal of Ecology* **70**: 55-75.

Aphalo PJ, Ballare CL. 1995. On the importance of information acquiring systems in plant-plant interactions. *Functional Ecology* **9**: 5-14.

Baldwin JM. 1896. A new factor in evolution. *American Naturalist* **30**: 441-451.

Ballare L, Scopel AL, Sanchez RA. 1990. Far red radiation reflected from adjacent leaves: an early signal of competition in plant canopies. *Science* **247**: 329-332.

Barlow PW, Baluska F. 2000. Cytoskeletal perspectives on root growth and morphogenesis. *Annual Review of Plant Physiology and Molecular Biology* 51: 289-322.

Bateson G. 1963. The role of somatic change in evolution. *Evolution* **17**: 529-539.

Bazzaz FA. 1996. *Plants in Changing Environments.* Cambridge University Press, Cambridge ,UK.

Begg JE. 1980. Morphological adaptations of leaves to water stress. In: Turner NC, Kramer PJ, eds. *Adaptation of Plants to Water and High Temperature Stress.* New York: John Wiley and Sons, 33-43.

Bell DL, Sultan SE. 1999. Dynamic phenotypic plasticity for root growth in *Polygonum*: a comparative study. *American Journal of Botany* **86:** 807-819.

Bennet-Clark TA, Ball NG. 1951. The diageotropic behaviour of rhizomes. *Journal of Experimental Botany* **2:** 169-203.

Bloom AJ, Chapin FS, Mooney HA. 1985. Resource limitation in plants-an economic analogy. *Annual Review of Ecology and Systematics.* **16:** 363-392.

Bose JC. 1924. Plant Response as a Means of Physiological Investigation. London: Longmans.

Bradford KJ, Trewavas AJ. 1994. Sensitivity thresholds and variable time scales in plant hormone action. *Plant Physiology* **105:** 1029-1036.

Bradshaw AD. 1965. Evolutionary significance of phenotypic plasticity in plants. *Advances in Genetics.***13:** 115-155.

Bradshaw AD, Hardwick K. 1989. Evolution and stress-genotypic and phenotypic components. *Biological Journal of the Linnean Society.* **37:** 137-155.

Brownlee C. 2002. Role of the extracellular matrix in cell-cell signalling: paracrine paradigms. *Current Opinion in Plant Biology.* **5:** 396-401.

Burdon JJ. 1980. Intra specific diversity in a natural population of *Trifolium repens*. *Journal of Ecology* **68:** 717-735.

Chapin FS. 1980. The mineral nutrition of wild plants. *Annual Review of Ecology and Systematics.* **11:** 233-260.

Clausen J, Keck DD. Hiesey WM. 1940. *Experimental Studies on the Nature of Species.* Carnegie Institute of Washington publication no 520. Washington D.C.

Clifford PE, Fensom DS, Munt BI, McDowell WD. 1982. Lateral stress initiates bending responses in Dandelion peduncles: a clue to geotropism. *Canadian Journal of Botany.* **60:** 2671-2673.

Csete ME, Doyle JC. 2002. Reverse Engineering of Biological Complexity. *Science* **295:** 1664-1669.

Dawkins R. 1976. *The Selfish Gene.* Oxford: Oxford University Press.

Dennison KL, Spalding EP. 2000. Glutamate gated Ca^{2+} fluxes in *Arabidopsis*. *Plant Physiology* **124:** 1511-1514.

Desbiez MO, Tort M, Thellier M. 1991. Control of a symmetry breaking process in the course of morphogenesis of plantlets of *Bidens pilosa*. *Planta* **184:** 397-402.

Diggle PK. 1994. The expression of andro-monoecy in *Solanum Hirtum*-phenotypic plasticity and ontogenetic consistency. *American Journal of Botany* **81:** 1354-1365.

Ding B, Itaya A, Woo Y. 1999. Plasmodesmata and cell communication in plants. *International Review of Cytology.* **190:** 251-316.

Dostal R. 1967. *On Integration in Plants.* Edited by Thimann KV. Massachusetts: Harvard University Press.

Drew and Saker (1973)

Durrant A. 1962. The environmental induction of heritable changes in *Linum*. *Heredity* **17:** 27-61.

Edelman GM. 1993. Neural Darwinism: selection and re-entrant signalling in higher brain function. *Neuron* **10:** 115-125.

Elowitz MB, Levine AJ, Siggia ED, Swain PS. 2002. Stochastic gene expression in a single cell. *Science* **297:** 1183-1186.

Elsasser WM. 1988. *Reflections on a Theory of Organisms.* Quebec: Orbis.

Evans JP, Cain ML. 1995. A spatially explicit test of foraging behaviour in a clonal plant. *Ecology* **76:** 1147-1155.

Farley RA, Fitter AH. 1999. Temporal and spatial variation in soil resources in a deciduous woodland. *Journal of Ecology* **87:** 688-696.

Federoff N, Fontana W. 2002. Small numbers of big molecules. *Science* **297:** 1129-1131.

Fitter AH. 1986. The topology and geometry of plant root systems: influence of watering rate on root system topology in *Trifolium pratense*. *Annals of Botany* **58:** 91-101)

Geber MA. 1990. The cost of meristem limitation in *Polygonum arenastrum*; negative genetic correlations between fecundity and growth. *Evolution* **44:** 799-814.

Gilroy S, Trewavas AJ. 1990. Signal sensing and signal transduction across the plasma membrane. In: Larsson C, Moller IM. *The Plant Plasma Membrane* Berlin: Springer-Verlag 203-233.

Gilroy S, Trewavas AJ. 2001. Signal processing and transduction in plant cells: the end of the beginning? *Nature Molecular Cell Biology Reviews* **2:**

307-314.
Greengard P. 2001. The neurobiology of slow synaptic transmission. *Science* **294:** 1024-1030.
Gregory FG, Veale JA. 1957. A reassessment of the problem of apical dominance. In: Porter, HK ed. *Society for Experimental Biology Symposium, XI. Biological Action of Growth Substances.* 1-20.
Griffiths M, McIntyre HCH. 1993. The interrelationship of growth and frost tolerance in winter rye. *Physiologia Plantarum* **87:** 335-344.
Guet CC, Elowitz MB, Hsing WE, Leibler S. 2002. Combinatorial synthesis of genetic networks. *Science* **296:** 1466-1470.
Guiness Book of Records. 1998. Guiness Publishing Ltd, UK.
Hanson J, Trewavas AJ. 1982. Regulation of plant cell growth; the changing perspective. *New Phytologist* **90:** 1-25.
Hartgerink AP, Bazzaz FA. 1984. Seedling scale environmental heterogeneity influences individual fitness and population structure. *Ecology* **65:** 198-206.
Hartwell LH, Hopfield JL, Leibler S, Murray AW. 1999. From molecular to modular cell biology. *Nature* **402:** C47-52.
Haywood V, Kragler F, Lucas WJ. 2002. Plasmodesmata: pathways for protein and ribonucleoprotein signalling. *The Plant Cell* **14:** S303-325.
Heathcote DG, Aston TJ. 1970. The physiology of plant nutation. I. Nutation and geotropic response. *Journal of Experimental Botany* **21:** 997-1002.
Henslow G. 1895. *The Origin of Plant Structures by Self-Adaptation to the Environment. London:* Kegan Paul, Trench, Trubner & Co. Ltd.
Hetherington A. 2001. Guard cell signalling. *Cell* **107:** 711-714.
Hsaio TC, Acevedo E, Feveres E, Henderson DW. 1976. Water stress, growth and osmotic adjustment. *Philosophical Transactions of the Royal Society, London* **273:** 479-500.
Hunt R Lloyd PS. 1987. Growth and Partitioning. *New Phytologist.* **106:** supplement 235-249.
Hutchings MJ. de Kroon H. 1994. Foraging in plants: the role of morphological plasticity in resource acquisition. *Advances in Ecological Research* **25:** 159-238.
Ingolis NT, Murray AW. 2002. History matters. *Science* **297:** 948-950.
Ishikawa H, Hasenstein KH. Evans ML. 1991. Computer-based video digitizer analysis of surface extension in maize roots. *Planta* **183:** 381-390.
Jackson D. 2000. Opening up the communication channels; recent insights into plasmodesmatal function. *Current Opinion in Plant Biology*. **3:** 394-399.
Johnsson A. 1976. Oscillatory water regulation in plants. *Bulletin of the Institute of Mathematical Applications* **12:** 22-26.
Johnsson A. 1979. *Circumnutation.* In: Haupt W, Feinleib FE eds. Physiology of Movements. Encyclopedia of Plant Physiology New Series Volume 7. Berlin: Springer Verlag 627-647.
Johnsson A, Israelsson D. 1969. Application of a theory for circumnutations to geotropic movements. *Physiologia Plantarum* **21:** 282-291.
Jonak C, Okresz L, Bogre L, Hirt H. 2002. Complexity, cross talk and integration of MAP kinase signalling. *Current Opinion in Plant Biology.* **5:** 415-425.
Jorgensen RA, Atkinson RG, Forster RLS, Lucas WJ. 1998. An RNA based information superhighway in plants. *Science* **279:** 1486-1487.
Kacperska A, Kulesza L. 1987. Frost resistance of winter rape leaves as related to changes in water potential and growth capability. *Physiologia Plantarum* **71:** 483-488.
Kandel ER. 2001. The molecular biology of memory storage. A dialogue between genes and synapses. *Science* **294:** 1030-1038.
Karban R, Baldwin IT. 1997. *Induced Responses to Herbivory.* Chicago: University of Chicago Press.
Kelly CK. 1990. Plant foraging: a marginal value model and coiling response in *Cuscuta subinclusa*. *Ecology* **71:** 1916-1925.
Kelly CK. 1992. Resource choice in *Cuscuta europea*. *Proceedings National Academy of Sciences USA* **89:** 12194-12197.
Kim M, Canio W, Keller S, Sinha N. 2001. Developmental changes due to long distance movement of a homeo-box fusion transcript in tomato. *Science* **293:** 287-293.
Kleijn D, Van Groenendael JM. 1999. The exploitation of heterogeneity by a clonal plant in habitats with contrasting productivity levels. *Journal of Ecology* **87:** 873-884.
Korner CH. 1991. Some often overlooked plant characteristics as determinants of plant growth: a reconsideration. *Functional Ecology* **5:** 162-173.
Kramer PJ. 1980. Drought stress and the origin of adaptations. In Turner NC, Kramer P eds. Adaptation of Plants to Water and High Temperature Stress. New York: John Wiley 7-21.
Kuijt J. 1969. *The Biology of Parasitic Flowering Plants.* California: University of California Press.
Lake JA, Quick WP, Beerling DJ, Woodward FI. 2001. Plant Development: signals from mature to new leaves. *Nature* **411:** 154.
Levsky JM, Shenoy SM, Pezo RC. Singer RH. 2002. Single cell gene expression profiling. *Science* **297:** 836-840.
Lloyd DG. 1980. Sexual strategies in plants. I. An hypothesis of serial adjustment of maternal investment during one reproductive session. *New Phytologist.* **86:** 69-79.
MacDonald SE, Lieffers VJ. 1993. Rhizome plasticity and clonal foraging of *Calamagrostis canadensis* in response to habitat heterogeneity. *Journal of Ecology* **81:** 769-776.
Macleod K, Firn RD, Digby J. 1987. The phototropic response of *Avena* coleoptiles. *Journal of Experimental Botany* **37:** 542-548.
Mahall BE, Calloway RM. 1991. Root communication among desert shrubs. *Proceedings of the National Academy of Sciences USA* **88:** 874-876).
Malho R, Moutinho A, Van der Luit A, Trewavas AJ. 1998. Spatial characteristics to calcium signalling; the calcium wave as a basic unit in plant cell calcium signalling. *Philosophical Transactions of the Royal Society. Series B.* **353:** 1463-1473.
Maun MA, Lapierre J. 1984. The effects of burial by sand on *Ammophilia brevilugata*. *Journal of Ecology* **72:** 827-839.
Mazer SJ, Gorchov DL. 1996. Parental effects on progeny phenotype in plants: distinguishing genetic and environmental clues. *Evolution* **50:** 44-53.
McAdams HH, Arkin A. 1999. It's a noisy business. *Trends in Genetics* **15:** 65-69.
Milthorpe FL. 1956. The relative importance of the different stages of leaf growth in determining the resultant area. In: Milthorpe FL ed. *The Growth of Leaves.* Proceedings of the Third Easter School in Agricultural Science, University of Nottingham. London: Butterworths 141-150.
Mott KA, Buckley TN. 1998. Stomatal heterogeneity. *Journal of Experimental Botany* **49:** 407-417.
Mott KA, Buckley TN. 2000. Patchy stomatal conductance: emergent collective behaviour of stomata. *Trends in Plant Sciences* **5:** 258-262.
Nakajima K, Sena G, Nawy T, Benfey PN. 2001. Intercellular movement of the transcription factor SHR in root patterning. *Nature* **413:** 307-311.
Nick P, Ehmann B, Furuya M, Schafer E. 1993. Cell communication, stochastic cell responses and anthocyanin patterns in mustard cotyledons. *The Plant Cell* **5:** 541-552.
Nick P, Schafer E, Furuya M. 1992. Auxin redistribution during first positive photropic curvature in corn coleoptiles. *Plant Physiology 99:*1302-1306.
Nissen P. 1985. Dose responses of auxins. *Physiologia Plantarum* **65:** 357-374.
Nissen P. 1988*a*. Dose responses of gibberellins. *Physiologia Plantarum* **72:** 197-203.
Nissen P. 1988*b*. Dose responses of cytokinins. *Physiologia Plantarum.* **74:** 450-456.
Palmgren MG. 2001. Plant plasma membrane H^+- ATPases; powerhouses for nutrient uptake. *Annual Review of Plant Physiology* **52:** 817-845.
Petterson J, Ninkovic V, Ahmed E. 1999. Volatiles from different barley cultivars affect aphid acceptance of neighbouring plants. *Acta Agricultura, Scandavica. Section B. Soil and Plant Science.* **49:** 152-157.
Pigliucci M. 1997. Ontogenetic phenotypic plasticity during the reproductive phase in *Arabidopsis thaliana* *American Journal of Botany* **84:** 887-895.
Quatrano R, Assmann SM, Sanders D, Eckhardt NA. 2002. Signal Transduction. *The Plant Cell* **14:** supplement.
Rascher U, Hutt M-T, Siebke K, Osmond B, Beck F, Luttge U. 2001. Spatio-temporal variation of metabolism in a plant circadian rhythm: the biological clock as an assembly of coupled individual oscillators. *Proceedings of the National Academy of Sciences USA.* **98:** 11801-11805.
Raschke K. 1970. Stomatal responses to pressure changes and interruptions in the water supply of detached leaves of *Zea mays* L. *Plant Physiology* **45:** 415-423.
Raschke K. 1979. *Movements of stomata.* In: Haupt W, Feinlieb ME eds. Physiology of Movements. Encyclopedia of Plant Physiology, New Series, Volume 7 New York: Springer Verlag 383-442.
Raschke K. 1988. *How abscisic acid causes depressions of the photosynthetic capacity of leaves.* In: Pharis RP, Rood SB eds. Plant Growth Substances 1988. Berlin: Springer-Verlag 383-390.
Ravasz E, Somera AL, Mongru DA, Oltvai ZN, Barabasi AL. 2002. Hierarchical organisation of modularity in metabolic networks. *Science* **297:** 1551-1555.
Ray TS. 1987. Cyclic heterophylly in Syngonium (Araceae). *American Journal of Botany* **74:** 16-26.
Ray TS. 1992. Foraging behaviour in tropical herbaceous climbers (Araceae). *Journal of Ecology* **80:** 189-203.
Rich TSG, Smith H. 1986. Comparison of lag times in plant physiology. *Plant Cell and Environment* **9:** 707-709.
Salzman AG. 1985. Habitat selection in a clonal plant. *Science* **228:**

603-604.
Salzman AG, Parker MA. 1985. Neighbours ameliorate local salinity stress for arhizomatous plants in a heterogenous environment. *Oecologia* **65:** 273-277.
Sanders D, Pelloux J, Browleee C, Harper JF. 2002. Calcium at the crossroads of signalling. *The Plant Cell* **14:** S401-417.
Schlichting CD. 1986. The evolution of phenotypic plasticity in plants. *Annual Review of Ecology and Systematics.* **17:** 667-693.
Schlichting CD, Pigliucci M. 1998. *Phenotypic Evolution.- A Reaction Norm Perspective.* Massachusetts: Sinauer Associates.
Schroeder JI, Allen GJ, Hugouvieux V, Kwak JM, Waner D. 2001. Guard cell signal transduction. *Annual Review of Plant Physiology and Molecular Biology* **52:** 627-658.
Sessions A, Yanofsky MF, Weigel D. 2000. Cell-cell signalling and movement by the floral transcription factors LEAFY and APETALA1. *Science* **289:** 779-781.
Sheen J, Zhou L, Jang JC. 1999. Sugars as signalling molecules. *Current Opinion in Plant Biology* **2:** 410-418.
Shen-Miller J. 1973. Rhythmic differences in the basipetal movement of Indole- acetic acid between separated upper and lower halves of geo-tropically stimulated corn coleoptiles. *Plant Physiology* **52:** 166-170.
Silvertown J, Gordon GM. 1989. A framework for plant behaviour. *Annual Review of Ecology and Systematics.* **20:** 349-366.
Simpson GG, Dean C. 2002. *Arabidopsis*, the rosetta stone of flowering time? *Science* **296:** 285-289.
Smart CC, Trewavas AJ. 1983. Abscisic acid-induced turion formation in Spirodela polyrrhiza. I. Production and development of the turion. *Plant, Cell and Environment* **6:** 507-514.
Steeves TA, Sussex IM. 1972. Patterns in Plant Development. New Jersey: Prentice Hall.
Stenhouse D. 1974. *The Evolution of Intelligence- A General Theory and some of its Implications.* London: George Allen and Unwin.
Stocker O. 1960. Physiological and morphological changes in plants due to water deficiency. *Arid Zone Research* **15:** 63-104.
Strong DR, Ray TS. 1975. Host tree location behaviour of a tropical vine (Monstera gigantea) by skototropism. *Science* **190:** 804-806.
Sultan SE. 1996. Phenotypic plasticity for offspring traits in *Polygonum persicaria*. *Ecology* **77:** 1791-1807.
Sultan SE. 2000. Phenotypic plasticity for plant development, function and life history. *Trends in Plant Sciences*. **5:** 537-541.
Sultan SE, Bazzaz F. 1993*a*. Phenotypic plasticity in *Polygonum persicaria*. I. Diversity and uniformity in genotypic norms of reaction to light. *Evolution* **47:** 1009-1031.
Sultan SE. Bazzaz FA. 1993*b*. Phenotypic plasticity in *Polygonum persicaria*. II. Norms of reaction to soil moisture and the maintenance of genetic diversity. *Evolution* **47:** 1032-1049.
Sultan SE, Bazzaz FA. 1993c. Phenotypic plasticity in *Polygonum persicaria*. III. The evolution of ecological breadth for nutrient environment. *Evolution* **47:** 1050-1071.
Sultan SE, Wilczek AM, Bell DL, Hand G. 1998. Physiological responses to complex environments in annual *Polygonum* species of contrasting ecological breadth. *Oecologia* **115:** 564-578.
Taiz L, Zeiger E. 1998. *Plant Physiology*. 2nd edition. Massachusetts: Sinauer Associates.
Takahashi H, Scott TK. 1993. Intensity of hydrostimulation for the induction of root hydrotropism and its sensing by the root cap. *Plant Cell and Environment* **16:** 99-103)
Takahasi K, Isobe M, Knight MR, Trewavas AJ, Muto S. 1997. Hypo-osmotic shock induces increases in cytosolic free calcium in tobacco suspension culture cells. *Plant Physiology* **113:** 587-594.
Takayama S, Sakagami Y. 2002. Peptide signalling in plants. *Current Opinion in Plant Biology* **5:** 382-387.
Tilman D. 1982. *Resource Competition and Community Structure.* New Jersey: Princeton University Press.
Tooke F, Battey NH. 2000. A Leaf-Derived Signal Is a Quantitative Determinant of Floral Form in *Impatiens*. *The Plant Cell* **12:** 1837-1848.
Trewavas AJ. 1981. How do plant growth substances work? *Plant, Cell and Environment* **4:** 203-228.
Trewavas AJ. 1986*a*. Timing and memory processes in seed embryo dormancy- a conceptual paradigm for plant development questions. *Bioessays* **6:** 87-92.
Trewavas AJ. 1986*b*. *Resource allocation under poor growth conditions. A major role for growth substances in developmental plasticity.* In Jennings DH, Trewavas AJ eds. Symposium of the Society for Experimental Biology and Medicine Volume XL. Plasticity in Plants 31-76.
Trewavas AJ. 1988. Gibberellin, amylase and germination. *Bioessays* **9:** 213-214.
Trewavas AJ. 1991. How do Plant Growth substances work. II. *Plant Cell and Environment.* **14:** 1-12.
Trewavas AJ. 1999. Le calcium c'est la vie: calcium makes waves. *Plant Physiology* **120:** 1-6.
Trewavas AJ. 2000. *Signal perception and transduction.* In Buchanan BBB, Gruissem W, Jones RL. eds. Biochemistry and Molecular Biology of Plants. Maryland: American Society of Plant Physiologists 930-988.
Trewavas AJ. 2002*a*. Plant cell signal transduction; the emerging phenotype. *The Plant Cell* **14:** S3-4.
Trewavas AJ. 2002*b*. Mindless Mastery. *Nature*.**415:** 841.
Trewavas AJ, Malho R. 1997. Signal perception and transduction: the origin of the phenotype. *The Plant Cell* **9:** 1181-1195.
Turkington R. 1983. Plasticity in growth and patterns of dry matter distribution of two genotypes of *Trifolium repens* grown in different environments of neighbours. *Canadian Journal of Botany* **61:** 2186-2194.
Turkington R, Harper JL. 1979. The growth distribution and neighbour relationships of *Trifolium repens* in a permanent pasture. I. Ordination, pattern and contact. *Journal of Ecology* **67:** 201-218.
Van der Luit A, Olivari C, Knight MR, Trewavas AJ. 1999. Calmodulin gene expression regulated by wind-induced nucleoplasmic calcium levels in *Nicotiana plumbaginifolia*. *Plant Physiology* **121:** 705-714.
Verdus MC, Thellier M, Ripoll C. 1997. Storage of environmental signals in flax: their morphogenetic effects as enabled by a transient depletion of calcium. *The Plant Journal* **12:** 1399-1410.
Viner N, Whitlam G, Smith H. 1988. Ca^{2+} and phytochrome control of leaf unrolling in dark-grown barley seedlings. *Planta* **175:** 209-213.
Voinnet O. 2002. RNA silencing; small RNA's as ubiquitous regulators of gene expression. *Current Opinion in Plant Biology* **5:** 444-452.
Waddington CH. 1957. *The Strategy of the Genes.* London: Jonathan Cape, London.
White J. 1979. Plants as a metapopulation. *Annual Review of Ecology and Systematics.* **10:** 109-146.
Wijesinghe DK, Hutchings MJ. 1997. The effects of spatial scale of environmental heterogeneity on the growth of a clonal plant: an experimental study with *Glechoma hederacea*. *Journal of Ecology* **85:** 17-28.
Wijesinghe DK, Hutchings MJ. 1999. The effects of environmental heterogeneity on the performance of *Glechoma hederacea*: the interactions between patch contrast and patch scale. *Journal of Ecology* **87:** 860-872.
Williams RJ. 1956. *Biochemical Individuality-the basis for the genetrophic concept.* New York: Chapman and Hall.
Willmer C, Fricker M. 1996. *Stomata.* (2nd edition). London: Chapman and Hall.
Winfree AT. 1987. *When Time Breaks Down.* New Jersey: Princeton University Press.
Zambryski P, Crawford K. 2000. Plasmodesmata: gatekeepers for cell-cell transport of developmental signals in plants. *Annual Review of Cell Developmental Biology.* **16:** 393-421.
Zangerl AR, Bazzaz FA. 1984. Effects of short-term selection along environmental gradients on variation in populations of *Amaranthus retroflexus* and *Abutilon theophrasti*. *Ecology* **65:** 207-217.
Zieschang HE, Sievers A. 1991. Graviresponse and the localisation of initiating cells in roots of *Phleum pratense*. *Planta* **184:** 468-477.

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IN THE COMPANY OF TREES

In this essay, Lucy Davis looks at the recurring references to Tree Duet*—a performance series by Singapore theatre company spell#7 (Paul Rae and Kaylene Tan)—through a series of explorations of trees in modern and contemporary visual art works from Singapore and colonial Malaya.* Tree Duet *is a poetic meditation on the "demands" that "trees make of us" in theatre and everyday life. Davis extends this thesis through readings of the "demands" made by trees in visual art works.*

Text by Lucy Davis

Tan Tee Chie
Fig 1. *Persuading*, *huang yang* woodblock print on paper, 20.5 x 31 cm, 1958. © Reproduced courtesy of the National University of Singapore Museum Collection.

In Persuading, a 1958 print by Singapore modern woodcut artist Tan Tee Chie, a frangipani tree surrounds two men seated on a wooden bench. While speaking, the older man taps the thigh of the younger man with his fingertips, an intimate gesture that the latter does not appear to reciprocate. My students often read this exchange as a sexual overture. However, in a 1950s context Persuading has other resonances. For Tan Tee Chie and members of the left-aligned Singapore Woodcut Society,[i] who produced their prints in the turbulent postwar climate leading up to Singapore's independence in 1965,[ii] images of vice on the street—such as prostitution, extortion, gambling and smuggling—were popular motifs. This scene may be a "guidance session" where the older man is asking the reluctant younger man to follow his teachings, or perhaps there is a shady business proposition at stake.[iii]

What is less ambiguous is the frangipani. The tree has never been far from the frame of dreams of modern Singapore/Malayan life.[iv] At first glance this frangipani is an anthropomorphic mirror of the older man as it winds around the two figures, heavy with flowers. A rosette of leaves opens to the left of the men's heads, drawing the viewer in to a third spherical centre. Another splayed bunch of leaves to the right of the older man mirrors his gesticulating fingers.[v] But what I find particularly persuasive in Persuading is the way that this invocation of a frangipani, carved from a Chinese huang yang (boxwood) block, slowly outgrows the didactic subject matter of the print. The tree appears to have a life of its own, with branches that rise up beyond the edge of the scene and forward towards the space of the viewer, threatening to disrupt the composition. The black ink of the trunk and branches connect the tree to the wooden bench upon which the men sit, to the cavernous wooden doorway in the background, and to the pathway upon which the men rest their feet. The path is uneven and sloping downwards, evoking organic, subterranean forces, which contrast with the controlled, pale geometry of the human structures in the space behind.[vi]

That this frangipani tree actually emerges from a small block of wood serves to doubly emphasise the materiality and intensity of the tree. The frangipani extends beyond the heavy outline of the thing itself, absorbed through still-porous cells of wood to the dark, uneven tiles of the path (which resemble a scaly kind of bark) and to the black elevated ridges, which when pressed and absorbed into the paper, outline the milky-sap forms of both men. There is—at least at the level of material—a two-way dynamic going on here, as wood grain becomes skin, earth, concrete and wood again.

TREE DUETS

This essay is partly a response to a series of performances by Singapore theatre company spell#7 and performed by its co-directors Paul Rae and Kaylene Tan between 2007 and 2009, all entitled *Tree Duet*.[vii] Tree Duet came about in turn as a response to a tree that Rae and Tan had tried to incorporate into the end of an earlier piece *Duets*, performed in Singapore at *The Substation* arts centre in 2007:

> … at the end of *Duets*, there was a kind of coup de theatre, where I walked over to this corner of the stage, and lifted up a trap-door to reveal the top of a beautiful tree growing up, as if it were growing out of the stage.
>
> I spoke to it for a while, then I sat down here and the lights went down.
>
> But even as the audience began to applaud, I knew that although the show had ended, it wasn't finished. It was the tree. You can't just put a tree on stage and expect it to do what you want it to do. I'm not saying trees have their own agendas—but they are their own things. (1 p.1)[viii]

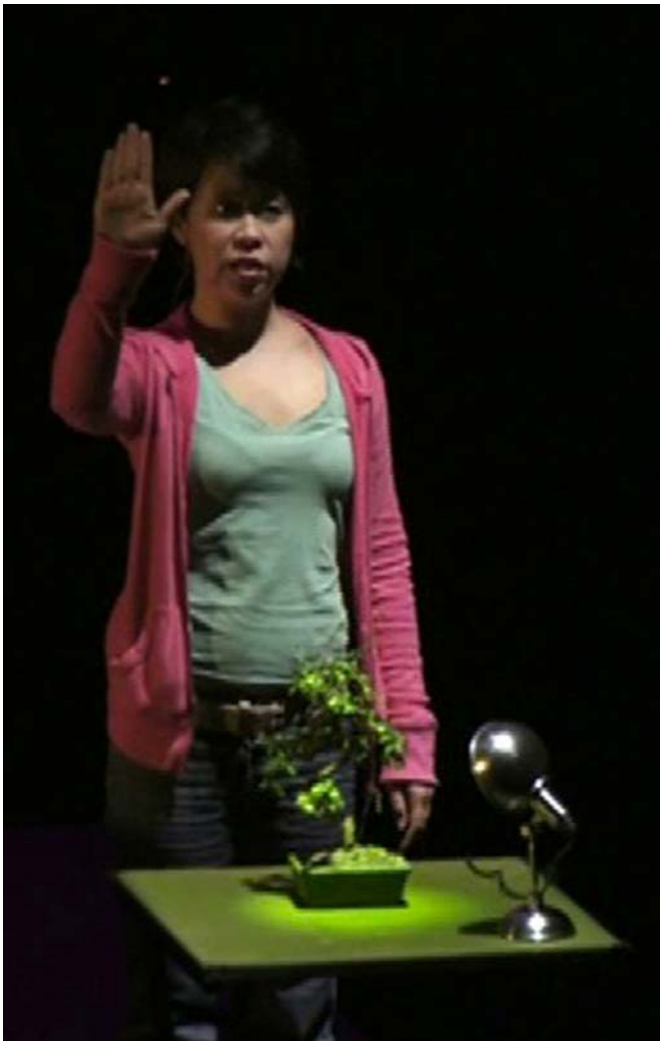
I saw three versions of *Tree Duet* at different venues in Singapore.[ix] All three experiences have now folded in my mind in a slow cycle of recurring images, gestures, words and sounds which resound with music composed by Olivier Messiaen and Toru Takemitsu (who composed pieces about trees in response to Messiaen), played live on the piano and harpsichord by Shane Thio.

Citation, recitation and the taking in and transformation of words and worlds by the "sly work of memory" (1 p.5) were the means by which this "ecology of the stage" evolved. As Rae puts it, "[E]verything is recycled" (2). This

"recycling" is rhetorical, symbolic and material. There are recurring stories of people and trees: politicians and trees, children playing around trees, dances with trees, historic individuals and trees, ancestors and trees. These stories are told and retold in layers, which resound through the gentle density of the piece. A considerable amount of water is consumed from plastic bottles by both performers. Most of the materials used in the production are tree products: a piano, a harpsichord, a broom, rubber balls (a reference to the Malayan rubber industry and included in a story of Henry "Mad" Ridley, self-styled rubber seed evangelist who was appointed Director of the *Singapore Botanic Gardens* in 1888),[x] a book of plays by the revered "father" of Singapore theatre Kuo Pao Kun,[xi] handwritten notes for a eulogy to Rae's grandmother, and a temple woodblock percussion instrument. And then there were 100 Singapore five-dollar bills, which are green and although no longer made of paper, bear the image of a Singapore "Heritage" tembusu tree.[xii][xiii]

In the play, monologues by Paul Rae—which skirt around the conventions of a performance lecture—alternate with physical and spoken interventions by Kaylene Tan, which complicate Rae's prolixity. At one point she says, "You talk a lot" and the audience laughs. During my second and third viewings, I found myself zoning in and out of Rae's sequences of recurring stories—and instead drifted with other rhythms within the piece: the poignant but independently demanding temporalities of Toru Takemitsu's *Rain Tree Sketches I and II* and *Rain Dreaming*; the earnest and somewhat wooden "tree dance" that Tan and Rae return to (Tan assuredly, Rae haplessly);[xiv] the sound of the temple woodblock; the sound of breath; the sound of wind; the sound of the sweeping of leaves on a temple floor.

One particular temple featured in the performance. The *Jin Long Si* temple, situated in a quiet, nondescript Singapore neighbourhood, houses what is estimated to be the largest and oldest bodhi tree (Ficus religiosa) on the island. (The bodhi is the tree under which the Buddha is said to have reached enlightenment.) Unfortunately, the temple is situated on land that was purchased by the state in 2003 to develop the Mass Rapid Transport system's new Circle Line. After petitions and letters to the press, in early 2010 the bodhi tree was finally awarded the official status of "Heritage Tree" and therefore permitted to remain.[xv] The temple however, will probably be relocated and the existing temple building demolished.



Paul Rae and Kaylene Tan
Fig 2. *Tree Duet*, staged at the University Cultural Centre Theatre, during the National University of Singapore Arts Festival. Video still, 2009. © Paul Rae and Kavlene Tan

The last version of *Tree Duet* I saw, the performance began with Tan entering slowly along a slightly-raised, plankway carrying a bonsai tree, to the sound of a wind machine.[xvi][xvii] Tan walked towards a table and the wind sound increased. When she placed the tree on the table the noise stopped. She raised her right flat palm and traced invisible words in the air, as if reading Braille but also in the manner of the Buddhist abaya or goodwill mudra. Her voice was clear but emotionless, as if slowly learning the words:

Jin Long Si. Viewing sacred tree: 9 a.m.–6 p.m.
Jin Long Si. Viewing sacred tree: 9 a.m.–6 p.m.
But for how long?

'Rain Tree Sketch II' by Takemitsu began to play and Tan looked at the bonsai. (3 p.1)

These lines were repeated twice, passed back

and forth between Rae and Tan and then later on, Tan's hand "read" the sign a third time, without the accompanying words as though they were already absorbed into her body (and our memory).[xviii]

"For how long?" has a simple pathos to it—asking "how long" (in the days prior to its Heritage Tree status) the bodhi tree would be around before it was chopped down to make way for the train line. "For how long?" also refers to an absurd disconnect between human scales of measurement: between urban Singapore time and tree time, and a recurring theme in the play of our failure to measure tree experience in formats such as "viewing hours" or "heritage". How long is tree time? How long is a tree? Is a tree long? A few lines later in the play, Rae states:

> … faced with a tree, we are caused to behave in particular ways. It is as if trees make certain demands of us, demands we can almost never fulfil, even though we have been striving to do so for millennia. (3 p.2)

I want to trace Rae and Tan's thesis about the "demands" that "trees make of us" through and around readings of the demands made by trees in modern and contemporary visual art works from Singapore and colonial Malaya. In all these examples, the shelter or symbol of the tree is "on loan" in order to say something or frame something pertaining to human life. The trees lend their presence and/or their material to the art works and compel the artist to do things—in, with and beside them. I will explore the extent to which trees—even in the realm of pictorial representation—are somehow "their own things" beyond the time and space of the other subject matter and perhaps intentions of the artist.

Another way of thinking about the things trees ask of us is to think of human-tree cultures as co-productions, or what Donna Haraway would call companion species relationships. For Haraway companion species "partners do not precede their relating; all that is, is the fruit of becoming with." (4)[xix] That being the case, could our continuous attempts to fulfil the "demands" our arboreal familiars make of us, be considered a "becoming with" trees—even or precisely if we continue to misunderstand their demands in human culture? I will explore how this might manifest in and through the demands asked of us by trees in these particular works of visual art.

OUTPERFORMED?

Liu Kang (1911–2004) was the longest living, best connected and arguably therefore most canonised member of a diverse group of painters of Chinese ethnicity who migrated to Singapore in middle of the 20th century,[xx] loosely known as the "Nanyang Painters" or, somewhat fawningly, the "Pioneer Artists". "Nanyang" was a geographical designation used by soujourner Chinese communitites in Southeast Asia. It means "South Seas" and specifically refers to Singapore and Malaysia (then known as Malaya).

The Nanyang Painters were influenced by experiments in the southern Chinese cities of Shanghai, Nanjing and Guangdong, which aimed to rejuvenate classical techniques and formats by introducing aspects of Western representational painting. They were also influenced (as were many modern Chinese artists) by post-Impressionism, Fauvism and Cubism, and the experimental energies of the School of Paris.[xxi] These Franco-Sino influences were channelled through the specific geo-cultural subject matter of "Nanyang" and can be read as a way migrant artists came to terms with and legitimated their increasingly permanent residential status in Malaya. Paradoxically, however, the foundational dream of "Nanyang" took form famously not in the burgeoning island trading port of Singapore or the rhythms of the rubber plantations of Malaya, but instead on a trip that four of the artists made in 1952 to the island of Bali.

Possibly inspired by a series of exhibitions depicting orientalist fantasies of Bali by the Belgian post-Impressionist painter Adrien Jean Le Mayeur (which were staged in Singapore in the 1930s and 1940s),[xxii] the Bali trip is celebrated as a defining experience for the four male artists[xxiii] from whence the diverse tendencies of what has become popularly known as a "Nanyang style" were consolidated.[xxiv] In contrast to the slightly younger woodcut artists and artists from the leftist *Equator Society*,[xxv] Liu Kang and his companions did not engage overtly in political or nationalist subject matter. Indeed, they have often been dismisssed for being pro-status quo and for decorating or naturalising colonial rule with sentimental kampung (village) scenes and visions of bare-breasted women in idyllic tropical landscapes, far from the political and economic imperatives of modernising Malaya.[xxvi]

The Padang, painted in 1953, is one of

Liu Kang
Fig 3. *The Padang*, oil on canvas, 87 x 127 cm, 1953. Liu Kang family collection at the Singapore Art Museum. Image courtesy of the Nationa of Singapore © Liu Kang

few works by Liu which depict the Singapore city. In this painting the subject is the central green of the colonial settlement that has functioned as the site of military parades, the Japanese surrender after World War II and later, Singapore's Independence and National Day ceremonies. Ho Tzu Nyen, whose film series about modern Singapore art I will return to later, has this to say about the painting:

> In other words, the "Nanyang Style" was a "modern" art style that rejected the face of modernity itself. There is indeed something unbearable about the few paintings by Liu that were "scenes of modern industrial areas and commercial areas."[xxvii] The broad brush strokes characteristic of Liu's outlines take on an extreme clumsiness when applied to the geometry of modern day architecture.
> The Padang depicted the seat of power of the Colonial State, and the twin giant phalluses—the City Hall of the Parliament and the Supreme Court; it repulses the viewer in a way that only the vulgarity of unsheathed power can. Nothing in it seduces, and nothing in it can evoke the idyllic that was Liu's typical painterly domain. Nothing in the painting can ameliorate the representation of labour that sticks out like a sore thumb in the foreground of *The Padang*. A lone Indian man, presumably sweating under the extreme heat of Singapore, has removed his top as he mows the lawn alone. There was no way Liu could have painted modern life without the signs of labour. And there was no way labour could have been depicted as idyllic. (5 p.229)

Nanyang Painters

Fig 4. A much-reproduced photograph of the Nanyang Painters on their Bali trip, together with Jean Le Mayeur and his Balinese wife, dancer and model Ni Polok, surrounded by frangipani trees and with the dappled shadow of a frangipani in the foreground.[xxii] "Bali Field Trip 1952: Liu Kang, Cheong Soo Pieng, Unknown person sometimes called Luo Ming, Ni Polok, Jean Le Mayeur, Chen Chong Swee and Chen Wen Hsi". Photograph taken by the writer during the exhibition Encountering Cheong Soo Pieng, National University of Singapore Museum, 5 March-31 July 2010

What interests me here is a curious disconnect between an admittedly nauseating homage to imperial power on a violent blue tropical day and the quite glorious rain tree that we peer through in order to view the scene.[xxviii] The use of a tree to consecrate a particular perspective of the world beyond it is a device with a rich lineage in both Western and East Asian landscape painting. A lone tree or a small cluster of trees often frames what appear today to be impossibly defoliated depictions of Southeast Asia's colonial settlements—Batavia, Manila, Singapore—celebrations of conquest over "tropical possessions" which gleam with an affiliated zeal to Liu's *Padang*. I say "impossibly defoliated" because although up to 90 per cent of primary forest in Singapore was cleared for construction and plantations during the 19th century,[xxix] it is difficult to fathom how early colonial settlements really were kept so clean of foliage when—even in as meticulously controlled a metropolis as 21st-century Singapore—bird's nest ferns or banyan (strangling fig)[xxx] roots will sprout high up on

John Turnball Thomson

Fig 5. *Singapore Town from Government Hill Looking South*, 1846, water colour, 44 x 27 cm. Image courtesy of John Hall-Jones New Zealand. Reproduction from John Hall-Jones, *The Thomson Paintings: Mid-Nineteenth Century Paintings of the Straits Settlements and Malaya*, Oxford University Press, 1984 p 31 © John Hall-Jones New Zealand

any building left alone for more than a couple of months, feeding dreams (as Kevin Chua has argued in a different vein elsewhere) of our own extinction (6).[xxxi]

The lone rain tree stands, like us, on the edge of the *Padang*, marking a boundary between the viewer and the colonial architecture and lending us its shade. We do not step onto the grass of the *Padang* itself, but one has the sense that we might be able to approach the tree, to hide behind it or perhaps lean against it's trunk.

The motif of the tree as a mediator between people and power also appears in *Tree Duet*, when sections of Kuo Pao Kun's play *The Silly Little Girl* and the *Funny Old Tree* are revisited:

> PAUL: On the face of it, The Silly Little Girl and the Funny Old Tree is a simple, even simplistic play. A girl befriends a tree [Kaylene takes out bonsai and attends to it]. She treats it like her grandfather, and the suggestion is that it compensates for her troubled relationship with her family, and her lack of cultural roots.
>
> KAYLENE: [Quoting from The Silly Little Girl …] Trees are like people.
>
> PAUL: But what's interesting is that the tree doesn't entirely agree. He doesn't always say the things the girl wants him to say, or do the things she wants him to do. Later in the play, he asks her if she wants to sing and dance with him.
>
> KAYLENE: [Quoting from The Silly Little Girl …] I thought you can

only sing and dance when there is wind?

PAUL: [in a booming voice] That's what the wind says. Actually, it's only when we sing and dance is there wind, only when our leaves and branches swing is there wind. Wind mustn't be so proud. (7 p.107)

Rae continues:

According to Confucius, in matters of governance, the figure of the gentleman (on which Singapore's authoritarian politicians have been known to style themselves)[xxxii] is as the wind to the grass of the small man.

For Kuo, who spent four years in the 1970s in detention for his left-wing views, although our politicians and our governments often think they can bend the people to their will, it's only because the people allow them to that they can be our politicians and our governments at all. (8 p.6)

Kuo's allusion to tree experience however, draws us into a time and expanse that transcends political metaphor. In 'Why there is wind', an article on trees and performance in Singapore, Rae cites a series of further examples in Kuo's play where the experience, ecology and time of the tree is beyond the ken of the little girl and unravels an otherwise simplistic allegory (9). In a section entitled 'Outperformed', Rae connects these insights to the oft-photographed performance of Singapore politicians planting trees and the inference that the politician, like the tree and the nation, will be there for the dependable long run. Analysing the photographic archive of Singapore's founding leader Lee Kuan Yew repeatedly planting trees throughout his life, Rae argues how the trees inevitably outperform him:[xxxiii]

Lee grows older. From a stripling bedding down his plant-kingdom familiars, he becomes the octogenarian custodian of spry whippersnappers, and where the formers' futures entwine, the latters' bifurcate: now the sapling stands in mute testament to a Leeless future. Worse: although the accompanying plaque may memorialise him when he is , the tree as such is indifferent, a splinter of otherness, materialising a concept otherwise almost as inconceivable as death itself (9 p.206).

The rain tree in Liu's painting is specific. This is not the projected spirit or essence of a tree from Chinese painting conventions, nor is it a stylised abstraction of the kind painted by some of Liu's contemporaries. And perhaps because we are supposed to look past it towards the spectacle of power, the tree does not seem overly burdened with meaning. To be sure, its arching branches provide some kind of benediction to the gleaming colonial edifice. But in this tree duet, the vivid, tactile individuality of the tree also outperforms the background subject matter. The Padang behind is a rapidly-painted, toy-town—a mistaken backdrop for an intended image of the tree, where perhaps a flash has gone off by mistake. Curiously, Ho Tzu Nyen's critique of The Padang, cited above, comes out of a dissertation entitled *Afterimages* (5).[xxxiv] But when Ho looks at this painting, what he sees is The Padang and Liu's incapacity to represent labour. From the very first time I saw it all I could remember about it, and indeed all I do still see if I close my eyes after looking at the work, is the tree.

Perhaps this duet is not between impermeable colonial buildings and "inconceivable" treeness but is more about an extended arboreality; a personal relationship between the artist/viewer and a tree as individual. We stand with this tree, in its shade, and while we will never be able to know or fulfill what it demands of us, we do sense an invitation to lean in, to touch that orange sunspot on its trunk—so much more inviting than the pat red roofs of the buildings behind. And if we did touch the tree, perhaps spores of those epiphytes would rub off on our clothing, to be flicked off elsewhere on the island. And so the influence of this specific tree migrates beyond the anxieties and pretensions of a 1950s Nanyang artist, and the colonial scenography it frames.

Paul Rae and Kaylene Tan
Fig 6. *Tree Duet*, staged at the University Cultural Centre Theatre, during the National University of Singapore Arts Festival. Video still, 2009 © Paul Rae and Kaylene Tan

VERTICALITY & TREE TIME

While Paul Rae in *Tree Duet* elaborates, in a slightly preachy manner, upon the "things trees demand of us", Kaylene Tan sweeps around him, as though sweeping a temple floor. She continues as Rae says, "whether by praying at the foot of a tree and leaving offerings, dancing around the tree, telling stories underneath it, or planting new ones—the result often takes the form of a performance". As he concludes, Tan props the broom up on its brush end so that it balances vertically, and sits down on a teak garden chair, opening and drinking from a plastic water bottle. The broom is upright in centre stage—not a person and not a tree, but something in-between and of itself. Rae looks at the broom and then at Tan. The audience laughs.

Talking about *Tree Duet*, Rae remarked how one reason why we so often project ourselves onto trees is to do with verticality and our perceiving trees as upright beings—familiars. This was perhaps one of many reasons why, when he tried to write about trees for Tree Duet, he ended up writing about people (2).

Cheong Soo Pieng (1917–1983) was another of the four Nanyang artists on the 1952 Bali trip. The subject matter of his painting Tropical Life is the Malay kampung or village, and it is in the possession of the *Malaysian National Art Gallery*. At first glance, the painting appears to be a slightly clichéd quotation of Gauguin's Where do we come from? What are we? Where are we going? and yet another idyllic village scene, far removed from the fraught political energies of the time. Like Liu's The Padang and Tan's Persuading, Tropical Life was painted during the Malayan Emergency (1948–1960), during which the communist *Malayan People's Liberation Army*—many of whose soldiers had fought valiantly against the Japanese during World War II but who were subsequently pushed out of pre-independence power-sharing arrangements with the British—took up violent guerrilla struggle in the jungles. The political sympathies of rural Malayan kampung dwellers were an object of some concern as *British Commonwealth* forces feared that Malaya would be the next Southeast Asian nation to "fall".

The first episode of 4x4 Episodes of Singapore Art, an experimental TV series of four films by Ho Tzu Nyen, is entirely devoted to the painting (10). The first film features a

Cheong Son Pieng
Fig 7. *Kehidupan Tropika* (*Tropical Life)*, Chinese ink and gouache on Chinese rice paper, 88.9 x 45.6 cm, 1959.

contemporary Singapore couple arguing about possible interpretations—whether the painting is nostalgic and reactionary or whether it has reflexive, critical potential.[xxxv]

What interests me about Tropical Life is the way that the interactions between the people are both mirrored and mediated by the vertical rhythms of a series of stylised tree trunks. At the far right, a woman combs a little girl's hair, with a tree bending over her, echoing the curve of her back. At the centre of the painting, a woman appears to be hiding behind a tree, possibly eavesdropping on the conversation of the two women on the other side. A third tree also appears to be bending over towards the two women. And in the far left a man with his back to us, wearing a songkok (traditional headwear) leans against a fourth tree.

The forms of trees have been drawn upon as punctuation devices in Southeast Asian narratives for centuries. The intricately perforated shadow puppet depicting the cosmic Tree of Life begins and concludes wayang kulit shadow theatre performances. Trees both mark narrative breaks and are intertwined with the action on the reliefs of Angkor and Borobudur. A question requiring inquiry outside the boundaries of this essay is how these narratives might read without their arboreal support-structures—if the teak tree branch was not there for Queen Maya to grab hold of, would Siddhartha have been born from her side?

The trees in Cheong Soo Pieng's Tropical Life do not have the specificity of Liu Kang's rain tree. Cheong's emphasis was upon line, form, pattern and rhythm,[xxxvi] and the trees, while they have a certain woodenness about them (a woodenness they share with the human figures, to which I will return) comprise a series of stylised blocks with a somewhat fussy arrangement of leaves beneath. Kevin Chua, who regards the painting as both iteration and critique of the modern dream of kampung life, says of these trees:

> The vertical trees break up the rhythm of the horizontal space, yet coordinate the space so effortlessly (bleeding into the border itself), that they seem to emerge only belatedly as trees, as nature. It is as though we have gone through and come out on the other side of fragmentation. (11)

I would argue however, that these trees—even in this reductive form, neither representational, nor expressive, nor, essential in the manner of Chinese painting—are both markers of human time while at the same time complicating it, persisting with their own discretely dense coordination—however belatedly they emerge.

There are already at least two notions of human time operating in this painting. There is the way that time moves across a landscape in Western painting, generally from left to right, and

there is, as T.K. Sabapathy has famously argued, the more intimate but fragmentary timeframe of the Chinese hand scroll, which while conventionally unrolled from right to left, only reveals a certain opening in the narrative at any one time, after which the section is rolled up again (like a dry leaf) to be reopened in a different place. Many of Cheong Soo Pieng's works are characterised by experiments to transfer both the horizontal intimate and vertical monumental formats of Chinese scrolls into modern painting with oil, gouache and water colour (12). Indeed the scale of this 88.9 x 45.6 cm painting permits a transference of the intimacy of the hand scroll—an activity ergonomically suited for only one or two persons—onto a larger format.[xxxvii] The long trunks of the trees, like the edges of a rolled-up scroll, create windows for shifting stories, temporalities, subject matter and perspectives.

"But for how long?" And is a tree long at all? Trees, as biology teachers told us, do not just grow upwards as determined by a central control tower or brain in the trunk, which increases its distance from the ground as the tree grows taller (as do so many trees with faces in children's stories). Trees grow outwards and upwards in density and extremity, around and to the side of, they bud, twig flower, leaf, fruit and seed, with all their coordinates and pathways of water and sugars, interconnected but without determining, hierarchical organs, however hard we project onto them our feet, hearts and crowns.[xxxviii]

The branches of the trees in this painting create a border not unlike the foliage in batik patterns and in stone and wooden temple reliefs. They compel us to look through their latticework and into vignettes of romantic rural leisure—or the bird-caged fragmentation of modern life, depending upon our political persuasion. While so doing, they give us a measure with which to stabilise our forms and relativise our histories. And we believe as we discard naturalism for formal experimentation that they follow all the more the patterns we project through them. But even in this reduced form we are not completely in control of these trees.

Theatre director Peter Brook in *The Shifting Point* remarks how naturalism in theatre "requires that images stay in the frame long after the need is over. If we have a 10-minute scene in a forest, we can never get rid of the trees" (13 p.62). It's no coincidence that he uses the tree as an example of something we can "never get rid of" or that he refers to an earlier affiliated arboreal inquiry by Edward Gordon Craig: "How much is it essential to put on stage to convey a forest" (13 p.61). Brook's main point is that with an uncluttered stage, the "physical side down to a simple outline … then you have more means at your disposal". But I'm not so sure that the outline of a tree can be so easily disposed. These are the only lines I remember from reading this discussion as a student in Copenhagen in 1994. I still have such a strong "afterimage" of those off/on-stage trees—ghostly outlined, badly painted—even though I never saw them. Perhaps trees—even a reference to trees, tree abstractions or patterns, trees that are on loan to echo our length or to coordinate our positions, or to give rhythm to a rural idyll, even trees that are to be removed to make space for theatre—have a density that persists.

From Tree Duet:

> KAYLENE: To be honest, progress doesn't bother me. The roots run deep. They wrap around the temple, the roads, they run under sewer lines, branching out beneath government houses and big city buildings. Buried under your house, eating the dead while you fuck, drinking the rain as you dream, extending beyond, even as your children grow up, old and die. On and on, for generations after you: family you will never know, and who will forget you—you, their so-called "roots"; you, who once lived sky high on the 53rd storey of a condo in a place where a temple used to be, before they knocked the condo down and built a mall, a football field, a discotheque, an interchange, a temple again … (3 p.16)

KAYU

In Tropical Life we don't have trees with human faces, but we do have a human child without a face. Kevin Chua writes:

> If there is a moment of strangeness in the painting it is

> the boy next to the solitary backturned figure on the left. His head is odd, with neither a back nor a front: a Janus face within colonial modernity … Suddenly the kampung becomes material as myth shorn of its illusory sheen. Rural and urban inside and outside, past and present everything seems to refract from this one moment of refusal … (11)

I read something wooden in this "refusal", in this "material as myth" as if the little boy's head is made of wood. In fact many of Cheong Soo Pieng's forms appear wooden, inspired perhaps by examples of woodcarving Cheong experienced in Bali or Sarawak.[xxxix]

One of the first forms of abuse I learned in primary school in Singapore was "kayu!", the Malay term for woodhead or blockhead—an epithet for someone who is stupid and who doesn't get the picture. Strangely what happened once I realised that in Tropical Life this boy's head looked wooden, the other figures began to appear wooden too—a material linking of the rhythms, figures and tree blocks might be seen to root their collective forever-presence in rural tropicalia. Or otherwise this blockheaded boy, which Ho's female protagonist calls a "monster" of modernity, looks both ways and can no longer "get" the picture. In Ho's film the boy walks off the left hand side of the picture, arms outstretched as though blind or sleepwalking through apocalyptic documentary footage of construction sites and scorched forests.

But perhaps there is a gentler interpretation of this blockheaded boy—one that requires a bit of "becoming with". In "Why there is Wind" Rae discusses another section of Kuo's play, *The Silly Little Girl* and the *Funny Old Tree*:

> Later, when [the little girl] goes to the Tree at night, she is at first startled that it sees her in the dark, but goes on: "Why can't humans see in the dark? Because human eyes are made to see only light. (Reflecting for a moment)". (7 p.110)
>
> In this reflection lies not only a moment of personal realisation, but a space for the audience, too, to think through the ecologised epiphany that derives not so much from the precise answer as from the shift in logic that it entails. (9 p.209)

This "ecologised epiphany" implies some sort of understanding outside of ourselves. We may not understand how a tree is in the world but we move beyond ourselves while trying to do so. An affiliated reflection occurs towards the end of *Tree Duet*—one which seems to want to move beyond a linear conception of time to a temporality which, like a tree, is there, is sensed but cannot be fully articulated.

> A man peels off from the group praying in the temple. He walks over to the chair under the tree, and sits down on it, looking out over the construction site. He's got his prayer beads, and he's reflecting, contemplating. I look at him and I think: "now that's a tree duet!" You sit under the tree. You allow it to shade you, you listen to it, and you think. But you don't look at it. The only thing was, watching that man under the tree looking out over the construction site, I couldn't work out if he was facing backwards, or forwards. (8 p.17)

GRAFTING

There has been a fair bit of grafting going on in this essay. Kevin Chua once complained to me that writers from Singapore "really have got to stop citing each other" (14). But in the case of Singapore culture, when one top down story has predominated for so long and where so many paths have been erased or unused, I don't see a problem just yet with writers and artists somewhat blindly connecting and transplanting their ideas for the moment.

Tree Duets is also a form of grafting. Rae and Tan insert sections of Kuo Pao Kun's The Silly Little Girl and The Funny Old Tree into their play, and in a section of an earlier version, Rae invoked contemporary artist Zai Kuning's performance and sculptural tribute to the late Kuo, entitled *A Tree in a Room*, in which two parts of a felled tree, with a presence far too big for the gallery, were sewn back together with nails.[xl]

Paul Rae and Kaylene Tan
Fig 8. Paul Rae and the Bonsai tree in *Tree Duet*, staged at the University Cultural Centre Theatre, during the National University of Singapore Arts Festival. Video still, 2009.

Simryn Gill's *Forest* series from 1996 comprises a series of 16 black and white photographs of installations, (taken by Nicholas Leong) which she made by cutting paper strips or plant, leaf and root shapes from canonical texts—the Ramayana, The Origin of Species, The Portrait of a Lady—and grafting them onto plants, trees and walls in Singapore and Malaysia.[xli] One photograph depicts cut-out strips of an English translation of the Javanese Ramayana, embedded into the horizontal ridges of a coconut palm in a garden in Port Dickson, Malaysia. In another, strips of Darwin's Origin of Species were pasted onto the intertwined aerial roots of two kinds of banyan trees on Fort Canning Hill in central Singapore.[xlii]

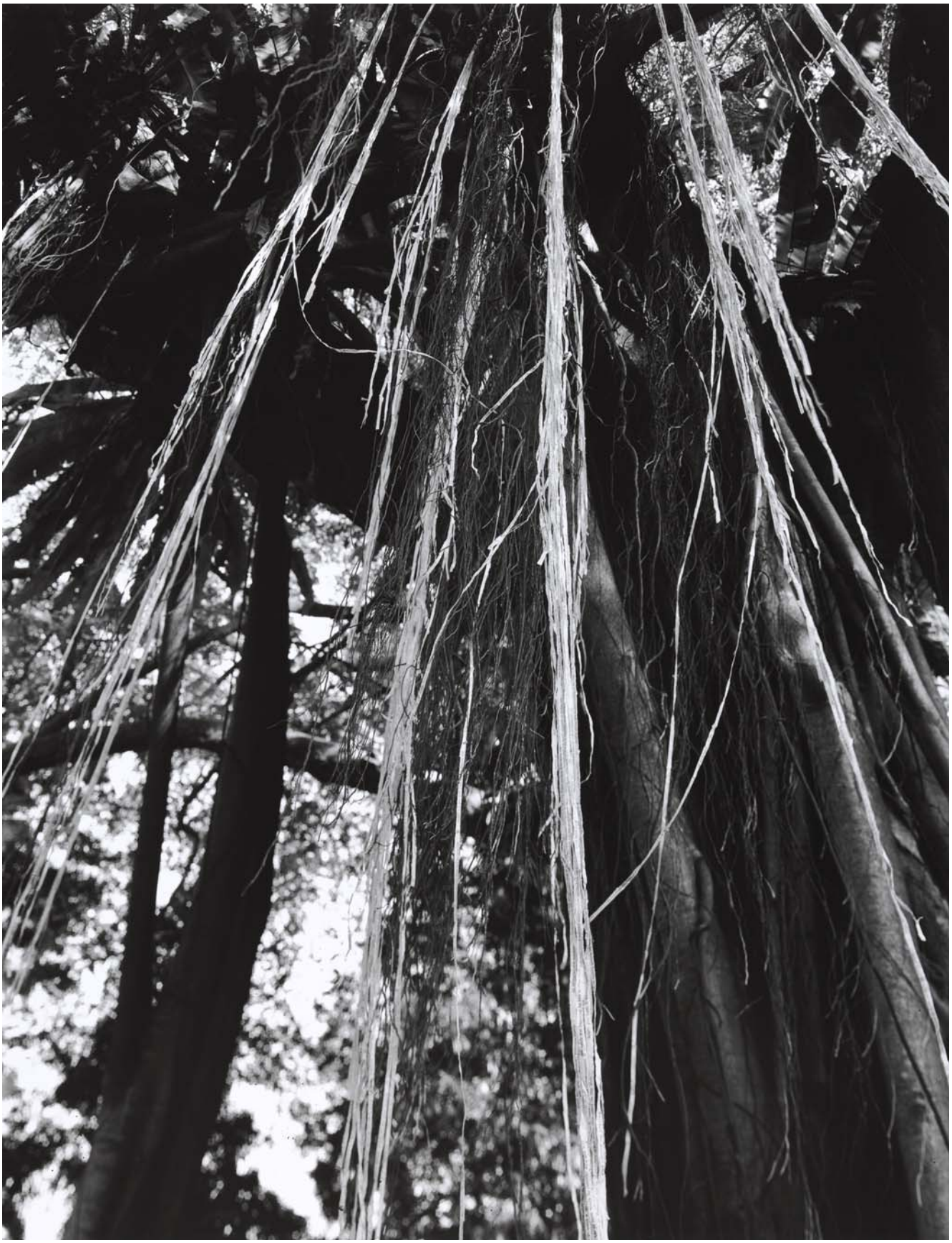
The Forest photographs tease and complicate essentialist desires pertaining to location, nature and origins via a playful and subversive insertion of paper and text onto real trees and plants. The images are slowly revealing of our anxious attempts to naturalise migrant humans and humanise a migration of flora. But the works also have a capacity to embed themselves in a way that is neither just about Gill's grammatic gestures and pithy textualities, nor the nostalgic authority of the black and white photograph.

The affective power of *Forest* on the one hand resonates from the powerful presence that the host plant feeds the metaphor and on the other, a breach Gill splices between metaphor and material experience. I am at first tricked by the paper cut-outs and then realise and try and read the text, but the process of parsing text, paper and photograph brings me into closer proximity with the skin of the tree or the plant. I am reminded of experiences of tropical plant and tree textures—fleshy, mossy, damp—and how they differ from the dry paper of Gill's installations.

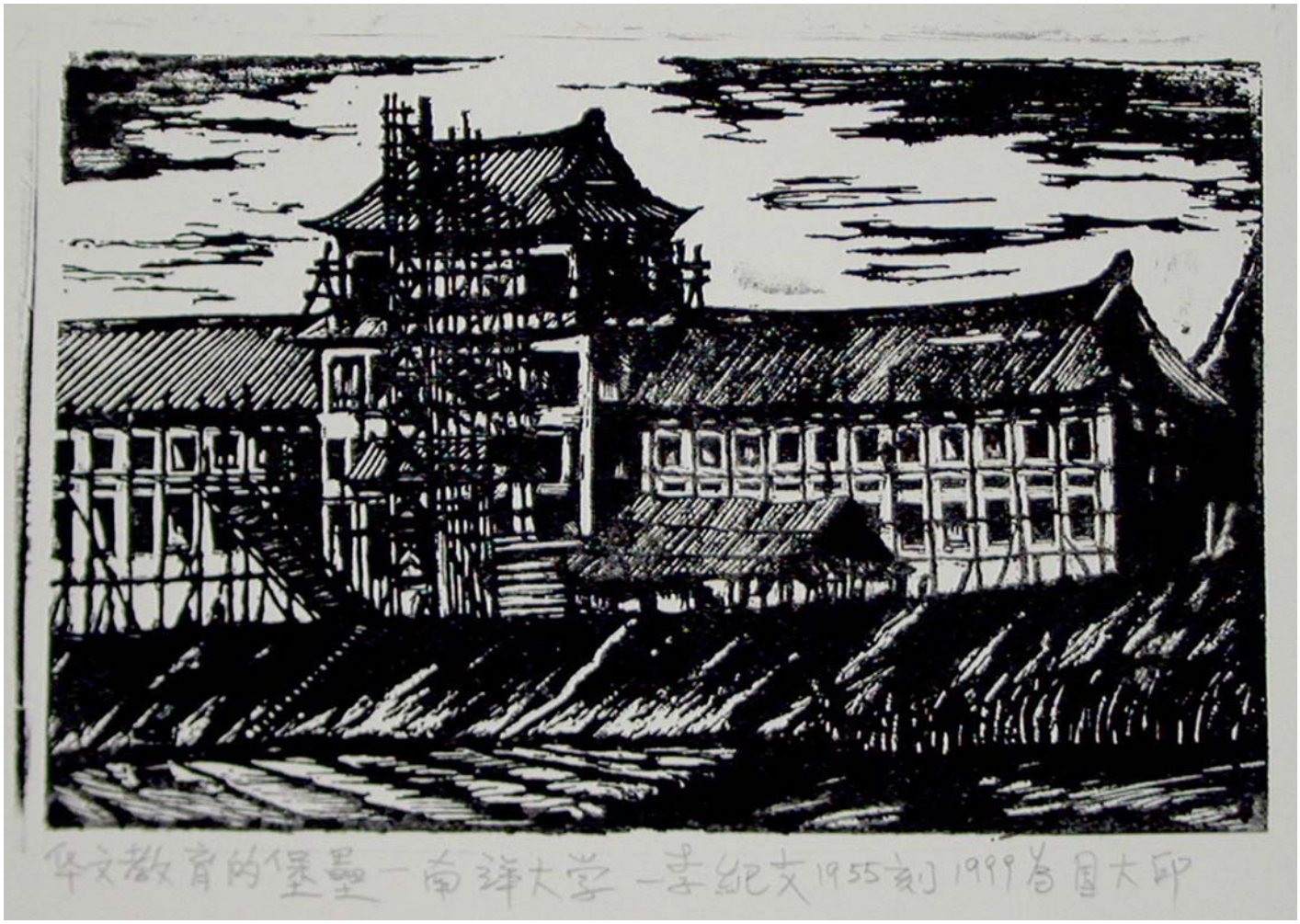
While Gill makes explicit our layers of cultural-linguistic grafting onto nature this revelation also opens a space between our projections and a material awareness of the actual plant or tree. We know that under the equatorial sun the text will fade, that the edges of the delicately contrived paper creepers will curl in the humidity, and when it rains that these cut-out slices of dry words will melt into mush and disappear into the soil—but that the swinging red roots of the banyan and the smooth rings of the palm onto which these paper parodies are pasted, and from which arboreal authority, verticality, density, fecundity, excess is borrowed, will persist.

I want to end by returning to another example of modern woodblock art and thinking about a material experience of grafting as a kind of "becoming with" trees. Lee Kee Boon's Nanyang University consists of an image of another "path not taken" (15).

Simryn Gill
Fig 9a *Forest* #2. Series of 16 silver gelatin photographs, 120 × 95 cm, 1996–1998



Simryn Gill
Fig 9b *Forest* #4. Series of 16 silver gelatin photographs, 120 × 95 cm, 1996–1998



Lee Kee Boon
Fig 10. *Nanyang University*, woodblock print on paper, 20 x 31 cm, 1955 (1999 print). Reproduced courtesy of the National University of Singapore Museum Collection

It depicts the construction, in 1955, of the predecessor of my current university Nanyang University—more familiarly known as Nantah—with funds collected from diverse, independent members of the migrant Chinese community in Malaya.[xliii]

Nantah has been described as having a "good claim to being the first Southeast Asian university" because although its medium of instruction was Chinese, Nantah was resolutely located in Malaya (16). But the heroic May 4th movement-inspired and left-leaning vision espoused by Nantah founders and students proved to be at odds with the anglophile, pro-capitalist government of post-independence Singapore.[xliv] Nantah was closed in 1979 and merged with the National University of Singapore. An engineering institution was developed on the original site in 1982, and in 1991 this was renamed Nanyang Technological University—where I currently teach.

The energy and anxieties of the Nantah vision, so different from those of the Nanyang Painters, resound through the rough-worked lines of this woodblock print. Here the concrete dreams of a modernising China, transplanted onto a plot of orange soil, carved out of hilly jungle, farms and plantations in western Singapore, are held in place by a fragile exoskeleton of wooden scaffolding and inscribed with much energy—much labour, into a woodblock.[xlv]

May 4th Movement literary ideologue Lu Xun advocated that Shanghai woodcut artists (who were emulated in Singapore) let the woodblock speak via an "aesthetic of vigour"—li zhi mei (17).[xlvi] In Nanyang University there is an unfinished dance between the porous material and concrete dream, between the raw expressiveness of the grain and the construction of a modern that was not to be. Today the Nantah administrative building itself still stands but turned into a *Chinese Heritage Centre*—an impossible attempt by the institution to co-opt this unruly historical matter into their own legacy—a process not unlike the ascribing of "heritage" to trees.

Paul Rae and Kaylene Tan

Fig 11a &b. Paul Rae and shadow of the Bonsai in *Tree Duet*, staged at the University Cultural Centre Theatre, during the National University of Singapore Arts Festival. Video still, 2009 © Paul Rae and Kaylene Tan

Grafting then is not just about citing or recycling the energies or projected properties of an existing subject or material to suit our needs, nor is it about critically appropriating the premises of the host from the perspective of the contemporary. When we graft our modern dreams or contemporary critiques onto living material, we enter into collaborations that we cannot control. And sometimes in the process we become more than us.

At the end of *Tree Duet,* Paul Rae lies down, corpse-like, with a book of Kuo Pao Kun's plays under his head like a pillow. Tan walks across the stage and brings the bonsai tree and scissors. She matter-of-factly opens Paul's shirt where he is wearing a bandage—as though there is a wound. She cuts the bandage, swabs it with iodine[xlvii] and crudely grafts the roots of the

tree onto his stomach. She buttons the shirt up around the tree and positions a desk lamp by his side to project a large shadow of a tree onto the wall. The imposing shadow bonsai moves up and down with Rae's stomach as he breathes. It looks like a tree on a hill in a Chinese ink painting but also somewhat like the filigree of embryonic fluid inside a womb. Tan then attaches a long tube, which winds across the floor from a plastic water bottle to Paul's mouth. And he drinks the whole lot.

> "But even I knew that although the show had ended, it wasn't finished. It was the tree".[xlviii]

Bibliography

1. Rae, P. and Tan, K. Tree Duet, unpublished playscript, 2008.
2. Rae, P. Conversation with author, Singapore, December 2009.
3. Rae, P. and Tan, K. Tree Duet, unpublished playscript, 2009.
4. Haraway, D.J. When Species Meet, Minneapolis, University of Minnesota Press, 2008, pp.16–17.
5. Ho, T.N. "Afterimages—Strands of Modern Art in Singapore", MA diss., National University of Singapore, 2007.
6. Chua, K. "The Tiger and the Theodolite: George Coleman's Dream of Extinction". Forum on Contemporary Art and Society (FOCAS) 6, 2007, p.143.
7. Kuo, P.K. "The Silly Little Girl and the Funny Old Tree", in Images at the Margins: A Collection of Kuo Pao Kun's Plays, Singapore and Kuala Lumpur, Times Books International, 2000.
8. Rae, P. "Tree Duet" in Ritschel, U. and Gerverus, I.-M. eds. Performing Life—Performed Lives: Aesthetics and Anthropology, Berlin and London, LIT Verlag, 2009.
9. Rae, P. "Why There is Wind: Power, Trees, Performance" in Christie, J., Gough, R. and Watt D. eds. A Performance Cosmology: Testimony from the Future, Evidence of the Past, London and New York, Routledge, 2006.
10. "Cheong Soo Pieng—A Dream of Tropical Life." 4x4 Episodes of Singapore Art. Scripted and directed by Ho Tzu Nyen, Free Flow for Arts Central, 20 September 2005.
11. Chua, K. "Painting the Nanyang's Public: Notes towards a Reassessment" in Clark, J., Peleggi, M. and Sabapathy T.K. eds. Eye of the Beholder. Reception Audience and Practice of Modern Asian Art, Sydney, Wild Peony Press, 2006, p.84.
12. Sabapathy, T.K. (1982). "Scroll met easel". Straits Times Annual, 1982, pp.114–127.
13. Brook, P. The Shifting Point, New York, Harper and Row, 1987. Cited in Mitter, S. Systems of Rehearsal: Stanislavsky, Brecht, Grotowski, and Brook, London, Routledge, 1992.
14. Email correspondence with Chua, K., 2007.
15. Yao, S. "All Quiet on Jurong Road, Nanyang University and Radical Vision in Singapore" in Barr, M. and Trocki, C. eds. Paths Not Taken Political Pluralism in Postwar Singapore, Singapore, National University of Singapore Press, 2008.
16. Reid, A. "A Saucer Model of Southeast Asian Identity". Southeast Asian Journal of Social Science 27(1), 1999, p.11.
17. Tang, X. Origins of the Chinese Avant Garde: The Modern Woodcut Movement. Berkeley, University of California Press, 2008, p.128.

Notes

[i] The history of the left-leaning politics of Singapore's populations in the mid-20th century is contested. Leftist members of migrant Chinese communities and students in Chinese schools have been painted by post-independence histories as communist affiliates if not card-carrying members of the Malayan Communist Party. Others argue that the collective-oriented culture of the Chinese in Singapore in the mid-20th century had more to do with the values of the earlier May 4th Movement—a movement to modernise China and throw off the shackles of tradition, emerging from disillusion with the 1911 revolution and Chinese territory loss after World War I—than later affiliations with communism. See for example Yao, S. "All Quiet on Jurong Road, Nanyang University and Radical Vision in Singapore" in Barr, M. and Trocki, C. eds. Paths Not Taken Political Pluralism in Postwar Singapore, Singapore, National University of Singapore Press, 2008

[ii] In a presentation for my students in 2008, oral historian, archivist and former Singapore History Museum curator Koh Nguang How connected this print and others to a movement amongst the Chinese left in the 1950s and 1960s called the "anti-yellow culture movement", which aimed to rid Singapore of Westernisation, materialism, vice and corruption. In an interview for this article, Tan Tee Chie was somewhat vague about what it is that is being persuaded in this exchange, as indeed he was with regard to much of the iconography of this woodblock. Although modern woodblock artists are known for their didactic or political prints, a number of Tan's works stage intriguing urban exchanges whose dark undertones are accompanied by ambivalent titles, such as for example Transaction (1953) and Cigarette Seller/Transaction (1958), in which the dynamics of the communication are not immediately clear. Tan Tee Chie, interview with author, translated by Daniel Lim, Singapore, 29 May 2010.

[iii] As the few surviving sources that discuss modern woodblock art are written in Chinese, I have relied heavily upon the writings in English of Lim Cheng Tju, an MA dissertation by Joyce Fan and discussions with oral historian, archivist and former Singapore History Museum curator Koh Nguang How for the sections on woodblock art in this essay. See for example: Lim C.T., "Fragments of the Past": Political Prints of Post-war Singapore". The Heritage Journal 2(1), 2005, pp. 22–47; Foo, K.W. et al, Imprints of the Past - Remembering the 1966 Woodcut Exhibition: Commemorative Catalogue, Singapore, National Library Board, 2006; and Fan, J. "Social Commentary in Prints During the 1950s and Early 1960s", MA diss., Pratt Institute, 2000.

[iv] The conflation of Singapore with Malaya is due to the fact that prior to Singapore's independence in 1965, nationalist energies in the island had long been focused on a merger with Malaya. In 1963 Singapore was indeed merged with the Federation of Malaya to create Malaysia, together with the newly decolonised eastern states of Sabah and Sarawak. However, Chinese-majority Singapore was expelled from Malay-majority Malaysia two years later in a climate of political, economic and ethnic distrust.

[v] Frangipanis, and especially the white-flowered Plumeria Singapore Obtusa (originating not from Singapore but Latin America), are popularly associated with death in Southeast Asia by both the Malay and Chinese communities. To the former, the scent of frangipani (kemboja in Malay) at night is said to mean that a female vampire (pontianak) is in the vicinity. Although things have changed and there is a current vogue for frangipani-fringed Balinese gardens, in colonial Singapore such trees were only planted alongside European buildings (such as, for example, the Raffles Hotel) and/or around Chinese cemeteries.

[vi] Tan Tee Chie states that he intended it to look like there were pretentious modern buildings going up in the background—a reference to the dangers of urban materialism. Tan Tee Chie, interview with author.

[vii] Tree Duet was first performed in August 2007 at the Siam Society, Bangkok (Live Art Bangkok festival) and thereafter in: September 2007 at the Substation, Singapore (Septfest); April 2008 at the Central School of Speech and Drama, London, UK (Theatre Materials/Material Theatres Conference); August 2008 at the Drama Centre Black Box, Singapore

(Singapore Theatre Festival 2008); 1 March 2009 at the University Cultural Centre Theatre (National University of Singapore Arts Festival 2009); and16-22 August 2009 at New Town Theatre (Mysterious), Edinburgh, Scotland (Singapore Showcase, Edinburgh Festival Fringe), as part of the fringe of the Edinburgh International Festival in 2010.

[viii] As different versions of the performance incorporated different material, I am referring to three versions of Tree Duet in these notes: two unpublished playscripts from 2008 and 2009, and a published version, Rae, P. "Tree Duet" in Ritschel, U. and Gerverus, I.-M. eds. Performing Life—Performed Lives: Aesthetics and Anthropology, Berlin and London, LIT Verlag, 2009.

[ix] See note 7.

[x] "He had developed a way of getting latex out of the tree without killing it [Kaylene 'scores' line across Paul's stomach with laser pointer], and he travelled all around Malaya trying to encourage planters to switch to rubber. He was initially unsuccessful, but then the bottom fell out of the coffee market because Brazil started undercutting them on price, and they started planting rubber. This was somewhat ironic, because the 22 seeds Ridley had originally started experimenting with had come from Brazil." Rae, P. and Tan, K. Tree Duet, unpublished playscript, 2008, p.3. See otherwise Purseglove, J.W. (Director of Singapore Botanical Gardens). The Ridley Centenary, 10 December 1955, Tribute to H.N. Ridley on the occasion of his 100th birthday, Singapore, Government Printing Office, 1955, p.10.

[xi] The book was Images at the Margins: A Collection of Kuo Pao Kun's Plays, Singapore and Kuala Lumpur, Times Books International, 2000. Kuo Pao Kun (1939–2002), alongside being Singapore's most locally and internationally respected playwright, was "one of the most important figures in Singapore arts and civil society". He was the founder of Practice Performing Arts School (1965), The Theatre Practice (1986), The Substation (1990) and the Theatre Training & Research Programme at Practice Performing Arts School (2000). As Rae states in Tree Duet, Kuo was detained without trial in the 1970s under the Internal Security Act for alleged subversive activities. He produced his major body of theatrical works after his release in 1980. He was known for his poetic utopian allegories, his humanist outlook and also for the bringing together of all four official Singapore languages on stage. The Substation. About Us/History/Founder – Kuo Pao Kun. 2007. Available at: http://www.substation.org/about_us/kuo_pao_kun.html (Accessed: 8 June 2010).

[xii] "I was amazed to discover that the Hongkong and Shanghai Banking Corporation had sponsored the tree on the $5 note. I thought: 'that's amazing—a bank sponsoring the image on a bank note!' It was only after looking at the note more carefully that I realised HSBC has sponsored the original tree that is depicted on the note." Rae and Tan, Tree Duet, 2008, p.7.

[xiii] "The Heritage Trees Scheme serves to identify, recognise and conserve majestic individual trees in our landscape. Only trees endorsed by the Heritage Trees Panel would be accepted as Heritage Trees. The criteria for endorsement of a Heritage tree include a girth size of 5 m, rarity of species, aesthetic, historical significance, cultural reason, social and educational value". National Parks Singapore. Nominate A Heritage Tree. 2009. Available at: http://www.nparks.gov.sg/cms/index.php?option=com_chronocontact&chronoformname=nominate_heritage_tree (Accessed: 8 June 2010).

[xiv] The "tree dance" refers to dances with trees in Kuo Pao Kun's The Little Girl and the Funny Old Tree, in Images at the Margins: A Collection of Kuo Pao Kun's Plays, pp.98–116.

[xv] See note 13.

[xvi] Possibly Tan and Rae felt that the bonsai—while evoking clichés about a well-pruned Singapore society—would have somewhat less of a stage presence and be more hardy than the 2.5-m tall brassia which perished after the earlier Duets performance.

[xvii] Rae tells me that the construction of the stage, with a central wooden area and a wooden plankway stage right, was inspired by Noh theatre. Noh theatre conventionally has three pines along the side of this plankway (replaced by wind machine, harpsichord and piano), and there is a tree image on the back wall of the stage, which in the case of Tree Duet was where a shadow of the bonsai was projected at the end of the performance. Rae, P. Email and conversation with author, 4 June 2010.

[xviii] The repetition of Tan's lines, Rae informs me, is a reference to an opening question in Noh theatre. Tan's character—which subtly transforms from a sweeper of a temple floor to a kind of tree spirit or oracle—also has resonances in Noh conventions where a lowly intercessor welcomes the traveler and then reveals his/her powers later in the performance. Rae, P. Email and conversation with author, 4 June 2010.

[xix] In When Species Meet, Haraway distinguishes an always-in-process, co-producing "companion species" from the historically situated "companion animal". Haraway's "becoming with" is moreover to be distinguished from Deleuze and Guattari's "becoming-animal" as it is an everyday, individuated matter of species "making each other up in the flesh", "full of the patterns of their sometimes-joined sometimes-separate heritages". Haraway, D.J. When Species Meet, Minneapolis, University of Minnesota Press, 2008, pp. 16–17 and 25.

[xx] Lui Kang was born in China but as a child came to Muar, in what is now peninsular Malaysia. He returned to Shanghai to attend art school and then went to Paris for six formative years, after which he taught at schools in Shanghai and Singapore.

[xxi] Senior art historian T.K. Sabapathy has done the most rigorous work on the varied influences and connections of modern Singapore artists. See for example Sabapathy, T.K. "Tradition and Modernity: The Nanyang Artists" in Long, R.A. and Kirchhofer, D. eds. Change and Continuity in Southeast Asia: the Papers of the Distinguished Scholars Series, University of Hawaii, 1982, Honolulu, Southeast Asian Studies, Center for Asia & Pacific Studies, University of Hawaii at Manoa, pp.59–67.

[xxii] Le Mayeur was in turn inspired by Paul Gauguin's paintings of Tahiti. Kwok, K.C. "Images of the South Seas—Bali as a Visual Source in Singapore Art" in From Ritual to Romance—Paintings Inspired by Bali, Singapore, Singapore Art Museum, 1994, p.40.

[xxiii] A fifth important "pioneer" artist and female colleague of the group, Georgette Chen, was not invited to join this trip.

[xxiv] There were a series permutations of this style. Some of the defining tendencies involved a combination of: the simplified forms and flat planes of colour of post-Impressionist painters, a concern with the line quality of Chinese brush painting, the incorporation of horizontal and vertical formats of Chinese scrolls, and an inventive use of the white lines left by the wax in the process of making Indo-Malayan batik. This combination of black outline with a white outline that is slightly separated from the colour plane and the form, gives an animated imediacy to the most persuasive examples of this technique.

[xxv] The Equator Art Society was founded in 1956 by Lim Yew Kuan, whose father Lim Hak Tai founded the first art school in Singapore, the Nanyang Academy of Fine Arts. Lim Yew Kuan was also a woodblock artist. The Equator Art Society was a left-oriented and May 4th movement-inspired anti-colonial group of artists who specialised in social realist art works and solidarity with the underclasses of Malaya. See Lim C.T., p.14 and Lim Yew Kuan, interview by author, June 2008.

[xxvi] Koh Nguang How, in a guest lecture in February 2008 at the School of Art, Design and Media at Nanyang Technological University, pitted the Equator Art Society artists against the pro-status quo Nanyang Painters. For a critique of the gendered and orientalist aspects of Liu Kang's work, see Ho, T.N. "Afterimages—Strands of Modern Art in Singapore", MA diss., National University of Singapore, 2007. Ironically such exotic imagery had already been rejected in Indonesia itself in the 1930s in nationalist artist S. Sujojono's famous diatribe against Mooie Indie (beautiful Indies art)—22 years before the Nanyang Painters journeyed to Bali. See Holt, C. Art in Indonesia, Continuities and Changes. Ithaca, Cornell University, 1967, pp.195–196.

[xxvii] Cai, B. "Interview with Singapore's Pioneer Artist Liu Kang". Nanyang Arts Magazine 3, 2001, p.11. Cited in Ho, p.226.

[xxviii] Rain trees (samanea saman) were introduced to Singapore from South America in the second half of the 19th century, and are one of Singapore's most common and well-regarded urban trees. Called "rain trees" because their leaves close up at night and during rainfall, they grow relatively quickly and are home to a fecund variety of ferns and orchids. A familiar task for schoolchildren is to count the different kinds of epiphytes hosted by any one tree. Rain trees also have prolific, wide-reaching branches and are often planted along the side of streets, where they form an overhead canopy.

[xxix] "By 1883, more than 90 per cent of this forest had been cleared for agriculture and half the cleared area abandoned to lalang". Cantley, N. Report on the Forests of the Straits Settlements. Singapore, Singapore Printing Office, 1884. Cited in Corlett, R.T. "Plant Succession on Degraded Land in Singapore". Journal of Tropical Forest Science 4(2), 1991, pp.151–152.

[xxx] The banyan (strangling fig) is an epiphyte which slowly takes over the host tree (or indeed building), and forms a magnificent network of roots which become tree trunks. The banyan is one of the most powerful metaphysical arboreal presences in modern Southeast Asia, and Taoist, Hindu and Buddhist shrines and offerings are often found at the base of the same tree. In Malay lore the infrastructure of the banyan houses beings from other dimensions.

[xxxi] Kevin Chua ends his essay on the man-eating tiger as liminal spectre, marking the edges of colonial capital incursions into the Malayan interior by "want[ing] to think" of surveyor George Coleman, the key protagonist in one of the main works he analyses, "dreaming not only of the spectral tiger but also of his own extinction". Chua, K. "The Tiger and the Theodolite: George Coleman's Dream of Extinction". Forum on Contemporary Art and Society (FOCAS) 6, 2007, p.143.

[xxxii] Paul Rae states that in Hanyu Pinyin, Confucius' term for the gentleman ruler is junzi. Rae, P. Email with author, June 2009.

[xxxiii] Rae raises a possibility of how "[t]his exploration of an image where the age/fate of tree and man/men are intertwined recalls your initial discussion of [the patriarchal figure and the tree in Tan Tee Chie's] Persuading". Rae, P. Email with author, June 2010.

[xxxiv] "Afterimages" involves a method of art historical inquiry through a "migration" of recurring "motifs" which then critique and unravel each other. Ho, p.13. I am doing something similar in this essay by grafting spell#7's Tree Duet in and through readings of trees in modern Malayan art by Ho and others.

[xxxv] The film was inspired by the following article: Chua, K. "Painting the Nanyang's Public: Notes towards a Reassessment" in Clark, J., Peleggi, M. and Sabapathy T.K. eds. Eye of the Beholder. Reception Audience and Practice of Modern Asian Art, Sydney, Wild Peony Press, 2006.

[xxxvi] See for example Sabapathy, T.K. "Cheong Soo Pieng's Style". The Straits Times, 6 March 1981 and Sabapathy, T.K. "Earlier efforts recycled". The Straits Times, 18 November 1980.

[xxxvii] I am grateful for conversations with my colleague art historian Ying Chua on this point. See also Vinograd Richard. "Situation and Response in Traditional Chinese Scholar Painting: The Journal of Aesthetics and Art Criticism". Journal of Aesthetics and Art Criticism 46 (3), 1988, pp.356–357.

[xxxviii] When thinking about tree complexity and length, it is perhaps interesting to note that a recent human measure of trees posits that the DNA strand for trees is 60 to 100 times longer than our own. Oi, M. "Tree DNA to Fight Illegal Logging". 20 August 2009. Available at: http://news.bbc.co.uk/2/hi/business/8209645.stm. (Accessed: 9 June 2010).

[xxxix] Cheong Soo Pieng also worked with woodblock and for a recent retrospective at the National University of Singapore Museum, Encountering Cheong Soo Pieng (5 March–31 July 2010), one of his rhythmic woodcut prints, Fruit Seller (1954), was reproduced on the publicity flyer.

[xl] I do not talk about Tree in a Room in a room in depth in this essay. Paul Rae has done so very poignantly elsewhere. See Rae, P. "Why there is Wind: Power, Trees, Performance", p.210 But briefly, Zai's performance also concerned a layering of a series of experiences: there was a reference to conversations that Zai and Kuo Pao Kun had shared around another tree—a banyan (Ficus benjamin) that Zai had brought to the rehearsal room of a theatre school that Kuo founded. That the Tree in a Room had a presence too big for the space in which it was exhibited was a reference to another of Kuo's plays, The Coffin is too Big for the Hole. And the sewn-together pieces resonated with another work, Descendants of the Eunuch Admiral, in which the legendary story of eunuch voyager Zheng He is cast as allegory of corporate Singapore. A scene in the latter play recounts the obligation of family of a eunuch to reunite them with their amputated penises in death. Kuo, P.K. Descendants of the Eunuch Admiral, Singapore, SNP Editions, 2003, p.42 and Kuo, P.K. The Coffin is too Big for the Hole and other plays, Singapore, Times Books International, 1990.

[xli] Gill mentions that the specific matching of these texts with trees and plants in Forest was quite random. She found the books in a box that was being thrown out at the National University of Singapore. Gill, S. Phone conversation with author, June 2010.

[xlii] Fort Canning Hill was the site of the colonial Governor's residence, then called Government Hill. Prior to the British take-over of Singapore, the hill was known as Bukit Larangan or "forbidden hill". It still houses a Malay muslin keramat—gravestone, said to be the resting place of the last Malay king of the island. Gravestones of early colonial settlers also make up a wall that runs up the hill. Gill tells me that the strangling figs were "in battle" intertwined around the trunk of a third host tree, which she was told by a park administrator was Burmese teak. Gill, S. Phone conversation with author.

[xliii] Donors included clan associations, businessmen, trishaw drivers and dance hall hostesses. Kee, P. and Choi, K.K. A Pictorial History of Nantah, Singapore, Chinese Heritage Centre, 2000.

[xliv] See note 1.

[xlv] I am grateful to Paul Rae for assisting my thinking through relations between the woodblock and labour in this section.

[xlvi] Tan Tee Chie and Lim Yew Kuan speak of the Singapore woodblock artists hungrily reading textbooks on modern woodblock mailed to them from Shanghai, and teaching themselves the techniques from these books. Lim Yew Kuan also names Lu Xun as major influence. Lim Yew Kuan, interview with author and Tan Tee Chie, interview with author.

[xlvii] Paul Rae informs me that one of the intended resonances of this medicalised process was with Zai Kuning's Tree in A Room. See note 41.

[xlviii] Thanks to Yu-Mei Balasingamchow, Ben Slater, Paul Rae and Lee Weng Choy for generously reading and commenting upon versions of this essay, to T.K. Sabapathy, Isrizal, Alfian Bin Sa'at, Shawn Lum, N Sivasothi and Ying Chua for conversations and readings which fed this analysis, and to Daniel Lim for translation assistance.

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BEUYS' ACORNS

Beuys' Acorns *was exhibited in London at the* Royal Academy of Arts GSK Contemporary Earth: Art of a changing world, *December 2009/January 2010. Ackroyd & Harvey conducted a series of public 'in-conversations' with invited guests every Friday evening throughout the run of the exhibition.*
Text by Ackroyd and Harvey

Beuys' Acorns (2007-) is a project in its infancy, started three years ago in late autumn when we took a train to the German city of Kassel to gather fallen acorns from Joseph Beuys's seminal artwork *7000 Oaks*. Regarded as one of the most influential artists of the 20th century, Beuys advocated radical social change through the transformative power of art and as a passionate advocate of environmental bio-diversity, one of his projects, perhaps the grandest in scope, is *7000 Oaks* which is regarded as epitomizing Beuys' ideas about art and its ability to effect social change.

The first tree was planted by Beuys in 1982 for the inauguration of *Documenta 7*, the last by Beuys's son in 1987, the year after his father's death.

On returning to our studio in Surrey we potted up over 700 acorns. To date we have around 300 surviving saplings, perhaps not a great rate of return, but we had not really taken into account just how opportunistic the grey squirrels would be. Perhaps our sense of protecting these tender trees is heightened by this slightly bruising confrontation with nature's predatory instinct, by a loss (or gain, depending on who's counting) that is more keenly felt as a result of our growing awareness of Beuys's relevance at the beginning of the twenty-first century.

> The capital of the world is not the money as we understand it, but the capital is the human ability for creativity, freedom and self-determination in all their working places. Beuys (1)

Beuys, an artist and a teacher, through his multi-faceted practice, brokered new relations between art, performance, teaching, ecology, economics, politics and philosophy. In the 1970s he was also a founding member of the fledgling *German Green Party*, (though he quickly got out of politics when he realized how toxic it was!), and was writing and talking about recycling of materials in the '70s in a way that it seems the UK has only recently cottoned on to. He refused to draw a line between art and life. To our minds his most inspiring work is *7,000 Oaks*, a time-based sculpture for which Beuys initiated the planting of 7,000 trees, each marked by a basalt column, a monumental artwork living and breathing with generations of people as they pass through life. This is how we interpret the 4D aspect of working with the oaks which are very slow growing trees. Beuys' *7000 Oaks* is still a relatively young work given it takes 60-80 years for an oak to reach maturity, his trees are only around 40 years old. If they survive climate change they may grow to be 300 hundred years and more. At the heart of his vision was a transformation of consciousness, where the biosphere, as a healthy, biological and essential atmosphere would be consistent with human, species and plant needs.

Heather Ackroyd and Dan Harvey
Beuy's Acorns, Acorn's collected from Joseph Beuys' artwork *7000 Oaks*, 2007 – onwards © the artists

We see Beuys' legacy as very significant in a time of unprecedented ecological, economic and environmental degradation. Nearly twenty five years after his death the world picture is deeply troubling. Bio-diversity is being lost at an overwhelming rate and seventy percent of biologists believe that we are in the early stages of a mass global extinction caused by habitat degradation, over-exploitation, agricultural monocultures, human-borne invasive species and human-induced climate change. As carbon emissions increase, vast areas of primal forest – the lungs of the planet – are razed to make way for mechanised plantations.

In its formative stages our own incipient project *Beuys' Acorns* is dedicated to growing the saplings in parallel with ongoing research into the cultural, biological and climatic significance of trees.

Every Friday evening at the Royal Academy we conducted a series of public 'in-conversations' with invited guests to share thoughts and insights into why trees matter more than ever.

Dr. Roland Ennos of the Department of Life Sciences, University of Manchester spoke of his work discerning that what is known as the 'urban heat island effect' – higher temperatures in urban areas – can be significantly reduced by a ten percent increase in green space and trees in cities and towns. As water evaporates from the leaves of trees it cools the surrounding air reducing the air temperature by up to four degrees Celsius. More trees would help mitigate the predicted rise in the Earth's temperature over the next 75 years caused by global warming. (2) This is compelling research in light of the acknowledged loss of too many veteran trees from our urban landscapes.

The idea that city planning could include planting many more trees reflects Beuys' vision of towns and cities becoming 'forest-like'. He saw *7,000 Oaks* as a catalyst for change, a symbolic start of the transformation of society, of the whole ecological system. Beuys' aesthetics could be regarded as remaining as sensitive to the living tissue that covers and nourishes the earth as to the skin that covers our own flesh.

Dr. Ennos says that the impact of trees in the urban space has been neglected in pursuit of rural studies. As a way of providing data evidence he has instigated the i-trees project in Manchester

Heather Ackroyd and Dan Harvey
Beuys' Acorns, One of the 300 trees grown from Joseph Beuys' artwork *7000 Oaks*, 2007 – onwards © the artists

to demonstrate the contribution green cover makes to climate change resilience and adaptation. Through the creation of a living laboratory in Manchester, evidence could lead the way to legislation and funding to encourage mass tree-planting programmes in the urban space.

In January we invited Polly Higgins, international environmental lawyer and founder of Trees Have Rights Too (3) to speak about her appeal to the United Nations to implement a Universal Declaration of Planetary Rights, a proposal that draws a parallel between the current planetary emergency and the humanitarian crisis in the wake of the Second World War, in response to which the 1948 Universal Declaration of Human Rights was implemented. Polly describes the seismic shift that is needed in our attitude towards the planet as akin to the revolution brought about by Copernicus when he demonstrated that the earth moves around the sun. The gathering call is to change our perspective from a human-centred mechanistic one to a more holistic, ecological world view.

Genocide was a word introduced by Rachael Lemkin to describe the atrocities of the holocaust in World War 2. This year, 2010, marks the International Year of Biodiversity and a word had been needed to describe the extensive destruction, damage or loss of ecosystems of a given territory, whether by human agency or other causes. Polly describes this word as *ecocide.*

The word 'ecocide' already exists, yet there has been no formal legal definition of it. She says, "We want to get this word out into the public consciousness so that we can call for the restoration of ecocide territories and protection of those territories at risk of ecocide. Ecocide is not as yet recognisable in law. To do so would open the door to the creation of international legal governance of territories at risk or subjected to ecocide, and create laws to prevent those who, as a result of their commercial activities, are damaging and destroying vast tracts of the planet."

Polly points out how in 2008 history was made when the people of Ecuador voted by an overwhelming majority for a new constitution that recognizes legally enforceable nature rights, the first in the world to do so.

She has dedicated much time recently to writing an account of *ecocide* in her new book, published September 2010, "Eradicating Ecocide: laws and governance to prevent the destruction of our planet."

Law is one necessary way forward. Another is creativity. Beuys regarded love as the most creative and transformative force and as an expression of this he promoted the simple and powerful act of planting trees. To this we would add the need to protect the existing trees that we have.

Many trees in the urban space in the UK are removed because of property owners citing subsidence damage by tree roots, yet only 1% of claims out of the 40% of cases submitted are justified and between 2003 and 2008 London Boroughs have felled over 40,000 trees. (4) Trees are perceived as a threat. Yet, as David Ball, professor of risk management at Middlesex University, put it to an audience of silviculturalists, given that temperatures above 21C increase the risk of death, 'if you wanted to be a mass murderer you could chop down a lot of trees'. (5)

Trees are too often dispensable when faced with an architectural venture that needs land or a vertical vista of glazing and steel unspoilt by branch and tree. To counteract this trend Jim Smith of the Forestry Commission has set up the Trees and Design Action Group (6), spearheading moves to increase awareness of the need to bridge the practicality gap that exists between the aspirations to include trees within the built environment and the practical requirements needed to achieve this. Jim spoke with us alongside architect Steven Johnson of The Architecture Ensemble, a design office dedicated to the positive environmental and aesthetic construction qualities of wood in creating timber buildings and sustainable local commerce. Together, they spoke of the crucial need to give value to our trees and woodland.

Michael Pawlyn, founder of Exploration-Architecture observes nature very closely. He sees and recognises extraordinary adaptations and physical characteristics of creatures and plants that inspire his practice of designing buildings. His description of the attributes of the Namibian fog-basking beetle in harvesting water from its shell quite simply captivated us, and his work on the Sahara Forest Project inspired us through the combination of Concentrated Solar Power and distilled seawater capture in potentially reversing desertification and establishing reforestation.

Beuys declared a need for radical action, to go another way, to push against the system. Radically. Mark Lynas argues in the concluding chapter of *Six Degrees: Our future on a hotter planet*, that the dire situation we find ourselves faced with in a rapidly warming world, calls not for fatalism, but for *radicalism*.

Heather Ackroyd and Dan Harvey
Beuys' Acorns, installation view, *GSK Contemporary, Earth: Art of a Changing World*, Burlington House, London, curated by the *Royal Academy of the Arts* and *Cape Farewell* © the artists

> ***Radical*** *late ME A. Adj. Of or pertaining to a root or roots. Forming the root, basis of foundation; going to the root or origin; thorough; esp. r. change, cure 1651. (Shorter Oxford English Dictionary.)*

Our question is how deep do our roots with trees go?

When in-conversation with writer Jay Griffiths we discussed a book we had recently read by Robert Pogue Harrison, *Forests: The Shadow of Civilization*. In his beautifully observed book Harrison describes how since the dawn of Western civilization, 'a sylvan fringe of darkness' defined the limits of its cultivation, and he explores how the governing institutions of the West originally established themselves in opposition to the forests, from the beginning, the first and last victims of civic expansion. Significantly, he shows how from the time of Cro-Magnon through the end of the last ice age and into the Neolithic period – the human race was the child of the great Mother goddess and he regards her violent overthrow by the male sky gods during the bronze age as probably the most momentous cultural revolution in our human past to date. The earliest written tablets commemorate the exploits of the first civic hero, Gilgamesh, who memorialized his name from the earliest dawn of history through the act of slaying a forest demon and cutting down vast swathes of trees on the sacred Mount of Cedar.

It is a sorry fact of history that human beings have never ceased re-enacting the gesture of Gilgamesh. The destructive impulse with respect to nature all too often has psychological causes that go beyond the greed for material resources or the need to domesticate an environment. There is too often a deliberate rage and vengefulness at work in the assault on nature and its species, as if one would project onto the natural world the intolerable anxieties of finitude which hold humanity hostage to death. There is a kind of childish furore that needs to create victims without in order to exorcise the pathos of victimage within. The epic of Gilgamesh tells a story of such furore; but while Gilgamesh ends up as the ultimate victim of his own despair, the logs meanwhile float down the river like bodies of the dead. (7)

Jay Griffiths, author of *Wild: An Elemental Journey* spoke of how trees are good to think with, how everywhere in the world, people have

Heather Ackroyd and Dan Harvey
Beuys' Acorns, installation view, *CUBE Manchester, Environment 2.0*, curated by *Futureverything* © the artists

associated tree and thought, idea and forest.

We give the last word here to Griffiths, for she captures the spirit of tree that is poetic, haunting and revealing.

"In one of the most fascinating anthropological accounts I've ever read, Gerardo Reichel-Dolmatoff wrote breathtaking studies of the thoughtways of the Amazonian people of Colombia. It takes five pages for him even to begin to describe the associations of just one tree for the Tukano people, to show how the "bow wood tree" or jacaranda represents maleness, dominance, aggression and procreative energy. It also suggests a "package" and "thunder", "pollination" and the "semen spurt" of a man's ejaculation. So many concepts are held in one tree, says Reichel-Dolmatoff, that it suggests "dimensions of mind hardly suspected." The Amazon forest itself, according to a Desana elder, "is a wide expanse, similar to a perceptive human head.

"The Tree of Knowledge is well known: trees have long been associated with knowledge; the Buddha meditated under a tree, and sought wisdom from it. In the early years of Buddhism it was thought that certain spirits of the trees lived in tree trunks and spoke from there. Druids, too, the ancient shamans or priests of the British Isles, heard the voice of the oaks.

"For indigenous people everywhere, nature is an enlargement of your mind, and your sense of kin, your social mind. The Malo people of northern Bangladesh used to have a custom of marrying a girl to a tree and a boy to the river, before their marriage to each other. For the Karen in the forests of northern Thailand, the umbilical cord of a baby would be tied to a tree; the spirit of the child dwelt there, and to harm the tree would be to harm the child; the ritual thus intricately linked person to tree.

"Forests can also offer political lessons. Indian poet Rabindranath Tagore identified democratic pluralism and an ecological culture as the distinctiveness of Indian civilization. "From the forests, we learnt democracy," says Vandana

Shiva: "that every species has its place." Black Elk of the Lakota people saw trees as having rights equal to people, referring to them as the "standing peoples, in whom the winged ones built their lodges."

"In the Amazon, the wisest men and women are called vegetalistas; plant experts steeped in forest knowledge. But there's more – people don't just learn about plants, they learn from certain plants called "plant teachers" or doctores which teach people medicine. These plants are sacred, honoured and stolen, patented by pharmaceutical companies.

"Forest lore and shamanic knowledge is an entire way of knowing, as beautiful and profound as any in the West. A curandero is a qualified doctor, a shaman is a professor, a grove a university library. The Amazon has its artists, musicians and poets, its John Clares, and its Mozarts, its Platos, Debussys and Ovids. Everywhere a depth of art and curing, music, metaphor and mind. The Amazon is a forest of knowing. But the fundamentalist sects, together with the corporations and States, are deforesting the human mind".

"When I spent time with the Aguaruna people in the Amazon, they told me how, some fifteen years before my journey, missionaries had persuaded them to kill their shamans, their wisest men, their doctors and philosophers".

"The Dominant Culture, the Euro-American culture, has long operated an intellectual apartheid, arrogantly certain that its own expertise is the only knowledge worth the name. That its spirituality is the only one. In the days of empire, that single way of knowing invaded the wild world and as it did so it claimed that it was an age of "discovery" and an expansion of the "known" world, the false claims of European history that knowledge increased in that era. It did not. The truth was the opposite. For, destroying forests and human cultures through missionaries and all other kinds of imperialism, there was in fact a net reduction in the world's knowledge. In the Amazon, the assault against nature is an assault against culture, hundreds of tribal cultures.

"So kill pity. Crack down on kindness. Pour mercury over metaphor. Burn their books, hack down their languages and axe their philosophies. Tip Agent Orange into the eyes of a forest Picasso. Tie a Shakespeare's hands behind his back – with razorwire. Break the ankles of a Sufi dancer, stamp on Fonteyn's feet. Crack Mozart's head against a wall until the music whimpers and fails him. Daub graffiti over an El Greco. Bulldoze the sculptures of Rodin. Burn the entire Oxford English Dictionary. Slash every copy of the Mahabharata. Napalm the Berlin Philharmonic.

"That is how the sacred cultures of the Amazon are being destroyed.

.....

"We speak of the roots of a word, too, its earliest source, the roots of meaning going down into the past; and the roots of these words for oak, (dharaich, daragh, derwen, deru) go right back down into darkness, into that dreamtime language known as Indo-European; the root language from which Indian and European languages branch out. In Indo-European, there is a word base, 'deru', meaning 'oak' and 'tree' as well as 'firm and steadfast'. The English word 'tree' is related also to this word 'deru'. So indeed is the word 'druid' for whom oaks were magical, and a source of wisdom".

"Trees speak, and oak trees in particular speak to those who listen. In myth and tradition, people have thought that oaks had stories and messages. Groves of trees have long been sacred to diviners and seers. Celtic and Norse cultures revered the oaks".

"A woodland is a way of knowing, a medicine cabinet and a library, a store of metaphor and a guide to life. So if people are forced off their land, they lose far more than the physical place, whether that is the Clearances of Scotland or the land thefts in the Amazon. To lose your land is to lose your language, and to lose your language is to lose your culture and maybe even your mind".

"The Common Man (or the Common Woman, me, you) heard the songlines of the forest sung in green, and carrying a long knowledge. The 'Tree of Knowledge' is a widespread idea, and for many cultures, trees are sacred, the Tree of Life. The Common Man, across the world, seems to have seen wisdom in trees".

"The Qur'an refers to a parable which says that a good word is like a good tree, whose root is firm, and whose branches are in heaven. It is as if there is something minded about a tree.

"As if, in the midst of all the uncertainty of the forest, the shape-shifting and the impish Robins and Pucks and Jacks, as if, finally, the Common Man finds in a tree an embodiment of certainty, something firm, steadfast – something, in a word, true".

"And the word 'true' is actually related to the word 'tree'; the root of both of them are in

Joseph Beuys
7000 Oaks, Kassell, 1982-86, photograph by Ackroyd and Harvey, 2007 © the artists

that base-word 'deru' of Indo-European, which suggests that something is true when it is steadfast as a tree. Deru is a concentrated poem. Like an acorn, containing an entire tree within it. It is a seed for the world mind".

"So Deru gave rise to the related words tree and true. But there's more. Deru also gave rise to these words: trust, tryst, troth, betroth, truce, trow and durable and endure. I spent an ecstatic day, a few months ago, looking at all these connecting words, wanting to write a sentence for the Common Man which connected all these words and which summed up, like an acorn, the connecting meaning".

"The words for tree in many languages is the same, from Persian to Welsh. In Scottish Gaelic, the oak is dharaich, and the word is very, very interesting. In Manx, the word for oak is daragh; very similar. In Old Irish it is darach. In Welsh it is derwen. In Greek it is deru. The words are all related, with that characteristic 'd…r..' sound. They all come from the same root".

"And the Common Man waited quietly by the oak and whispered to its leaves: "I have a tryst with a tree, which I trust to tell me the truths of the enduring betrothal between woods and words."

"You cannot argue with a tree. The instinct to trust a tree is the same as the instinct to trust a language. Both trees and language are well-rooted. In trees, the human mind comes home to truth, a dwelling for the mind. And in this kind of dwelling, finally, the Common Man saw that the Green Man could be discerned. And he gasped as he realized that the woodlands were not, after all, a veil behind which the Green Man hid, but something else entirely. Not a curtain but rather a strange, deep mirror, reflecting his green self. And the Common Man – who is also you, and me, and him and her – the Common Man felt the transformation. His own toes were moving down into the earth like roots, his own head reaching tall to ask questions of the sky, and his own arms outstretched like branches to the winds. The Green Man is everywhere in the woods, and everywhere within. He dwells where he always has, right inside the sweet psyche of the human being. The wild reverie of the woods is within us". (8)

References

1. Joseph Beuys in America, *Energy Plan For The Western Man*. Writings by and interviews with the artist.

2. Research is part of the Adaptation Strategies for Climate Change in the Urban Environment (ASCCUE) project, School of Environment and Development, Manchester University.

3. http://www.treeshaverightstoo.com/

4. 'Chainsaw Massacre', London Assembly Environment Committee report on London's street trees 2007.

5. The Observer Sunday 12th October 08, 'Chainsaw Massacre' by Lucy Siegle, from research http://jech.bmj.com/cgi/content/abstract/56/5/367

6. http://www.forestry.gov.uk/forestry/INFD-7KDEHU

7. "Forests: The Shadow of Civilization" by Robert Pogue Harrison

8. Extracts from a presentation Jay Griffiths gave to the Sacred Arts Festival in India, 2009.

Ackroyd and Harvey have been recipients of numerous awards including two RSA Art For Architecture awards, Wellcome Sci-Art, NESTA Pioneering Award and the L'Oreal Art & Science of Colour Grand Prize. Selected solo/group exhibitions include Mostra SESC Des Artes, Sao Paulo, Brazil (2008); Bios 4, Andalusian Centre for Contemporary Art (2008); Japan's Miraikan Museum (2008); FlyTower, National Theatre London (2007), Big Chill UK(2007), Liverpool Art Biennale (2006), Natural History Museum, London (2006), World Expo, Aichi, Japan (2005), Sculpture Quadrennial, Riga (2004), Musee de' L'Elysee, Lausanne (2004), Dilston Grove, London (2003), Chicago Public Art Program (2003), Isabella Stewart Gardner Museum, Boston (2001), Beaconsfield, London (2000), V&A Museum, London (2000).

FUTUREFARMERS

Futurefarmers is a group of artists and designers working together since 1995. Our design studio serves as a platform to support art projects, artist in residency programs and research interests. They are teachers, researchers, designers, gardeners, scientists, engineers, illustrators, people who know how to sew, cooks and bus drivers with a common interest in creating work that challenges current social, political and economic systems.
Interview questions by Renny Pritikin

Renny Pritkin: When did Futurefarmers start?

Amy Franceschini: "Officially" *Futurefarmers* started in 1995 as a design studio, artist in residency program and umbrella name for art projects created by a range of practitioners. But I think it started much earlier in fact. My relation to agriculture stems from my parents' opposition to farming practices. My father was an industrial farmer in the San Joaquin Valley and owned a pesticide company and my mother was an organic farmer and activist near San Luis Obispo. Although their ideologies were seriously opposed, my parents' involvement in growing food was politicized in their own way; my father heavily involved in water politics and labor issues and my mother fighting local strawberry farmers to stop using Malathion. Through canvassing and attending public hearings I was introduced to food politics in action. The conflicting logics of my parents approach to farming practice forged my interest in using farming or food as a lens to look at the many systems connected to it; environmental justice, distribution, water rights, land use etc.

Is it organic?

In terms of organic…

Futurefarmers has grown and changed in a very "organic" way since 1995. The artist in residency program is a big part of who *Futurefarmers* is and has become. Since 1995 we have hosted over 23 artists from 14 countries who have become the basis of a distributed network of collaborators. Depending on the projects we are working on, we assemble in different configurations.

The name implies that at some time in the future you will be a farmer, like communism evolving toward the withered central government. I don't think so though. You kind of have been a farmer already with the Victory gardens...

Franceschini: Yes, initially, the hope was to move to a farm and operate from a working farm. Since that dream has not come true yet, *Victory Gardens*, a culmination of many years of projects and research, became a way to look at the city of San Francisco as the farm. In 2006, we began to focus our energy on how to make our immediate surrounding more like a farm.

Victory Gardens 2007+ was presented to the city of San Francisco as a utopian proposal that was created in the form of an exhibition at the San Francisco Museum of Modern Art in 2007. This proposal was a call to

Amy Franceschini - Futurfarmers
Victory Gardens 2007+, Victory Gardens Bikers Barrow, mixed media project, 2007 © the artists

the city for action–ALL OUT FOOD PRODUCTION!! It grew out of the legacy of the Victory Garden programs from the First and the Second World were growing food in their backyards, vacant lots, parks and schools which produced over 47% of the total food in the United States. While during these times people were hungry and mobilized by a very strong national campaign to join gardening as an extension of the war effort, the positive outcome was a coming together of people and a connection to the land that is inherent in growing your own food. Between 2006-2009, *Victory Gardens 2007+* planted eighteen backyard gardens and a garden in front of San Francisco's city hall. As part of the *2007+* program, a suite of sculptural and printed propaganda was distributed as a means to invite people to participate in the program.

The name "Victory Gardens" was appropriated as a means to re-invent the term "victory" as self-reliance and a "victory" in terms of becoming independent from the industrial food system. The question is how to sustain the interest and cultivate programs that generate participation without dogma or patriotic propaganda. I don't think urban agriculture alone

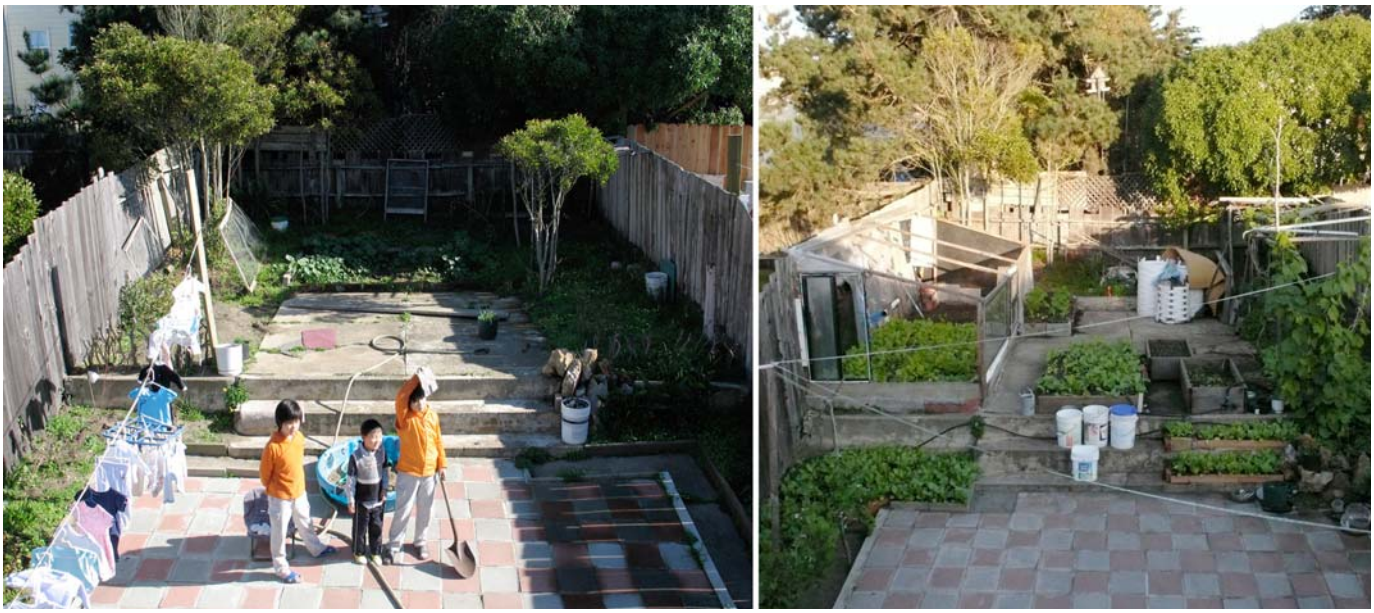
Amy Franceschini - Futurfarmers
Victory Gardens 2007+, Garden Posters, mixed media project, 2007 © the artists

will change our "food economy", but it plays a big part in moving towards a more decentralized food system and local economy.

My sweet little cactus in my urban balcony is leaning toward the light almost dangerously. Is this dance?

Or it can be seen as worship or a struggle for life. We once did a project called *Photosynthesis Robot* that was a sketch of a possible perpetual motion machine driven by phototropism- the movement of plants towards the direction of the sun. The sculpture suggested that the motion of the plant reaching towards the sun would slowly propel the four-wheeled vehicle forward over a period of time.

The most beautiful outcome of the piece was that each time we would show the piece in a gallery, the install crew would contact us to ask



Amy Franceschini - Futurfarmers
Victory Gardens 2007+, Back Gardens, mixed media project, 2007 © the artists

how far the sculpture would move during the run of the exhibition. They would ask how far it should be from the wall and how far it would move each day. While the sculpture was purely a "non-functional", the combination materials put forth a quandary of fact and fiction. By using "live" material, people seem to project a sort of animism into the piece.

I've been told by a scientist that returning land to indigenous plants is wrongheaded because the fauna adapt very quickly to the new, invasive species, and by suddenly changing the habitat we're actually killing off the bugs and birds?

This is very interesting in terms of notions of "sustainability". Your example brings to mind a recent preservation project here in San Francisco in the Presidio. This area was formally a military base and has now been transitioned into a National Park. It is the first national park to exist within city limits. Due to this fact many new definitions of "park" are being determined. One quandary was about the landscape the park should aim to preserve in terms of visible flora and shape. Since the military took over the land in the late 1800's the area has been planted with several non-native plants, but if you pull these plants out now (100 years later) you will also loose the a huge population of urban butterflies, bees and birds that have adapted to these introduced species.

In 2008, I did a project called Nearest Nature in Umea, Sweden. The project consisted of a series of workshops, a public action and an installation at Bildmuseet. In collaboration with local botanists, Academy of Fine Arts students and the general public a body of work was created to respond to the Linnaean system of taxonomy, knowledge of local flora and its inference on the effects of globalization on the local environment. Using Carl Linnaeus, the father of taxonomy, and his stay in Umeå in 1732 as a starting point, workshoppers were given tools and costume to perform research in the field. We worked with a local botanist to recognize and name flora according the workshoppers lay knowledge. Their invented naming system served as a new botanic folksonomy – much like tagging on flickr. With botanist and curator, Stefan Ericsson, of Umeå University herbarium, we studied a plot of local flora. The plot was sectioned off and each group identified the diversity of plant life within their section. A log of all flora was kept and each participant chose one plant to name, classify and describe using their own invented taxonomy. Later Stefan helped participants identify the plants, learn their Latin and dialect names and how they were organized according to Linnaean taxonomy. Through these actions a tense debate emerged regarding the classification of "native", "non-native", and "introduced" species. While some wanted to remain open to the invitation of new species, other's had very strong opinions about the a point in history when a landscape is "native".

Amy Franceschini and Michael Swine – Futurfarmers
Photosynthesis, mixed media project, 2003 © the artists

preservation of the "native landscape". These examples ask us to consider a frame that defines In determining the criteria for this frame, issues of adaptation, cultural identity and biopolitics surface reminding us of the logic that dominates the perception and understanding of these conditions. When we desire to reverse the social and cultural trajectory of land management, we also remove species that have adapted to these environments. In fact the cultivated and manicured spaces of city parks might be just as "wild" as a re-introduction of "native" species to these sites.

Renny Pritikin has held three positions in arts organizations in Northern California over the past thirty years. For more than a decade he was director of New Langton Arts in San Francisco, an alternative space that specialized in new and experimental work in visual art, performance, new music, and literature. Following that, again for more than a decade, he was chief curator at Yerba Buena Center for the Arts, San Francisco. At the current time he is director and curator of the Nelson Gallery and Fine Art Collection at the University of California, Davis.

Amy Franceschini was born to a farming family and grew up amid the fields and orchards of California's San Joaquin Valley. In 1992 she received a BFA from San Francisco State University where she studied photography and sculpture. In 1995, she co-founded Atlas (www.atlasmagazine.com), an online magazine. Atlas was selected as the first website to be included in the permanent collection of the San Francisco Museum of Modern Art. The site has won two Webby awards (the equivalent of an online Oscar) for Art and Design, and has been internationally recognized for its unorthodox approach to online publishing. In 1995, Amy also started *Futurefarmers*, *Futurefarmers* hosts an artist in residence program and develops new media projects for many corporate clients.

Michael Swaine is an inventor and designer working in many media. He is the analog anchor of the studio. Michael has collaborated with Futurefarmers since 1997. Michael is dedicated to working in the community, Swaine's "Reap What You Sew" Generosity Project involved him pushing an old fashioned ice cream style cart on wheels with a treadle-operated sewing machine on it through the streets of San Francisco. Currently, Michael is teaching at California College of the Arts.

ASPARAGUS: A HORTICULTURAL BALLET

Pil and Galia Kollectiv *are London based artists, writers and curators working in collaboration. Their work addresses the legacy of modernism, exploring the promises and ruins of the avant-garde discourses of the twentieth century. It deals with the way these failed utopias operate in the context of a changing landscape of creative work and instrumentalised leisure.* Pil and Galia Kollectiv *are interested in the relationship between art and politics, and the role irony and belief play in its current articulation. They often use choreographed movement and ritual as both an aesthetic and a thematic dimension, juxtaposing consumerism and religious ceremonies to find the underlying rites and convictions of a secular, post-ideological society. Reading Dada, Constructivism, and the Bauhaus backwards through punk and new wave, they find new uses for futures past.*

Text by Pil and Galia Kollectiv *– Interview Questions by* Rikke Hansen

Pil and Galia Kollectiv
Asparagus: A Horticultural Ballet, 35 mins, photography: Chris Davis, courtesy of the Showroom Gallery © the artists

Being knowledgeable about music sure isn't what it used to be, now that any kid can run a *Google* search, download on Soulseek and buy on eBay faster than you can say broadband. The elders of punk, who were there in the early days and pogoed all ten of them at the first Sex Pistols concert, those who lost their right arm at Woodstock only to find it ten hours later when the acid wore off - who needs them? It's only a matter of time before a giant iPod descends from the heavens and buries both them and their filthy record collections.

We've come to expect such an immediate conversion of reality to information that it's almost a shock to come up against fragments that don't add up to neatly classifiable discographies on allmusic.com. Nevertheless, every once in a while the primordial cyber ooze conjures up a name that frustrates any attempt to tie it down to any concrete information. In this case, barely a name, just three letters that you are more likely to find on a site devoted to sex with animals or some kind of equally perverse computer programming language than to succeed in relating it back to the band it describes: xex. But even though most of the story of xex seems to have been swallowed up by the black hole that will gradually eat up anything that doesn't find its way into internet code, it is well worth trying to reconstruct it from what little traces of it have survived the digital revolution.

As a result of the disturbing time warp commonly known as the eighties revival, xex's music sounds more contemporary now than it probably ever did when the band was in existence. Certain aspects of it never really went away, and you can sort of recognise them on all kinds of dark/gothic/electro/minimal/synth compilations from the eighties onwards. However, it doesn't quite sound right next to your bog standard post-human, post-apocalyptic theme tunes of despair that usually fill these compilations. Something about the joie de vivre expressed in the face of the impending soviet invasion, or the glee with which the band suggests novel ways of torturing a poor cat, somehow doesn't sit right with the deathly seriousness of their peers.

So where did xex come from? Whatever happened to delete their memory from the collective consciousness that has managed to dig up just about every other forgotten new wave relic in the name of retro? What fate could have brought together two stern looking men, two rather comical moustaches and a lady named Thumbalina to record this strange, Devo-lutionary music in 1980? We originally heard the band on Choking on Cufflinks, Michael Goodstein's legendary radio show on *WFMU*. In fact, we would not have discovered the *Group: Xex* album if not for Tom Smith finding it in the station's archive. Having fallen in love with the band's DiY record, obtained after much searching on eBay, we had been trying to reconstruct the mysterious history of Xex, when we were contacted by Mike Appelstein of WFMU, who informed us that he had managed to track down and interview Waw Pierogi, mustachioed founding member of the band.

Miraculously, the story he had to tell was not so far off from the one we imagined, only slightly more suburban, the story of college kids raiding the soundlab and fooling around with early electronics. But it was one detail that really caught our attention: while trying to develop the concept for the ultimate nightclub, the curious story of a vegetal ballet emerged. *Asparagus: A Horticultural Ballet*, Pierogi's experimental audio-visual extravaganza, incorporated "a musical composition structurally based on the growth and branching patterns of the asparagus plant, with the compositional structure exposition synchronously with the projection of an animated or time-lapse film of the process of a representative plant's growth, and introducing arrays of rotating hanging baskets of asparagus ferns (to dispel the reception of the piece as serious art with a lowbrow kitsch reference to the rotating disco mirror balls and fern bars of the 1970s) and pirouetting ballet dancers in green headpieces shaped like asparagus spears, reaching the coda: attendants serving platters of freshly cooked asparagus, their movement through the performance space causing its aroma to spread to the multi-sentient performance attendees (who are not limited to being 'spectators' or 'the audience.')".

It soon became clear to us that the asparagus ballet needed to be staged. We had long been interested in the aesthetics of modernism, and when we came across Oskar Schlemmer's Triadic Ballet, it seemed to us to point the way forward for our own asparagus obsession. At the height of modernism, Schlemmer sought to use dance to create a theater of abstraction, exploring the themes of man in space, light in motion and architecture. Like Waw Pierogi's student work, no documentation of Schlemmer's ballet has survived other than a handful of still images, although several attempts at reconstruction have been made. We did not wish to recreate either, but we were intrigued by the possibilities opened up by marrying the ideas left behind by yesterday's art movements, our own interpretations and recombinations hopefully

Pil and Galia Kollectiv
Asparagus: A Horticultural Ballet, 35 mins, photography: Chris Davis, courtesy of the Showroom Gallery © the artists

investing them with meanings they never knew they had. In the absence of an original choreography for the project, then, and with no experience of dance whatsoever, we decided we needed to impose an arbitrary structure on it that would dictate the movements. Karl Marx's 'Das Kapital' seemed both obvious and ideal, being itself the story of abstraction, with human relationships transposed by those between commodities and ultimately lose all meaning in the joyless grind of endless accumulation while producing the transcendent mythical figure of capital. Consequently, our ballet narrates the rise of capital in the medium of asparagus. Reading Marx, dada and the Bauhaus backwards, through punk and new wave, we wanted to rescue the humour and critical vitality that have been subsumed by the canonisation and commodification of modernism.

Having collaborated with Les Georges Leningrad on our last film project, we came to discuss the potential for developing the Asparagus Ballet in collaboration with them. Their own music they have often challenged the hierarchies of the historical canon, juxtaposing abstract jazz and modern classical music with contemporary pop and electronics and their unique pertrochemical rock seemed like the perfect complement to our vision of dancing greens. An amazingly dedicated group of art students was recruited to perform the rigid movements in the constricting felt costumes we had constructed. Jacques Rancière writes in *The Politics of Aesthetics:* "Cauliflowers remain cauliflowers, juxtaposed to high rhetoric. They carry no message. They are supposed to enhance political energy out of their very opaqueness...The Brechtian identity of allegory and debunking of allegory supposes that you can play on the connection and the disconnection between art and cauliflowers, politics and cauliflowers. Such a play supposes that vegetables themselves have a double existence: one in which they bear no relationship with art and politics and another where they already bear a strong relationship with both of them.

As a matter of fact, the relationship of politics, art and vegetables existed before Brecht, not only in impressionist still life, reviving the Dutch tradition, but also in literature. One novel by Zola, *Le Ventre de Paris*, had notably put them as both political and artistic symbols. The novel was based on the polarity of two characters. On the one hand there is the poor old revolutionary who comes back from deportation in the new Paris of the Halles where he is overthrown and smashed by the flood of cabbages, meaning the flood of consumption. On the other hand there is the impressionist painter, singing the epics of the cabbages, the epic of Modernity, the glass and iron architecture of the Halles and the piles of vegetables that allegorized modern beauty in contrast to the old pathetic beauty symbolized by the gothic church nearby. The political allegory of the cauliflowers was possible because the connection of art, politics and vegetables, the connection of art, politics and consumption already existed as set of moving borders, enabling artists to both cross the border and make sense of the connection of the heterogeneous elements and play on the sensory power of their heterogeneity". In the end, the music and choreography that has emerged from working on the project have very little to do with xex, Schlemmer, Marx or any of the other references we piled onto the project as it grew to ridiculous proportions in reality and in our heads. But hopefully, it invokes a utopian meeting point where they can co-exist and where timeless knowledge can be replaced by a more dynamic retro-gardism which ransacks the past for future activation.

Pill and Galia in conversation with Rikke Hansen

Rikke Hansen: Firstly, could you tell us something about how you came to collaborate as artists and what your main interests are within your practice in more general terms, besides your piece Asparagus: A Horticultural Ballet?

Pill and Galia: We met in highschool in Jerusalem, so we've "never not collaborated". We find it hard to imagine an individual practice outside of collaboration. We also collaborate with others a lot, whether performers or musicians. A very important part of *Asparagus: A Horticultural Ballet* was our collaboration with Les Georges Leningrad. We are generally interested in the relationship between art and politics, particularly in relation to the legacy of modernism and the avant garde. Our work also deals with the role of creativity in contemporary articulations of work. Notions of irony and belief are also important to us, and there is a strong element of ritual in a lot of what we do. We are trying to figure out the underlying religious rites and convictions of a secular, post-ideological consumer society.

Asparagus *seems different from your other art works. Yet, the piece makes several*

Pil and Galia Kollectiv
Asparagus: A Horticultural Ballet, 35 mins, photography: Chris Davis, courtesy of the Showroom Gallery © the artists

aesthetic references to early Modernist performance art, which is a theme you revisit throughout your practice. But what do the asparagus, as a nonhuman life-form, represent to you?

Asparagus was one of our first attempts at performance art, using live performers as opposed to working with collage animation. A lot of what we have been doing since has evolved from that piece, especially the anti-expressive theatricality that we have adopted from Bauhaus theatre, and the combination of minimal Constructivist stage sets with absurdist dada and Futurist costumes. The actual vegetables were almost incidental within this juxtaposition. We had seen the title *Asparagus: A Horticultural Ballet* in an interview with a former member of an obscure minimal synth band called xex, and we thought it was very funny, but we knew we didn't want to do a straightforward re-enactment of his piece (which we had little information about). The idea of having the movements of the green spears represent scenes from Karl Marx's Das Kapital was initially a joke, but we decided to take the joke seriously and found that it worked quite well as a metaphor. Marx's book deals with the abstraction of human relationships into exchanges of money and commodities, so using a non-human life form made a lot of sense.

We think about plants as being both the oldest things on earth but at the same time easily subject to decay and withering. Generally, in your work, you filter the past through the present by "reading Dada, Constructivism, and the Bauhaus backwards through punk and new wave". Are you using the metaphor of the plant to explore something around these issues?

The plant was not a metaphor in the piece. We see it more as an arbitrary signifier that gains meaning only in retrospect, so that having decided on the title and costumes, we found images of asparagus gods and rhizomatic rhythms to fit the concept. We did not consider decay, but we did briefly toy with the idea of a class struggle with the white asparagus beloved of the Germans.

The piece is described as a ballet, not as a performance as such. What do you think the difference is? And how does it make the piece different from your more *directly performance-based or performative works?*

The title was given, so we did not designate it a ballet very deliberately. However, we do think our work sits uncomfortably between theatre and performance categories, as it has until recently been silent and more sound and movement than text based, at the same time as being a lot more formal in its setting and preparation than much performance art. Although we work with amateurs, we rehearse the work extensively, and we quite like having a seated audience in an auditorium rather than a casual display in a gallery. Also, we did not perform in the piece ourselves, so in many ways our role was closer to choreographers than performance artists. We've variously referred to our performances as mimes, ballets, sermons and performances whilst looking for a vocabulary to describe what we do, which is choose cringey media and try to find ways to both thwart and embrace the discomfort and awkwardness of the live experience.

Could you say something more about the role of irony and humour in Asparagus? Does your use of such notions also relate to a theatrical panto tradition?

We have always espoused seriousness rather than irony, but we have come to be interested in irony through people's responses to our work. We are beginning to think there might be different kinds of irony, and while we reject the kind of irony that produces what Kierkegaard calls an aristocratic discourse, speaking over the heads of those who do not 'get it', we are quite interested in what Zizek calls 'overidentification', which he defines as 'taking the system more seriously than it takes itself seriously'. In *Asparagus*, this manifested as a serious commitment to a very stupid idea. We don't know enough about panto to make claims about a relationship to that tradition, but in a way the carnivalesque tradition is also the most horrifying form of serious political oppression: Bakhtin thought of this concept in relation to the theatricality of the Stalinist show trials.

Your interest in producing a vegetable ballet originally came from an undocumented event orchestrated by Waw Pierogi. In the original event actual asparagus were supposedly served to the audience by the performers. Yet, you chose to re-enact the work in a more traditional stage performance version.

Pil and Galia Kollectiv
Asparagus: A Horticultural Ballet, 35 mins, photography: Chris Davis, courtesy of the Showroom Gallery © the artists

Why is that?

We suspect that kind of multi-sensory, interdisciplinary art was a lot more radical back then, but now that performance art in galleries has itself become a tradition, with historical happenings canonised and re-enacted routinely, actually going back to a very formal, institutional context seemed more relevant. At a time when institutions are weak and underfunded, doing something quite grand and yet also very DIY and amateurish attracted us, especially on the occasion of our first 'major' solo show: the asparagus costumes would be much funnier presented with such pomp, and yet the stage also allowed for the humour subsiding and a more sustained event unfolding. It was a combination of self-parody and an authentic yearning for the lost power of the institution. The stage is still a site of real power and in inevitably in theatre a political relationship is created. Instead of avoiding it altogether we wanted to conflate this power with another kind of politics: networks of information, half truths, rumours. We think of the actual site of the stage as only the temporary carrier of the surviving documentation, an un-contextualised jpg on a random site which we hoped someone would later find, as we had found the original reference to the ballet.

You cite Jacques Ranciere's discussion of Bertolt Brecht's epic play Der aufhaltsame Aufstieg des Arturo Ui*, in which the protagonist rules over and controls an illegal cauliflower business by eliminating all opposition. For Brecht, this was an allegory of a wider political problem, namely the rise of authoritarian totalitarianism. However, leaving that aside, do you perceive your own reference to asparagus to be allegorical of human life? Or is the production and consumption of vegetable goods itself a political issue that's relevant to your piece?*

We don't think the asparagus are an allegory, but it did stand in for many things in Marx's text. We cited Ranciere's discussion of Brecht because we thought he identified quite well the way in which a random vegetable could stand for lots of specific things, and yet be completely arbitrary. We were reassured to see that someone like Ranciere, interested in the politics of the spectacle and of aesthetics in general, could also see the relevance of such a methodology.

As you've mentioned, the ballet partly takes its score from Marx's Das Kapital*, with individual acts dedicated to "commodity", "labour" and "capital". How is this reflected in the actual performance?*

The physical movements in the ballet are literally translations of sentences from *Das Kapital* into choreography. The section about commodity exchange was represented by performers swapping places and mimicking each other as commodities turn into equivalences, and finally the mediation of a third character, money. Labour was expressed as the subordination of individual bodies to a co-ordinated machine that transfigures and constrains their movements. And finally capital, a very mystic being according to Marx, was a still figure, worshipped by the surrounding vegetables. We included the relevant sentences in the program and were surprised at how many viewers claimed to follow the text, even spotting mistakes in the performers' actions.

Marx notoriously compared the life of commodities to a dance in which non-human objects appear to have independent power. In recent decades, writers such as Bill Brown and Bruno Latour have described how humans and nonhumans, such as animals, plants, technologies, and "things", exist in complex social networks in which they continually act upon, shape and produce each other. Plants are clearly conditioned beings which respond to their immediate environment. But do you think that this mean that plants "perform" in some sort of way?

We think Capitalism is a very good illustration of a phenomenological system in which non-human objects, and even non-material abstractions, serve as agents which operate and influence the human sphere. Marx himself was very persuasive in claiming that a category of 'human rights', which are inherent and unique to humans, is a very poor basis for a politics of equality. But we wouldn't go as far as attributing agency to non-humans until we know more about the origin of volition in humans. Perhaps the term 'delegating' agency that Latour uses is more adequate. Plants might perform various functions, but whether they are able to choose not to perform them (and whether humans actually make such choices or are programmed to act as they do by DNA, etc.)

is the question we must answer before making any claims about their comparability to humans.

The costumes in* Asparagus *are impressive but also quite constricting. Or, as the writer Ian Hunt notes, your performance piece makes one wonder whether asparagus would know what to do with arms. So there appears to be a clash between the human and the non-human body in your piece. What comes out in this clash of different bodily abilities and affordances?

We decided quite early on that there would be strict limitations to the performers' movements, partly to address our hatred of expressive stage work and partly to adequately represent asparagus. We wanted them to produce movement in relation to one another, rather than individually, more like an animated computer ballet generated by algorithms, or a Busby Berkley style mass spectacle, than a virtuosic performance of balletic skill. We hoped this would in turn abolish the alienation produced by viewing incredible feats beyond the capacity of the audience, like a punk gig. The spectacle is a product of collective action in concert, not the abilities of particular bodies. Despite this equal starting point, failure is inevitable. Our amateur performers, no matter how restricting we were in our direction or how much we rehearsed, could not help but show signs of idiosyncrasies. They all did the same things but interpreted the actions in a totally different way. The piece was as much about this dynamic as an exploration of performative, post-Fordist labour than of the industrial, assembly line work on which Marx focused.

Rikke Hansen is a writer and an art critic, living and working in London, and a regular contributor to the UK-based journal Art Monthly. She mainly writes on issues pertaining to performance, video and installation art. She's also hosted a weekly radio programme, titled Nature Calls: Animals in Visual Culture on Resonance 104.4 FM, London's arts radio station and teaches cultural studies at Metropolitan University in London.

Most recently, **Pil and Galia Kollectiv** have produced a performance for the Herzliya Biennial and participated in *Late at Tate* Britain. In 2008 they were artists in residence at S1 Artspace. Sheffield. They also presented No Haus Like Bau at Hau 1, a post-fordist neo-constructivist mime, as part of the fifth Berlin Biennial. Their solo exhibition at the Showroom Gallery in 2007, Asparagus: A Horticultural Ballet, involved the recreation of an obscure, mythical art production by a new wave band from the 1970s and comprised a live performance and a video, incorporating dance and appropriating the bio-mechanics of early modernist ballet. Other exhibitions include *Apocatopia*, Castlefield Gallery, Manchester and *Roll it to Me*, Collective Gallery, Edinburgh and the curatorial projects *The Instititue of Psychoplasmics, Modern Lovers, DaDaDa: Strategies Against Marketecture and Turn to the Left,* a fashion show of artists' costumes. They work as lecturers in Fine Art at the University of Kent and Goldsmiths College, and are the London editors of *Art Papers* magazine.

FAMILIAR CONTACT: PLANTS IN MEXICA (AZTEC) STONE SCULPTURE

Renee McGarry provides an exploration of a small subset of Mexica stone sculpture that used materials and technique to naturalistically represent plants. Many scholars have focused on the entrenched symbolic function of these sculptures and have produced no satisfactory explanation. McGarry eschews questions of symbolic value and discusses the relevance of the represented plants in Mexica everyday life.

Text by **Renee McGarry**

The Aztecs dominated the Basin of Mexico from approximately 1325 until the arrival of Spanish conquistador Hernán Cortés in 1521. Despite their short rule, the Mexicas created a large tribute empire that extended over a large portion of present-day Mexico—and they not only ruled the people in these lands. They also extended their rule over the natural world of these regions. Rulers demanded tributes of plants, animals, and minerals from the far-reaches of the empire and used these long-distance, exotic goods to create a hegemony focused on nature. The best-known example of this practice was Motecuhzoma II's zoo, where he maintained a vast menagerie of animals from throughout Mesoamerica.[1] Domination over nature was the very core the Mexica worldview, and this continued insistence on the subservience of peoples, plants, and animals allowed them to serve as one of the most powerful, if short-lived, empires in the Americas. The relationship of the Mexicas to plants and animals did not end at those that existed in the living world—they also represented plants, animals, and their relationships to them in stone sculpture, architectural ornament, ceramics and manuscripts. In this paper, I explore three of these representations, a cactus, a pumpkin and a gourd as representations of the everyday, plants with which the Mexicas regularly interacted. Far from exotic, these plants dominated the Mexica worldview through both their use as food, as capital, as tribute, and as mythohistory.

Existing Literature

Scholarly literature has largely treated intermediate-sized plant (and animal) sculptures as religious and ritual in nature. This treatment has been based a very limited context in which these objects have been discovered. After the Spanish invaded and destroyed the Mexica capital of Tenochtitlan in 1521, they threw stone sculptures and ceramics in the canals as part of an effort both to deface the objects and to fill in the canals and build a new city. The Spanish crown then built Mexico City over the Mexica capital, both systematically and chaotically burying and repurposing pagan objects. In fact, Mexican archaeologists did not discover the site of the main Mexica temple (*Templo Mayor*) until 1978, when utility workers uncovered a surprising find. A number of plant (and animal) sculptures have been discovered in the *Templo Mayor* district, as well as archaeological evidence of

sacrificed remains of plants and animals.

Unfortunately, scholars have become obsessed with the ritual-religious context and have focused on a single, unanswerable question: what do these objects mean? Art historian Esther Pasztory began this line of inquiry in her 1984 book, *Aztec Art*, where she states, "They used animals as metaphors to illustrate special abilities, and not every animal that had symbolic significance for them was represented in stone sculpture."[2] She continues to search for meaning in these objects, looking for both how they were used and what purpose they served, throughout this very brief section. In another popular and widely read book, *Aztecs: An Interpretation*, historian Inga Clendinnen initially establishes her resistance to this line of inquiry, citing Pasztory, but eventually surrenders, agreeing that these objects "probably were" ritual "display" objects.[3] Clendinnen attempts to focus on what she terms the "aesthetic" experience of these objects (she also integrates other art forms such as poetry and literature), yet her consideration of the aesthetic qualities is romanticized and still neatly positions the objects within a ritual context.[4] She remains firmly in Pasztory's box.

Catalogs for both 2002 Aztec exhibitions in New York City and London echo this sentiment, with essays by historian Mercedes de la Garza and archaeologist Alfredo López Austin.[5] These essays create even more of a mystique around plant (and animal) imagery. Of course, there is mystery around these objects—it is probable that scholars will never know the meaning and purpose of each of them. But approaching the objects with a laser-beam focus on the "meaning" of each sculpture puts scholarly literature in an unending loop. In order to better understand Mexica plant sculpture, we must abandon the questions of meaning and context—at least temporarily. We can use this reframing to determine what these objects represent and what relationship their formal characteristics bear to both their natural world counterparts and Mexica perceptions of nature vis-à-vis their mythohistory. I am far more interested in what plant sculptures tell us about the natural world and Mexica relationships to it than I am in what they tell us about Mexica cosmology.

The Natural World in Mexica Mythohistory

In order to understand the Mexica relationship to the Basin of Mexico, it is important to note that they did not always live there. Rather, like many Mesoamerican peoples, the Mexicas were a product of an origin myth that took them from their homeland in the north, called Atzlan, through over 80 years of travel through Central Mexico until they founded their capital city, Tenochtitlan, in the middle of Lake Texcoco. This explains the deep and intense knowledge of the world around them, for after leaving the Seven Caves in Atzlan, the Mexicas moved throughout Mexico. Yet they were not a nomadic people. There is instead a consistent presence of agriculture on this journey, a hallmark of Mesoamerican civilization, and the Mexicas use this opportunity to best get to know they land that will eventually become their empire.[6]

The Mexicas used this mythohistorical manipulation to reinforce their role as masters of the natural world. In one episode in the migration myth, they approach a local king and ask for a place in his territory to settle. The chieftans, elders, and the king settle on a place called Tizaapan, or "In Chalky Water," a region largely undesirable to natives. In his 1581 re-telling of this mythohistory, Dominican friar Diego Durán writes:

> On seeing the great number of reptiles and little poisonous creatures that were there, at first [the Mexicas] were horrified and afraid but later they became accustomed to these dreadful beasts, capturing them in order to eat them. The people, from that time on, ate no other meat except these reptiles, vipers, and lizards found on that hill. They became so fond of them as food that they consumed most of the snakes there, until it became difficult to find even one.[7]

Clearly, this episode illustrates a mastery over even the most difficult to tame locations, which eventually became integral to the Mexicas self-perception and the power they were able to garner in Central Mexico.[8]

The foundation of the Mexica empire is also based on natural world phenomenon, but counters the idea of the Mexica's complete control of the world around them. Again during their migration, the Mexica patron god, Huitzilopochtli was incarnated on a local hill and told a priest where the Mexicas would come to found their city, and the Mexicas began searching for this omen:

> the water rushed out in two streams,

Anonymous
Catcus with image of Tenoch on its base, 1325-1520 © the National Institute of Anthropology and History (INAH - Mexico)

> one red like blood, the other so blue and thick that it filled the people with awe. Having seen these mysterious things the Aztecs continued to seek the omen of the eagle. Wandering from one place to another, they soon discovered the prickly pear cactus. On it stood the eagle with his wings stretched out toward the rays of the sun, basking in their warmth and freshness of the morning. In his talons he held a bird with very fine feathers, precious and shining. When the people saw the eagle they humbled themselves, making reverences almost as if the bird were a divine thing. The eagle, seeing them, bowed his head in their direction.[9]

Here the Mexica migration journey came to an end, controlled by divine intervention in the natural world. The Mexicas could not control where their capital city was founded—if they could, they may not have chosen a location in the middle of a lake that would require a great number of modifications to become a workable urban center.

After the foundation of their great capital, the Mexicas went to great lengths to orient the city based on the locations of mountains, bodies of water, and stars and modified the world around them to make the city livable. They built a series of causeways over the lake that allowed for movement in the city. They dammed Lake Texcoc to stop periodic flooding of the region and build up a system of *chinampas* (called "floating farms" by the Spanish)[10] and provided food for the region. The Mexicas built aqueducts to provide clean drinking water and allow for large-scale irrigation of agricultural project. They built mountainside terraces that extended the altitudes at which they could farm. These manipulations, both small and large, provide evidence that the Mexicas went to great lengths to know and use their environment.

Cactus (*Nopalli)*

The cactus clearly played a pivotal and active role in the foundation of the Mexica empire. Scholars, myself included, have often focused on the importance of the eagle-as-sun metaphor in the Mexica foundation emblem while paying very little attention to the vital role of the cactus. Yet, Mexica mythohistory indicates that the siting is just as integral to the location of the capital as was the presence of the eagle; in fact, Tenochtitlan does not translate to "the place where the eagle sat" but to "the place of the Mexica among the stone cactuses." Specifically, the Mexicas were searching for a most unlikely occurrence: a prickly pear cactus growing out of a rock. Scholarly analysis readily explains away this anomaly as an act of the gods, a part of what Mexican scholar Alfredo López Austin refers to as the belief that "divinity and creation shared the same substance."[11] In his estimation, like many other indigenous peoples, the Mexicas approached all flora and fauna as other animate beings with which they interacted in a divine world.

In his brief essay about the natural world for the *Aztecs* catalog, López Austin implies that the Mexicas approach both plants and animals[12] with what philosopher Donna Haraway refers to as "the intersecting gaze."[13] In other words, when the Mexicas looked at plants, their worldview would not allow them to deny that plants looked back. But, López Austin refuses the notion of the true intersecting gaze. Rather, using his assessment, both the Mexicas and modern-day viewers can only engage with Mexica plants and animals without true reciprocity—like Derrida in "The Animal That Therefore I Am (More To Follow), López Austin is not "curious" about what the plants are doing when they look back.[14] For López Austin, (representations of) plants and animals are only mythological and religious. In the case of animal representations, this flexibility of the notion of divine and real is much easier. Animals are frequently the alter ego (*nahualli*) of a god or man, and gods are frequently depicted as their animal counterparts. But representations of plants force scholars to consider the notion of the everyday. There are few religious affiliations of the cactus. Outside of its role as imperial marker, it is just a plant in the desert.

Like other Mexica representations of plants, the somewhat smaller-than-life-size basalt cactus sculpture is carved with such realism that scholars have been able to identify its species, determining that it is the *cereus marginatus,* or Mexican pipe organ. These grow in the rocky desert throughout Mexico and can become up to twelve feet tall. It is commonly know that these are used to create fences in small villages in modern-day Mexico, and therefore it has been speculated by scholars Felipe Solís Olguín and Roberto Velasco Alonso that these sculptures were used to mark the boundary between the Mexica capital of Tenochtitlan and its sister city, Tlatelolco.[15] While little archaeological evidence exists to bolster this argument, it is certainly a viable non-ritual function for the sculptures.

In his hypothesis, Solís Olguin recognizes the mythological and imperial importance of the cactus, but—like López Austin—does not allow for an intersecting gaze. The cactus is nothing more than imperial ambition or mythological representation in visible and hidden space.[16] Yet *The Florentine Codex* Book 11 illustrates that the indigenous desert dwellers understood the cactus beyond these functions, and they engaged with the plants on an everyday level. The eighth paragraph of the sixth chapter (which concerns trees) of the manuscript is dedicated in its entirety to native descriptions of *nopalli,* which is the collective name of the *nopal*. The indigenous description is detailed and does not include any reference to its imperial or mythological role:[17]

> the branches are wide, thick, green, thorny, smooth like a smooth reed. It has an excretion; it has tunas, fruit, tubes. It is string; it becomes like nerves. It forms a branch, it forms branches, it produces leaves…The name of the fruit of this *nopal* is tuna. It is round, with a top like a splindle whorl, the top filled out, round, slender-based. It is prickly, full of thorns.[18]

This text is only a small portion of a five-page discussion of cacti in *The Florentine Codex*. Native informants describe ways in which they cook and eat *nopalli,* what each variety of cactus looked like and where it grew, the size of it, how one sort of fruit differed from another. The detailed descriptions of the purging effects of one variety of cactus, the *cimatl*, can be understood as a description of how to reach a hallucinogenic state.

Supplemental illustrations in *The Florentine Codex* further demonstrate a deep and intense knowledge of cacti. While these are schematic and not nearly as realistic as the stone sculpture, one image depicts a Mexica man interacting with the *nopal* itself, picking its tuna, presumably

Anonymous
Flowering Trees, Florentine Codex, Book 11, Earthly Things, 1540-1585 © University of Utah

to bring home as food. Despite the vivid oral-to-written descriptions of these plants, the illustrations do not bring them to life. Yet, there is an element of the intersecting gaze, particularly when the manuscript illustrations are wed to the descriptions and then paired with the stone cactus; they describe a desert plant that had an impact on their digestion, on their agriculture, and on their lives in general. For the Mexicas, there was a living and real aspect to this plant

that went beyond imperial ambitions and mythological connections. This everyday interaction—wherein the Mexicas were literally and metaphorically surrounded by it—shaped the role of the cactus in the Mexica empire and afforded a mere plant, often nothing more than food or a mythological or literary figure, a form of agency in its use.

Pumpkin

The stone sculpture of the common Mexican pumpkin makes use of its materials to accurately mimic the heft and the bulk of the actual fruit. Carved from diorite, a hard, gray igneous rock, the sculptor has used the veins of the stone to create the idea of "stains" on the pumpkin. While the *Aztecs* catalog entry describes this as a "venerated fruit"[19] there is very little evidence of the symbolism, meaning, or relevance of the pumpkin to the Mexicas.

Pumpkins and squashes of all kinds were a Mexica (and central Mexican) dietary staple, and they were eaten in tandem with maize, manioc, beans, chía, and amaranth to create a varied diet that fulfilled the nutritional needs of the people. According to archaeological evidence, pumpkins were grown in both house gardens and larger-scale agricultural operations, such as the *chinampas* in Xochimilco. The distribution of the crop is important, as it shows that any Mexica had access to the fruit. As a dietary staple, the Mexicas were familiar with both its appearance and its effect on digestion and their diet.

Formally, the sculpture is carved with intense perfection and with such careful attention to detail that scholars have again been able to identify its species. This is in keeping with the discussion of sculpting in Book 10 of *The Florentine Codex*: "What is carved should be like the original, and have life, for whatever may be the subject which is to made, the form should resemble the original and the life of the original … Take great care to penetrate what the [being] you wish to imitate is life, and how its character and appearance can best be shown."[20] This clear demand for attention to detail has been taken by some as an "exhortation" to show the "sacred affiliation" of each being carved.[21] In fact, scholars have no evidence that this was more than an aesthetic preference, that carved objects should be close facsimiles to the original as possible. Pasztory refers to this aesthetic preference as a "naturalistic but simplified style."[22] Pasztory and Clendinnen are in complete disagreement about the formal characteristics of the sculptures; Clendinnen argues that they are incredibly detailed and specific while Pasztory seems them as schematic and generalized renderings. This contradiction is the extent of scholarly discussion about the formal characteristics of the works, as scholars continue to search for the meaning of each of these objects.

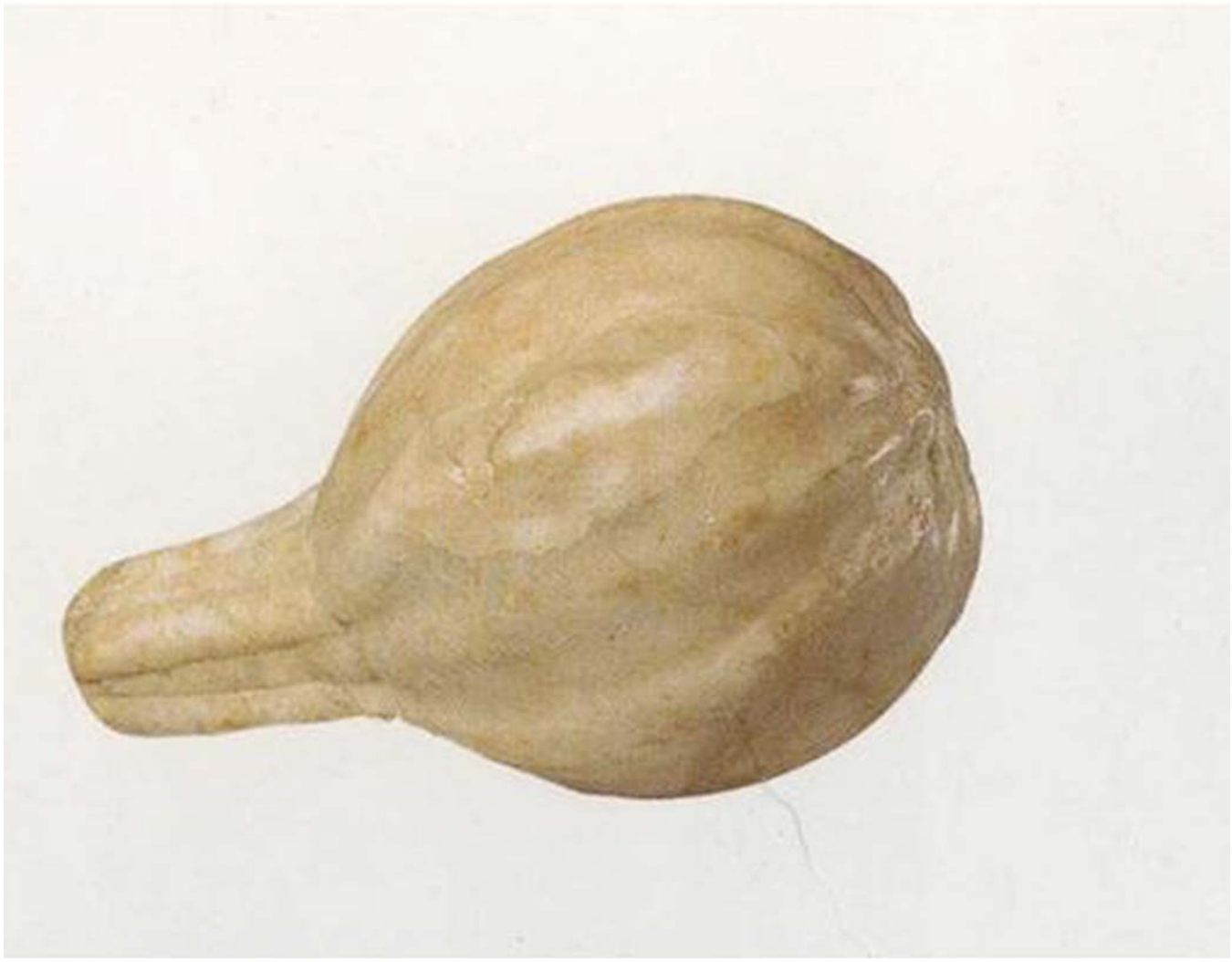
Both the illustration in *The Florentine Codex* and the final paragraphs of Book 11 indicate that the Mexicas engaged pumpkins (*tzilacayotl*) primarily as a crop that could be used both as food and as agricultural capital. The pumpkin itself is drawn both whole, and then it is drawn split in half, with a focus on the internal seeds. The written description draws out both its internal physical qualities, "it is white, long, pointed on both ends, having an eye," as well as its external physical qualities.[23] This offers an indication of how well the Mexicas knew the crop and how a sculptor could replicate in such detail.

Interestingly, though, there is no mention in the native discussion of the plant of its ethereal qualities, or the pumpkin's function in religion and ritual. Rather, Book 11 focuses on the everyday qualities of the vegetable: "I parch gourd seeds. I eat gourd seeds. I make gourd tamales…"[24] There is no indication that the vegetable was more than a food product, though it is assumed by scholars that the sculpture was used for ritual and religious purposes.

Gourd

Like the sculpture of the pumpkin, the gourd is carved in hyper-realistic detail, with the sculptor paying close attention to many of the small particulars. The color of the stone is similar to that of real gourds, a light subtle brownish orange. The sculptor makes use of the veins in the stone to convey the subtle imperfections of any vegetable. He also carved the ridges, bumps, and base of the gourd in detail. He used the stone to imitate the gourd's distinctive attributes and make it easily recognizable.

Interestingly, this particular type of gourd does not have a specific entry or illustration in Book 11 of *The Florentine Codex*. Rather, it is lumped under "native edible squashes" (*yecayotli*.) These gourds are described as "flower-like, sweet, pale, tasting of ashes, tasteless, stemmed, juicy, stringy, prickly."[25] Readers learn also that the gourd is edible, harmless, and "causes one's stomach to swell."[26] This general description of gourds, particularly when paired with the pumpkin description, reinforces the notion of squash as a food source rather than a ritual-religious

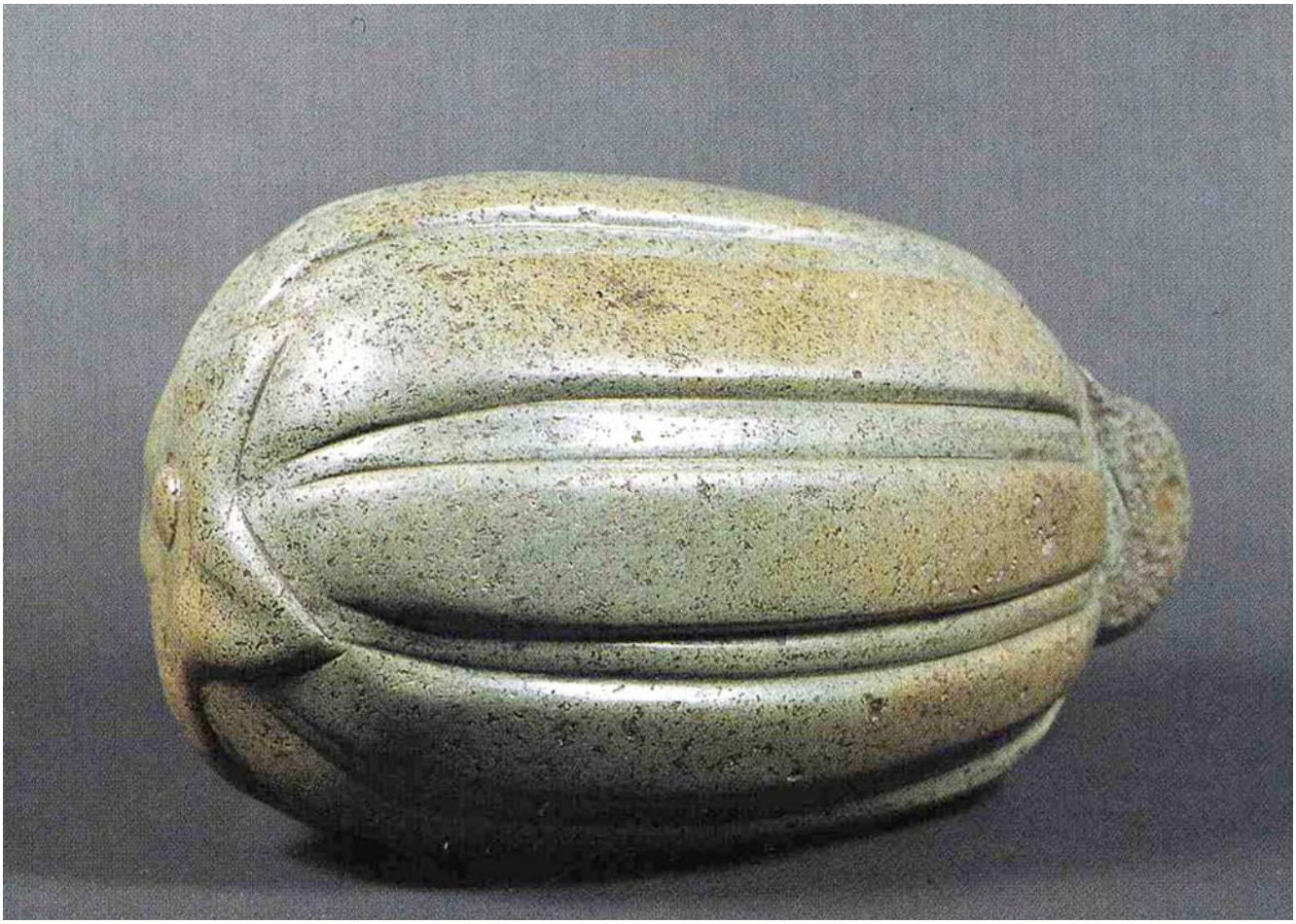


Anonymous
Common Mexican Pumpkin (also called squash), 1325-1520 © the National Institute of Anthropology and History (INAH - Mexico)

implement.[27]

Contemplating these sculptures as a food source, rather than as a religious tool, indicates a level of interactivity between plants and the Mexicas. There is no denying from their descriptions of each plant in *The Florentine Codex* that the Mexicas engaged with plants on an everyday level—that plants were not just symbols but also had lives of their own.[28] With the lives of their own came the capability to return the human gaze with true reciprocity, beyond that of a mythological and religious symbol. The Mexicas chose which plants to eat, farm, and domesticate based not only on their own desires but on the plants ability (and some might argue will) to survive in the places they planted them. The Mexicas were capable and competent agriculturalists, but they were not magicians. They could not make the rainforest grow in the desert. They saw gourds, pumpkins, and cacti as a means of survival, and depicted them in drawings, manuscripts, and in stunningly realistic stone sculptures.

The Mexicas created hyper-realistic stone sculptures of plants—and scholars will probably never know why. It is obvious from both their sculptural repertoire and descriptions in *The Florentine Codex* that the Mexicas spent many hours studying plants in order to represent them. Plants were not rendered marginal in the Mexica world, cast aside as an afterthought of ritual-religious practice. They were also part of an everyday existence, set aside from their potential cosmological and cosmomagical meanings. Like animals in John Berger's "Why Look at Animals?", scholars have reduced Mexica plants to the point that they "are always the observed. The fact that they can observe us has lost all significance."[29] The question remains, if the Mexicas lived in a world where plants were only symbols, if they were only the observed and not the observer, could they have sculpted them so well?



Anonymous
Squash, 1325-1520 © the National Institute of Anthropology and History (INAH - Mexico)

References

[1] Art historian H.B. Nicholson wrote one of the few articles on this zoo. See H.B. Nicholson, "Montezuma's Zoo," *Pacific Discovery* 8:4 (July-August 1955), 3-11.

[2] Esther Pasztory, *Aztec Art* (New York: H.N. Abrams, 1983), 233. Because there are very few plant sculptures, they are most frequently lumped into the category of "plant and animal sculpture." Therefore, I treat art historical statements about animal sculpture as extending to plants as well.

[3] Inga Clendinnen, *Aztecs: An Interpretation* (Cambridge: Cambridge University Press, 1991), 225.

[4] The romanticization of the Mexica attitude toward nature is often in stark contrast to our popular notion of them as bloodthirsty, sacrificing savages. This is of particular note in Clendinnen's book, which has been attacked by art historian Cecelia Klein for its overemphasis on sacrifice imagery.

[5] See Eduardo Matos Moctezuma and Felipe R. Solís Olguín, *Aztecs* (London: Royal Academy of Arts, 2002); Felipe R. Solís Olguín, *The Aztec Empire* (New York: Guggenheim Museum Publications, 2004.)

[6] This account of the migration myth is taken from Diego Durán's *History of the Indies of New Spain*. Diego Durán, *The History of the Indies of New Spain*, trans. Doris Heyden, Civilization of the American Indian series, 210 (Norman, Okla. ;London: Univ. of Oklahoma Pr, 1994).

[7] Durán, 35.

[8] Durán also indicates that this mastery drove fear into the hearts of those native in the region, 36.

[9] Durán, 31.

[10] *Chinampas* were not by any stretch of the imagination floating. They were an ancient system of agriculture used by the Xochimilcans and turned over to the Mexicas when they conquered the region. *Chinampas* are an extensive system of farming islands created using silt and bottom much that are then rooted and anchored using willow trees. They were most commonly used for seedlings but could also be used for mature plants. Many of them are still in use today in the outskirts of Mexico City.

[11] Alfredo López Austin, "The Natural World," in *Aztecs*, ed. Eduardo Matos Moctezuma and Felipe R. Solís Olguín (London: Royal Academy of Arts, 2002), 141.

[12] He goes even further and includes minerals! López Austin, 141.

[13] Donna Haraway, *When Species Meet*, (Minneapolis: University of Minnesota, 2008), 21

[14] I refer to the episode when Derrida reports feeling ashamed of being naked in front of his little cat. Haraway later comments that for all of Derrida's work in criticizing those that only approach animals as literary/mythological figures "he failed a simple obligation of companion species; he did not become curious about what the cat might actually be doing, feeling, thinking, or perhaps making available to him in looking back at him." (*When Species Meet*, 20.) For the Mexicas, plants are a companion species, and modern-day scholars are failing both the Mexicas and the plants they lived with.

[15] See *The Aztec Empire: Catalogue of the Exhibition* (New York: Guggenheim Museum Publications, 2004), 10.

[16] The sculptor carved the head of Tenoch, the founder of Tenochtitlan on the base, as well as the tuna of the cactus, which was held in the mouth of the eagle upon the Mexica's discovery of it.

[17] This may be attributed to the ways in which Fray Bernardino de Sahagún posed the questions. Scholars do not have access to the questionairres he used.

[18] Bernardino de Sahagún, *Florentine Codex: General History of the Things of New Spain, Book 11—Earthly Things*, trans. Charles E Dibble and Arthur J.O. Anderson, (Santa Fe: The School of American research and the Univ. of Utah, 1982), 122.

[19] *Aztecs: Catalogue of the Exhibition, 48.*

[20] Bernardino de Sahagún, *Florentine Codex: General History of the Things of New Spain, Book 10—The Merchants*, trans. Charles E Dibble and Arthur J.O. Anderson, (Santa Fe: The School of American research and the Univ. of Utah, 1982), 73.

[21] *Aztecs: An Interpretation*, 226.

[22]*Aztec Art*, 235.

[23] *Earthly Things, 288.*

[24] *Ibid,* 288.

[25] *Ibid,* 288.

[26] *Ibid,* 288.

[27] I do not deny that these plants could have served as both ritual-religious objects and parts of everyday life—but the focus has been so much on plants' ethereal and mythological qualities that this reading has been lost.

[28] Lorraine Daston and Gregg Mitman, *Thinking with Animals: New Perspectives on Anthropomorphism* (New York: Columbia University Press, 2005), 13.

[29] John Berger, *About Looking* (New York: Pantheon Books, 1980), 16.

Renee McGarry is in her fourth year in the PhD program in Art History at the CUNY Graduate Center specializing in Pre-Columbian art and architecture. Her main interests include the intersection of secular and religious imagery in indigenous visual cultures and Aztec imagery of the natural world. She will gladly pontificate for hours about how the Aztecs made her vegan and how one time she tried ordering a "quesadilla sin queso" on research trip in Oaxaca. Her request was denied.

The article article 'Familiar contact'is a part of her on-going dissertation, *Exotic Contact: Flora and Fauna in Mexica (Aztec) Visual Culture,* which considers how both plants and animals are represented in Mexica sculpture and manuscripts.

JANAINA TSCHÄPE: BOTANICA

In a curious botanical milieu peopled with costumed creatures born from myths and folktales, Janaina Tschäpe *makes extremely fascinating works of art employing diverse media such as painting, video and photography. Julien Salaud interviewd the artist for Antennae.*

Questions by Julien Salaud, *Translation by* Joann Kim

New York based Brazilian and German artist, "Janaina Tschäpe shares her forename with a Brazilian water goddess, and, not coincidentally, her photographs and performances-to-video feature sumptuously organic, watery, distorted female figures," writes Frieze. Since 1997, the artist has employed the female body as her muse, creating universes of polymorphous landscapes, embryonic forms and ambiguous characters. Tschäpe's drawings, photographs, films and installations seek to give form to the trance of art making, portraying not a dream world, but the sensation of being in one as she deftly exploits and subverts notions of identity and reality in her work.

Her first solo exhibition in Ireland opened to the public at the Irish Museum of Modern Art on Wednesday 25 June 2008. *Janaina Tschäpe: Chimera* was structured around the genetics of the fabled beast, to create a very specific atmosphere. Comprising some 20 works, the exhibition focused mainly on Tschäpe's latest paintings that embody a sense of the extraordinary through colourful botanical notations. Displayed and intertwined amongst these paintings are her film and photographic works.

Chimera stands for a fusion of multiple identities in a single body or creature. In her interview from the exhibition catalogue with Rachael Thomas, Head of Exhibitions at IMMA, Tschäpe describes the relationship between the *Chimera* and her work:

> What makes the chimera a fearful monster isn't any of [its] traits in particular, but the fact that they are all combined in a single being. It is this notion of the chimera that applies to the way I structure the process of my work. Whether I'm making videos, photographs or paintings, the process is similarly multifaceted to the point that it departs from being a work strategy to become the reason for the work to exist. When I am immersed in this sort of media amalgamation I am allowed to lose control and be free.

In this exhibition Tschäpe created an environment of dream and fantasy, where the everyday world metamorphoses into a mythical place, populated by fabricated creatures and florescent vegetation. The four screen video installation, *Blood, Sea* (2004), is a mesmerizing example of

Janaina Tschäpe
Moon Blossom, oil on canvas, 90” x 60”, 2007 © the artist, courtesy of Nichido Contemporary Art

Janaina Tschäpe
Lair, oil on canvas (triptych), 118" x 79", 2009 © the artist, courtesy of Forest Vilaca Gallery

Tschäpe's fantasy worlds. Its narrative plays with the evolutionary biology of sirens and mermaids, from fables such as the water sprites of Irish lore to the Brazilian Iemanjá - spirit of the seas, lakes and fertility - from the Candomblé religion. In this work Tschäpe plays creator to magnificent and fantastical creatures and environments.

The fertile worlds found in *Blood, Sea* and the photographic series *Botanica* (2004-05) are juxtaposed with the simplicity of an earlier series spanning over a number of years. *100 Little Deaths* (1996-2002) explores danger and the horror for an artist of a failure of ideas. This exhibition is a unique opportunity to discover Tschäpe's contemplative and melancholic, yet surreal, practice.

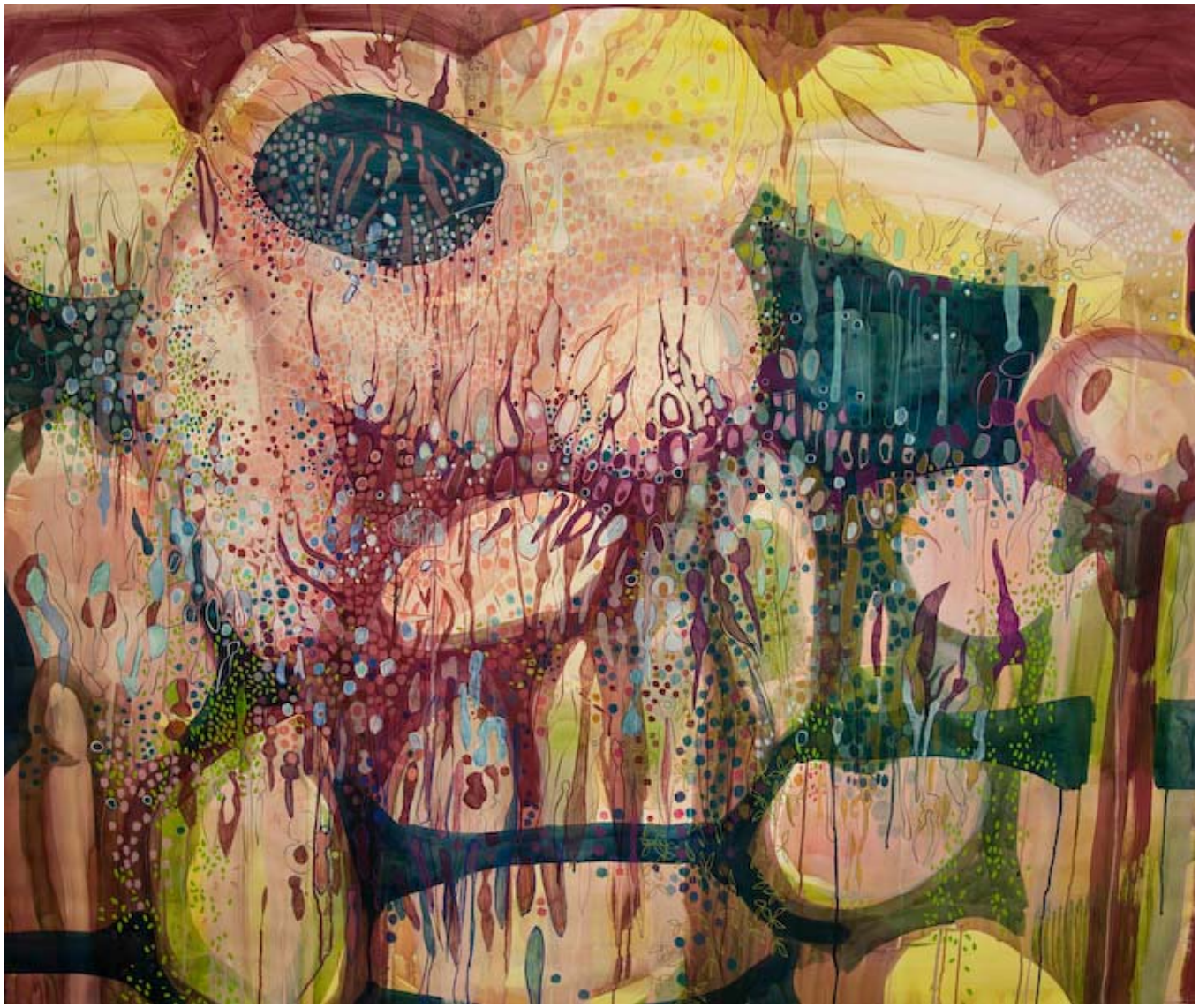
*Images of sleeping women are recurrent in your artworks since your first exhibition (*Exercises*, 2002). It is noticeable that your images attempt to capture a dream-like dimension. Did your dreams influence the development of your artistic process? In what way?*

Janaina Tschape: Dreams are but one component of what influences my work. I draw as much inspiration from nature, fairytales, water, and the subconscious as I do from dreams. Dreams can reflect our desires, both secret and blatant, through the subconscious state of our sleep and through this ego-less channel storytelling emerges and freely influences my work.

Fluidity is another strongly present characteristic all through your productions. In 2003, water crossed the exhibition After the rain *(Albi, France): liquid, solid or gaseous captured in video sequences; the elements also took place directly in the creation of your watercolors (*Interior*). Why do you attempt to depict a word through the flux?*

Water is a powerful force in nature, a form that plays into many mythologies and fables within various cultures alongside providing the fluidity of narrative, both abstract and representational, within a single artwork. Water is the female, water is the womb, water is the eternal formless encapsulator of mass and volume. It is the subject of fantastical figures such as Yemanha, the 'mother of the waters' and serves both a liberating and suffocating virtue.

In this exhibition, a cycle of photos called Livia *showed several self-portraits. They all offered a figure hard to delineate: a woman, an octopus, a jellyfish or maybe seaweeds at the same time. What is the meaning of these blurred bodies and*



Janaina Tschäpe
Polipos, watercolour and pastel on paper, 71" x 85", 2010 © the artist, courtesy of Forest Vilaca Gallery

what do they say about animals? Are you interested in metamorphosis?

I am very interested in metamorphosis and have utilized the female body and it's multiple representations within mythologies and fairy tales to re-present and provide an alternative, and more personal, reinterpretation of the physical and psychological manifestations of sex. An emphasis in the sea, and how figures find movement and breath within the medium.

From the first drawings to the last paintings, we can notice the development of the motifs we encountered in Polipos *(2010): for this piece, they have been repeated through variations of scales and colors. Initially, those forms were already showed through drawings of microcosms (*Interior*, 2003), landscapes (*I found me in a gloomy wood*, astray, 2004), or photos of unusual plants (*Botanica*, 2004). But it seems that they got their autonomy as motifs from* Hortus period *(2005). Can you give us your perspective on this evolution?*

The motifs found within my work have developed throughout the years while experimenting with a more liberated process, one that didn't involve staging, posing, propping. Painting and drawing became a practice that involved more chance and spontaneity of form than precise mark making. Within this intuitive, personal and direct mode of production there was a common vocabulary built around the works, organic shapes and fluid marks, repetitive strokes and patterns of various shapes, asymmetrical and imperfect in its handmade natural state. Each work reflects the unpredictability and non-uniformity of nature, its overwhelming and eruptive tendency to visually consume, and its

Janaina Tschäpe
Wilt, oil on canvas, 110.2" x 236.2", 2009 © the artist, courtesy of Forest Vilaca Gallery

effortless tirade of beauty and harmony.

In Untitled 2 *(2010), a green swarm of those motifs surrounds a sleeping human figure. Does the repetition of motifs have anything in common with the natural laws that govern the appearance of the vegetal word?*

In addition to my work reflecting natural laws of repetition, pattern, and cycles, the motifs also developed out of a personal vocabulary emphasizing the spontaneous and liberated, expressive and irrational.

*In some of your paintings, plants seem to be depicted through the overlapping of different points of view, different focal distances (*Wilt*, 2009). Is it relevant to consider* Wilt *as an image mixing the microscopic interiors of plants and their external appearance?*

I draw my influence from both microscopic and grandiose, both internal and all encompassing perspective of nature.

What are the productivities of these overlappings of the artist, the artworks, and the audience?

Specific to my artistic practice, I'd like to think the audience viewer is entrapped in a world that is created through my paintings, photographs and videos. Perhaps a temporary escape from everyday reality, entering a world laced in fantasy, mysticism, mythology, and inspire viewers to take the fragmented narratives to formulate their own.

Can you explain your 'plastic use of colors'?

I wouldn't say the colors have a plastic value in my work, the colors are mostly hues of a dense and opaque nature, layered and stroked in shades of deep crimson red, green, and blue. I use plastic mediums such as plasticine to experiment with shape and form in the same way I would use paint to create a painting. There is also the latex balloons and condoms, elastic that is used to morph and mutate figures within my work, to gorge and fill with water, its material providing brightness and flexibility.

From those thematic and plastic characteristics, one could conclude your artworks often have a lot in common with the paintings of an Australian native representing the Dreamtime. Is this comparison relevant to you?

Dreamtime images are of a completely different context but reflecting on my works from a purely formalist perspective, one can say that the organic shapes and motif as well as the color palette are similar.

Janaina Tschäpe
Veratrum Bulbosus, from the *Melantropics* series, 40" x 49", C-Print, 2006 © the artist, courtesy of Sikkema Jenkins & Co.

The recent reorganization of Pompidou Center's permanent collections for an exhibition called Elles *("They, (women)") included some of your artwork. Can you explain us the feminine dimension of your artistic process? How does this affect you relationship with plants?*

Mythological female characters, 'mother nature', the sea as the womb and source of renewal, religiosity and maternity, these are all elements that influence much of my work. But more than my work being "feminine" and not "masculine", I'm more interested in defying the notions of the permanent and rigidly defined and focus on playing with sexual and emotional anatomies of the figure and converge the internal and external facets of personage. Nature is in a constant state of change and metamorphosis, there is no certainty, no permanence, no sameness within it. I explore the same concept with the stories and figures reflected in my work.

According to you, what would be the beneficial effect if contemporary art was more "feminine" than "masculine"?

As an artist, my utmost priority in my career is that of being an artist. Within that component there is not much room or hearsay to consider if contemporary art is feminine or masculine. The art world, both in its history and in its current state, both in cultural production and commercial output, it is a white-male-centered majority. It is easy to describe a specific such as a particular artist's oeuvre as more feminine, or conjuring subjects of the maternal, sexual, natural and organic but to group an entire sector of society to a particular sexual orientation is outside of my interest.

Could men possibly "work as women"?

Men could work as women as much as women could work as men. How either case is received

Janaina Tschäpe
Cadmium Infecto, from the *Botanica* series, 9.125" x 13", Digital C-Print, 2005 © the artist, courtesy of Calier Gebauer

might differ and bend significance toward that of a "dominating" sex's change of role. My interests purely lie in producing works that are not dependent in its being received of a particular sexual orientation or culturally modified gender.

Would it be desirable?

Not any more than vice versa.

Born in Germany in 1973 to a German father and Brazilian mother, Janaina Tschäpe lived primarily in San Paulo, Brazil as a child. She studied at the University of Fine Arts in Hamburg from 1992 to1998 before moving to New York and completing her MFA at the School of Visual Arts in 1998. Tschäpe has exhibited her paintings, drawings, photographs and video installations throughout the world, with solo shows at the University at Buffalo Art Gallery, the Scottsdale Museum of Art, the Reina Sofia Art Center in Madrid, Artforum Berlin, and Centre d'Art a Albi, Toulouse, France, among others. Her work is included in numerous private collections and the permanent collections of museums in Europe, the United States, Brazil and Japan.

LAUREN BERKOWITZ: *MANNA*

Lauren Berkowitz's *complex and multifaceted practice concerns issues of humanism, contemporary feminism and the environment, explored through the binary lenses of order and chaos. Typically working within the stylistic idiom of post-minimalism, Berkowitz collects various natural and recycled objects to create sensuous hanging and floor-based installations. Her process-based drawing practice similarly reflects her sculptural methodologies of collecting, arranging and repetition.*

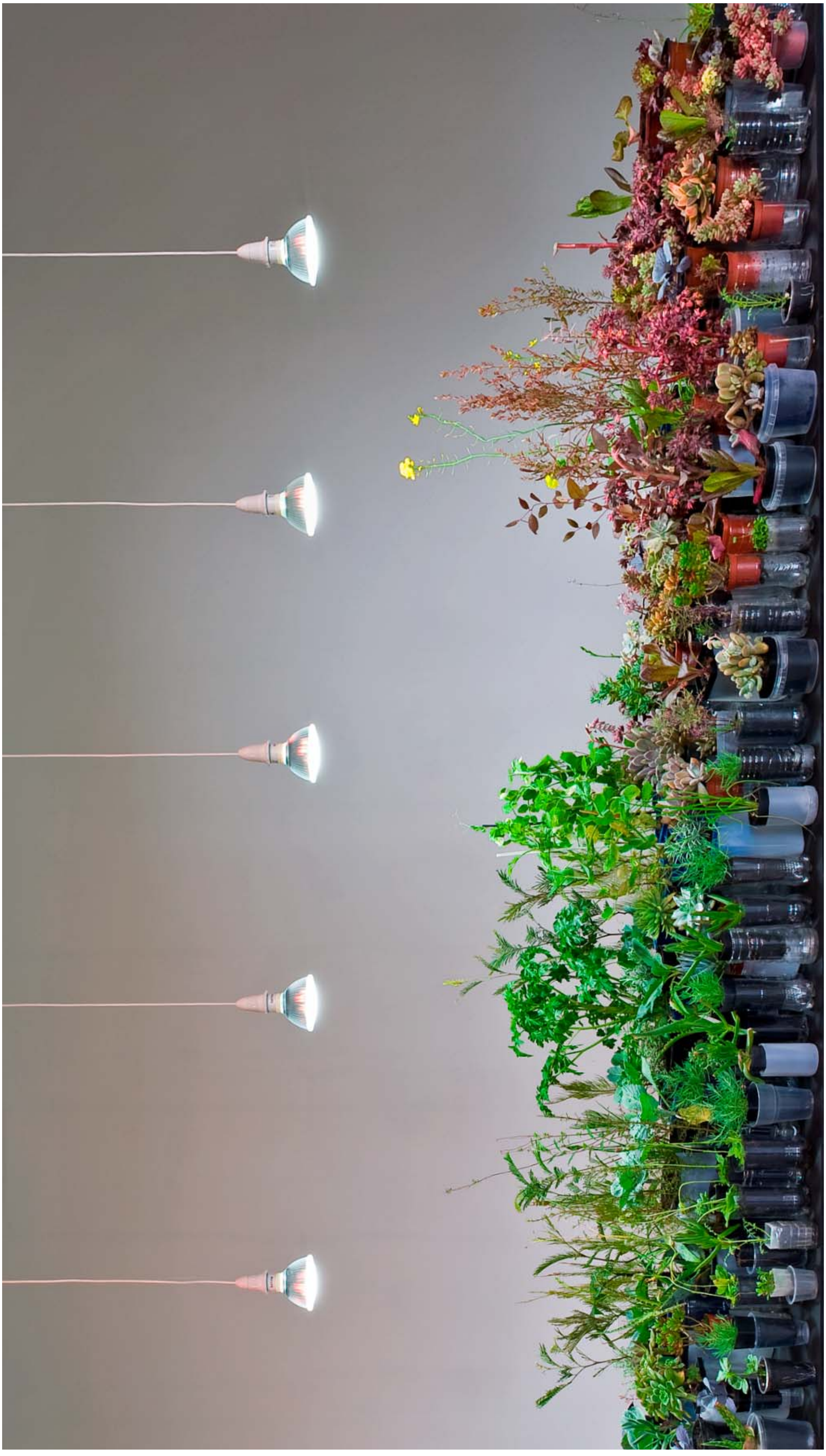
Text by Dr. Alana O'Brien

Like the alighting of the Biblical Manna on the ground, Lauren Berkowitz, in her artistic practice, wishes to tread lightly on the land, and just as the Israelites gathered up the Heavenly Manna for nourishment in the desert, she collects together plants that are both edible and sustainable. Found materials, frequently drawn from the immediate environs, comprise a significant section of a work, if not the entire work. The artworks regularly consist of post-consumer waste. Similar to the *Manna*, the materials are easily accumulated and require low technology, while many of the artworks share with it an ephemeral nature. Berkowitz's carefully conceived works are richly layered with meaning. Among the various themes that she explores are the stratified history of a landscape, issues of sustainability, Jewish culture, and memory.[i]

At the beginning of the 1990s Berkowitz's works began to emphasise the enormity of consumer waste. While studying in New York Berkowitz was shocked by the masses of paper bags that were distributed with nearly every purchase. Perhaps the most extreme example of this was the allocation of a bag with a takeaway cup of tea, provided to hold the sugar, napkin and spoon. During her time in New York Berkowitz collected all the paper bags that were given to her, eventually constructing Recyclable, 1993 at the SVA Galleries, N.Y. In this work a flat cardboard 'road way' or 'path way' enabled the viewer to navigate their way between the tightly clustered collection of bags; like a giant walking through a crowded cityscape.[ii]

Berkowitz has frequently utilized the plastic waste objects that clutter our lives in her art works. They pass through our houses, workplaces and life with ever increasing frequency – plastic cups, take-away food trays, cherry tomato and strawberry containers, compartmentalised trays for kids school snacks, and beverage bottles. People are becoming more accustomed to recycling - a relatively easy process at home where councils provide most households with recycling bins. But a quick glance at any public bin will reveal that vast quantities still go directly to landfill. And what of those containers that we confidently throw into the recycling bin? Can we really be certain about where it all ends up?

The excess of plastic containers is just a part of the process through which we have lost



Lauren Berkowitz

Manna, various medicinal and edible food plants, 60 x 460 cm, 2009, photo: Kalli Karvelas © the artist, courtesy of La Trobe University Museum of Art, Melbourne

touch with nature, and a sense of where food comes from. Supermarkets are well-known for their over-packaging of produce, especially in the fruit and vegetable section. Lemons, avocados and odourless tomatoes are frequently presented on trays under several layers of plastic, and mushrooms are found in containers, pre sliced.

A connection of food with plastic packaging is made in Berkowitz's *Manna* produced specifically for Three Degrees of Change, but here the herb and food plants – the food sources – are delicately arranged, in, amongst, and balanced upon, the plastic post-consumer waste. Berkowitz's plants congregate on a long low table. The gallery space has been temporarily transformed into a greenhouse. The lighting has been modified to provide environmental conditions able to sustain and promote the growth of the plants. But the artist's intervention is required to sustain and maintain the artwork. As the planet becomes hotter, water becomes scarcer and the weather becomes more extreme, the sustainability of food production becomes a growing concern.

The plants are diverse in colour, form, and continental origin - most being exotics. Berkowitz has included many edible plants or ones with medicinal properties. Like a kitchen garden, the work is a sensory delight. It does not only appeal to the eye, but also to the olfactory and potentially even to the tastebuds.[iii] Most of us will be able to recognise the lettuce, parsley and tomato plants or the aloe vera.[iv] But who can pick the indigenous species, the chocolate lily, the bulbine lily, apple berry, pigface and ruby saltbush – all of which contain edible fruit or tubers – or the river mint, used to ease the symptoms of coughs and colds. The tableau also includes a number of succulents, plants that have evolved to inhabit harsh, water-poor locations.[v]

When Europeans first colonised Australia, they attempted to create a new Arcadia in the image of the landscape they had left on the other side of the globe. They found the Australian environment harsh, threatening, and unaesthetically scraggly. They wanted to transform the landscape into something more 'comforting', bringing water or nutrient intensive crops, aggressive and ultimately unsustainable agricultural processes and animals that would degrade the fragile Australian environment. Despite the fact that Aboriginal people had lived off the Australian landscape for 60,000 plus years, the indigenous plants and animals were largely ignored in favour of the foods that the colonisers and later migrants introduced.

While the introduction of many exotic plants from Europe, Africa, Asia and the Americas has caused immense damage to the Australian landscape, it would be naïve to suggest that we now abandon these sources of nutrition/food. Rather, Berkowitz suggests that the way forward will include these introduced species, but not at the expense of the indigenous plants. There needs to be a cultural shift, part of which can be facilitated by further research and education into the use of bush tucker.

In keeping with her practice of sourcing material from the local environs, Berkowitz has sourced most of the indigenous plants from the Melbourne Wildlife Sanctuary (previously known as Keelbundora), a significant indigenous nursery specializing in flora from the Lower Yarra Valley. Located in the northern area of the La Trobe University (Bundoora) Campus, the Sanctuary was established in 1967 to restore and manage the pre-colonisation local environ, both for fauna and flora. Through the inclusion of food-plant species specific to the local area, Berkowitz also wishes to acknowledge the Wurundjeri people who used and managed the resources of this area sustainably prior to colonisation.

In *Manna* Berkowitz draws together themes and practices explored in various works produced throughout her career, but it is not a summary of these works. It is a step forward. While many of the past works provided commentaries and created awareness about certain issues – and this is in fact the case with many art works that appear in ecology or environment exhibitions – in *Manna* Berkowitz is offering the viewer a course of action. The work draws on the richly layered Jewish concept Tikkun Olam, which can be loosely translated as healing or repairing the shattered world.[vi] It allows that even simple, practical steps can be undertaken by an individual to contribute to the restoration of the world at large. From an ecological viewpoint the planting of food and medicinal plants might comprise some of those small steps.

Manna celebrates and encourages the expansion of the 'grass roots' (or should they be called 'herb and veggie roots'?) movements in urban spaces around Melbourne, and many other western cities where people are spontaneously reclaiming land – the nature strips before their and their neighbours' houses, and even before town halls. Perhaps the most notable reclamation of land for cultivation is Michelle Obama's construction of a garden within the presidential lawns of the White House. These movements draw on the tradition of Victory

gardens – which began in England, Europe and America as a result of shortages of fresh produce at the time of World War II.[vii] Just as the world was in need of healing during and following the war, it needs healing again.

The people of the world are searching for their own answers, performing their regenerative acts toward the earth. The 'random acts of edible gardening', whether performed by individuals or communities, on the nature strip, rooftops or tiny balconies, helps us to reconnect with the natural Berkowitz is inspired by "futuristic images of apartment buildings with balconies covered in greenery to feed and [to] offset greenhouse gasses".[viii] She suggests that food production within the cities might be part of "a practical solution to combat global warming and depleted food supplies".[ix] This solution would also contribute to planetary health through the saving of 'food miles'. And people could also ensure for themselves, that they were consuming food that is not sprayed with pesticides or genetically modified.

While in the gallery space *Manna* will demand a level of active and continual care unusual in an art work, it won't cease to exist at the close of this section of Three Degrees of Change. Like the Manna from Heaven the food will be gathered and distributed as a gift. The plants will be dispersed and planted in various sites around Melbourne, including a school vegetable garden, and community and individual gardens; this is in keeping with the theme of Tikkun Olam, a small gesture toward healing the world.

Notes

[i] Links to many texts discussing Berkowitz's artworks can be accessed at: http://www.laurenberkowitz.com.au/text.html.

[ii] By contrast, *Bags*, 1994, brings to mind, a situation more relevant to the Australian context, the over abundance of plastic shopping bags. In fact, public concern over the distribution of light weight plastic bags at checkouts has recently led to them being banned in South Australian. The work references consumption in other ways. It stands 4 metres tall and 6 metres long, and the audience can walk between the two 'walls', an experience which is likened to entering the digestive tract.

[iii] The appeal to these other senses was similarly a factor in her work *Follies* where the hanging of lavender, chillies, and Banksia enveloped the viewer, not only physically but also through the aroma carried through the air.

[iv] Furthermore, seeds (soya, alfalfa, red and black beans, mustard, and corn) from Berkowitz's *Cornucopia* will be recycled, grown into seedlings, to include in this work.

[v] In recent years, concepts regarding gardens and the history of specific sites have had a growing importance in Berkowitz's works, such as *Karakarook's Garden* 2005-6, *Demeter's Garden*, 2007 both produced at the Museum of Modern Art at Heide, Melbourne.

[vi] According to the Lurianic Kabbalah, the earth required healing after the vessels of Divine Light that God sent out to create the world were shattered. Some of the sparks became trapped in the broken shards and thus became evil. Mystical Jewish traditions hold that prayers, blessings and meditations are needed to restore the Divine sparks and repair the damaged world. In contemporary Jewish ethics good deeds also serve the same purpose. Berkowitz has also explored aspects of her Jewish heritage in *Salt and Honey* where food makes allusions to yearly Jewish festivals, many of which originated from pagan festivities of the harvest, but are consequently overlaid with other meanings. For example Tu Bi-Shevat the festival of the New Year of the trees celebrates renewal and regeneration.

[vii] The development of one's own garden as a source of produce has a strong and continuing tradition among families of Greek and Italian immigrants.

[viii] Artist notes, 2009.

[ix] Artist notes, 2009.

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Lauren Berkowitz studied sculpture at the Victorian College of the Arts, Melbourne and later received a Masters in Fine Arts (Sculpture) at the School of Visual Arts, New York. Since 1985, she has shown in 19 solo exhibitions and 66 group exhibitions in Australia, Japan and the United States. She is the recipient of numerous awards and grants, including Project Grants from the Visual Arts and Craft Board of the Australia Council and, most recently, an Arts Victoria International Cultural Exchange Grant, which assisted her participation in the Echigo-Tsumari Art Triennial, Japan (2003). Her 2004 exhibitions in Sydney at Artspace (an ephemeral floor-piece) and Sherman Galleries (works designed for domestic and corporate spaces) featured sands and salt, referencing the coastal and built environment of Sydney and Australia's desert regions. In 2005, her installation, *Shadows and Light*, at the Lake Macquarie City Gallery, comprised coal and indigenous wood shavings, reflecting the history of the region. Lauren Berkowitz's work is held in the collections of a range of institutions in Australia and the United States, including the Museum of Modern Art Library, New York.

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