









# **Do Rubber Trees Dream of the Rainforest?**

Dr. Ruben Gutzat

Master's Thesis  
Vienna, 05.12.2023  
University of Applied Arts Vienna

Art & Science  
Supervisor: Prof. Virgil Widrich



|                                                  |           |
|--------------------------------------------------|-----------|
| <b>ACKNOWLEDGMENTS</b>                           | <b>9</b>  |
| <b>FOREWORD</b>                                  | <b>10</b> |
| <b>INTRODUCTION</b>                              | <b>14</b> |
| Plant love/interspecies love                     | 14        |
| What is the meaning of love in Biology?          | 17        |
| Can I heal a plant's genetic disorder?           | 18        |
| Marrying a rubber tree                           | 20        |
| The Swiss Case                                   | 21        |
| What is plant dignity?                           | 23        |
| <b>WHERE DO RUBBER TREES COME FROM?</b>          | <b>27</b> |
| How plants make babies                           | 27        |
| The Arrival                                      | 32        |
| The long history of plants and humans            | 35        |
| Where do our companion rubber trees come from?   | 38        |
| <b>GETTING TO KNOW BETTY AND BOSSI</b>           | <b>44</b> |
| Why rubber trees?                                | 44        |
| My two new companions                            | 46        |
| What is treeness?                                | 53        |
| What is it like to be a ...?                     | 53        |
| <b>WHAT HAVE I LEARNED FROM BETTY AND BOSSI?</b> | <b>58</b> |
| What is a plant?                                 | 58        |
| Plant swarm intelligence                         | 61        |
| Can I feel rubbertreeness?                       | 62        |
| The cry of the rubber tree                       | 63        |
| <b>REFERENCES</b>                                | <b>66</b> |



## Acknowledgments

First and foremost, I thank Prof. Virgil Widrich for his supervision and the remarkable opportunity to return to this program after many years.

Special thanks to Martin Reinhart for his assistance with the manuscript and to both Martin and Noor Stenfert Kroese for the discussions we've had.

To Betty and Bossi, my vegetal muses and personal therapists - thank you for not leaf-ing my side and for proving that sometimes the best counsel comes without words.

A special acknowledgment goes to Stefanie Koemeda, my fiancée and anchor, whose unwavering support has made navigating deadlines easy and who fully understands and supports my exuberant passion for biodiversity on our windowsills.

I am thankful to Dr. Ethan Stewart for granting me access to the plant phenotyping facility and for his assistance in scanning Betty and Bossi.

My thanks also go to the eagle-eyed Dr. James Matthew Watson for proofreading my thesis.

A big thank you to Crystin Moritz for her help with the layout of my thesis, and also to Karl Salzmann for his support with attempting to detect ultrasound from plants.

I also want to extend my gratitude to my family: my parents, Diethard and Beate, and my sisters, Rebecca and Mirjam, for always indulging my peculiar enthusiasm for floral and faunal critters.

Lastly, I would like to thank my classmates for their camaraderie and the relaxed atmosphere they cultivated. Our WhatsApp group has been a lighthouse of laughter and advice.

## Foreword

Over the past decade, I have been dedicated to understanding the molecular life of plant stem cells. My research uncovered that these cells exhibit a notable activity of "jumping genes." This indirectly shows that plants are individual units of selection throughout evolution, implying they possess agency in their existence.

Before this exploration and during my Ph.D. in Switzerland, my attention was on understanding tumour suppressors in plants. For this, I generated miniature *in vitro* plant embryonic tumours, which provided insights into how plants transition from embryonic seeds to autonomous, photosynthetic organisms. During this time at the ETH Zürich, I was confronted with the concept of plant dignity. Remarkably, Switzerland is the only country that grants a constitutional right to safeguard the dignity of all beings, plants included <sup>1</sup>. This posed a challenge for us as researchers—how could we ensure our studies respected this principle? The idea was met with skepticism and ridicule in our community, mainly because acknowledging plant dignity would suggest plants have some semblance of consciousness.

I always found it narrow minded to deny consciousness to entities outside the realm of highly intelligent mammals. I believe "consciousness" is the most significant scientific mystery. Getting closer to understanding concepts of consciousness might also be a route to unlocking humanness and connectivity with all our earthly and non-earthly companions and the earth's ecosystem as a unit itself (the latter has been conceptualised and its existence hypothesised by Lynn Margulis and James E. Lovelock and referred to as "Gaia" <sup>2</sup>). However, so far, we lack even a universally accepted definition, let alone a comprehensive theory, of consciousness. How can we negate the presence of something we struggle to define? If we fail to imagine the possibility that plants are conscious agents, how will we ever recognize or even conceptualize consciousness in otherworldly or non-biological entities, like AI?

While the "hard problem" of the subjectivity of consciousness might never be solved, I believe that framing consciousness around the concept of "experience" can reveal objective truths about the universe and the intricate

workings of our brains. This can be explored using artistic methodologies, capturing emotions and sensations that are otherwise intangible.

To further this endeavor and as models for an otherworldly consciousness, I studied and portrayed my two vegetal muses, Betty and Bossy, a pair of rubber trees.

Through this exploration, I aim to unravel the quintessence of "rubber-treeness," thus scrutinizing the nature of scientific culture and my own capacity for empathizing with the potential consciousness of plants.

This text also serves as a template for a more extensive work, a book that leaves more room for pop-science and that delves into the interplay between scientific and artistic modalities in exploring vegetal agencies.

Complementing this written exploration, my practical efforts will feature an installation, with Betty and Bossy as its center. A short, immersive film will endeavor to capture the essence of life as a rubber tree. By aligning diverse visual elements — from the microscopic intricacies of cellular architecture to the vast expanses of forests, and from sterile scientific environments to lush, untamed natural settings — I intend to juxtapose my methodical scientific approach with a more empathetic, experiential one.





# Introduction

## Plant love/interspecies love

*"Love is life. All, everything that I understand, I understand only because I love. Everything is, everything exists, only because I love. Everything is united by it alone. Love is God, and to die means that I, a particle of love, shall return to the general and eternal source."*

— Leo Tolstoy

The Oxford English Dictionary defines "love" as "a profound feeling of deep affection or a strong enjoyment or interest in something. This term has its origins in Old English "lufu", tracing back to the Indo-European family, and is related to the Sanskrit "lubhyati", which means "desires" <sup>3</sup>.

The interpretation of "love" varies with cultural backgrounds and linguistic roots. For example, Greek language categorizes the meanings of love into six distinct forms <sup>4</sup>: agápē represents brotherly love, philía signifies friendship among equals, érōs denotes sexual passion, philautía refers to self-love, storgē encapsulates parent-child affection, and xenia describes hospitality towards strangers or guests.

I love plants.

Maybe this sentiment resonates with you, and you nurture a little vegetable garden in your little front yard, and you cherish the yield of your harvested cucumber or tomatoes; or maybe you are sitting in your office chair right now staring lovingly at your little cactus sitting on your pc - which is supposed to represent your charm and was given to you by your witty colleagues.

But is it not an overstatement to say you love a plant - to love across biological kingdoms?

Love, in my own definition, symbolizes a harmonious connection, a resonance in the frequency of experiencing the world. It embodies deep friendship, attraction, care, anticipation, and an enduring fascination.

I have experienced these dimensions of love towards plants.

As a child, I would go out at night, sneak below the windows of the living room, and climb up a fir; it had this wonderful shape. Close to the stem, you wiggled your way up through the branches, and just before they opened up to reveal the night sky, the main stem made an S-shape, and from its base were branches radiating in all directions, providing a perfect seat, with the tip of the tree as the gentle back cushion. I perched, high up there, and could see the world with the eyes of the fir; we were in tune underneath the occasional visible star in the city nightlight. Together, we were observers of these strange primates visible through the windows, spending most of these evening hours hypnotized by the blueish light radiating from the tv.

During my teenage years, I had my first flirtations with succulent plants - plants that can store water in their tissue to survive long periods of dryness. I was the proud owner of an *Adenia glauca*, a plant with a green, bottle-like trunk native to South Africa. I was awaiting its first leave after its period of dormancy. When I found the first tiny buds appearing, I spent my days carrying the pot throughout my parent's house so it would always be in the sun to receive as much light as it would get in the rocky hills of the Transvaal. I would daydream about the holy grail of succulent plants displayed in a yellowed edition of "The Lexicon of succulent plants" from our local library. For me, it was the most elusive thing in the world, and its name sent ripples of anticipation down my spine: *Whitesloanea crassa*, probably the most unattainable plant in the world. Known from a few sightings in Somalia, the lexicon only contained sketches of a cube-shaped brown plant with dragonback-like ridges on its four corners. It mentioned that it was probably extinct but might still be present in the hands of some collectors. Will I ever set eyes on a living *Whitesloanea crassa*? (Remarkably, some plants have persisted among collectors, thriving in the hands of experienced growers. Periodically, seeds or specimens become available in specialized nurseries Figure1)



*Figure1: My Whitesloanea crassa, cultivated from seeds, in bloom on my windowsill. The flower emits an aroma akin to decaying flesh, and I have found starving fly larvae inside, abandoned by their bewildered mothers.*

Later, when I studied Biology, I frequently walked from my tiny house - part of a student living complex widely called "the rabbit hutches" - through the woods to University.

Sometimes, perhaps too often, I skipped the first lecture, but I would pack coffee and snacks. On the way in the woods, at a curve that went right, one could go left instead, through dense shrubs. You would end up at a small clearing, with a bleached beech stem becoming a perfect bench, to lay down, listen to the wind rushing through the surrounding beech and spruce trees, and drink my slightly intoxicating hot extract of *Coffee arabica*. This spot was strangely comforting and I reasoned that nature itself was a more enlightening teacher than a bored professor in front of a whiteboard.

Much later, again, I was living in a big city surrounded by oceans of concrete cake that was iced every morning in front of my door with puke from partying bypassers. My workplace was where hundreds of biologists happily rode on the concrete wave seven days a week from dawn to dusk. I was strangely sexually aroused by the provocative bloom sent out in the middle of winter by the mother bulb of *Amorphophallus konjak*. A reddish brown pinkish phallus emanated out of the soil line from the pot in front of the balcony

door of my shared apartment and erected to an astonishing size of 112cm within two weeks, opening up into a vaginal spathe with a reddish rod piercing out. This display of vitality evolved to satisfy its sexual desires by deception - as is the case for most flowers - and abusing the hunger of flies for rotting meat for its own. As the rod in the center of the flower starts producing heat, the fierce smell of a rotten corpse emanates from it, inviting flies to stumble across its reproductive organs so that pollen with its sperm cells may stick all over the fly and may be carried to another *Amorphophallus* flower.

Despite my fierce protest, my flatmate absolutely insisted the flower be taken out onto the snowy balcony.

Here, in this concrete jungle, I rediscovered my love for the small and succulent. It started with 6 tiny *Lithops* and quickly exploded into hundreds of rare and rarer succulents from the loneliest valleys of the Richtersveld to the unique specimens of the plant artisan Gerhard Marx, who breeds *Haworthias* with the most beautiful mother-of-pearl shiny patinas.

### **What is the meaning of love in Biology?**

In biology, the interpretation of behavior is classically addressed by asking Nico Tinbergens' seminal four questions (Tinbergen 1963); in the case of love, these questions are:

- (i) What are the mechanisms that cause romantic love?
- (ii) How does love develop over an individual's lifetime?
- (iii) What are the fitness-relevant functions of love? And
- (iv) What is the evolutionary history of love?

While the first two proximate questions can be answered descriptively by studying physiology, the latter two ultimate questions refer to functionality. The fitness relevant functions of love are reproduction, including mate choice, sex, pair bonding, caring for children, and establishing a social environment suitable for raising offspring.

Proximal causes for the success of sex are still one of the big mysteries in Biology. Why the need for sexual reproduction? Why are there, in most cases, only two sexes? Why are most animals separated into different sexes, but most plants are not?

One important purpose of sex is to exchange genetic material and produce a diversity of offspring that contain a big mix of genetic material which can adapt and evolve further.

Ergo, exchanging genetic material is a prerequisite for the emergence of romantic love during evolution.

### **Can I heal a plant's genetic disorder?**

So, while contemplating how to prove my love for plants, I also contemplated merging my genetic information with those from a plant. Of course, I was hoping that I could do something for the plant and that it would be consensual. As it is difficult to talk with plants, I further reasoned that if I could heal a plant from a genetic disorder through the contribution of a genetic package of my own, I should have done the plant a favor.

And this could, in fact, work, given our deep relatedness; the structure of many genes and proteins in organisms as diverse as, let's say, the weed in your front yard, and a primate is, in fact, very similar. Luckily, the weed in your front yard, the green little rosettes you pluck out beneath your freshly planted tomatoes, is a plant many molecular biologists love. Its name?

Mouse-ear cress, or in scientific terms *Arabidopsis thaliana* - or briefly and meaningfully familiar with its first name: Arabidopsis. From this modest weed, one can obtain plants exhibiting almost any genetic disorder; which is why molecular biologists love it so much. It contains all the features necessary to be a good "model" for genetics: easy to breed (it is a weed, after all), a relatively small amount of genetic information (its genome is small), and when you look at the flowers through magnifying glasses, they actually look pretty.

You can now shop online for plants with genetic disorders, briefly "mutants."

Something I always enjoyed when working with Arabidopsis as a scientist myself was venturing through the vaults of perfectly climatized growth chambers, enjoying the ocean of little green rosettes, with tiny white flowers, underneath the ever-roaring winds of the ventilation system and underneath the perfectly balanced blend of different colored LED lights, to produce the wealthiest menu possible for the little critters. Sometimes, one could discover new mutants that one of my colleagues was growing. Tiny plantlets, looking

like bonsai miniatures of the already small plant, or some with jawed, roughed-up leaf blades, some tortured with virus infections, others with multibranched inflorescences. When very fortunate, one could discover tiny, filled flowers, like miniature white roses, or even mutants that made little trees instead of ground-hugging rosettes. There is an almost endless possibility of plant shapes and growth habits that can be obtained only with mutants in *Arabidopsis*.

However, when looking at a very disfigured plant, it is virtually impossible to educatedly guess what the underlying mutation could be. Because it is relatively easy to mess things up.

One subtle mutant was very intriguing. *Arabidopsis* leaves typically form orderly rosettes with minimal rotation. Yet, one mutation can make the rosette twist into a helical, clockwise direction <sup>5</sup>. The underlying mutation (named "*lefty*" by the authors) that causes this twist is within a gene that encodes one of the basic molecular bricks of the cell. The dramatic macroscopic shift was a direct consequence of the underlying molecular shifts, a bit like removing one tooth from a tiny gear of a giant clock, causing the clock to go in the wrong direction - from clock- to counterclockwise. As this molecular brick is so fundamental to all cells, they are essentially the same in plants and people. Therefore, I toyed with the idea of isolating that gene from myself and introducing it into the *Arabidopsis* mutant with the wrong twist to restore its natural rosette structure.

Of course, this was only one gene mixed into the whole genome of the plant, which does not even come close to the sexual mixing of a complete set of a mummy and daddy genome. As I was thinking about which gene to tackle, how to do this technically, how to draw blood from myself, and not even considering the intimate foreplay that should be good manners before any consideration of mixing up genetic material, I was so amazed when I heard about the wedding of an Austrian artist with an ordinary rubber tree - *Ficus elastia*.



*Figure2: Thomas Feuerstein and his significant other. Picture from 7*

## **Marrying a rubber tree**

Thomas Feuerstein went all in for his work HONEYMOON <sup>6</sup>. He traveled to India, into a village that allows marriage beyond human boundaries, and married a stout and bushy rubber tree (Figure 2).

Although, according to the description of his honeymoon from 1996, the rubber tree served merely as a "metaphor for exoticism and a symbolic residue of nature in houses and flats", he still went beyond the ceremony. He was determined to have a biological unification with his spouse. In collaboration with a

Swiss institute, he coated tiny gold particles with his own DNA and bombarded those genetic-coated gold particles into the tissue of the rubber tree.

This might sound a bit wild to the non-accustomed reader. The reality is that this so-called gene gun used for gold particle bombardment is much more boring of an instrument than one would imagine, given the spectacular name. It consists of a little chamber where - in this case - tissue of the rubber tree is put. On top of the chamber, a hole connects to a second chamber, and there, you place a little net with the coated gold particles. You switch on a pump that sucks out the air from the chambers, and when a very low air pressure is reached, a valve is opened, and the air which shoots through the chambers takes the gold particles along a journey into the cells of the plant. By mere chance, once in a while, a bit of coated DNA will be incorporated into the genome of one of the plant cells. And now comes the - to me much more wondrous event - the regeneration. As is the case for most plants, it is very easy to clone rubber trees; every gardener and plant breeder knows this

intuitively. You just take off a branch, root it, and have a new plant. The same is true not only for a branch but also for less tissue, and you can regenerate a whole plant from a bit of tissue bombarded in your gene gun.

It is very exciting to perform this procedure precisely three times. After that, it gets boring; it is an endless coating of gold, mixing, drawing a vacuum, releasing, rinsing, and doing it again.

Whether the biological marriage of Thomas Feuerstein and the rubber tree (unfortunately, it is not mentioned by name; imagine, you announce your marriage to a "human" ) was successful, we will never know, as the director of the mentioned Swiss institute was not happy about the prospect of creating human-rubber tree chimeras and ordered the destruction of the plants that were regenerated after these "experiments" or rather attempts of "honeymoon."

This may also be why we find so little information about this honeymoon in Switzerland in 1996.

### **The Swiss Case**

Despite the fear of the head of the institute, it seemingly did not influence - at least not in disfavor - the Swiss gene technology referendum in 1998. Swiss citizens had to vote over whether to enforce strong restrictions on the ability to use gene technology in research and application. After an intense debate, a clear majority voted against restrictions; however, a couple of years later, a majority voted for a temporary ban on using gene technology anywhere but outside of basic research. This also explicitly included plants.

Due to the fierce discussions surrounding this vote, a Swiss ethics commission for the non-human was established in 1998. This commission encountered the following problem: why would it be unethical to perform gene technology on plants? Suppose plants are highly sophisticated sun-gathering automates, machines shaped by evolution over billions of years, and call insects sexual facilitators. Why should it be unethical to modify their software, aka genes? It would be like forbidding an engineer to modify a computer's software because some people believe that computers are heavenly creatures and their software should, therefore, not be messed with. But are plants synonymous with computers in their ability to perceive the world? To solve this, it was incorporated that plants - as all creatures shall

possess dignity, and the Gene technology law, effective as of 2004, states: "The Confederation shall legislate on the use of reproductive and genetic material from animals, plants and other organisms. In doing so, it shall take account of the dignity of living beings as well as the safety of human beings, animals and the environment, and shall protect the genetic diversity of animal and plant species." <sup>1</sup>

Consequently, researchers, including those in plant research applying for grants, were required to clarify how they considered plant dignity in their work. This requirement led to a dilemma: neither the researchers nor the ethics commission knew what it meant to acknowledge plant dignity, let alone how to apply this concept. It took the ethics commission four years to develop a five-step decision tree addressing this confusion, a feat that earned them the peace Ig Nobel Prize, an award given annually for particularly unusual research <sup>8</sup>. Notable past winners include fellow Swiss researchers who, in 2009, investigated whether it's more harmful to be struck on the head with a full or an empty beer bottle, and the mayor of Vilnius, Lithuania, Arturas Zuokas, who in 2011 demonstrated how illegally parked luxury cars could be dealt with by driving over them with a tank.

In their guidelines, the ethics commission stated that every organism should have the right to reproduction that facilitates the natural continuation of its species. However, a slim majority of the commission disagreed with the idea that species as a whole should maintain their dignity and, consequently, their reproductive autonomy. This implies that Thomas Feuerstein's experiments with interspecies hybridization do not infringe upon species dignity, as per the ethics commission's stance. Nevertheless, this viewpoint overlooks potential ethical dilemmas around consent.

## What is plant dignity?

Let us have a look at the decision tree produced by the Swiss Ethics commission (Figure 3).

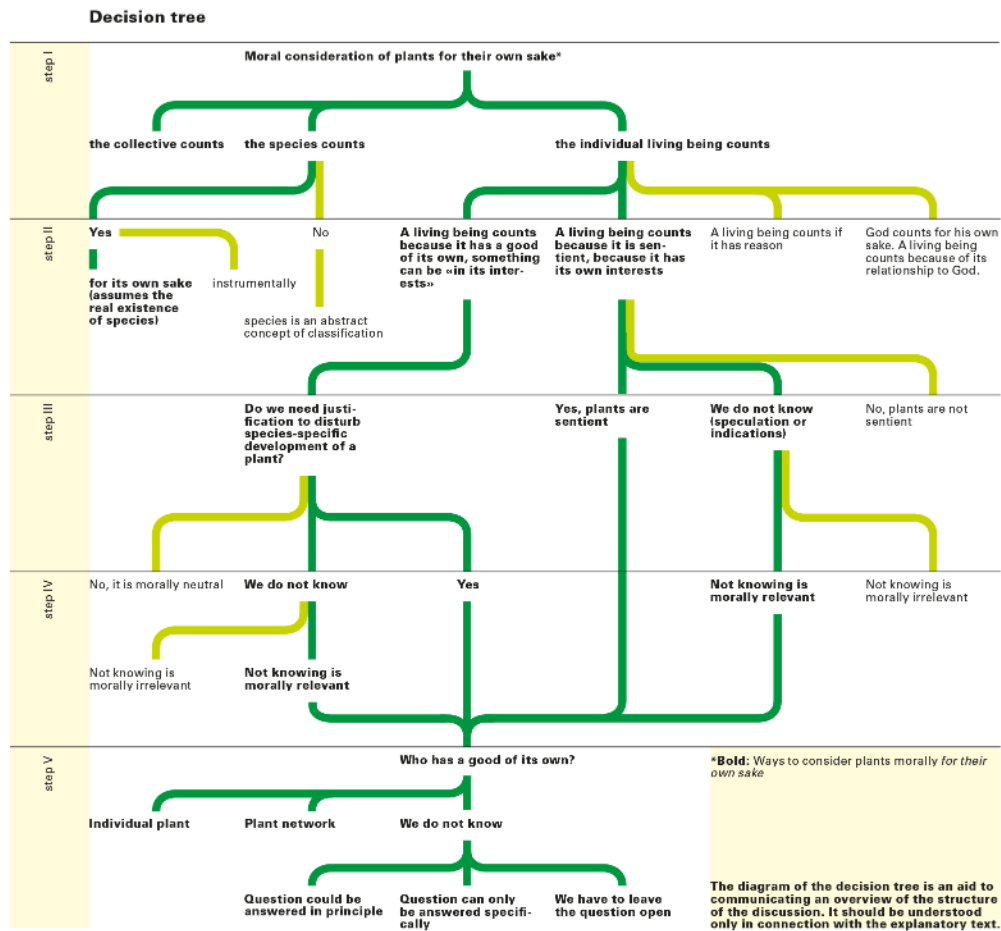


Figure 3: Decision tree for the moral consideration of plants for their own sake by the Swiss Federal Ethics Committee on Non-Human Biotechnology. From <sup>9</sup>

The decision tree, thoroughly detailed in the accompanying text <sup>9</sup>, navigates the thought process through five steps. Each step may conclude at a branch or progress to another, leading to the subsequent stage. At every step, the agent is categorized into one of three value estimations: instrumental value (e.g., an agent is valuable because it serves another), relational value (e.g., an agent is valuable due to its relationship with another), or intrinsic value.

The first step determines the focus unit, which could be the collective, the species, or a single organism. Intriguingly, some theorize that a plant isn't a solitary agent but a collective of units capable of independent growth and propagation, as evidenced by the possibility of generating offshoots from many plants. From this perspective, a tree would be considered a colony of individual agents.

Step II explores the causality behind a plant's intrinsic value. Does it stem from plants being goal-driven agents? Do plants possess interests and the capacity for emotions?

Step III questions whether plants, if capable of emotions, can experience positive or negative feelings. Step IV, acknowledging our uncertainty in this area, ponders the significance of this ignorance in ethical decision-making. Step V circles back to the potential agency's unit: Is it the plant community, the individual plant, or, considering their modular architecture, a part of the plant to which our conclusions should apply?

Notably, an outcome from navigating this decision tree by the ethics commission recommends that the genetic modification of plants does not violate their dignity unless it hampers their reproductive capacity and, thereby, their evolutionary potential. This reminds me of Dr. Ian Malcolm's warning in Steven Spielberg's Jurassic Park: "Life finds a way."





# Where do rubber trees come from?

## How plants make babies

Plant sex and reproduction are astonishingly intricate. Much more complicated than in humans.

This is why, in university botany courses, one starts by learning about the sexual systems of the simplest plants, unicellular algae, and then progresses toward increasingly complex organisms. The grand finale of this educational journey are flowering plants, with their shameless display of sexual organs.

However, I'll admit that algal sex never enticed me. So let's fast-forward a few hundred million years to explore organisms already quite advanced compared to algae but still primitive compared to other land plants: Ferns. Picture a rainforest brimming with a diversity of ferns, birds nest ferns, elephant ferns, and green penny ferns; amongst them, young naked men caressing the long fern fronds, slowly licking the young nestling unfurling leaves. This disturbingly arousing video of the Taiwanese artist Zheng Bo from 2016 <sup>10</sup> goes on: The men move slowly, in an attempt to attune to the speed of ferns; one of them copulates with a bird's nest fern before eating the young leaves.

The artist provokes a surprising emotion: it feels almost sacrilegious to eat the fern after such an intimate interaction. Eating the creature that was intimately loved just moments ago appears cannibalistic.

The act blurs the boundaries of consent and raises questions about interspecies relationships. Despite the ferns' ancient lineage and exquisite beauty, they appear vulnerable—mere passive subjects to the men's impulses.

Zheng Bo portrays ferns as queer plants for queer people. The notion seems contradictory, considering ferns are essentially asexual, making any form of sexual engagement inherently against their biology. But how do ferns actually reproduce?

Observant wanderers may have noticed tiny brown or grey capsules on the underside of fern leaves. These are not seeds but spores, which are washed down into the soft forest litter by rain.

Now comes the thing that is so fundamentally different from reproduction in animals. Each spore does not develop into a new fern but into a small heart-shaped greenish structure, the so-called prothallium - that is, in most cases, able to produce both sperm and egg cells. These then undergo the act of fertilization, and from the resulting embryo, a new fern emerges. It is as if the fern does not want to engage in sex but makes a tiny mini-me mediating those frivolous activities. Imagine, if a little homunculus would grow from our sperm and eggs, which we could then observe having sex on our behalf.

What about flowering plants, to which rubber trees belong? Like ferns, they also employ a generational shift in their reproductive strategy, but with a modern twist. The process has been modified in "higher" flowering plants, with specialized leaves producing spores that grow into male or female "homunculi." These miniaturized beings, deprived of autonomy, are nurtured within the flower. The male "homunculi" are commonly known as pollen, while the female counterparts reside within the ovary.

A pollen grain is an extremely reduced version of a plant, so thoroughly reduced that it only contains two sperm cells and one other cell which acts as a proverbial wingman, devoting itself to ensuring the sperm cells' success. The female "homunculi" does not leave the flower but sits right in the centre of the ovary - the structure that develops into the fruit - and awaits the arrival of the sperm cells, which are pushed out from the pollen grain once it arrives on its landing platform - the stigma - delivered by either wind, or an animal, and channelled towards it.

Ironically, despite relinquishing the autonomy of sexual intermediaries, many flowering plants now rely on animal agent facilitators for pollination—be it insects, birds, bats, lizards, mammals, or even humans.

To facility the love life of plants struggling with pollinator scarcity The Plant Sex Consultancy adopts modern design strategies <sup>11</sup>.

This group targets vegetal clients and devises specialized 3D printed tools for assistance. A case in point is the *Cyclamen* (e.g. *Cyclamen persicum*), commonly found in sparse forests of Southern Europe during spring. This plant species lost its original pollinator, a large bee capable of vibrating the flowers to extract pollen <sup>12</sup>.

In response, The Plant Sex Consultancy developed the “Cyclamen Pollinator Vibrator”, a vibrating pod with a sensor that gently grips the flower. Activated by an insect's caress, this pod gyrates, scattering pollen onto the helpful hexapod.

While the project admits that “the reproductive augmentations conceived through this project are critical discursive objects rather than pragmatic design solutions”, it also highlights the pressing issue of declining insect populations, crucial for pollination and overall ecosystem health <sup>13</sup>.

After fertilization, an embryo forms within the nourishing maternal tissues. It is still nourished by its maternal surrounding tissue and becomes first a tiny ball, next a tiny heart, and finally a tiny plant, with one or two leaves, a little stem, and a tiny root, neatly folded together, surrounded by nurturing tissue, and a hardened shell - cutting all bonds with its caring parental tissue. These structures are called seeds, and each seed is a pod with a tiny plant inside that has been desiccated and can survive over incredible distances and harsh environments.

### **Where do rubber trees come from?**

So, how do the rubber trees reproduce? The rubber tree, *Ficus elastica*, is part of the fig-tree genus (*Ficus*), which comprises around 800 species, mostly native to tropical and subtropical regions <sup>14</sup>. This genus includes the common fig, a popular fruit-bearing tree in the Mediterranean, now increasingly found in temperate gardens and parks. The common fig, *Ficus carica*, might be humanity's oldest companion plant, with evidence of cultivation in the Middle East dating back over eleven thousand years <sup>15</sup>.

*Ficus* species have significant cultural and spiritual importance; for instance, the Christian Bible mentions the fig tree as the first plant, with its leaves used by Adam and Eve to cover themselves. Siddhartha Gautama, known as the Buddha, attained enlightenment under a sacred fig tree, *Ficus religiosa*. A

cutting from this tree, brought to Sri Lanka by a daughter of Emperor Ashoka in 288 BC, still grows in the sacred city of Anuradhapura, now over 2300 years old <sup>16</sup>.

*Ficus* species vary in form, from small creeping vines to towering rainforest giants. Many tropical species develop aerial roots that transform into secondary stems, contributing to their mythical appearance. Despite its name, the rubber tree -*Ficus elastica* - is not the source of natural rubber, which is mainly harvested from *Hevea brasiliensis*, a non-related species. *Ficus elastica* does produce a milky white latex but has never been exploited economically. Interestingly, in the northeastern part of Meghalaya, India, the broad curtain of aerial roots from large *F. elastica* specimens is woven into living bridges over jungle rivers, enduring for centuries.

The reproductive cycle of *Ficus* species, as it will be shown, is a saga of sexual enslavement, mutualism, feasting, violence, murder, and magnificence.

In all *Ficus* species, sexual reproduction depends entirely on a tiny wasp, and many *Ficus* species shepherd their own or even several wasp species <sup>17</sup>. Flowers of figs are minuscule, unattractive, and deeply buried within an inflorescence that looks like a tiny fig.

The entryway at the tip of this tiny fig is lined with inward-facing teeth, which make retreat impossible. During the arduous journey into this inflorescence, the female wasp often loses its wings and, occasionally, its antennae and legs. Despite these sacrifices, the wasp carries pollen in pockets on its underside that it has actively collected from its birthplace - a fig.

Once inside, the female wasp sets out to lay eggs in the female flowers. She encounters two types of flowers: those with long styles and those with short ones. Her ovipositor, the organ she uses to lay eggs, can only reach the ovules of flowers with short styles. In some fig inflorescences, all the female flowers have long styles, rendering the wasp's reproductive efforts fruitless—a tragic end for the wasp that will die without being able to reproduce. For those flowers she can fertilize, the wasp injects an egg along with a cocktail of chemicals that prompt the flower to grow tissue to nourish the developing larva. As she lays her eggs, she also deposits pollen onto the styles of nearby female flowers. Then she dies.

Male wasp larvae mature faster than females and, upon emerging, have two missions: to mate and facilitate escape. They chew holes through the ovules that contain the immature females and mate through these openings. Then they work collectively to chew an exit hole in the fig. The sudden inflow of fresh air reduces CO<sub>2</sub> levels inside the fig, which has three effects: it kills the male wasps, prompts the maturation of male flowers, and aids the development of female wasps.

Once mature, female wasps chew their way out of their breeding chambers, gather pollen from the newly matured male flowers, and exit through the hole created by the males. Armed with pollen and fertilized eggs, they embark on a quest to find a new host fig where they can lay their eggs and perpetuate the cycle. Meanwhile, the fertilized female flowers transform into fruits, becoming a feast for various animals.

If a bird consumes the fruit, the seeds might be deposited, via droppings, onto another tree, maybe one of those giant jungle trees. From the fruit, a small rubber tree grows high up on the branches of this other tree. It may even be part of a hanging garden of epiphytes, ferns, moss, and other little trees. Over time, the rubber tree grows bigger, sending roots down towards the forest floor. When reaching the ground, these roots thicken and sprout trunks that engulf the host tree.

As the rubber tree matures, it starts shading its host and monopolizes the resources in the ground, slowly killing its host and seizing its decomposing nutrients.

The next time you glance at your little rubber tree sitting beside your computer, consider the macabre journey that led it to you.

## The Arrival

So, I wanted (again) to own a rubber tree for my home office desk. What better source than to ask Thomas Feuerstein if I might get a branch of his spouse? I wrote him an email:

Dear Thomas Feuerstein,

I hope this letter finds you and your family in good health and high spirits. I am writing to you today with utmost respect to discuss a matter of great importance to me.

Throughout my life, my heart has been captivated by the enchanting world of plants. My earliest memories take me back to my childhood in Australia, where I once dug out a prickly pear cactus from the sidewalk on my way home from kindergarten. Its green, bubble-like form bewitched me, and unbeknownst to my younger self, these bubbles were quiet invaders, steadily yet resolutely claiming the vast expanse of the outback.

The first plant sitting proudly on the cabinet of my first room was a tender *Ficus elastica*, which I watched seemingly for hours, trying to observe the moment when the young new leaf peels from its phallus-like stipules. Alas, the memory of what became of that dear companion eludes me, and it remains a regretful mystery.

Time's passage saw me retreat from the omnipresence of rubber trees, tainted by the voracious gears of industrial production. My heart sought and found solace among the intriguing green denizens from South Africa's embrace; beings that whispered tales of endemic rarity and ecological humility. However, the siren call of my inaugural botanical infatuation—the unassuming rubber tree—echoes with growing resonance.

In one of your lectures at the Angewandte, you revealed your intimate bond with a diminutive, yet luxuriant *Ficus elastica* (do they have a name?) and your endeavors to foster biological offspring. This revelation sparked this idea within me, leading to this heartfelt request. I humbly seek your permission to obtain an offshoot or branch of your beloved *F. elastica* to root and provide it with a new home and companion.

As I acknowledge the complexities surrounding this kinship, I understand that we must navigate the nuances of our connection. Perhaps, dear Thomas, you emerge in the role of my familial patriarch or, intriguingly, as a brother, our bond cemented by your spouse.

Amidst such layered dynamics, my assurance remains steadfast: an unwavering allegiance to our shared botanical kin, fostering it with affection, sustenance, luminescence, and perhaps, a lineage of its own.

I would be honored if you would consider my request, and I eagerly welcome the opportunity to discuss your wife's dissemination further. Your insights and thoughts are of immense value, and I am wholeheartedly open to addressing any queries or concerns you may have. Thank you, for lending your time to absorb this letter. I await your response with bated breath.

Sincerely,  
Ruben Gutzat,

With the collaborative assistance of chatGPT-3.5

Unfortunately, he never replied; either he did not read my email, he did not fancy becoming related to me, or he did not want to break an organ off from his wife (which is understandable), so I had to find another source of Rubber Trees.

Ideally, I wanted to rescue a distressed rubber tree and not buy one from a generous gardener or nursery. Initially, I set my sights on saving a commodified rubber tree from mass retailers like Ikea, Penny, Lidl, and Hofer. The unfortunate thing was that none of them offered rubber trees - so I expanded my horizons to hardware stores, OBI, Bauhaus, and franchised garden centres Bellaflora and Dehner. Ultimately, at Dehner, I identified the possibility of getting my rubber tree.

As is my habit, I couldn't make a purchase—of any kind, from any place—without conducting thorough background checks on both the commodity and the salesman.

How many stars do the commodities have on Google? How many stars does the salesman have? Of course, I was aiming - in this instance - for the least stars and the most abused rubber trees I could get - as my mission was not merely to acquire one but to rescue one!

From Dehner, I learned that the rubber tree is a classical room plant; Bellaflora writes that the rubber tree is a retro plant, becoming modern again. Pflanzen-Kölle writes that rubber trees are popular, robust, and convey an exotic flair.

As there was only one Dehner store currently offering rubber trees, there was little for me to do except compare the reviews of different Dehner stores that were close by. As this comparison yielded little to distinguish one shop from another, I resorted to simply choosing the cheapest rubber trees I could find.

I thus dragged myself to the Dehner store in Simmering, where a whole shelf was dedicated to various-sized rubber trees, different varieties and different individuals (Figure 4). Trying to listen, trying to look, trying to examine. They all looked very similar. One *Ficus elastica* "Belize" with pinkish whitish variegated leaves at least had a crooked stem. This one was 12.99€, at least one of the cheapest. I found my new companion. But I did not want them to be alone. So I chose another tree of the same size - also for 12.99 - of a *Ficus elastica* "Abidjan" - a specimen with dark green leaves.



Figure 4: The shelf of rubber trees at the Dehner store  
Simmering / Vienna

## **The long history of plants and humans**

Why do we even desire to have plants in our houses?

As primary producers of all terrestrial ecosystems, the presence of plants is intricately convoluted with the evolution of animals, including humans.

However, some plants have taken this relationship a step further, luring humans into a dependency that transcended biological evolution and enabled cultural coevolution. These plants have initiated a positive feedback loop with humans, their most reliable cultivators, allowing them to dominate almost all ecosystems.

From the human perspective, this is the "invention" of agriculture, which permitted the development of human culture allowing the spread and inheritance of memes to proceed orders of magnitudes faster than the spread and inheritance of genes.

Fire allowed the evolution of humans with reduced jaw muscles, more efficient calorie absorption from food, and more calories to burn for a luxurious brain.

Agriculture catalyzed the evolution of culture by enabling calorie-dense food production in small areas, which in turn allowed for human settlements, specialisation of labour, and the distribution of knowledge, ultimately giving rise to capitalism <sup>18</sup>.

Yet plants are more than just calorie sources or feed for livestock. They are nurtured and cultivated for their aesthetic and medicinal properties. Isn't it remarkable that flowers, specifically designed to attract pollinators such as bees, butterflies, and birds, also captivate humans?

The bee and the human appreciate the same structures and the same smells! As I write this, I see a bee nervously crawling through a meadow of oregano flowers, putting its proboscis for seconds only in each flower, crawling over the inflorescence, and briefly flying from stem to stem. And I imagine this bee, feeling the buzz of being awake, working efficiently, tirelessly, and feeling the satisfaction of having done everything possible to prepare the colony for winter.

This shared appreciation across species could be seen as evidence of a universal, objective beauty—or perhaps it simply highlights our deep-rooted evolutionary kinship with insects.

Equally fascinating is the ability of plant compounds to influence human psychology. For example, nicotine, a superstrong neurotoxin against herbivorous insects, has an intoxicating and strangely addictive effect on humans. The list of human-active plant ingredients is very long and diverse, including phytoestrogens found in wild yams that can serve as precursors for synthetic progesterone and gestagens used in birth control.

Many plant compounds are also potent poisons and can block hormone receptors in the animal body. For every possible psychoactive or hormonal compound in animals, one will find a mirror image in the world of plants, where it is used to repel, attack and manipulate the animals. This again shows the intricate evolutionary history of co-dependency and deep relatedness.

The history of houseplants traces back to ancient Egyptians and Sumerians, who cultivated palm trees in containers <sup>19</sup>. During the Renaissance, Europeans became fascinated by the exoticism of plants discovered and brought back by botanists from tropical colonial regions. The very first portrait of Charles Darwin depicts him as a child, proudly holding a terracotta pot, which appears to contain a flowering dwarf aloe (*Lachenalia aloides*), from South Africa's Western Cape <sup>20</sup> (Figure 5).

Studies have indicated that houseplants can influence room air quality (although these effects are often negligible), and reduce stress, symptoms of depression, and negative emotions <sup>21</sup>.

Today, the global indoor plant market is valued at approximately 18 billion USD and is projected to grow to 27 billion USD by 2030 <sup>22</sup>. *Ficus elastica* is among the most popular houseplants and is featured as a typical houseplant in the English Wikipedia article titled “Houseplant.”



*Figure 5: Portrait painted by Ellen Wallace Sharples in 1816 of Charles and his sister Catherine Darwin. Charles Darwin was a succulent aficionado from a very young age! Picture from <sup>20</sup>*

## Where do our companion rubber trees come from?

Most labels on plant pots don't specify the origin of the "product." Instead, there's often just a number that appears to be linked to an EU passport. However, in my local flower shop around the corner, I found a rubber tree with a label from the "producer," RM Plants.

I became curious: Where do these rubber trees truly originate? Is there a colossal "mother" rubber tree that is continuously harvested? Could it even be possible that all the rubber trees we see globally, whether as houseplants or as outdoor plants in warmer climates, come from a single, massive holy Banyan tree hidden deep within an Asian rainforest?

So, I set out to discover where RM Plants sources their rubber trees.

## RMplants Commercial Team



*Figure 6: The friendly Staff at RM Plants, Always Eager to Assist. Picture from <sup>23</sup>*

## Email to RM plants (Figure 6):

Subject: Origin of *Ficus elastica*?

Dear Mauro Brenna and Rémi van Adrichem,

My name is Ruben Gutzat, and I am associated with both the Gregor Mendel Institute in Vienna, Austria and the University of Applied Arts' Art & Science program in Vienna. I have a profound interest in rubber trees, and alongside my scientific pursuits, I am involved in artistic research. My focus is on tracing the journey of young rubber trees (*Ficus elastica*) to our local garden centers. I'm keen to understand their genetic diversity and their transportation pathways.

I would greatly appreciate it if you could provide answers to the following questions:

- Do you breed or propagate the rubber trees you sell at your nurseries, or are they sourced from elsewhere?
- Are the rubber trees you offer primarily clones from specific mother trees or are they grown from seeds?
- If they are clones, are you aware of the locations of the mother trees?
- If they from seeds, where do you purchase the seeds from?

Any information you can provide would be immensely valuable. I must note that it's quite rare to find plants in garden centers with clear origin labels, so I'm particularly fond of RM plants ;)

Thank you very much for your assistance with this matter.

Warm regards,

Ruben Gutzat

Answer RM Plants:  
Subject: RE: Origin of Ficus elastica?

Hello Ruben,

We don't produce Ficus Elastica ourselves, we just trade these plants.

We buy these plants from several suppliers in holland, spain and sometimes Italy.

So for me difficult to give you answers on your question nr 3-3 & 4 I really don't know.

Best regards  
Rémi

Further inquiry helped nothing; suppliers' names are apparently protected by European privacy laws.

So I asked chatGPT

Where does Ficus elastica that is sold in garden centers come from?

ChatGPT:

The Ficus elastica, commonly known as the rubber plant, rubber fig, or Indian rubber bush, is native to regions in South and Southeast Asia, including countries like India, Nepal, Bhutan, Burma, Malaysia, and Indonesia. In its natural habitat, Ficus elastica can grow as a large tree, but it is often cultivated as a houseplant in many parts of the world.

The plants you find in garden centers are usually cultivated varieties specifically bred to thrive in indoor conditions. These are often grown in greenhouses and nurseries, sometimes quite far from their original native regions, to be sold as houseplants. Ficus elastica is popular for its attractive foliage and its relatively easy care requirements, making it a favored choice among houseplant enthusiasts.







## Getting to know Betty and Bossi

### Why rubber trees?

I am really bored of rubber trees. What I wrote to Thomas was correct. The first plant I owned in my own room was a rubber tree that I got from my Uncle - I was really fascinated by its young leaves, how they peel out from the red sheath surrounding them, and I really watched it and hoped I could see it growing.

But since I figured out that everyone has a rubber tree at home or at his or her boring office, in his or her boring laboratory, and even supermarkets sometimes sell rubber trees, my fascination vanished.

In my opinion, rubber trees are the epitome of dull plants: unremarkable stems, large but uninspiring leaves, and an absence of any feeling of luxury or uniqueness. Over time, the leaves will get dusty, and people spraying them with tap water will paint a grey layer of magnesium and calcium carbonate on the leaves. Most are also deprived of sufficient light, leading them to become elongated, slender, and ultimately unable to stand on their own.

In fact, rubber trees must be among the top 10 most boring indoor plants, challenged only by close relatives like *Ficus benjamina*, or the once-exotic *Phalaenopsis* orchid, and others like *Dieffenbachia*, the "Efeutute", *Dracaena*, or the modest Snake Plant (*Sansevieria*). And let's not forget the nicely named Peace Lily *Spathiphyllum*, another strong contender for the most uninspiring office plant.

These plants are almost proof that there is a God who created these plants to be put in pots with artificial soil or bubbles of blown-up fired clay, hydroculture to decorate large offices in large cities around the world. Made for people who might think the categories "green plants" and "flowering plants" in a garden centre are scientific distinctions or who mistake their cactus' desperate attempt to reach a few more photons for lunch in rapid, anorexic growth as a sign of their "green thumb."

However, there are some houseplants that I do find intriguing, like the Spider Plant (*Chlorophytum*), which grows in a simple yet pleasing rosette pattern and sends down baby plants like gems on a chandelier. Then there's the Monstera, with its thick aerial roots. Every time you look at it, you wonder, why are there holes in the leaves? Is it to have less wind resistance? Is it because some herbivores might be disgusted by a seemingly already chewed-on leave? Is it because some Butterflies would not dare to lay their eggs on the leaves because they think it is already home to a kindergarten of caterpillars? Or is it simply to provide more light to the leaves below?

I like it when a plant can make you think: Orchids that smell like bubblegum (e.g. of the genus *Stanhopeinae*), *Astrolochia* flowers that mimic the shape and the smell of forest fungi

(e.g. *A. arborea*), tiny succulents from Namaqualand that mimic the shape and colour of hyaena-droppings (*Avonia papyracea*).

So, why is it that among the 400000 species of plants each with unique colours, shapes, and growth habits, including the most unlikely colors, forms, shapes, and growth habits, with Cacti growing underwater (*Strophocactus wittii*), *Tillandsia* growing in the air (*Tillandsia*), plants that lay out traps and catch flies in tiny bear-traps (*Dionaea sp.*), —we end up with a handful of dull, non-edible plants adorning our offices (Figure 7) and homes worldwide?



Figure 7: A two-stemmed *Ficus elastica* variety "Abidjan" in the AI booth of dynatrace.com at the Ars Electronica Festival 2023 in Linz, a company dedicated to simplifying cloud complexity with AI. I could not determine the connection to *Ficus elastica*.

## **My two new companions**

I shall give my two future companions names. I don't like cooking, and I don't like cats. In Switzerland, there's a popular product line aimed at home cooks, sold at the "Coop" supermarket, called Betty Bossi. A good friend of mine named his two cats after this brand. One of the cats had a squint and couldn't catch anything that moved faster than a millipede, while the other seemed socially awkward and disliked going outdoors. These cats were my favourites because they were unlikely to harm birds or other small animals.

Anyway, I reasoned that this was an appropriate name for the two little rubber trees, as one of the cats was black, and the other black and white - just like my very dark-leaved and variegated rubber tree. The "Abidjan" was becoming "Bossi" and the variegated one "Betty".

I place them on my desk and watch (Figure 8).

As my fingers glide over their firm leaves, I feel the strong, round midvein branching into delicate, parallel secondary veins, stretching towards the leaf tips. The leaves' upper surface, shining like premium photo paper, is glossy and smooth, while the underside, with its matte texture, reveals the vein patterns under my fingertips.

Sturdy, rounded connectors, the petioles anchor each leaf to the stem. The leaf's tip is smoothly rounded, ensuring it's not sharp against the thumb.

The stem's base exhibits a woody texture - the bark of a baby tree – and gradually melts into a soothing greenish middle.

It feels smooth, warm, slightly elastic, yet firm upon a gentle squeeze. The youngest leaves are glossy on both sides and less rigid but already exhibit a tactile robustness akin to that of a plastic bag.

The not-yet-born leaf is cradled within a red sheath crafted from transformed structures of the leaf base, the stipules. It resembles a slender, stretched flower bud.

Intuitively, I begin to measure them.



*Figure 8: Betty and Bossi have to live with my mess.*

Bossi, sitting in a 17 cm dark pot:

14 leaves, arranged in  $120^\circ$  angles around the stem.

Stem at the base (ca 5 cm above the soil) ca 1,5cm diameter,

31cm long until the last branching point to the leaf.

Wooden structures only for the first 8cm.

Length of the hidden next leaf: 2,7cm.

Total height (from the top of the pot to the last branching point): 30,7cm

First leaf at 2 cm above the soil.

Largest leaf: (the 12th counting from the bottom) total length: 31.9cm,  
length of petiole: 4,4cm, largest width: 15cm

Smallest leaf: 1st: total length: 12.5cm, petiole: 1.3cm, broadest width: 6.1cm

Betty, also in a 17cm pot:

17 leaves plus one just peeling out of the protective stipule, also in 120° angles around the stem.

Stem at the base ca 1,4cm, 48cm long, wooden structure first 16cm, but some also emergent at the base of leaves (from bottom) 8-9, leaf 13.

Stem slightly S-form, total height of the plant 31,9cm (from top of pot till last branching point, or the SAM). First leaf at 4cm,

Largest leaf: 12: total length: 27cm long, petiole 5cm, largest width: 13,2cm.

Smallest leaf: 11.8cm total, 2.3cm petiole, 6cm largest width.

I was unsatisfied with my measurements. Questions arose:

What is the size distribution of Betty and Bossi's leaves? Is there a gradient in leaf size between the largest and smallest leaves, or are there outliers? Do leaves progressively get larger with the plant's height? How do these measurements change over time?

I continued to measure all leaves and repeated this measurement at regular intervals.

I considered having Betty and Bossi undergo comprehensive "phenotyping." Phenotyping involves measuring a plant's three-dimensional morphology, and modern methods employ conveyor belts to transport potted plants through various chambers (Figure 9). In each chamber one parameter is measured, such as the plant's physical structure in three dimensions, chlorophyll fluorescence intensities, and varying color transmissions. This process generates huge amounts of data per session. Analyzing this data involves segmenting the images to reconstruct Betty and Bossi's form and developing algorithms for automated processing (Figure 10).

However, given that Betty and Bossi are not standard "model" plants and may well be the first Ficus trees to be phenotyped in such detail, this task poses significant challenges. The computers in the phenotyping facility I experimented with, which are not advanced general intelligence (AGI) systems, have shown limitations. For example, an incorrect barcode on a pot can lead to substantial confusion and data processing errors (Figure 10). Therefore, I returned to manually measuring the previously measured parameters over a period of 95 days.

After collecting all the data, it's now the moment to delve into it, searching for patterns and unearthing the rough gemstones of potential hypotheses.

First, estimating the measurement error would be crucial simply by repeating the same measurement and observing data variation. This step would be particularly vital if multiple people were involved in the measurements, as different individuals might have slightly varied techniques in using or reading the ruler. Next, conducting "blind" measurements would be important to avoid bias. For instance, if I hypothesized that Bossi grows faster than Betty, I might subconsciously confirm this bias by rounding Bossi's values up and Betty's down.

Fortunately, I am alone, and I do not have a hypothesis. After all, my goal isn't scientific rigor but to understand Betty and Bossi better.

I approximate leaf area using a correction factor (CF) of 0.69, assuming an elliptical leaf with a length-to-width ratio between 10:1 and 1:1<sup>24</sup>. I plot leaf size in cm<sup>2</sup> over time against leaf number (Figure 11). Over 95 days, Betty produces three new leaves, Bossi only one. Had I wagered on this outcome, I would have lost. Despite Betty's pinkish-red variegated leaf margins having less surface area for photosynthesis than Bossi, they grow much faster.

Until leaf number 11, Bossi shows a clear correlation between leaf size and position on the plant (1 being the first leaf above the soil). Leaf growth only occurs when they are young, confirming that plants grow only at their shoot tips (true for internodes as well). Then, an outlier: leaf number 12 is almost a third larger than all other leaves, including those that follow (leaves 13-15). It seems Bossi expended all its energy on leaf number 12, after which leaf size decreases again. Betty's growth pattern is more chaotic. The first anomaly occurs at leaves three and four: did leaf three shrink since the first measurement, and leaf four grow? Observing Betty confirms my suspicion: leaves three and four are very close, perhaps leading to an accidental switch in measurements initially? Alternatively, could leaves three and four be anomalies that defy known plant developmental physiology?

Betty's leaf size then becomes a rollercoaster: up, down, and even further down at leaves nine and ten. Why did Betty produce these smaller leaves as

a young plant? What adversities did Betty face? Malnutrition, excessive heat and light, or perhaps a lack of light? Betty recovers with leaf number 11 and, astonishingly, peaks with leaf number 12 – mirroring Bossi.

During my tenure as Betty's caretaker, leaf size slightly decreased again, suggesting that leaf size doesn't necessarily correlate with well-being, given my diligent care.

This leads me to ponder: what is special about leaf number 12? Could all rubber trees have a massive leaf at this position? Can rubber trees count? Are we on the brink of a new understanding of rubber tree growth and “rubbertreeness”? What if all trees had their largest leaf at position number 12? Does leaf number 13 know when leaf number 1 falls off?

Leaf size might not be as thrilling a variable, but if all plants producing at least 12 leaves have their largest leaf at position 12, that's intriguing. I envision international plant physiology conferences titled “Genes, Chromatin, and DLM” (DLM being the acronym for Disciples' Leaf Mystery). In global agribusiness conference rooms, researchers from different fields fiercely debate how to harness the growth power of the 12th leaf for the fruits of major commercial crops.

Before getting too excited, I should conduct further tests. What would happen if I start pruning the leaves of Betty and Bossi?



Figure 9: Betty and Bossi are on track to generate 1Gb of data

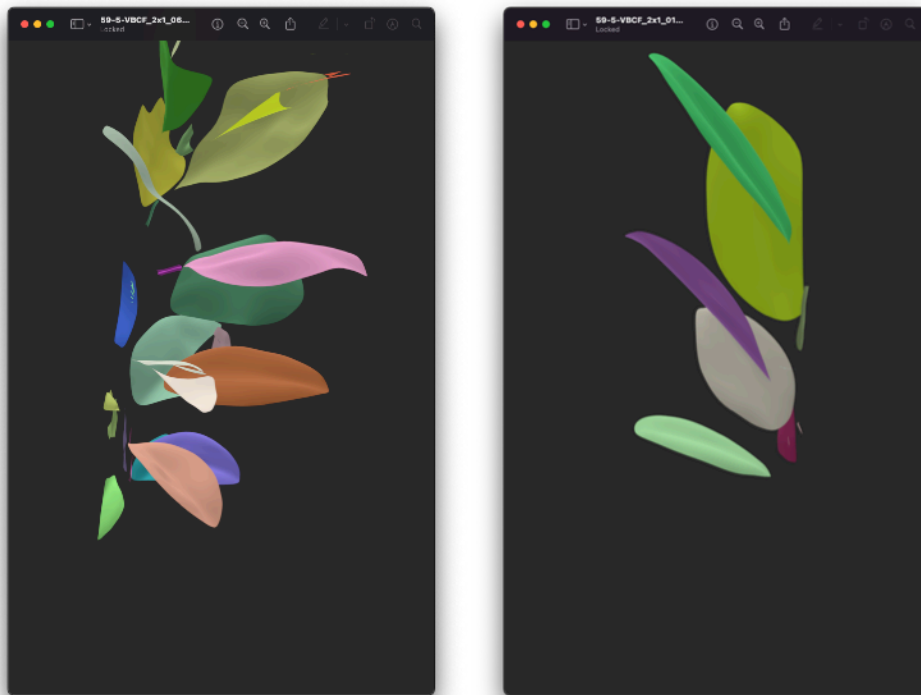


Figure 10: One 3D-modeled half of Betty and Bossi. Due to incorrect barcodes, data were collected for only half of each plant. Proper segmentation and annotation of the leaves require human intervention and advanced coding skills.

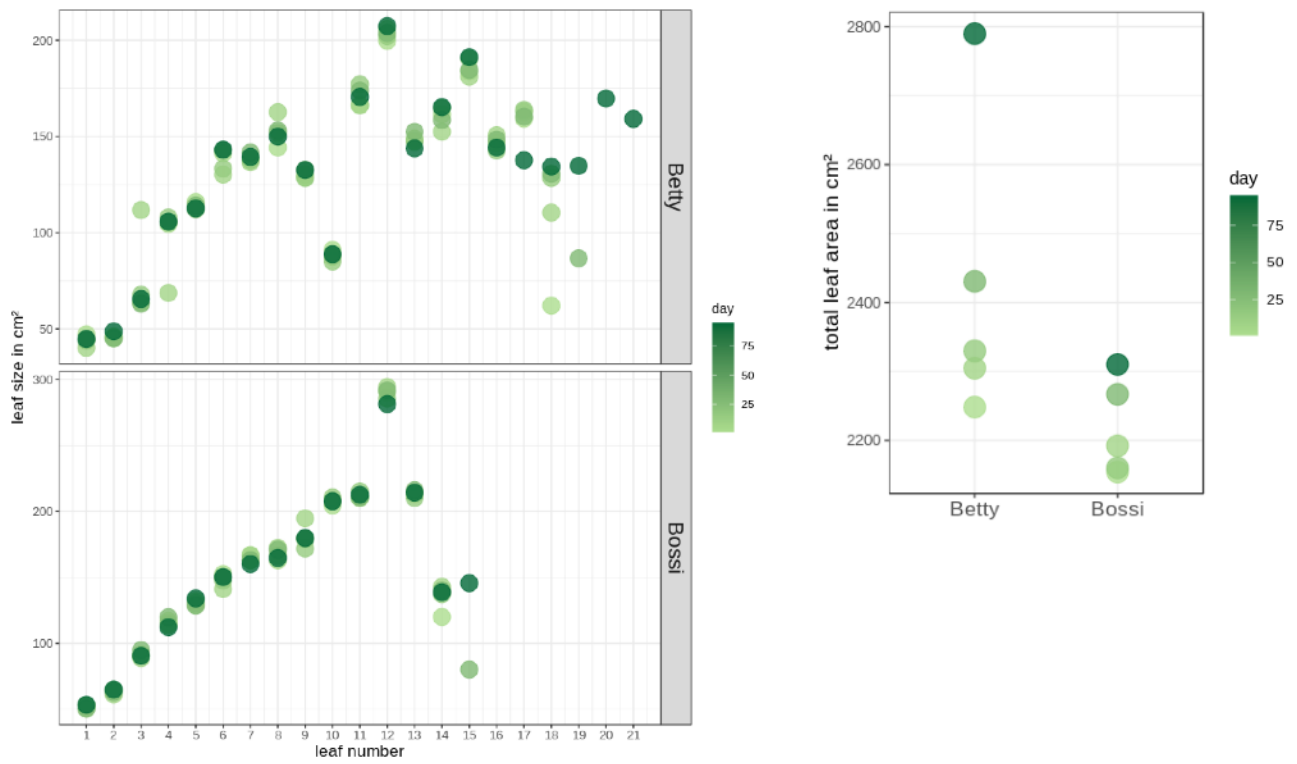


Figure 11: Betty and Bossi Leaf Sizes:  
A) Leaf area over a timespan of 95 days, plotted against leaf number.  
B) Change in total leaf area.

## **What is treeness?**

What is the experience of being a rubber tree? Ersin Han Ersin from the Marshmallow Laster Feast art collective asks: "What's it like to be a giant sequoia tree <sup>25</sup>? Through stunning visual displays available in VR headsets, complemented by haptic feedback via vibrating backpacks, people can "feel" the journey of water, from being taken up in the roots, being "spaghettified" during the sucking force of the capillary threads that lead all the way up into the crown of the - presumably- daunting sequoia tree.

While this immersive experience might be fantastic, I wonder: Does it genuinely convey what it feels like to be a sequoia tree?

This installation is a form of scientific visualization, translating human interpretations of what it might be like to be a tree into sensory stimuli. Humans use sensory input—light, chemicals, physical stimulation—to construct a simulation of their environment in their brains. These inputs are all converted into electrical signals sent to the brain, which then compiles these data and constructs our perception of the world. All our experiences are brain-constructed and can even occur independently of sensory input, as in the case of dreams or altered states brought on by psychedelic drugs.

## **What is it like to be a ...?**

In the seminal paper "What is it like to be a bat?" by Thomas Nagel <sup>26</sup>, it is posited that "our own mental activity is the only unquestionable fact of our experience." Nagel argues that consciousness cannot be fully explained without acknowledging the subjective nature of experience, which eludes reduction to mere materialism. This concept was further developed by David Chalmers, who differentiated between the 'hard' and 'easy' problems of consciousness <sup>27</sup>. The «easy» problem addresses functions and behaviors associated with consciousness, while the «hard» problem delves into its subjective, experiential aspects, suggesting the improbability of a purely physical, objective explanation.

John R. Searle compares our current understanding of consciousness to that of 17th-century alchemists theorizing about water without knowledge of its

molecular structure, implying that future insights might clarify the link between cellular activity and consciousness as clearly as we now understand water's chemical structure and its macroscopic behavior <sup>28</sup>.

Current theories of consciousness are generally split into monistic and dualistic perspectives. Dualism, originating from René Descartes, posits that consciousness resides within an immaterial “res cognitans”, distinct from material “res extensa” <sup>29</sup>. Modern dualists like neuroscientist John C. Eccles have suggested connections between consciousness and neurons via quantum physics through structures called “psychons” <sup>30</sup>, though these ideas lack empirical support.

In contrast, contemporary psychology and neuroscience largely favor monistic theories, which view consciousness through a materialistic lens, as first explicitly proposed in Julien Offray de La Mettrie’s “Man a Machine” <sup>31</sup>. Within these materialistic frameworks, there’s a distinction between panpsychism, which considers consciousness an inherent property of physical entities, and brain-centric theories, which narrowly link consciousness to the brain's structure.

Panpsychism itself varies <sup>32</sup>, with some proponents seeing consciousness as exclusive to living entities, while others extend it to atomic and subatomic units, albeit in a limited form, suggesting a correlation between consciousness and complexity.

Scientifically testable theories of consciousness fall into four categories: higher-order theories, global workspace theories, integrated information theories, and re-entry and predictive processing theories. These are summarized in a recent review <sup>33</sup>. Briefly, higher-order theories propose that awareness emerges from a brain's meta-representation of its perceptions. For example, the awareness of a visual image requires a separate brain structure that “sees” and acknowledges the image. Global workspace theories, meanwhile, posit that mental states become conscious when broadcasted across the brain's global workspace. Integrated information theories start from a mathematical framework and posit that consciousness is an intrinsic property of a system that contains sufficient integrated information, meaning the degree to which a system can integrate more information as the sum of

its parts. This theory is mostly aligned with a panpsychic view of consciousness.

Re-entry and predictive processing theories focus on the brain's ability to predict sensory input and refine these predictions through feedback mechanisms, with consciousness seen as the result of these ongoing simulations.

Therefore, it seems to be the case that consciousness and experience is constructed in data processing centers. Clearly, all living things have hot spots of data processing, which allows them to react to environmental stimuli accordingly. If we ask what it is like to be another living thing, we should then consider sensory input and data processing.

With our limited understanding of consciousness, I believe it is as equally valid to assert that only I possess true consciousness as it is to assert that only humans do, or even that all living things must have some form of it. Drawing a line somewhere along the evolutionary tree to delineate who or what is conscious becomes problematic and arbitrary. Endorsing panpsychism can alleviate this issue by positing that everything possesses consciousness. According to this view, an object can be described physically, e.g., its speed, energy state, etc., and consciousness is experiencing physical properties.

Regarding living organisms, the integrated information theory posits that consciousness is drawn towards centers of information processing. These centers, characterized by their intricate cellular connectivity and the wealth of sensory input they receive, should represent the apex of integrated information.

Where would we find those in plants? Plants don't behave like animals: they don't have a centralized brain to process electrical signals that then trigger behaviors through muscle fibers. Instead, plants receive environmental input, translated into electrical or chemical signals, that is then sent to their centers of developmental decision-making. The centers responsible for these developmental decisions in plants are found at the tip of the root and shoot, known as the root and shoot apical meristems (RAMs and SAMs, respectively).<sup>34</sup>





## What have I learned from Betty and Bossi?

### What is a plant?

For the majority of Earth's history, bacteria were the sole inhabitants, happily thriving in an atmosphere with minimal oxygen and high levels of carbon dioxide. Approximately 1.5 billion years ago, a pivotal event occurred: a symbiotic relationship formed between two distinct groups of bacteria, the archaea (archaebacteria) and the eubacteria (Figure 12). This union led to the emergence of the first ancestor of all complex, multicellular life forms: LECA, or the Last Eukaryotic Common Ancestor. In this symbiotic relationship, an archaeon became the host, while a eubacterium evolved into what we now know as the mitochondrion – the cell's powerplant. This mitochondrion was capable of using oxygen to metabolize sugars and fats, producing energy in a chemical form usable by the cell for various functions.

Approximately 500 million years after the emergence of the LECA, another unlikely event occurred. Some descendants of this Last Eukaryotic Common Ancestor incorporated a different type of bacterium, known as a cyanobacterium, marking the genesis of the first plant ancestor. This integration gave birth to a photosynthetic apparatus within the cell, the chloroplast. Chloroplasts harness light energy to extract hydrogen from water, combining it with the carbon from carbon dioxide. This process, photosynthesis, enables the assembly of life's fundamental building blocks—carbon atoms—into sugar molecules. These sugars are then metabolized by the cell's mitochondria, previously assimilated eubacteria, to produce ATP, the cell's energy currency.

Empowered by these two symbiotic partnerships, plant cells effectively linked solar energy directly to Earth's ecosystems, becoming both the foundation and the catalyst for the evolution of the biosphere. As a result, atmospheric carbon dioxide levels decreased, oxygen levels increased, and anaerobic bacteria retreated to niche environments. This shift set the stage for the proliferation of multicellular organisms, reshaping life on Earth.

This is the reason the philosopher Emanuele Coccia describes plants as 'cosmogonic,' suggesting that they don't merely inhabit the Earth but actively construct it <sup>35</sup>.

One can visualize the earliest life forms as rare minerals, crystallizing on a rocky, watery planet using the Earth's core energy. Chloroplasts, with their ability to harness alien energy—the sun's power—transformed the planet by building complex living structures from the air. This marked the beginning of diverse and intricate ecosystems, with plants evolving alongside animals into a myriad of extraordinary forms. Higher plants utilize the sun's energy, atmospheric carbon dioxide, and soil minerals to construct their bodies, with roots delving into the earth, shoots reaching for the sun, and leaves 'breathing' in the air. Being rooted in place, plants don't change their environment by moving but by reconstructing it to suit their needs and adapting their shapes and growth patterns to their surroundings. They influence their environment locally, such as by managing rainwater or interacting with animals, on an ecosystem level by affecting temperature and rainfall, and globally by altering the atmosphere.

Plants exhibit a striking contrast to most animals in their developmental flexibility. While animals typically follow a rigid embryonic development plan with limited adaptability, plants, although also adhering to a structured embryonic phase, display an open, modular development post-embryogenesis. This flexibility enables a wide range of growth outcomes, from the compact form of a bonsai to the towering stature of a giant sequoia, or the variance between a domesticated rubber tree and a sprawling banyan. Many plant species lack a predefined growth endpoint, essentially existing as immortal beings.

This unique developmental approach in plants parallels animal behavior, introducing an additional dimension to the concept of plant time perception. In animals, time perception is closely tied to their physiological and behavioral processes. Interestingly, when we accelerate our observation of plant growth using time-lapse, these beings seem to become more relatable, their development mirroring animal behavior in fast forward.

The philosopher Florence Burgat argues that the inherent indeterminacy of plant forms and their potential for biological immortality, particularly evident in the cyclical growth and dormancy patterns of annual and perennial plants, fundamentally challenges the validity of comparing plant and animal life <sup>36</sup>. These profound differences in existence raise the question: How can we advance our understanding of plant consciousness when our primary frame of reference is our own, vastly different animal mind?

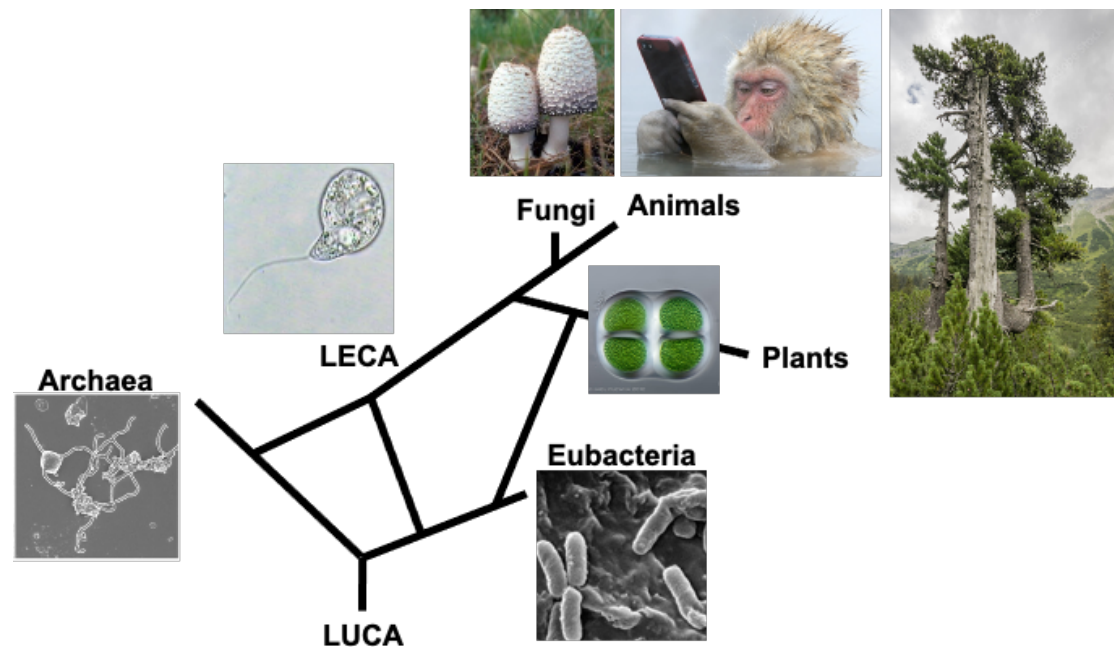


Figure 12: The tree of life is actually a net of life. LUCA = Last universal common ancestor, LECA = Last eucaryotic common ancestor. Images from <sup>37-40</sup>

## Plant swarm intelligence

Michael Levin, a developmental biologist, has conducted groundbreaking work with planarians (worms) and tadpoles, yielding insights that may also be relevant to our understanding of plant cognition. His research demonstrates that animals, too, can exhibit significant developmental plasticity and potential immortality, offering a framework for understanding cellular 'swarm intelligence' that could apply to cognition broadly.

Levin's team has engineered 'Picasso-tadpoles', altering the cranial development of young tadpoles to produce creatures with unusual, Picasso-esque faces <sup>41</sup>. Yet, during metamorphosis, these tadpoles reshape into frogs with normal facial structures, suggesting a cellular memory of the intended anatomical design. Extending this concept of cellular cooperation and plasticity, his team has also created 'Xenobots'—tiny, Pac-Man-like entities formed from embryonic frog cells capable of movement and collective behavior <sup>42</sup>.

As in the world of plants, cutting and re-rooting a tree branch can propagate a new plant, and so can worms of the planarian taxa. Some planarian species even reproduce by simply dividing, much like a single cell, demonstrating a form of biological immortality and possibly existing for millions of years <sup>43</sup>.

These observations suggest that the underlying cellular intelligence in plants and animals might not be fundamentally different. The capacity of individual cells for data integration, intelligence, and possibly consciousness could be a universal trait. Neurons, though uniquely shaped, share the fundamental ability to communicate and receive environmental information with other animal cells and plant cells <sup>44</sup>. All these cells are excitable and capable of communicating their states to neighboring cells. In plants, this communication is further facilitated by channels allowing high molecular information trafficking between cells.

This leads us back to panpsychism and integrated information theory: Could consciousness be an inherent property of cells, amplified through their collective swarm intelligence?

## Can I feel rubbertreeness?

Betty and Bossi have had a great time on my terrace during the tropical Viennese summer months, nestled among a jungle of plants including *Elettaria cardamomum* (Cardamom), *Phlebodium aureum* (Spotted Fern), and *Kalanchoe beharensis* (Elephant's ears).

These companions have equally relished the gentle movements of air, the warmth of the sun, the coolness of the night, and the refreshing summer rains. Their most significant growth spurt occurred before I had to relocate them indoors in October.

One splendid summer evening, I climbed up to the chimney's crest with Bossi, soaking in Vienna's skyline and the soothing sunset breeze (Figure 13). The plastic pot was hardly able to withstand a bit of wind, so I added stones and decided to make them proper clay pots.

As colder, greyer days set in, they bask under an LED lamp emitting a spectrum tailored for plant nourishment, placed above the kitchen windowsill.

Since they are indoors, a layer of sticky dust started coating their leaves. To remedy this, I treat them to a tropical rainstorm in the shower. Post-shower, it's crucial to mist them with filtered, distilled, or rainwater to prevent the formation of calcium deposits from tap water.

For watering, I use filtered water. In most regions, tap water has high concentrations of magnesium and calcium carbonate, and is slightly alkaline. This is great for the health of the drainage pipes, but not so great for the health of plants, which naturally thrive on soft, slightly acidic rainwater. Although most houseplants are capable of dealing with tap water, I choose to offer them the most favorable environment possible to ensure they robustly withstand the indoor season.

While working, I sometimes place Betty or Bossi by my computer screen. Their slow growth and subtle changes reflect in their quiet demeanor.

Watching them induces tranquility in me, although I must resist the temptation to linger, as pressing deadlines await...



*Figure 13: Summer is a good time for Betty and Bossi*

### **The cry of the rubber tree**

In the spring of 2023, a study captured attention both inside and outside of academia <sup>45</sup>. It revealed that plants can emit sounds, especially under stress, with different species producing distinct noises.

Intriguingly, these sounds varied depending on the stressor: lack of water or simulated herbivore attacks (using scissors and forceps). This suggested that the plants' "cries" carried specific information, potentially perceptible to other plants or animals.

The reason we don't hear the distress calls of our increasingly dry and overheated forests during summer walks is that these plant sounds are ultrasonic and beyond the range of human hearing.

This study prompted me to wonder: could I engage in a dialogue with Betty and Bossi? I acquired an economical ultrasonic microphone and familiarized myself with the necessary software. After placing the microphone near Bossi's stem, I began recording. Both Bossi and Betty remained silent.

Perhaps my companions were content and unstressed, or maybe my microphone wasn't equipped to handle low signal-to-noise ratios. I realized that ultrasounds could emanate from various sources, including my computer and screen, street noises, and even airplane sounds in the air.

The original study involved tomato and tobacco plants. I borrowed some young tomato plants from my neighbor and began recording their sounds. Initially, there was little to detect. The authors of the study had induced stress through drought and clipping. After withholding water until the leaves began to wilt, I listened again but was unable to discern any sounds during my 20-minute recording sessions.

I firmly took a leaf in my hand and tore it off; that was when I noticed a faint ultrasonic peak immediately following the audible sound of the leaf tearing.

I also stressed Betty and Bossi by withholding water from them. However, as young *Ficus elastica* can grow as epiphytes in the wild, they are remarkably resistant to drought. This resilience also explains why they make such good houseplants; they can tolerate almost complete dryness for short periods, as well as the soaking and moisture from a tropical rainstorm.

I then gently tore a leaf from Bossi right in front of the microphone, first using forceps, then my fingers, but still, Bossi remained silent.

Finally, I tore off Bossi's oldest, smallest leaf. White latex, the plant's "rubber", oozed from the wound. Similar to the tomato plant, there was a faint ultrasonic response after the audible sound of the leaf tearing. I then placed the leaf beside Bossi's stem, observing the slow ooze of liquid as the rubber sealed the wound.

Amidst these experiments, a quote from Czesław Miłosz echoed in my mind: "Not that I want to be a god or a hero. Just to change into a tree, grow for ages, not hurt anyone."



## References

1. Gentechnologie im Ausserhumanbereich Bundesverfassung der Schweizerischen Eidgenossenschaft Art. 120, Abs. 2.
2. Lovelock, J.E., and Margulis, L. (1974). Homeostatic tendencies of the earth's atmosphere. *Orig Life* 5, 93–103.
3. love | Definition of love in English by Oxford Dictionaries <https://web.archive.org/web/20180502140707/https://en.oxforddictionaries.com/definition/love>.
4. WIKIPEDIA Greek words for love.
5. Thitamadee, S., Tuchiara, K., and Hashimoto, T. (2002). Microtubule basis for left-handed helical growth in *Arabidopsis*. *Nature* 2002 417:6885 417, 193–196. 10.1038/417193a.
6. Feuerstein, T. (1996). HONEYMOON (Triton, Wien).
7. Thomas Feuerstein: WORKS / LABORATORY / Honeymoon [https://www.thomasfeuerstein.net/50\\_WORKS/75\\_LABORATORY/90\\_Honeymoon](https://www.thomasfeuerstein.net/50_WORKS/75_LABORATORY/90_Honeymoon).
8. IMPROBABLE RESEARCH <https://improbable.com/>.
9. Ausserhumanbereich, E.E. für die B. im (2008). Die Würde der Kreatur bei Pflanzen. Preprint, <https://www.ekah.admin.ch/de/themen/wuerde-der-kreatur> <https://www.ekah.admin.ch/de/themen/wuerde-der-kreatur>.
10. ZHENG BO [http://zhengbo.org/2019\\_PP4.html](http://zhengbo.org/2019_PP4.html).
11. Lin, P.-Y., Stamatis, D., Weiss, J., and Petrič, Š. (2014). The Plant Sex Consultancy. <http://psx-consultancy.com/#nonhuman>.
12. Schwartz-Tzachor, R., Dafni, A., Potts, S.G., and Elsikowitch, D. (2006). An ancient pollinator of a contemporary plant ( ): When pollination syndromes break down. *Flora* 201, 370–373. 10.1016/j.flora.2005.07.011.
13. Eggleton, P. (2020). The State of the World's Insects. *Annual Review of Environment and Resources*, Vol 45 45, 61–82. 10.1146/annurev-environ-012420-050035.
14. LANSKY, E.PHILIP, and PAAVILAINEN, H.M. (2017). FIGS: the genus ficus. (CRC Press).
15. Kislev, M.E., Hartmann, A., and Bar-Yosef, O. (2006). Early domesticated fig in the Jordan Valley. *Science* (1979) 312, 1372–1374. 10.1126/science.1125910.
16. Buddhist Studies: Bodhi Tree <http://www.buddhanet.net/e-learning/dharmadata/fdd23.htm>.
17. HONOMICHL, K., JACOBS, W., and RENNER, M. (1998). *Biologie und Ökologie der Insekten* 3RD ed. (Gustav Fischer Verlag Stuttgart).
18. Schaal, B. (2019). Plants and people: Our shared history and future. *Plants People Planet* 1, 14–19. 10.1002/ppp3.12.
19. Houseplant - Wikipedia <https://en.wikipedia.org/wiki/Houseplant>.
20. Temple, N. (2017). A portrait of a boy and his plant. <https://botanic-garden.bristol.ac.uk/2017/02/14/a-portrait-of-a-boy-and-his-plant/>.

21. Zhao, T.Y., Markevych, I., Romanos, M., and Heinrich, J. (2023). When green enters a room: A scoping review of epidemiological studies on indoor plants and mental health. *Environ Res* 216. ARTN 114715 10.1016/j.envres.2022.114715.
22. Global Indoor Plants Market - Industry Trends and Forecast to 2030 <https://www.databridgemarketresearch.com/reports/global-indoor-plants-market>.
23. RM Plants, Indoor en Outdoor planten, kwekerij, Amstelveen | RM Plants <https://www.rmplants.nl/>.
24. Schrader, J., Shi, P.J., Royer, D.L., Peppe, D.J., Gallagher, R. V, Li, Y.R., Wang, R., and Wright, I.J. (2021). Leaf size estimation based on leaf length, width and shape. *Ann Bot* 128, 395–406. 10.1093/aob/mcab078.
25. Features - Marshmallow Laser Feast <https://marshmallowlaserfeast.com/>.
26. Nagel, T. (1974). What Is It Like to Be a Bat? *Philos Rev* 83, 435. 10.2307/2183914.
27. Chalmers, D.J. (2010). Facing Up to the Problem of Consciousness. In *The Character of Consciousness* (Oxford University Press), pp. 3–34. 10.1093/acprof:oso/9780195311105.003.0001.
28. Searle, J.R. (1992). *The Rediscovery of the Mind* (The MIT Press).
29. Descartes, R. (1984). *Meditations on First Philosophy* 1641st ed. R. S. Cottingham and D. Murdoch, eds. (Cambridge University Press.).
30. Eccles, J.C. (1994). *How the self controls its brain*. (Springer-Verlag, Berlin).
31. De La Mettrie, J.O. (2018). *MAN A MACHINE* 1747th ed. G. C. Bussey, ed. (Createspace Independent Publishing Platform).
32. Panpsychism | Internet Encyclopedia of Philosophy <https://iep.utm.edu/panpsych/>.
33. Seth, A.K., and Bayne, T. (2022). Theories of consciousness. *Nat Rev Neurosci* 23, 439–452. 10.1038/s41583-022-00587-4.
34. Vegetative Growth - Developmental Biology - NCBI Bookshelf <https://www.ncbi.nlm.nih.gov/books/NBK10030/>.
35. Coccia, E. (2018). *The Life of Plants: A Metaphysics of Mixture* (Wiley).
36. Burgat, F. (2022). *Was ist eine Pflanze?* (Turia & Kant).
37. About Marsel van Oosten - Squiver <https://www.squiver.com/about-marsel-van-oosten/>.
38. Stefansbachtal Gevelsberg: Leben im Teich: Kugelblauualge (*Chroococcus turgidus*) (Cyanobacteria) <https://www.plingfactory.de/Science/Atlas/Kennkarten%20Procaryota/source/Chroococcus%20turgidus.html>.
39. Imachi, H., Nobu, M.K., Nakahara, N., Morono, Y., Ogawara, M., Takaki, Y., Takano, Y., Uematsu, K., Ikuta, T., Ito, M., et al. (2020). Isolation of an archaeon at the prokaryote–eukaryote interface. *Nature* 2020 577:7791 577, 519–525. 10.1038/s41586-019-1916-6.
40. *How To Be a \*Plant (\*Photosynthetic, Multicellular, Terrestrial)* (2013). *Plant Cell* 25. 10.1105/TPC.113.TT0713.

41. Vandenberg, L.N., Adams, D.S., and Levin, M. (2012). Normalized shape and location of perturbed craniofacial structures in the *Xenopus* tadpole reveal an innate ability to achieve correct morphology. *Developmental Dynamics* 241, 863–878. 10.1002/dvdy.23770.
42. Kriegman, S., Blackiston, D., Levin, M., and Bongard, J. (2020). A scalable pipeline for designing reconfigurable organisms. *Proceedings of the National Academy of Sciences* 117, 1853–1859. 10.1073/pnas.1910837117.
43. Levin, M. (2022). Technological Approach to Mind Everywhere: An Experimentally-Grounded Framework for Understanding Diverse Bodies and Minds. *Front Syst Neurosci* 16. 10.3389/fnsys.2022.768201.
44. Baluška, F., and Levin, M. (2016). On Having No Head: Cognition throughout Biological Systems. *Front Psychol* 7. 10.3389/fpsyg.2016.00902.
45. Khait, I., Lewin-Epstein, O., Sharon, R., Saban, K., Goldstein, R., Anikster, Y., Zeron, Y., Agassy, C., Nizan, S., Sharabi, G., et al. (2023). Sounds emitted by plants under stress are airborne and informative. *Cell* 186, 1328-1336 e10. 10.1016/j.cell.2023.03.009.







