FIELD TEST

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SCIENCE GALLERY

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FIELD TEST

RADICAL ADVENTURES IN FUTURE FARMING

CONTENTS

WHY FIELD TEST?

LYNN SCARFF

DIRECTOR OF SCIENCE GALLERY DUBLIN AT
TRINITY COLLEGE DUBLIN

Why an exhibition about farming? Like all our themes it's an area rich in juxtapositions—multidisciplinary players exploring new ideas, technologies and systems often in direct conflict with each other. It's also critical to our future. Our ability to produce food and products for growing populations on a finite amount of land with limited resources is unquestionably one of the great challenges we face globally. It may not be foremost in our minds when we do our weekly food shop but the decisions that we make as consumers and digesters can be critical influencers in the way these challenges play out. Do you want seasonal, local and organic or are you happy for mass produced? Does intensification of farming necessarily mean increased use of fertilisers and a decline in animal husbandry or is there a different way, such as "ecological intensification" as discussed by Jane Stout in the following pages.

If anything this exhibition raises more questions than answers. It will bring our visitors into dialogue with a range of artworks, products, farm hacks, robotics and microfarms that are real field tests—experiments at the boundaries of art, design, science and farming. Will we make hay while the sun shines, or when the sensors say? Will scientific researchers innovate to meet growing global consumption, or will visionaries and dreamers reinvent farms as on-demand food forests, skyscrapers or even theme parks? What crops should we be cultivating now for a very different future: bacon-flavoured seaweed, heirloom potatoes or fly meat steaks? In the next fifty years we will radically reinvent what, where and how we grow the crops and raise the animals that keep us alive, fed and warm.

Curated by the Center for Genomic Gastronomy, FIELD TEST brings together a dynamic group of experts, artists, designers, farmers, hackers, engineers and scientists who are responding to these challenges with radical innovations in products and systems. I'd like to thank all of our FIELD TEST participants and advisors for their time and contribution to the exhibition. I know the essays over the page will grab you just as much as the discussions we have been having over the exhibition development—we look forward to continuing the conversation with our audience over the next twelve weeks.

FIELD TEST: RADICAL ADVENTURES IN FUTURE FARMING

THE CENTER FOR GENOMIC GASTRONOMY

CURATORS OF FIELD TEST, AND AN ARTIST-LED THINK TANK THAT EXAMINES THE BIOTECHNOLOGIES AND BIODIVERSITY OF HUMAN FOOD SYSTEMS

Most of what we eat is grown on a farm. Many of the fabrics we wear, the materials we build with, and the medicines we consume are grown on farms too. If human civilisation transitions to a circular economy, reducing our reliance on nonrenewable resources, more and more of the objects that we live with will need to be derived from farms. The twenty-first century is indisputably the biological century, and the farm is where the action is. Farming is messy and imperfect. Organisms and environmental flows do not follow the linear paths we plot out in models, or observe in clean rooms. Changes on farms require field tests. Our future may very well be high-tech, slick and highly designed, but our future will be grown, not built. Farms—not mines or oil wells—will form the foundation of our sustainable civilisation, even if those farms look unusual or unfamiliar.

FARM CYBORGS: A BRIDGE SPECIES?

From Silicon Valley in California to the Silicon Docklands in Ireland, there is a race amongst engineers and entrepreneurs to embed sensors in every possible organism and environment related to farming. Cows, pigs, trees and grass have all become 'Farm Cyborgs', outfitted and equipped with wearable sensors, and reporting back to the glowing screens of humans. Fields are surveilled from a distance, through drones and satellites in the sky, and sensor networks embedded in the soil. These farm cyborgs are an interesting bridge species. They are born partly out of the desire for control, uniformity and automation that characterised the twentieth century, but the data they generate is a reintroduction to the nonlinear dynamics, complex relationships and responsive adaptations that characterised pre-industrial farming. It would be ironic if putting sensors on everything is what allowed us to remember that biology is messy and doesn't work in the same way as electrical engineering.

WE HAVE ALWAYS BEEN BIOHACKERS

Farms, crops and livestock do not consist of a standardised set of static parts. Plant breeders and other biohackers are constantly developing new varieties and testing them in the field, where they are exposed to varying conditions. Humans are part of an ongoing process of co-evolution with pests, pathogens, plant microbiomes, soil and more. In FIELD TEST we feature three very different kinds of capsicum in the exhibition, all developed within the last decade. Each has unique traits, and seemingly different eaters in mind. One pepper is small, very sweet and can be eaten raw: a perfect snack for health conscious people who are in a hurry. Another pepper was bred for its extreme spiciness and perhaps appeals to those who like their food to be a challenge, a competition, or a ritual. And finally we have a pepper which was bred in consultation with restaurant chefs, and fits their culinary requirements of flavour and texture. Plant breeding is increasingly a sphere for articulating a range of human desires through design. As methods for plant breeding become more precise, quick and widespread, will farming be a new arena for fast fashion, with new collections coming out every season? How will this »

activity conform or upend the intellectual regimes and legal battles around seed ownership that have been constructed over the last century? Perhaps a rising interest in fashionable cultivars will lead more people to preserve traditional 'retro' varieties, keeping our agricultural heritage alive in the Anthropocene — the period during which human activity has been been the dominant influence on climate and the environment.

IN VITRO MEAT: HOPE OR HYPE?

To many people, one of the most unconventional forms of future farming is in vitro meat—growing tissue culture in the lab or in a factory. This imagined future farming technique has received much media attention and hype during the last decade, but in FIELD TEST visitors can witness and debate the material reality of the research as it stands. A bioreactor in the exhibition will be growing insect cells in the gallery, a project from an artist who has been growing and serving in vitro meat since 2003. We also have the plastinated leftovers of the first in vitro beef burger—served publicly by a scientist in 2013—for visitors to examine. Can we imagine a future where the meat being produced by kitchen-top bioreactors is significantly larger than the original organism itself? Is this the organism of plenty that should be celebrated, or a monster to be rejected? What happens when our entire in vitro meat farm gets infected, and needs to be pumped full of antibiotics? One unusual culinary question that in vitro meat raises for us is about the biodiversity of the kitchen. If society embraces a farming future where only muscle, fat and bone cells are grown in vitro will we stop producing and eating organ meats? Does agricultural biodiversity apply to organs as well as organisms?

FIELD TESTS

Our own research at the Center for Genomic Gastronomy has primarily been on farming for food, studying the organisms and environments that are manipulated by human food cultures. Our mission is to map food controversies, prototype alternative culinary futures and imagine a more just, biodiverse and beautiful food system. The artifacts and artworks presented in FIELD TEST map out the controversies around seed saving and intellectual property, compare two key in vitro meat prototypes and present examples of farm cyborgs and future farms that visitors can embrace or resist in the process of articulating their own desires. Thank you to all of the exhibition contributors, we feel honoured to present the work of so many artists, farmers, scientests, architects and hackers who are conducting their own field tests: imaging, contesting and building the human food systems and farms of the future.

AN ATOMIC DANCE AT A PLANETARY SCALE

MUKUND THATTAI

FIELD TEST ADVISOR AND FACULTY MEMBER AT THE NATIONAL CENTRE FOR BIOLOGICAL SCIENCES, BENGALURU

The thing that always shocks me about DNA, when I find those rare moments to contemplate it, is the power of the genome as an algorithm. A sealed bag of flour containing a few beetle eggs can turn into a sealed bag of beetles, given enough time. No matter goes in, no matter comes out. Instead, what happens is a fine-tuned and rapid atomic-scale rearrangement of everything in the bag, taking it from passive dead white powder to a dynamic, living population of organisms. This atomic dance is choreographed by DNA.

Strands of DNA have an equal capacity to transform the planet Earth, the bag of flour in which we all live. Indeed, they already have. The transformation started 3.5 billion years ago when the autocatalytic and self-replicating chemistry of DNA was first invented, and continues unabated. The far-reaching consequences of this process are even visible from space, from hundreds of light-years away: true planetary engineering.

We humans have been engaged in our own attempts at planetary engineering for ten thousand years or more. The invention of farming and the subsequent development of sophisticated agricultural practices led to a boom in the human population, a new system of political economy, and then directly to our modern technical civilisation. In their time, the proto-cells of 3.5 billion years ago and the photosynthetic cyanobacteria of 2.5 billion years ago could lay claim to being the single most influential species on the planet. That dubious honour is now ours, and the Anthropocene is well under way.

So what's different this time around? Why is this transformation any more or less dangerous, unpredictable, or powerful than those which came before? Is it our ability to plan ahead? Surely the first farmers knew all about planning. Is it the scale of our ambitions? The architects of the Industrial Revolution had enough ambition for all future generations put together. I suggest that there are two differences: first, human-driven climate change is a confirmed scientific fact, whereas it was something we could only have guessed at earlier. The idea of irreversible tipping points in global geochemical cycles is frightening, and renders us temporarily powerless. Second, we now know about DNA, and we have started to understand its algorithmic nature. Along with this understanding, we have gained the remarkable capacity to manipulate DNA. The transformational power of DNA is juxtaposed with our seeming powerlessness in the face of climate change. These two ingredients, one at the atomic scale and the other at the planetary scale, collide when we consider the future of farming. Where will we live? How will we feed ourselves? FIELD TEST invites us to contemplate these perhaps overwhelming questions, through the work of the scientists and farmers who are creating this future, and through the eyes of the artists who give it meaning.

SUSTAINABLE FARMING IN THE FUTURE: IS ECOLOGICAL INTENSIFICATION THE SOLUTION?

JANE STOUT

FIELD TEST ADVISOR AND PROFESSOR IN NATURAL SCIENCES,
TRINITY COLLEGE DUBLIN

Technology-driven, modern intensive farming seems pretty far removed from 'nature'. And yet, unseen ecological processes still drive these systems: soil organisms break down dead material and recycle nutrients; insects transfer pollen between flowers to ensure fertilisation and seed and fruit production; and natural enemies of crop pests lurk in and around fields, keeping potentially damaging pests under control. These ecological processes, which we can think of as 'services' provided by nature, are as fundamental to farming now as they were at the dawn of agriculture.

Farmland also delivers more than just marketable products: landscapes which can benefit the health and wellbeing of residents and visitors are created and maintained, and farms contribute to large-scale biogeochemical cycles for carbon, water and oxygen. Unfortunately, modern agriculture, with high inputs in terms of chemicals and machinery, and the high carbon emissions associated with these, can erode the ability of ecosystems to function and provide these services. The irony is that modern intensive farming aims to replicate these ecological services. Artificial fertilisers are applied to soil, crops that don't require insects to pollinate the flowers are favoured, and pesticides are used. And although artificial fertilisers and pesticides may have some short-term benefit, they can have unseen longer term effects: degrading the environment and negatively affecting human health, and disrupting the pest-control services that natural enemies provide.

A solution may be found in 'ecological intensification'. This means managing agricultural practices to replace artificial inputs with 'free' natural services like maintaining soil fertility, pest control and pollination. This requires an understanding of how biological communities that provide services are influenced by land use at different scales—within farms, between farms and across entire landscapes. We need to understand which organisms deliver these services, and how they behave, their population dynamics, and how they interact in order to maintain the flow and stability of service and to maximise yield. We also need to learn how to manage the multiple services delivered by these organisms, the associated trade-offs, and how much this costs.

And how can farms practice ecological intensification? One answer may lie in diversity: the more different habitats there are in the landscape, or microhabitats there are on a farm, the more different resources there are and the more species can exist in that place. This diversity might be fostered by growing different crops in a rotation system, maintaining diverse hedgerows, or creating or restoring habitats like woodlands or ponds. If there are more species, there are more chances for beneficial organisms, such as natural enemies, to establish sustainable populations so that they can provide services. Alternatively, pollinators may be encouraged by planting flowers or allowing wild plants to flourish and flower in non-cropped areas. These approaches can also have knock-on benefits for farmland birds, wildflowers and other wildlife.

Farms of the future need to work with nature, not against it, and maximise the potential for ecological processes to produce high quality yields. The benefits of this approach can ultimately contribute to healthier lives and ecosystems, and an agri-food industry which can be sustained long into the future.

CULTIVATING DREAMS

ANDREW DOUGLAS

FIELD TEST ADVISOR AND CREATOR OF URBAN FARM,
AN AGRICULTURAL STARTUP BASED IN DUBLIN

"You'll never plough a field by turning it over in your mind"—an old Irish saying that Dixie, my grandfather, would shout when he'd catch me daydreaming instead of working in his little market garden. As a young boy I would think up ways to improve his methods and make my work easier. Some of my early field tests worked, others destroyed his beloved crops—I was a curious kid, what can I say?

Dixie's garden is long gone, a three storey supermarket car park in its place, but my daydreams are still alive and growing. The fields I dream of ploughing now are high up on the city's rooftops. With the necessary technology becoming readily available, my dreams of an efficient, modern, market garden have become reality. Urban agriculture can be defined as growing fruits, herbs, and vegetables and raising animals in cities, communities and neighbourhoods—a process that is accompanied by many other complementary activities such as processing and distributing food, collecting and reusing food waste and rainwater, and educating, organising, and employing local residents. The urban agriculture practice of growing and distributing food in a town or city has traditionally been soil-based vegetable growing in market gardens and allotments spread out over the city, worked by part-time growers subsidising their incomes by selling their produce locally.

Currently, reasons for practicing urban farming are similar—earning income through food production—but the ever-increasing demand for land sees these precious little patches of soil all but disappearing. In their place, apartment blocks and high rise office buildings are constructed. In turn, these small, intensive farming activities are pushed further away from the cities that consume their produce.

With an increased public consciousness when it comes to food: how it's produced; the associated food miles; and the use of genetically modified seeds, pesticides, fungicides, and petroleum-based fertilisers; both producers and consumers alike are now seeking transparent, local, organic food production models. According to the United Nations Population Division, by 2050 around 70percent of the world's population will be living in urban areas. Feeding these people will mean increasing our food production through a combination of higher crop yields and an expansion of the area under cultivation—but the additional land available for cultivation is unevenly distributed, much of it suitable for growing only a small variety of crops.

My daydreams are now being put to the plough. Through the use of controlled-environment aquaponics (the simultaneous farming of fish and the cultivation of plants in a symbiotic environment) housed on rooftops inside climate-controlled greenhouses, we can produce high-value crops at maximum productivity in an efficient and environmentally friendly way. Wi-Fi capability and instant notifications allow constant monitoring from a smart device.

Someday, we will probably be able to plough fields by just simply thinking about it (with a little help from artificial neurotransmitters). For the moment, I'm happy to check on the garden sensors, feed the fish, irrigate the plants and mostly stay at home daydreaming about mushrooms, all with a few texts from my phone. Dixie would be amused, and to quote him, "The apple will fall when it's ripe."
That time is now.

FROM SEED DRILLS TO CYBORGS: FORECASTING FARM FUTURES

NICOLA TWILLEY

FIELD TEST ADVISOR, AUTHOR OF THE BLOG EDIBLE GEOGRAPHY, AND NEWYORKER.COM WRITER

Jethro Tull—the man, not the British prog rockers—invented a horse-drawn seed drill in 1701. Using his machine, a farmer could, with a single motion, sow their seeds at regular intervals and at the correct depth. Because Jethro's drill planted seeds in a straight line, it allowed Jethro to invent a horse-drawn machine to remove weeds between the rows of crops. Combined, his innovations reduced waste and greatly increased yield: the resulting productivity boost helped fuel Britain's Agricultural Revolution, and, thus, its subsequent Industrial one. Of course, Jethro's seed drill also set the stage for many of the most serious problems facing farming today, from monocultures to erosion.

More often than not, thinking about the future of agriculture means thinking about the future of food. How will changes in the contents of our supermarkets and the composition of our dinner plates reshape the landscape around us in five, ten, or even fifty years? FIELD TEST offers a rare opportunity to consider this fundamental relationship from the other, less considered point of view: how will changes in the science and technology of farming change what we eat—and how we live?

If history is any guide, those changes will be both all-encompassing and rather slow. The dawn of agriculture, for example—an invention that is described with equal frequency as humanity's best and worst idea—eventually led to the development of mathematics, measurement, property rights, and government, while disrupting the planetary nitrogen cycle, triggering the Sixth Great Extinction, rewriting genomes across hundreds of species, and even weakening human shin bones.

These kinds of massive changes occurred over millennia, but even smaller shifts take generations: it wasn't until a century later, in the early 1800s, that Jethro Tull's seed drill finally displaced the ancient method of hand-broadcasting seed. Farmers are not, as a general rule, Luddites: as in any field, there are first adopters and laggards, and new technology often requires time and iteration in order to work at scale and economically. Plants and animals provide their own inertia, by virtue of their lengthy growing cycles.

Meanwhile, forecasting the future is a notoriously failure-strewn activity; humans are especially bad at imagining transformations that are long, slow, and interconnected. Nonetheless, the seeds of future farms are here now. When Cyrus Hall McCormick's mechanical reaper machine began the "power farming" era in 1831, it was for the most part seen as noisy, unreliable, and impractical. Few contemporaries had the foresight to imagine that, over the next 150 years, mechanisation would mean that farming would slip from a majority activity to a specialised profession carried out by a tiny percentage of the population.

Today, as embedded sensors, drones, and robot harvesters promise to revolutionise farming once again, can we do any better at predicting the future? If we follow their logic across continents, cultures, and climates, what can the signals gathered here—the kitchen bioreactor, the franchised apple, acoustic pest control—tell us about future ecosystems, epidemics, economic models, and, of course, meals?

FARM CYBORGS

This section presents some of the augmented organisms that are starting to inhabit our farms. The word cyborg may conjure up images of humans with robot appendages or enhanced vision, but over the last decade we have begun outfitting plants, landscapes and animals with sensors, actuators and wearable computers. Are these technologies an extension of electric fences and cowbells or something else entirely? Will we embrace an internet of living things or should we be careful of increased surveillance, automation and alienation on the farm?

Playing with Pigs: Pig Chase

Hein Lagerweij, Kars Alfrink, Irene Van Peer, Clemens Driessen, Marinka Copier of HKU University of the Arts Utrecht, and the Wageningen University and Research Centre (NL)

The *Playing with Pigs* project began investigating the complex relationship we have with domesticated pigs by designing a game. It started as the wild idea of a pig farmer frustrated with the lack of ways to save her pigs from debilitating boredom. It was also spurred on by a European directive that calls for farmed pigs to be provided with something they find interesting to do, to prevent bored, aggressive pigs from biting each other's tails.

Designing new forms of human-pig interaction can create the opportunity for consumers and pigs to play together, as well as to experience each other's capabilities. The first prototype game showcased in the video is called *Pig Chase*. It met some of the goals the creators had for their game: to create a genuine experience of playful interaction between two curious subjects. It appears to put humans in control, whereas both the pig and human player need to learn to move together, allowing for mutual adaptation and attunement. However, there are still numerous challenges ahead in creating a truly 'level' playing field.

The aim is to create an open-source platform that invites people to try out new modes of engaging and interacting with animals that would otherwise be hidden from view.

PROFILE

The *Playing with Pigs* team assembled around the challenge of rethinking the world's relationship to farmed pigs via interactive media, linking the HKU University of the Arts Utrecht and the Wageningen University and Research Centre. Hein Lagerweij is a Utrecht-based motion graphics animator and designer; Irene van Peer is an industrial and interaction designer teaching at the HKU; Kars Alfrink is a designer active in the area of play, technology and society currently based in East Asia; Clemens Driessen is a philosopher and cultural geographer at Wageningen University researching animals and technology; and Marinka Copier is a designer and director of the Expertise Centre for Creative Technologies at the HKU.

› **playingwithpigs.nl**

Moocall is a calving sensor worn on a cow's tail that measures over six hundred data points every second to determine the onset of calving. The device then sends a text alert to two mobile phones roughly an hour before calving, to ensure that the cattle breeder can be on location when a calf is born.

Moocall was invented when Irish farmer Niall Austin lost a calf and a cow due to an unexpected difficult calving. He believed that this could have been prevented if he had been there to assist and began looking for a solution. He did not want to use an invasive device and believed that tail movement could help anticipate calving. *Moocall* removes the need for farmers to keep vigil over pregnant cows and helps increase live births and farm profitability. The device, which can be moved simply from cow to cow once calving takes place, uses 3D motion sensors, algorithms, and an embedded SIM card that connects to a phone network.

Extensive on-the-farm prototyping helped shape the design and build of *Moocall*, resulting in a device strong enough to "counter the cow's natural curiosity to eat, lick and crush the *Moocall* units" and a battery that lasts up to thirty days.

PROFILE

Created by Irish farmer Niall Austin, with help from Emmet Savage, and Irish technology partners Motech Engineering and Dolmen, *Moocall* launched commercially in Ireland in January 2015 after four years of product development and prototyping. *Moocall* has won numerous design awards, including the Red Dot award. *Moocall* was nominated for London's Design Museum Design of the Year award in 2015. To date, *Moocall* has sold devices to over 2,500 farms across sixteen countries. An estimated 25,000 calves have already been born using *Moocall*.

› **moocall.com**
› **@moocallsensors**

Moocall Calving Sensor

Niall Austin & Emmet Savage (IE)

GrassOmeter believes data is the new soil; that soon data will be as important to the farm of tomorrow as the tractor is today.

The *GrassOmeter* is a complete mapping, measurement and management system that brings precision farming to the grassland farmer. It can be mounted on a stick and controlled via a mobile phone; the data is instantly recorded to the cloud. Using the GPS of an app-enabled smartphone, four ultrasound sensors and a nine-point orientation sensor, the *GrassOmeter* maps the topography of the ground and measures grass height to allow the farmer to accurately manage their resources. Grass is a crop like any other: manage it well and yields will increase significantly.

By taking the guesswork out of grass measurement and supplying accurate figures—factors farmers need to record and benchmark grass growth performance—*GrassOmeter* allows farmers (particularly dairy, beef and sheep farmers) to provide better quality feed for their animals and to increase their productivity whilst reducing their use of inputs, paddock by paddock, across the whole farm.

PROFILE

Monford AG Systems was founded by Steven Lock with the help of Jerry Manock, one of the designers of the original Macintosh Computer. The *GrassOmeter* was developed at Trinity College Dublin via an Enterprise Ireland Innovation Voucher and current investors include Kernel Capital, the Bank of Ireland Seed Fund, Glanbia, the *Irish Farmers Journal* and a group of farmers from Ireland and New Zealand.

› **grassometer.com**
› **@grassometer**

GrassOmeter

Monford AG Systems Ltd (IE)

From flies to lobsters, small insects and animals have long been ideal models for roboticists and computer scientists. Bees, for example, possess particular skills when it comes to flight, zipping from flower to flower with ease, and hovering steadily with heavy payloads.

Harvard University has been working on developing tiny flying robots for over a decade, achieving their first flight in 2007. Inspired by a fly, this early effort required a guideline to move forward because it wasn't yet possible to put control mechanisms on board. Building on the success of these early experiments, the *RoboBee* project was launched in 2009 to investigate what it would take to "create a robotic bee colony". In 2012, the researchers bypassed key technical challenges that allowed *RoboBee* to take its first controlled flight.

Inspired by the biology of a bee and the intelligence of bee colony behaviour, the *RoboBee* measures about half the size of a paper clip, weighs less than 0.1 grams, and flies using 'artificial muscles' comprised of materials that contract when a voltage is applied. The project aims to push advances in miniature robotics, microfabrication, bio-inspired sensors, compact power storage, ultra-low-power computing, and algorithms that coordinate multiple, independent machines.

Potential uses of a group of coordinated, agile, robotic insects could include pollinating a field of crops, search and rescue, hazardous environment exploration, military surveillance, high resolution weather and climate mapping, and traffic monitoring.

PROFILE

The *RoboBee* Project is a coordinated effort between Harvard University's School of Engineering and Applied Sciences; Harvard University's Department of Organismic and Evolutionary Biology in the Faculty of Arts and Sciences; Northeastern University's Department of Biology; and Centeye, a microelectronics firm in Washington, D.C. specialising in vision chip and visual sensor technology.

› **robobees.seas.harvard.edu**

Robobees

Harvard School of Engineering and Applied Sciences & Northeastern University (US)

Second Livestock, a virtual reality world for battery-farmed chickens, is a speculative project drawing parallels between how we treat animals and how we treat ourselves. Through a straight-faced parody of Second Life (a virtual reality world for humans), the project attracts visitors into a conversation about the reasons behind, and consequences of, people choosing to spend more of their lives in virtual spaces.

The work exists as a performance, an installation, and on the internet, and presents itself as eliminating the need for the physical space required for free-range livestock, through 'Virtual Free Range™'. This gives livestock the experience of free-range life while living within the confines of a facility.

The vocabulary and visual language of the project mocks the marketing devices and hype of technology firms that introduce new, 'disruptive' technologies. The artist performs the presentation in the persona of the CEO of *Second Livestock*. After the presentation, the visitors are invited to participate in an open discussion and experience the virtual reality (VR) world through a prototype of the CCI (Chicken-Computer Interface). This prototype consists of an Oculus Rift VR Headset and a custom-made omni-directional treadmill.

Second Livestock went viral in 2014 being covered by many international news outlets. This coverage led to a grand conversation across the internet about the ethical implications of virtual reality for chickens and virtual reality in general.

PROFILE

Austin Stewart is an American artist whose works of critical design are not meant to provide answers or support a particular opinion, but to instigate debates on pressing contemporary issues. He endeavors to make work that engages broad and diverse audiences. He received his B.F.A. from the School of the Art Institute of Chicago and his M.F.A. from the Ohio State University. His work has been exhibited internationally and has received extensive press coverage around the world.

› **theaustinstewart.com**
› **secondlivestock.com**

Second Livestock

Austin Stewart (US)

Silent Herdsman is a 'smart collar' monitoring system for cows. It monitors a cow's health round-the-clock and transmits the data wirelessly to a computer, mobile or tablet. The software tracks each individual cow on-screen in real-time and alerts the farmer to any changes associated with the onset of heat and/or the health of the animal. If there are changes, the farmer will be sent an email immediately to ensure no vital opportunities are missed. This results in optimal fertilisation times, earlier health interventions, and maximum milking efficiency.

Additional software called mySilent Herdsman Health Alert has been developed to provide early identification of animal illness before being observed or identified by a human. Eating and rumination is measured ten times per second, with the graphs displaying the average time spent by the cow eating and ruminating every four hours. Alerts are received when eating and/or ruminating declines. It has been proven to accurately and reliably alert farmers to the signs of illness—most commonly to the early onset of mastitis and lameness.

There's no impact on the farmer's working routine, so things can carry on exactly as normal. The system still works even if there isn't an internet connection and, as the data is available in the cloud, farmers can manage their herd any time, any place, and on any device, enabling them to make important decisions quickly and easily.

PROFILE

Silent Herdsman Limited has developed an integrated hardware- and software-based 'precision farming' platform for herd management in the dairy and beef farming sectors. The *Silent Herdsman* decision-support software tool for the agricultural market was launched in the UK in 2010. This initiative was a result of years of extensive research and development and an output of the Intermediary Technology Institutes program owned by Scottish Enterprise, delivering a condition-based monitoring program for livestock cattle.

› **silentherdsman.com**
› **@SilentHerdsman**

Silent Herdsman

Silent Herdsman Limited (UK)

Foraging is the practice of gathering fruits and vegetables from places other than farms or orchards—for example, apples from trees in parks or mustard greens from abandoned lots. In urban foraging, the trees, bushes, and plants are scattered around the city, often in awkward locations. As such, finding and monitoring the fruits and vegetables is difficult.

The *Bend-Branch Sensor* is a low-fidelity sensor system designed to monitor the ripeness of fruit that grows on trees, like apples, pears or plums. Rather than measuring and monitoring the fruit directly, the sensor monitors the bend in a tree branch: as fruit ripens it becomes larger and heavier, causing the branch to bend. Once the bend reaches a certain point, foragers are alerted that the tree is ready to be picked.

The *Designs for Foraging* project takes technologies from precision agriculture and redesigns them for the specific contexts of urban foraging. To date, it has explored the use of unmanned aerial vehicles like drones, sensor networks, and geographic information systems such as digital maps through a series of experimental prototypes and speculative designs.

PROFILE

The Public Design Workshop is a research studio. They explore new modes of socially engaged design practice and pedagogy, and collaborate with communities, civil society organisations, and government agencies to prototype speculative systems and services. Their focus is on designing 'alternative presents'—ways of questioning and reconfiguring contemporary socio-technical expectations and practices that allow people to experiment with new ways of living collectively. Their current work is focused on urban agriculture and food systems, and so-called 'smart cities'. The Public Design Workshop is directed by Carl DiSalvo, an Associate Professor at the Georgia Institute of Technology.

› **publicdesignworkshop.net**
› **@cdisalvo**

Designs for Foraging: Bend-Branch Sensor

Public Design Workshop: Carl DiSalvo, Tom Jenkins, Catherine Meschia and Karl Kim (US)

FARMSTAND FORECAST

Though it can be hard to tell, even highly processed and packaged foods contain ingredients that are grown on a farm. As crop varieties and farm systems shift, and new products emerge, what will we see in supermarkets and farmstands in the future? Farmstand Forecast presents emerging trends and fringe products, exemplifying changes that are underway in farming, food processing, and product development. From climate change to artificial intelligence, there are many environmental, technological and cultural shifts influencing what plants and animals we grow, and the resulting products we purchase.

The Farmstand Forecast is laid out in the following sections.

PROTEIN FUTURES

Eating meat has changed from an occasional treat to a daily staple in the last thirty years, but our desire for lots of cheap meat has major negative consequences for human and environmental health. The human population is expected to soar to ten billion by the end of this century, and long-term thinkers are investigating alternative sources of protein. How can plant-based proteins compete with our appetite for meat?

1/ **Pulses:** Nitrogen fixing, plant-based proteins
2/ **Ready Meals:** Covertly reducing animal proteins in fast food
3/ **Insects:** Using food and packaging design to convert the insect-averse

HYPE CYCLE

These miracle crops are repeatedly promoted as cure-alls for global hunger, malnutrition, resource shortages and rapid population growth. Why aren't they currently propagated and utilised everywhere? Sometimes they challenge local preferences and norms. Other times they only deliver on their promise after decades of research and refinement. And sometimes they are forgotten, only to be revived decades later. What would it take to phase in these farm fantasies?

1/ **Breadfruit:** Low-maintenance and high yielding tropical tree
2/ **Chlorella:** 1950s sci-fi food that keeps coming back
3/ **Mushroom Materials:** Biomaterials grown with fungi

ECO OPPORTUNISM

Many of the the disastrous environmental effects of climate change, decreased biodiversity and and the global spread of pests are known, but what unforeseen opportunities could arise? Every day, farmers observe and experiment within their local environment, but increasingly, they are confronted by long term planetary changes as well. How will human food systems creatively adapt and maintain vibrant traditions under these new conditions?

1/ **Ash Wood:** Endangered tree used in popular sport
2/ **Jellyfish:** Learning to eat the seafood that thrives during climate change
3/ **Nordic Wine:** Wine grapes migrate to northern latitudes »

Farmstand Forecast

The Center for Genomic Gastronomy (US/NO/IE)

DATABASES OF TASTE

Will the ability to store, retrieve and compare massive amounts of data change what we grow, how we process crops or what we eat? Some quantitative approaches to food are open-source and social, drawing on the wisdom of the crowd. Others are proprietary, leveraging intellectual property regimes to create the food equivalent of the iPhone or Google; ubiquitous, seamless and profitable. For a time.

1/ **Soylent:** Meal-replacement beverage with global ambition
2/ **Just Mayo:** Database-driven eggless mayo
3/ **Chef Watson Jam:** Cognitive cooking for seasonal overabundance

DESIGNER PRODUCE

Developing new food products for specific lifestyles or target markets is big business. Shifting human needs and desires are key drivers in the creation of new cultivars and products. The rise of fast fashion has seen short-lived trends surge through the marketplace at an increasingly rapid pace. As plant breeding techniques and food design timelines speed up, will we see a similar deluge of fashions on supermarket shelves?

1/ **Ghost Chili:** Hot pepper, bred as a weapon
2/ **Lullaby Milk:** Cows milked before daybreak for maximum Melatonin
3/ **Snack Peppers:** Sweet pepper bred for snacking alone

PROFILE

The Center for Genomic Gastronomy is an artist-led think tank that examines the biotechnologies and biodiversity of human food systems. Launched in 2010 by Cathrine Kramer (NO) and Zack Denfeld (US), the Center has completed research and exhibited in Asia, Europe and North America. they have collaborated with scientists, hackers, chefs and farmers. Their mission is to map food controversies, prototype alternative culinary futures, and imagine a more just, biodiverse and beautiful food system. Current members include Emma Conley (US) and Molly Garvey (IE). The Center's work has been featured in *WIRED*, *We Make Money Not Art*, *Science*, *Nature and Gastronomica* and they have shown work at the World Health Organization, Kew Gardens and the Victoria and Albert Museum. They continue to explore the future of our food system through traveling supper clubs and pop-up food carts worldwide.

› **genomicgastronomy.com**
› **@centgg**

Mycotecture bricks are bricks that are grown out of a living fungus. The fungus digests and binds together smaller pieces of organic materials into a tightly bound structure. Though incredibly strong and durable, fungal materials can readily be broken down with a range of benign processes and incorporated back into the world.

Fungal materials can be grown into the form of walls, arches, columns and other building components. They can also be grown with tunable qualities similar to plastics. They can be cut and machined like many other composites or rigid foams, but it is better to imagine the fungal tissue as a goo that will infiltrate, permeate and bind whatever it comes in contact with and can digest (it cannot digest humans).

Like all organisms, fungi are very sensitive to their surroundings, and by altering subtle factors it is possible to make their tissue express a range of desirable physical characteristics. Fungal tissue can quickly be amplified to an enormous volume if provided with the appropriate nutrients and environmental factors.

PROFILE

Philip Ross is an artist, inventor, and scholar whose research is focused on biomaterial design and life support technologies. Philip's innovations in engineering are globally recognised as foundational to the invention of mycotecture, the practice of building with fungal mycelium. He is a co-founder of MycoWorks and a thought leader on biomimicry. In 2013, his mycelium-based furniture won Ars Electronica's Award of Distinction for Hybrid Art. In 2014, Philip was invited to Stanford University's Department of Bioengineering as a Visiting Scholar where he has been pursuing research on fungal tissue development. In 2015, he joined the BioBricks Foundation as a Technical Lead on a project called The Bionet, which is an early projection towards the internet of biological things.

› **philross.org**
› **mycoworks.com**
› **@myconews**

Mycotecture Brick Wall

Philip Ross (US)

Ash Dieback, a chronic fungal disease first found in Ireland in 2012, poses a fatal threat to ash trees. Hurling and camogie, two of the most popular Irish sports administered by the Gaelic Athletic Association (GAA), use wooden ash sticks. Hurley sticks have been made from ash trees by craftsmen since before the recorded history of Ireland. Today, almost half a million hurleys are produced in Ireland each year. The GAA has approved a wood-free, synthetic hurley but can the cultural and ecological heritage of hurling be preserved in an age of globalised pathogens?

Scientists are attempting to breed disease-resistant trees through hybridisation, backcrossing and genetic modification, as well as isolating endophytes that might protect the trees against pathogens, which raises the question: Should we attempt to repair or replace our threatened species?

For FIELD TEST, Torpey Hurleys have carefully crafted one of their own hurleys, along with a hurley made from diseased ash wood.

PROFILE

With a heritage in the craft of hurley making dating back to the 1930s, Torpey Hurleys established itself as a premium hurley making business in 1981. For the past thirty-five years they have enjoyed making hurleys for some of the most renowned players in the sport of hurling. With a focus on performance, 'Use the best materials to make the best performing products' is their philosophy. This has led to some high profile customers experiencing a ‘Torpey’, including US President Barack Obama, Chinese President Xi Jinping, Indian Prime Minister Narendra Modi, Irish rugby legend Paul O’Connell, and golfing superstar Rory McIlroy.

› **torpeyhurleys.com**
› **@torpeyhurleys**

Clash of the Ash

Torpey Hurleys (IE)

SEED BOUTIQUE

We have always been biohackers. For 10,000 years creative individuals and groups have bred plants, selecting for desired traits and passing this information on through saved seeds. Although methods for saving and sharing seeds are quite straightforward, most commercial farmers today don't save seeds because of legal restrictions, inconvenience, or the preference for hybrid varieties which don't breed true and must be purchased each year. Plant breeding and selling seeds has been highly consolidated in the last twenty years, with three large companies controlling over half the world market share in seed sales. The seed boutique features ten plant seeds that each tell a story about current seed issues. Put a coin in the vending machine and help maintain the work of biohackers past.

The following seeds are available in the Seed Boutique.

Outredgeous Lettuce

Selection: Lane Selman, Director of Culinary Breeding Network (US)

It was only through a news article that Frank Morton of Wild Garden Seed discovered that his *Outredgeous Red Romaine Lettuce* would become the first produce grown and eaten on the International Space Station. After testing a range of vegetables, NASA chose this red-leafed lettuce because it had the lowest level of microbial growth on the leaf.

Frank Morton became a plant breeder after noticing a red lettuce amidst a field of green. Seeing this unexpected cross-pollination in his field in Oregon inspired him to try creating his own unique varieties. He now breeds more than two hundred varieties of lettuce. From tender to crunchy textures, his varieties are juicy and strikingly beautiful, showing off his love of contrasting colors and vivid patterns.

Through the Culinary Breeding Network, Frank receives chef and consumer input that he incorporates into his breeding process. Which traits would you choose? Which two plants would you cross?

Georgian Flat-leaf Parsley

Selection: Lane Selman, Director of Culinary Breeding Network (US)

In 2012 Wild Garden Seed embarked upon a parsley breeding project that started with fourteen different cultivars from ten different countries. The initial plan was to let the parleys cross-pollinate to produce a few quality varieties adapted to the region.

Bringing the Culinary Breeding Network into the conversation changed the trajectory. Participating chefs were able to identify unique flavours in a few parsleys that made them distinct for use in the kitchen, resulting in the creation of more varieties than originally intended, in order to preserve meaningful flavours.

The world is losing much of its agricultural genetic diversity, but there is still a fair amount of diversity to choose from when starting a plant breeding project. Our best chance for saving genetic diversity is finding desirable traits, and creating varieties adapted to our region and palates, and perpetuating them.

Stocky Golden Roaster

Selection: Lane Selman, Director of Culinary Breeding Network (US)

Many organic farmers rely on seed companies. But what happens when those companies stop selling what farmers want to grow?

Several years ago, farmers couldn't find seeds for 'Gypsy', a dependable sweet pepper variety they loved. Plant breeders created 'Gypsy' by crossing two inbred parents. Through this common process, their offspring, called hybrids, are very uniform and high yielding, which is great for farmers. However, once a company decides not to produce the hybrid anymore, it is gone for good. Any hybrid seeds that are saved and grown by the farmer will not produce a uniform pepper.

Farmers needed a substitute sweet pepper, and they wanted one that was open-pollinated (OP), which means it comes from a long lineage of stable genetics from which anyone can save seeds. Luckily, plant breeder Frank Morton of Wild Garden Seed had created several promising OP varieties that ripen early for the short Oregon season and have phenomenal flavour and texture. His work created independence for farmers, who now have the tools they need in perpetuity. This is seed sovereignty.

Rosalinda Sugar Beet

Selection: Kirstie McAdoo, Education and Learning Co-ordinator of Airfield Estate (IE)

Sugar was first extracted from the white beet, a tuber descendent of the sea beet, by German chemist Andreas Marggraf in 1747. The discovery was welcomed by many in Europe, including Napoleon Bonaparte, as a way of being sugar self-sufficient.

Ireland's first sugar beet farm opened in County Carlow in 1926 and supplied sugar to the British Isles during a time when cane sugar was scarce. After the two world wars, cane sugar flooded the market and the demand for beet sugar fell. The Carlow factory closed in 2007. However, beet sugar can also be used as animal feed and in ethanol production, a petroleum alternative. With the removal of EU sugar beet quotas in 2017, Ireland may be welcoming back a once-familiar and very diverse crop.

Temuco Quinoa

Selection: Irish Seed Savers Association, County Clare (IE)

International research into the ancient South American staple began in the 1990s, led by NASA in its search for space station sustenance. Grown in the Andean region of South America for at least 3,000 years the pseudograin began being promoted as a miracle whole food with an impressive arsenal of amino acids.

In the space of a decade, quinoa has gone from a low-yielding sustenance crop maintained by traditional small-scale farming in arid parts of Bolivia to a global commodity, sold as a luxury item in Lima, Peru and in health food shops worldwide.

Quinoa's hardiness and adaptability means that it can be grown in multiple climates, even one with as much rainfall as Ireland. Biodiversity of the grain has been maintained and nurtured by the traditional methods of Bolivian farming and 3,000 cultivars exist today, making it a strong crop for genetic research and crop security.

Stormont Cirrus Linseed

Selection: Irish Seed Savers Association, County Clare (IE)

This variety of of Irish linseed was once stored in the Vavilov Institute of Plant Industry in Russia, one of the world's first seedbanks.

Founded in 1927 in Leningrad (now St. Petersburg) by geneticist and botanist Nikolai Vavilov, the survival of the seed bank was first put to the test by the outbreak of World War II. During the twenty-eight month Siege of Leningrad, the bank was guarded by a group of scientists. Seed saving was of such importance that, at the siege's end, nine of the seed-guarding scientists had died of starvation instead of eating the seeds.

The institute came under threat again in 2010, this time from the Russian Housing Development Foundation who wished to demolish the bank to make way for flats. However, in April 2012 the Russian government ruled in favour of the preservation of the rare genetic repository over private development interests.

Flower Sprouts

Selection: Center for Genomic Gastronomy (US/NO/IE)

A *Flower Sprout* is a cross between kale and brussel sprouts. Launched in the autumn of 2014 by UK-based Tozer seeds, the flower sprout is described as a "brand new vegetable... which is versatile, easy to prepare and good looking".

Flower Sprouts are an example of contemporary crops that seem to have been bred for traits that would appeal to a very specific consumer demographic profile.

The vegetable can be used in very small quantities, without too much food wastage, perfect for a single person living alone. Its colour and novel appearance appeal to novelty-seeking home chefs. In addition, health-centric news outlets have welcomed the crossbreeding of two healthfood stables.

Biodiverse Grass Seed Mix

Selection: Dr. Trevor Hodkinson, Head of Botany, Trinity College Dublin (IE)

This biodiverse grass seed mix is a combination of five different types of grass. With its strong dairy and meat industry and plentiful rainfall, Ireland can easily grow grass which is converted into animal products. So much so that approximately a third of Ireland's greenhouse gas emissions come from the agricultural sector.

There are plans to considerably increase the national herd of cattle and sheep, which emit methane gas, and would cause Ireland to not meet its targets for reducing agriculture emissions. Introducing a more biodiverse mix of grasses may make better use of nutrients in the soil and reduce waste fertiliser inputs. It may be a small first step to more radical changes, such as adding trees where sheep are grazing, reforestation and changing land use overall.

GM Corn

Selection: The Center for Genomic Gastronomy (US/NO/IE)

When seeds are regarded as trade secrets that need to be protected, strange tales of industrial espionage emerge. In 2013, six Chinese citizens were indicted in Iowa on charges of plotting to steal GM seeds from Monsanto, DuPont and AgReliant Genetics. Mo Hailong, director of international business at Beijing Dabeinong Technology Group, was arrested after being spotted on his knees, digging in an Iowa cornfield.

The indictment claims that three of the defendants attempted to ship over one hundred kilograms of corn seed, packaged in ziplock bags, from Illinois to Hong Kong. On another occasion, a defendant attempted to smuggle corn seed on a flight, concealing it in one hundred Subway napkins within two boxes of Orville Redenbacher brand microwave popcorn.

Seeds can be stolen in a number of ways: transplanting seedlings before they germinate, obtaining ears of corn, self-pollinating a hybrid, laboratory analysis, and employee leaks. Companies attempt to prevent theft of corn germplasm by delivering seed close to planting time in unmarked bags and not telling contract growers what they are growing.

Beefy Resilient Grex Bean

Selection: The Center for Genomic Gastronomy (US/NO/IE)

2016 is the United Nations International Year of Pulses. A pulse is a crop harvested solely for the dry seed, like beans, peas and lentils. Pulses are high in protein, low in water consumption and are fixers of soil nitrogen. Whole nations exist and thrive on pulse-for-protein diets. Pulses are also food for our food; 25 percent of annual production is used for animal feed.

This Beefy Resilient Grex Bean was an accidental discovery by Carol Heppe, a Harvard plant geneticist and breeder based in Oregon in the United State. An unlikely cross between two pure bean varieties, the result is a high-yield, hardy bean that 'tastes more beefy than beef does'. This is also an Open Source Seed Initiative Pledged variety meaning that you have the right to use this seed however you want—breed with it, or even grow and sell the seed yourself. When you buy or accept this variety, however, you are agreeing to honour the OSSI Pledge.

In sealed rooms, as sterile as computer-processor factories, chicks hatch while being closely monitored. A huge hose sucks salmon out of a fjord. Metal teeth chomp up fields of sunflowers which have withered at just the right time thanks to chemicals. Chickens are cut up and pigs are gutted in seconds, though cows take a little longer. Welcome to the world of high-tech agriculture and the industrial production of food.

Our Daily Bread is an award-winning documentary that shows the places where food is produced in Europe: surreal landscapes plasticised and optimised for tractors and agricultural machinery, sterile rooms in cool industrial buildings designed to ensure logistic efficiency, and machines that require uniform materials for smooth processing. What might look like something from the world of science fiction is reality. Our food is produced in spectacular spaces which are seldom seen.

Precisely framed continuous tracking shots take on the system's efficiency and put it on display. Dispensing with commentary and explanatory interviews allows the viewer to form their own ideas about what they're watching, as the film unfolds with just the whirring, clattering, booming, slurping, and hydraulic breathing of the machines as a soundtrack—only the screeching of chickens is louder.

Our Daily Bread is a wide-screen tableau of a feast which isn't always easy to digest—and in which we all take part.

PROFILE

Nikolaus Geyrhalter is an Austrian filmmaker who has directed, produced, written, and worked as cinematographer for numerous documentaries. He has won awards for D*as Jahr nach Dayton* (1997), *Pripyat* (1999), *Elsewhere* (2001), and *Our Daily Bread* (2005).

› **ourdailybread.at**
› **geyrhalterfilm.com/en**

Our Daily Bread Nikolaus Geyrhalter (AT)

OPEN AG LAB

The inputs, processes and systems used to grow our food and materials are constantly being tweaked and refined. Changes in farming practices are driven by farmers trying out new crop rotations, scientists studying plant microbiomes in the lab, or inventors creating low-powered solutions to replace existing farm machinery. The Open Ag Lab presents some of the cutting edge research being field tested on farms and is a space for visitors to get their hands dirty learning to save seeds, teaching a computer about bee health, and culturing the microorganisms that grow in and around the plants that we eat.

Millions of the world's smallholder women farmers have limited access to farm energy, mechanisation and the most basic of agricultural and agri-processing tools. With minimal access to alternative energy sources (draught animals or mechanised farm equipment) such smallholder farmers remain largely dependent on human labour for cultivation and agri-processing: a deficit trap that can perpetuate rural poverty.

The National University of Ireland Galway's *3D4AgDev* programme works in partnership with women smallholder farmers in Malawi to harness the innovation and creativity of rural innovators to co-develop, field test and scale-up new or improved technologies and tools for smallholder farmers.

The *3D4AgDev* programme links the potential of user-led innovation with rapid prototyping (via 3D printing, arc welding and metal casting) to enable women smallholder farmers in Africa to design and develop their own labour-saving agricultural tools.

Facilitated by *3D4AgDev*, rapid-prototyping of tool designs has been conducted and prototype tools have been tested against existing tools in on-farm trials involving the innovator groups. The most promising of these are now being scaled up for production and dissemination using a social enterprise approach involving the smallholders themselves.

PROFILE

Zewdy Gebremedhin is a *3D4AgDev* Research Officer conducting her Ph.D. research on labour-saving technologies for women smallholders. Charles Spillane and Una Murray are engaged in *3D4AgDev* research management and supervision. All three are members of the Plant and AgriBiosciences Research Centre at the National University of Ireland Galway (NUIG) where the *3D4AgDev* Programme is located. The *3D4AgDev* Programme is a research partnership programme between NUIG and Concern Worldwide, and is hosted at the International Center for Tropical Agriculture in Malawi. The programme is funded by the Bill and Melinda Gates Foundation Grand Challenges Exploration program, and also the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH.

› **3d4agdev.org**
› **@3D4AGDEV**

3D4AgDev

Zewdy Gebremedhin (CA), Charles Spillane & Una Murray (IE)

Tinder for Bees is an interactive project that allows visitors to participate in the protection of honey bees. Blazer Technologies is dedicated to digitising the apiculture (or beekeeping) industry to protect honey bees from things like Colony Collapse Disorder (CCD). CCD is a term used to describe the mass disappearance of worker bees from honey bee hives, resulting in a breakdown of colonies. It poses a major threat to the apiculture industry, with more than one third of honey bee colonies collapsing every year.

The primary challenge beekeepers face in combating CCD is the early detection of its causes, including: Varroa mites, a deadly parasite that sucks bees' blood and transmits diseases such as deformed wing virus; pest intrusions, such as wasps, who kill bees and steal their honey; malnutrition, due to the monoculture trend in farming and the lack of variation in their diets; and pesticide exposure, that poisons and kills bees.

One way Blazer aims to protect against CCD is by installing honey bee monitoring devices on hives around the world to notify beekeepers of threats. The device will take pictures and use machine vision technology to identify problems. The team aims to develop a fully automated system for removing both Varroa and pests from hives without using any chemicals.

This exhibit consists of images collected from Blazer's second generation prototype. In order for the images collected to be useful for development they must first be classified by the visitor into different folders based on what's in them. With the images classified, Blazer will be able to train algorithms that can be used to automatically recognise these problems and begin saving honey bees.

PROFILE

Blazer Technologies was co-founded by three Trinity College Dublin students in 2015 with the aim of digitising the apiculture industry to protect and preserve honey bees for future generations. Joseph Lanzillotta studied business and economics and is now Blazer's CEO. John O'Reilly studied engineering and is now Blazer's CTO. Francis Yates continues to study mechanical engineering and, after initiating the idea, has maintained his role as Blazer's Innovation Officer. The team first came together for the Trinity College Dublin LaunchBox incubator program in the summer of 2015. It was during this program that the team was introduced to Movidius, the world leader in embedded machine vision technology. With direction from Movidius, the team has now built a first and second generation prototype. The second was used to collect the images for this exhibit.

› **blazer.buzz**
› **@BLazerBuzz**

Tinder for Bees

Blazer Technologies Ltd (IE)

The Dublin Honey Project is working with native Irish Black Bees to produce honey from each of the Dublin postcodes. They currently have six apiaries (bee yard where beehives are kept) spread across Dublin city and county, and work closely with educational institutions and companies to educate the people of Dublin about the need to conserve Ireland's native bees.

Within the relatively small geographical area of Dublin, they have still managed to produce honeys with a variety of tastes and flavours, including heather, buckwheat, and apple and lime. This is because cities can offer a more diverse range of pollen for bees, as opposed to more rural areas where only one crop might be grown for miles around. The *Dublin Honey Project* also contend that cities can actually be 'cleaner' for bees in terms of chemicals in the environment, as cities tend not to extensively use dangerous pesticides in the same areas that pets and children frequent.

The Dublin Honey Project aims to use by-products from beekeeping, collecting the raw materials (pollen, wax and propolis) and developing a range of wax candles and pure beeswax cosmetics.

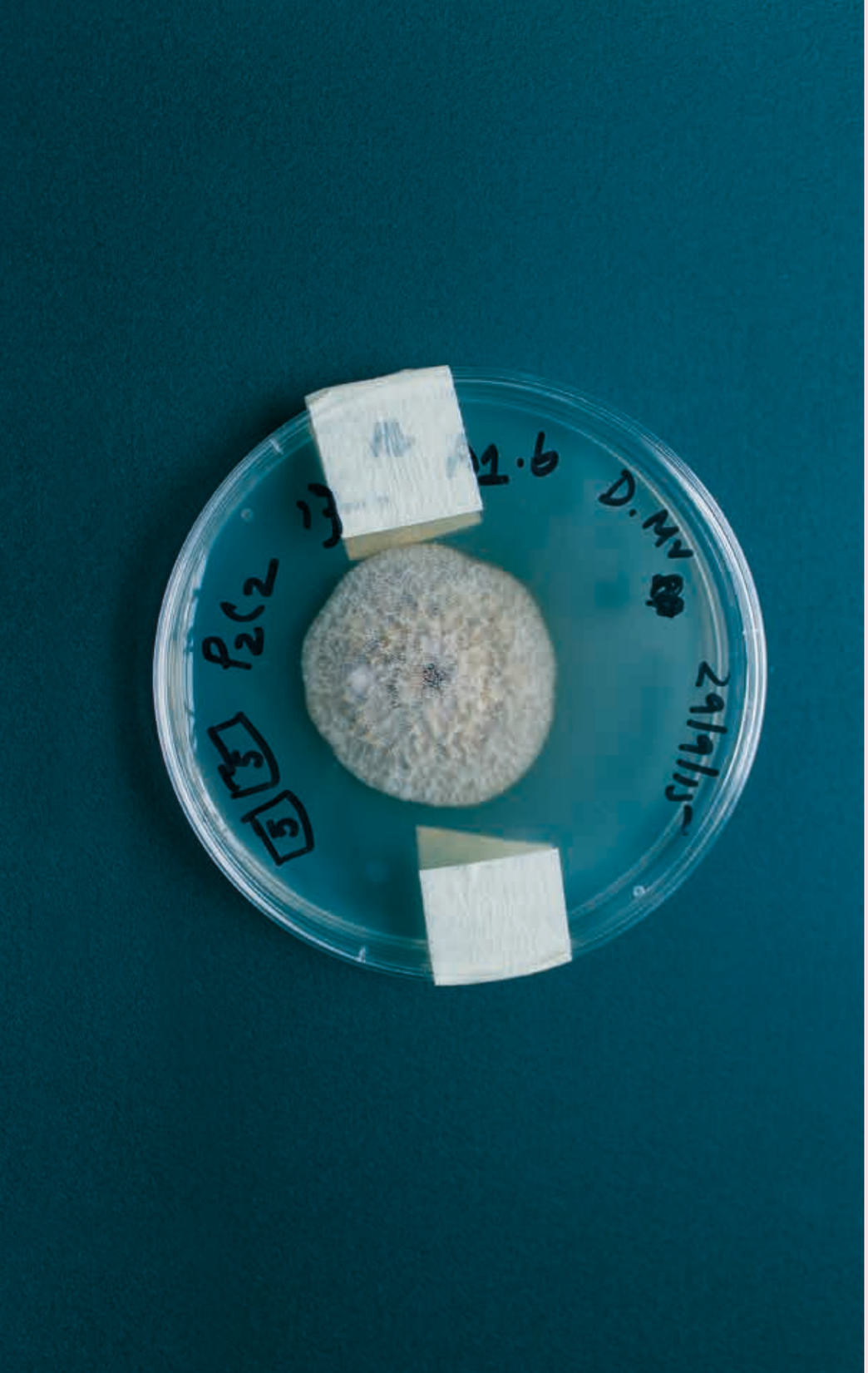
PROFILE

The Dublin Honey Project was founded in 2014 by commercial photographer Kieran Harnett and architect Gearóid Carvill and is based in Newmarket in Dublin 8. Kieran and Gearoid are united by shared beliefs in the importance of food provenance and supporting biodiversity in local food production.

› **facebook.com/DublinHoneyProject**
› **@dublinhoney**

The Dublin Honey Project

Kieran Harnett and Gearóid Carvill of The Dublin Honey Project (IE)



A ‘microbiome’ is all of the microorganisms in a particular environment, including the human body or a part of the body. Plants contain a microbiome in a similar way to humans and other animals. There is a diverse range of microbes that live within plant cells and tissue that help the plant grow. Some of these are classed as endophytes. Endophytes are organisms, especially a fungus or microorganism, that live inside a plant without causing apparent disease, in a parasitic or mutualistic relationship.

Endophytes have been found in all species of plants studied to date, but the relationship between endophyte and plant is still not very well understood. Some endophytes are believed to enhance host growth, nutrient acquisition, and may improve the plant’s ability to tolerate environmental stresses, such as drought, and enhance resistance to insects and mammalian herbivores.

Researchers at the Botany Department in Trinity College Dublin are undertaking research to discover the diversity and uses of these microbes, which include both bacteria and fungi. Some can be used as seed coats to infect plants and boost yields, some provide valuable chemicals for medicine and others might protect plants against pathogens, such as Ash Dieback disease.

PROFILE

The Botany Department of Trinity College Dublin is a leading centre of teaching and research in plant sciences. Their interests range over the areas of plant systematics, plant community ecology, and environment and sustainability. They study plants because they are of vital importance; as the source of our food, the oxygen we breathe and most of the medicines we use. They are central to the processes of global climate change and to the provision of food and energy for an expanding human population. Trevor Hodkinson is the Head of the Botany Department.

› **bit.ly/trevorhodkinson**
› **@TrevorHodkinson**

Endophyte Club

Trevor Hodkinson, Brian Murphy, Anna Kaja Hoeyer and Anindita Lahiri
of the Botany Department in Trinity College Dublin (IE)

Searching for a complex object in a world filled with complex objects is difficult for any animal, including insects. Shannon B. Olsson and Pavan Kumar Kaushik of Naturalist-Inspired Chemical Ecology Lab (NICE) started the *Insect VR* project with the intention of placing visitors in the 'mind of a bug' so they can understand how pests find food crops—or even humans, in the case of mosquitos.

Their group theorises that effective pest management requires both an understanding of the symptoms, as well as the cause, of pest damage. This requires a knowledge of the problem from the pest's point of view, which they attempt to simulate here. *Insect VR* is a virtual reality (VR) project in which students from Trinity College Dublin collaborate with and translate the research of NICE during FIELD TEST.

The intention is to create a VR game that simulates what an apple-seeking fly might experience while searching for an apple. The VR world is based on real-world data obtained from insect behaviour. VR headsets such as the Oculus Rift can be used to simulate a fly-like experience for a human user, with modifications to account for our sensory differences. The user's task is then to find the apple in a virtual group of trees. Currently the NICE lab is testing a similar VR setup for actual apple maggot flies. The data from the sensors of the VR headset will provide valuable trajectories that they will use to compare human and fly trajectories.

This data not only gives insights on human search strategies but also can be compared against a fly in the identical VR world to provide deeper understanding on how a fly finds its host. Such information can be further used to develop more ecologically-based pest management programmes.

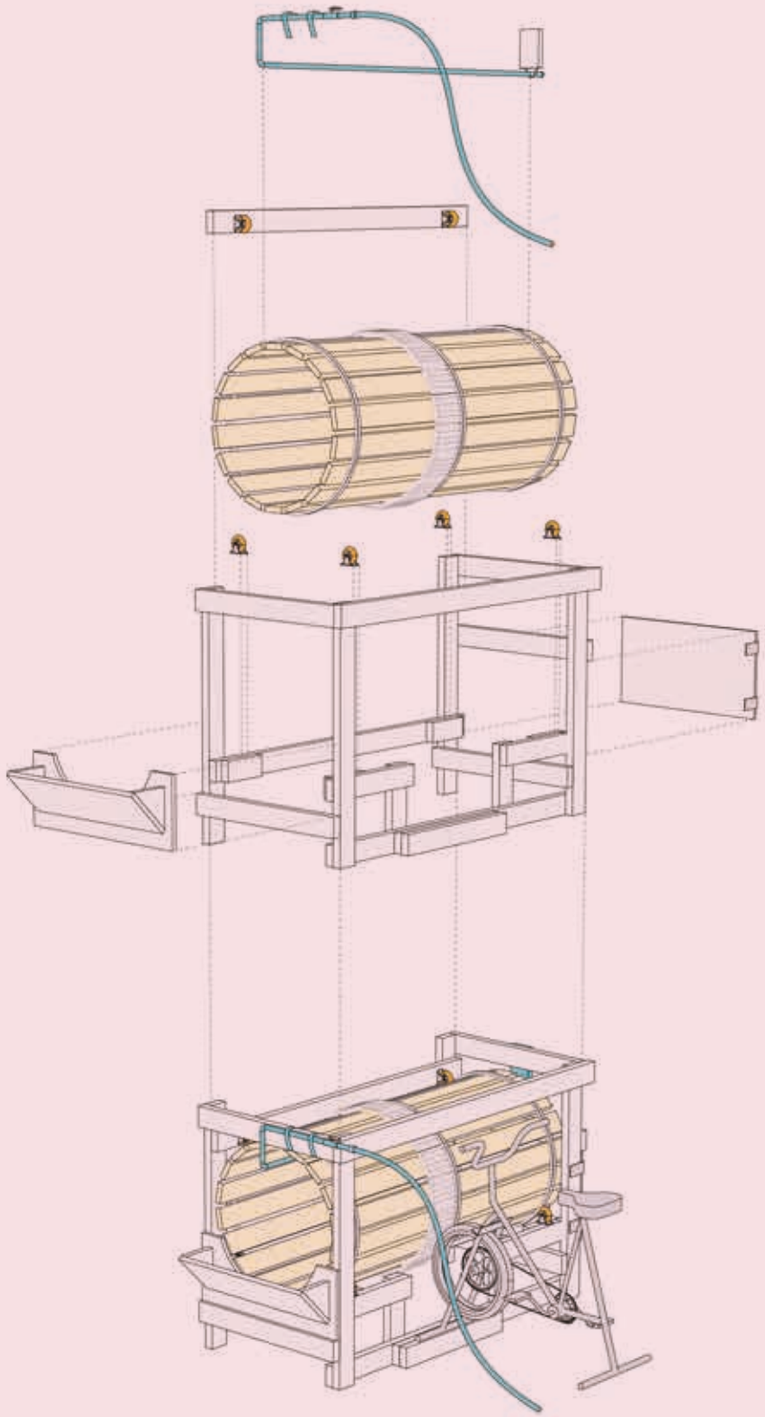
PROFILE

Shannon Olsson is the Principal Investigator of the Naturalist-Inspired Chemical Ecology Lab (NICE) at the National Centre for Biological Sciences, Bangalore, India. Her lab is currently investigating wild pollinators, the physiology of insects, insect speciation, naturally-derived insect repellents, and crop pests. Pavan Kumar Kaushik is a lab member at NICE and his research is on quantifying decision making through ethology, ecology, and engineering. The Idea Translation Lab is a broad curriculum elective course taught by Zack Denfeld at Trinity College Dublin.

› **nice.ncbs.res.in**
› **@odorobjects**

Insect VR

Shannon B. Olsson and Pavan Kumar Kaushik (IN) with students from the Idea Translation Lab (IE)



Farm Hack is a worldwide community of farmers that build and modify their own tools through the long-standing farm traditions of tinkering, inventing, fabricating, tweaking, and improving things that break. It has evolved into an open-source community for farmer-driven design and collaborations. Two projects brought to life by the Farm Hack community are the Rootwasher, and the 3D Printed Seeder Roller.

Made partly from repurposed bicycle parts, rollerblade wheels, and an old exercycle, the Rootwasher cleans twenty kilograms of roots in under five minutes and does not require any electricty to operate. A five-acre vegetable farm harvests up to 250 kilograms of root crops per week, including radishes, carrots, turnips, potatoes, parsnips, and celeriac. Washing the roots by hand can take about three hours per 250 kilograms, and is very unpleasant in cold weather. The bicycle-powered Rootwasher provides the farmer with gentle exercise and helps makes washing roots fun.

Seeder rollers are plastic cogs that space out small seeds precisely whilst sowing. This saves a farmer from wasting seeds and time when planting. As part of FIELD TEST, Ash Watson from our MAKESHOP team has produced a new hack for Jang seeder rollers inspired by an existing Farm Hack user, jellenbogen. This new hack is an OpenSCAD script that lets the user define all of the characteristics they desire—like the seed well size, depth, shape, number and offset—to generate a 3D printable model that is a fraction of the price of a purchased seeder roller.

PROFILE

The Farm Hack community consists of farmers of all ages, but the project has special relevance to young and beginning farmers as a place to learn from their peers' and their elders' successes, mistakes, and new ideas. They also seek to bring their non-farmer allies on board: engineers, architects, designers, and the like. Together, with an open-source ethic, they believe they can retool farms for a sustainable future. These designs were submitted by Lu Yoder and Ash Watson.

› **farmhack.org**
› **@osfarmhack**
› **@WeAreMakeshop**

Farm Hacks

Lu Yoder (US) & Ash Watson (IRL)

Coffee is one of the largest globally-traded commodities, yet only one percent of the plant biomass ends up in the cup after the final brewing process. With today's dwindling resources and increasingly complex food system, it's important to minimise the waste of nutrients. The bulk of coffee waste ends up in landfill, where it often breaks down to produce harmful methane gases. Thousands of kilos of coffee grounds are thrown away every week in Ireland and, unbeknownst to many, these grounds make a fantastic substrate for growing mushrooms.

Coffee grounds are perfect for growing oyster mushrooms, because they are full of essential minerals and necessary elements for healthy, gourmet mushrooms to thrive on. After two or three harvests the grounds are spent as a medium for mushrooms, but become a nutrient-rich soil enhancer for a garden and a livestock feed.

URBAN OYSTER is tackling three problems by reducing waste, food miles, and Ireland's carbon footprint. It also operates as a social enterprise which adds benefit to the community by recruiting local people to carry out training programmes, assembling grow-at-home kits, running educational workshops and events, thus creating a location for further food enterprise. Together, it forms an innovative venture that brings benefits economically, environmentally and socially.

PROFILE

Andrew Douglas is the creator of URBANFARM, an agricultural start-up based in Dublin. Andrew and his team initiate urban agriculture projects within the city by promoting the re-use of the city's waste stream materials, or more technically collaborative projects. The projects use the latest technologies in LED lighting and micro-processors to create controlled environments for aquaponic and hydroponic food systems, helping to create an efficient city that can grow its own fresh, local produce.

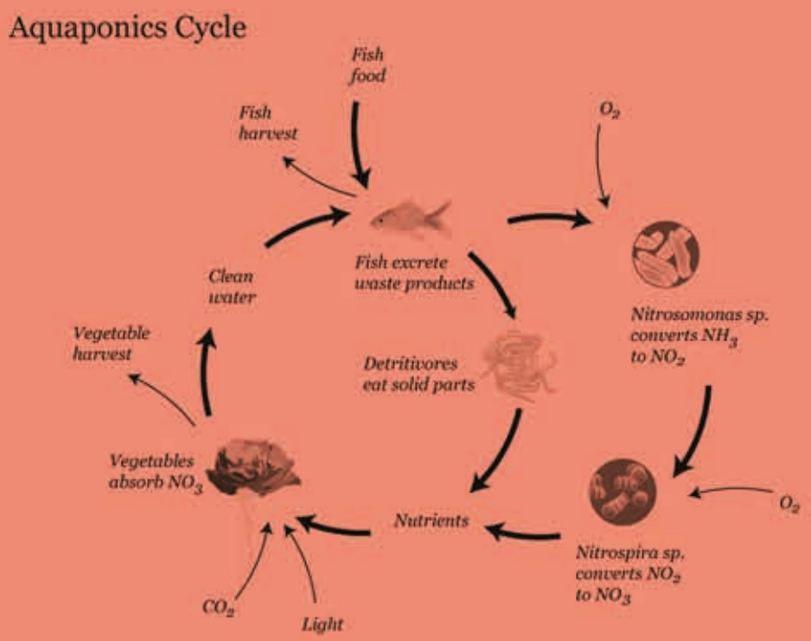
› **urbanfarm.ie**
› **@urbanfarm_**

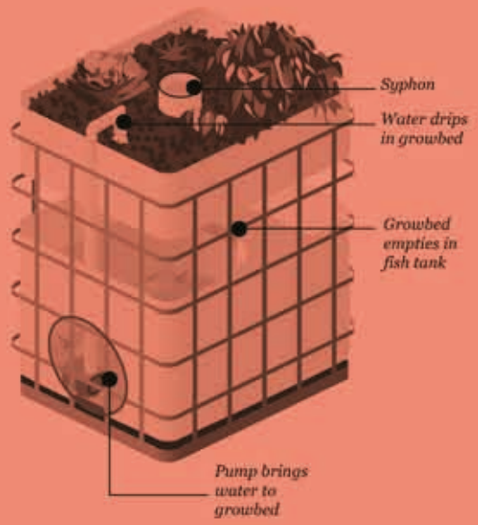
URBAN OYSTER from the Ground Up

URBANFARM (IE)

GROW HOUSE

For centuries the divide between cities and the rural lands that feed them has been increasing. Can we imagine a future where this divergence decreases? City farms, rural urbanism and home-grown in vitro meat are examples of the blurring boundaries between home, garden, city and farm. This section collects a number of projects which propose to bring agriculture out of the fields at the periphery of town and into the centre of our houses, cities and factories. It also examines the advantages and challenges to the many architectural and infrastructural sites that lie between farm and plate. Reconnecting agricultural producers and consumers holds promise, but growing in our homes will take more than just bringing plants, animals and microorganisms inside. We'll need to consider pests, hygiene and energy usage too. These projects take ironic, sincere, darkly comic, and entirely plausible approaches to our more dense and intensive food futures.





Aquaponics refers to any process in which fish and plants are farmed together in one integrated, symbiotic system. The term is a mashup of 'aquaculture' (raising fish) and 'hydroponics' (soilless cultivation of plants in water).

AQUAlab raises fish not only as a food source, but also to provide fertiliser for beds of leafy greens, edible flowers, microgreens and fragrant herbs. The source and beginning of everything is organic fish nutrients, which start the system. Fish eat and grow, producing waste during the process, which is comprised of ammonia and manure.

This waste, now present in the water, is pumped through a natural bio-filter, which transforms the ammonia waste into usable nitrates. These nitrates enrich the water used to irrigate the plants and vegetables, and fertilises them. The plants purify the water, which is now recirculated back into the fish tanks, ready to begin a new cycle. *AQUAlab* does all of this using renewable energies, LED lighting, recirculating hydroponics and open-source microprocessors that control and monitor the life in the systems.

PROFILE

Andrew Douglas is the creator of URBANFARM, an agricultural start-up based in Dublin. Andrew and his team initiate urban agriculture projects within the city by first promoting the re-use of the city's waste stream materials, or more technically collaborative projects. The projects use the latest technologies in LED lighting and microprocessors to create controlled environments for aquaponic and hydroponic food systems, helping to create an efficient city that can grow its own fresh, local produce.

› **urbanfarm.ie**
› **@urbanfarm_**

AQUAlab URBANFARM (IE)

The Open Agriculture Initiative (OpenAG) at Massachusetts Institute of Technology (MIT) is on a mission to create more farmers for the future of food production. They are developing open-source hardware and software platforms for sensor-controlled hydroponic and aeroponic agriculture systems. Chris Crisman photographed scientist and founder of the CityFARM project at MIT, Caleb Harper, and his team working on the MIT CityFarm at the MIT Media Lab in Boston.

The OpenAG process begins with the production of controlled-environment agriculture systems. These personal food computers are set to provide specific controlled environments that can be modified, manipulated, upgraded, and hacked as users experiment to find the perfect growing conditions for their favorite fresh foods. Nutrition and flavour can be maximised, water and energy use can be minimised, and preferences can be customised to suit every individual set of needs.

The open-source platform enables contributors to keep track of their data and discoveries so that the conditions for the local environments they've created can be shared around the world. Breaking down geographical limitations and cutting down on transportability requirements will allow local growers to focus on feeding people in their own communities. Even cities can become the perfect growing grounds to produce the kinds of healthy, fresh foods that they will need to support their growing populations.

PROFILE

Caleb Harper is a research scientist and director of the design and development of the MIT CityFARM. He leads the anti-disciplinary group of engineers, architects, urban planners, economists and plant scientists in the exploration and development of high performance urban agricultural systems. His current work is focused in the areas of building integrated and control environment agriculture, actuated sensing, control automation and data-driven resource and energy optimisation. Chris Crisman is an internationally recognised commercial photographer. Chris is a graduate of the University of Pennsylvania in Philadelphia. His work has been recognised by prestigious trade organisations such as *Luerzers Archive*, *Communication Arts*, *American Photography*, *Photo District News*, *Graphis*, and the International Photography Awards.

› **crismanphoto.com**
› **@crismanphoto**
› **openag.media.mit.edu**
› **@MITOpenAg**

Photo of OpenAg Initiative at MIT

Chris Crisman & Caleb Harper (US)

Hedge H.U.G. (Horticultural Urban Growth) is an exploration of rural urbanism, a speculative proposal that asks, "What if we reverse the trend of urban farming and reintroduce the city into the farm?". The fictional town prompts people to think differently about how integrated their lifestyle is or could be to a farm.

Hedge H.U.G. operates in the space freed up when consumers live near where their food is grown. This space includes the area dedicated to growing food that is lost during storage and shipping. The artists concentrate this 'free' space toward the periphery of the farm, outlining its boundaries and occupying the area traditionally reserved for hedges.

The artists' proposal does not eradicate the hedge, however. Hedges are important components of the farm which provide archaeological, historical, landscape and wildlife value. Instead, this intervention operates as an enlarged hedge and they re-imagine the functions hedges traditionally serve while adding new value and opportunities. Their hedge is composed of blocks, reminiscent of enlarged stones, which contain the urban programmes. In between these blocks are spaces that serve the double function of providing public urban space, as well as concentrated ecological habitats. The installation demonstrates a potential configuration for a *Hedge H.U.G.,* while also providing loose blocks for visitors to construct their own and imagine new forms of reoccupying the farm.

PROFILE

Design With Company, founded in 2010 by Stewart Hicks and Allison Newmeyer, is a Chicago-based firm that specialises in small-scale constructions, installations, and speculative urban scenarios. They pride themselves in creating spaces that are seriously playful and bring joy to those who experience them. Recently, Design With Company was chosen to participate in the 2015 Chicago Architecture Biennial. Their work has been widely published internationally in magazines, online, and in books. In 2015 they authored the book *Mis-Guided Tactics for Propriety Calibration*, published and funded by the Graham Foundation. Both principals are fellows of the MacDowell Colony, Lucien Lagrange Prize Fellows, and Graham Foundation Award recipients.

› **designwith.co**
› **@designwithco**

Hedge H.U.G. Design With Company (US)

In a world first, Mark Post of Maastricht University revealed a ‘Cultured Beef’ burger at a press-release event in London in August of 2013. The burger was fried and tasted at this event, and the left-overs were then plastinated in a process where water and fat are replaced by plastic, so it will not smell or decay.

Cultured Beef is created by harvesting muscle cells from a living cow. Scientists then feed and nurture the cells in a nutrient solution (usually fetal bovine serum extracted from unborn calves) so they multiply to create muscle tissue. The tissue is grown by placing the cells in a ring, like a donut, around a hub of gel. The muscle cells grow into small strands of meat. Some 20,000 strands are needed to make one 140 gramme burger. The meat created is biologically the same as the meat tissue that comes from a cow. They go through the same process with fat tissue, and at a later stage, they mix the in vitro meat with the in vitro fat in specific proportions to get a juicy and tasty result. This process is still under development and it could take ten years or more before it is commercially viable.

The Food and Agriculture Organization of the United Nations estimates that the demand for meat is going to increase by more than two thirds in the next forty years and current production methods are not sustainable. In the near future, both meat and other staple foods are likely to become expensive luxury items thanks to the increased demand, unless we find a sustainable alternative. The increase in demand will also significantly increase levels of methane, carbon dioxide and nitrous oxide, and cause loss of biodiversity.

Although Mark’s burger is only intended as a proof of concept and it will be a while before Cultured Beef appears on supermarket shelves, if at all, it is likely to change the way we eat and think about food forever.

PROFILE

Mark Post is a medical doctor whose main research interest is the engineering of tissues for medical applications and for food. The medical applications of Mark’s research focus on the construction of blood vessels that can be used as grafts for coronary artery bypass grafting. Mark has held positions at Harvard Medical School, Dartmouth Medical School, and is currently the Chair of Physiology and Vice Dean of Biomedical Technology at Maastricht University in the Netherlands.

› **culturedbeef.net**
› **@culturedbeef**

Laboratory Burger

Mark Post (NL), kindly on loan from Museum Boerhaave (NL)

MicroFarm is a prototype for an automated, wall-mounted living space aeroponic (the process of growing plants in an air or mist environment without the use of soil) system that grows edible plants at high speed. *MicroFarm* sets out to challenge the relationship between food production and consumers in today's complex food chain, and to enable urban dwellers to become producers of nutritious and delicious plants.

MicroFarm concentrates on growing 'microgreens'—the shoots of vegetables such as rocket, celery, beetroot or pak choi—that are picked just after the first leaves have developed. Microgreens contain remarkably higher levels of vitamins and nutrients than their mature plant counterparts. For example, according to research published in the *Journal of Agricultural and Food Chemistry*, red cabbage microgreens had forty times more vitamin E and six times more vitamin C than mature red cabbage. *MicroFarm* offers a system for more deliberate nutritious eating habits in the home environment.

In addition to the Internet of Things enabled physical unit, it provides an online platform that enables growers to filter and purchase seeds, engage with other microgrowers and control their *MicroFarm* from their phone. What if our appliances helped us easily create our food? *MicroFarm* can be seen as a slick and user-friendly domestic appliance for growing systems, an automated device that hides the mechanics. Can you imagine a *MicroFarm* alongside your coffee machine and toaster?

PROFILE

From an early age, Fabian Strunden has designed and scripted engaging websites with a strong focus on clear design aesthetic and user experiences. This sparked his passion for experimenting with circuitry that make his designed objects smarter by connecting them to online services and web based communities. Fabian uses technology to reduce redundant tasks, allowing him to focus on the beautiful aspects of life.

› **strunden.com**
› **@strunden**

MicroFarm

Fabian Strunden (GE)

Stir Fly is a speculative domestic appliance that could be used in the kitchen of every home: a prototype domestic bioreactor to culture and farm insect meat. A bioreacter is any manufactured or engineered device that supports a biologically active environment—in this case, a vessel to grow cells taken from a fly. Unlike most bioreactors, which must be kept close to 36.5 degrees Celsius, insect cells grow at room temperature which makes the process effective and readily available to the domestic environment.

The popular media is currently filled with stories about a food future where we will eat insects, industrially-grown in vitro meat, and develop biotechnologies for use in our home kitchens. These hype-filled articles rely on seductive rendered images and promotional language without articulating the material, ecological, and ethical implications of industrially scaling these fantasies. This work takes the idea of in vitro meat and protein, and translates it into an absurd conclusion—and in the process unveils the nutritional requirements of the cells.

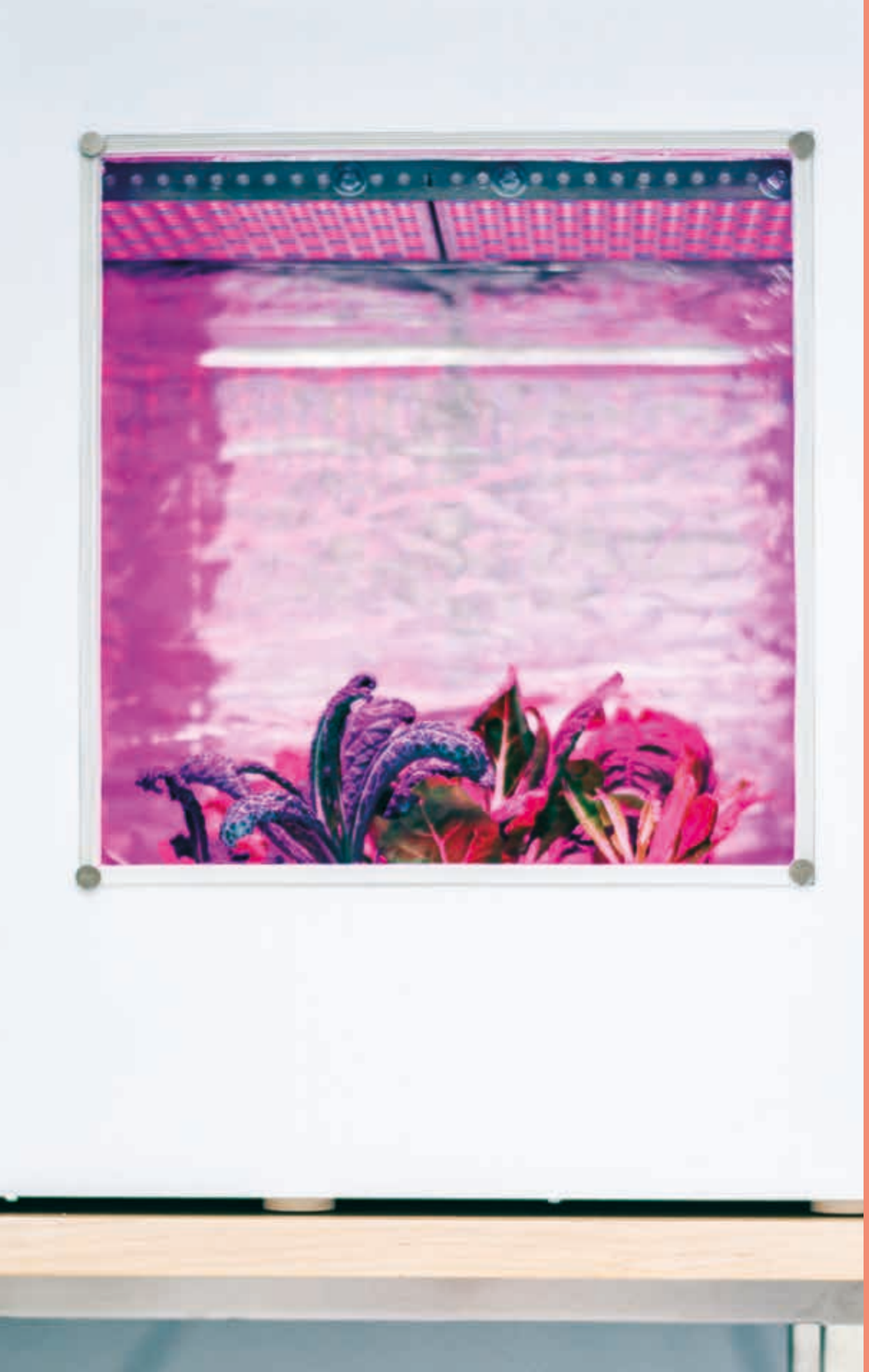
PROFILE

Oron Catts and Ionat Zurr form the Tissue Culture & Art Project. Oron is the Co-Founder and Director of SymbioticA: the Centre of Excellence in Biological Arts at the University of Western Australia and is a Professor of Contestable Design at the Royal College for the Arts in London. Ionat Zurr is a researcher and SymbioticA's Academic Co-ordinator. Both are visiting professors at Biofilia—Base for Biological Arts at the Aalto University Finland. They are considered pioneers in the field of biological arts and publish widely, exhibit internationally and their work has been collected by Museum of Modern Art New York. Robert Foster initially trained as a silversmith at the Australian National University School of Art. He founded Fink and Co, a leading design and production house. His creative practice spans across many fields, from art, craft and design to architecture, engineering and manufacturing. He has chaired on boards, taught, lectured and exhibited internationally. Robert and Oron exhibited together in Israel in 2014 and in 2015 at The University of Western Australia with *DeMonstrable*.

› **symbiotica.uwa.edu.au**
› **tcaproject.org**
› **finkdesign.com**
› **@OronCatts**

Stir Fly: The Nutrient Bug 1.0

The Tissue Culture & Art Project (Oron Catts & Ionat Zurr) in collaboration with Robert Foster (AU)



The *Personal Food Computer* is a controlled-environment agriculture technology platform that uses robotic systems to control and monitor climate, energy, and plant growth inside a specialised growing chamber. Climate variables such as carbon dioxide, air temperature, humidity, dissolved oxygen, potential hydrogen, electrical conductivity, and root-zone temperature are among the many conditions that can be controlled and monitored within the growing chamber. Operational energy, water, and mineral consumption are monitored and adjusted through electrical meters, flow sensors, and controllable chemical dosers throughout the growth period.

Each specific set of conditions can be thought of as a climate 'recipe', and each recipe produces unique results in the phenotypes (an organism's observable characteristics or traits) of the plants. Plants grown under different conditions may vary in colour, size, texture, growth rate, yield, flavour, and nutrient density. The *Personal Food Computer* can even program certain stresses, such as an induced drought or introducing certain organisms, to create desired plant-based expressions.

Food computers can be made in a variety of sizes, for production and experimentation on a wide range of scales.

PROFILE

The MIT Media Lab Open Agriculture (OpenAG) Initiative is on a mission to bring out the farmer in everyone by creating healthier, more engaging, and more inventive food systems. OpenAG is building collaborative tools and platforms to develop an open-source ecosystem of food technologies that enables and promotes transparency, networked experimentation, education, and local production. By making the science behind modern agriculture more accessible, they hope to break down the barrier of entry and put the power of food production back in the hands of the people. Rob Collins and Derek Williams are the Exhibition Technician and Technical Manager, respectively, at Science Gallery Dublin. The Idea Translation Lab is a broad curriculum elective course taught by Zack Denfeld at Trinity College Dublin.

› **openag.media.mit.edu**
› **@MITOpenAG**

Personal Food Computer

Built by Rob Collins, Derek Williams and students from the Idea Translation Lab (IE) from MIT Open Agriculture Initiative schematics (US)

In Europe and the United States, roughly fifteen percent of the harvest is lost to pests, and in tropical countries, that percentage can be much higher. The problem is that we can't find the insects that are treating our fields and grain silos as an all-you-can-eat buffet in time to do anything about them. To speed up and automate that detection process, Richard Mankin has spent decades building a library of insect sounds: the rustling of a seventeen-day-old rice weevil larva as it dines on a wheat kernel; the crunching of an Indian meal moth larva feeding on dry dog food; and the mooing of a horny lady psyllid in the citrus groves of Florida are just a small example of his extensive library.

Using these sounds, Richard has built a prototype Acoustic Location Fingerprinting Insect Detector: a probe you can stick inside your food storage container that sets off an alarm at the first sign of insect activity. His latest project involves using his lady psyllid recording to lure hopeful male Asian citrus psyllids into traps—an acoustic pesticide that he hopes will save the Florida orange juice industry.

Here, writer Nicola Twilley has compiled a playable database of some of his insect recordings.

PROFILE

Richard Mankin is an entomologist with the U.S. Department of Agriculture, based in Gainesville in Florida. His research is focussed on the acoustic detection and control of crop pests. Nicola Twilley is a contributing writer at *The New Yorker*, the author of the *Edible Geography* blog, and the co-host of the *Gastropod* podcast.

› **bit.ly/richardmankin**
› **ediblegeography.com**
› **@nicolatwilley**

Pest Sounds

Richard Mankin (US), as selected by Nicola Twilley (UK)

LOCI FOOD LAB

LOCI Food Lab is a travelling food cart for prototyping, serving, and debating a range of bioregional food futures at different sites around the world. A bioregion is an area bounded by natural rather than political borders, which has characteristic flora and fauna, and includes one or more ecosystems.

Visitors to the cart explore ‘bite-sized bioregionalism’ by identifying the attributes of the food system that are important to them. After identifying the three most important qualities of an ideal food system, they are served a customised, algorithmically-generated snack from a set menu of ten ingredients. The menu features crops, livestock, and food products grown within the bioregion.

LOCI Food Lab has previously created bespoke menus in collaboration with Heather K. Julius in Portland, Oregon, USA and with Ben Reade in Edinburgh, Scotland.

The LOCI Food Lab in Dublin, focuses on the Celtic broadleaf forest ecoregion of eastern Ireland, a subset of the Atlantic bioregion. A personalised snack is created when visitors digitally select food characteristics important to them, such as biodiverse, efficient, or delicious. The ingredients used include:

1/ Rye crackers, from rye grown and milled in Dunany in County Louth
2/ Dried apple slices, from apples grown in County Armagh
3/ Shoots and leaves, grown by the McNally family in North County Dublin
4/ Black pudding, made by Jack McCarthy from Tipperary-raised pigs, and rolled in Llewellyn apple balsamic vinegar
5/ Dillisk, coast-harvested seaweed by Wild Irish Sea Veg
6/ Sweet salty yoghurt, farm-cultured yoghurt from County Dublin and Macroom feta from County Cork
7/ Baby formula brittle, from Nestlé's Wyeth nutrition processing plant in County Limerick
8/ Homemade Dirt, made from imported Barry's Tea, Wilkie's Chocolate, and dark spices
9/ Mushroom Dust, foraged in County Cork by Ballyhoura Mountain Mushrooms
10/ River Trout Caviar, farmed in Little Arrigle River in County Tipperary

PROFILE

The Center for Genomic Gastronomy is an artist-led think tank that examines the biotechnologies and biodiversity of human food systems. Launched in 2010 by Cathrine Kramer (NO) and Zack Denfeld (US), the Center has completed research and exhibited in Asia, Europe and North America, and has collaborated with scientists, hackers, chefs and farmers. Their mission is to map food controversies, prototype alternative culinary futures, and imagine a more just, biodiverse, and beautiful food system.

Current members include Emma Conley (US) and Molly Garvey (IE). The Center's work has been featured in *WIRED* (UK), *We Make Money Not Art*, *Science*, *Nature* and *Gastronomica* and they have shown work at the World Health Organization, Kew Gardens and the Victoria and Albert Museum. They continue to explore the future of our food system through travelling supper clubs and pop-up food carts worldwide.

› **genomicgastronomy.com**
› **@centgg**

LOCI Food Lab

The Center for Genomic Gastronomy (US/NO/IE)

ACKNOWLEDGEMENTS

LOCI Food Lab
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AQUAlab
URBANFARM would like to thank Kijani Grows for their support in this project.

Stir Fly: The Nutrient Bug 1.0
This project was hosted at SymbioticA in The Centre of Excellence in Biological Arts, School of Anatomy, Physiology and Human Biology at The University of Western Australia.

Science Gallery Dublin would like to thank Juan-Pablo Labrador and Ash Watson from the Labrador Lab in the Smurfit Institute of Genetics at Trinity College Dublin for their support and expertise in the development of this exhibit.

Endophyte Club
This project was made possible thanks to Horizon 2020 Catalyst Award.

MicroFarm
Fabian Strunden would like to thank the Product Design Department at National College of Art and Design and Sorcha Harman for their support.

Playing with Pigs: Pig Chase
The *Playing with Pigs* team would like to thank the Utrecht School of the Arts, Wageningen University, and the Dutch Science Foundation for their support.

Designs for Foraging: Bend-Branch Sensor
Public Design Workshop would like to thank Concrete Jungle for their ongoing collaboration in the Designs for Foraging project and Sean Mackey for project documentation. This work was supported in part by funding from Intel and the National Science Foundation.

Mycotecture Brick Wall
Phil Ross would like to thank Michael Sgambellone for his support in making this work happen.

Seed Boutique
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—Thanks to Irish Seed Savers for the Temuco Quinoa and Stormont Cirrus Linseed seeds.
—Thanks to David Barry at Goldcrop Seeds for the Rosalinda Sugar Beet seeds.
—Thanks to Daniel Fait at Tozer Seeds for the Flower Sprout seeds.
—Thanks to Brown Envelope Seeds for Beefy Resilient Grex Bean seeds.

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Shadow Creations Ltd

Exhibition 3D Design
Cathrine Kramer

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James Kelleher and Sinéad Foley

Catalogue Print
Plus Print

We would also like to thank the extended Science Gallery Dublin team and mediators for their work on all aspects of FIELD TEST.

For more details on the people behind the scenes please see: **dublin.sciencegallery.com/staff**.

IMAGE CREDITS

FIELD TEST Model
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FIELD TEST Cover Photography
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Exhibits

GrassOmeter
—GrassOmeter

Moocall Calving Sensor
— Moocall

Playing with Pigs: Pig Chase
—Playing with Pigs

Robobees
—Wyss Institute/ Harvard

Second Livestock
—Austin Stewart

Silent Herdsman
—Silent Herdsman

Designs for Foraging: Bend-Branch Sensor
—Sean Mackey

Farmstand Forecast
—Cathrine Kramer

Mycotecture Brick Wall
—MycoWorks

Clash of the Ash
— Torpey Hurleys/ Sean & Yvette

Seed Boutique
—Sinéad Foley

Our Daily Bread
—Nikolaus Geyrhalter Filmproduktion GmbH

3D4AgDev
—Zewdy Gebremedhin

Tinder for Bees
—Blazer Technologies Ltd

The Dublin Honey Project—Kieran Harnett

Endophyte Club
—Trevor Hodkinson

Insect VR
—Pavan Kumar Kaushik

Farm Hacks
—Lu Yoder

URBAN OYSTER from the Ground Up
—Andrew Douglas

AQUAlab
—Andrew Douglas

Photo of OpenAg Initiative at MIT
—MIT Media Lab

Hedge H.U.G.
—Design With Company

Laboratory Burger
—David Parry/PA Wire

MicroFarm
—Fabian Strunden

Stir Fly: The Nutrient Bug 1.0—Robert Foster

Personal Food Computer
—MIT Media Lab

Pest Sounds
—USGS Bee Inventory and Monitoring Lab

LOCI Food Lab
—Cathrine Kramer

ABOUT THE ADVISORS

NICOLA TWILLEY
Nicola is a writer based in New York. She is a co-host of *Gastropod*, a podcast that looks at food through the lens of science and history. Nicola is a contributor to *The New Yorker*, and also runs the blog *Edible Geography*. Nicola is deeply obsessed with refrigeration, and is currently writing a book on the topic. She recently explored China's coldscape for *The New York Times Magazine*, and, in 2013, she curated an exhibition exploring North America's spaces of artificial refrigeration with the Center for Land Use Interpretation.

MUKUND THATTAI
Mukund is a scientist whose interests straddle many disciplines. Mukund's laboratory at the National Centre for Biological Sciences in Bengaluru, India uses both experimental and computational techniques to study how cells work. He has made key contributions to the emerging field of synthetic biology, and serves on the organising committee of MIT's International Genetically Engineered Machines Competition. Mukund's most recent work deals with the billion-year-old evolutionary origins of complex compartmentalised cells.

JANE STOUT
Jane is a Senior Lecturer and Research Group leader in the Department of Botany at Trinity College Dublin. Jane's research expertise is in the field of ecology, with an emphasis on human impacts on biodiversity and ecosystem services. She seeks to understand the processes and consequences of changes in land management and non-native species invasions, using plant-pollinator interactions as a model system. Jane's expertise covers both botanical and zoological fields, but she also collaborates on her research with geographers, socio-economists, chemists and molecular biologists, both nationally and internationally.

CHARLES SPILLANE
Charles is the Established Professor (Chair) of Plant Science, and Head of the Discipline of Botany and Plant Science at the National University of Ireland Galway (NUIG), Ireland. In the 1980s Charles produced the first genetically engineered potatoes in Ireland and has been working in plant genetics and biotechnology for over twenty years. Charles' Genetics and Biotechnology Laboratory at NUIG works on genetic improvement and biotechnology of photosynthetic organisms (plants and microalgae). Charles is the Principal Investigator within the Irish Technology Centre for Biorefining and Bioenergy and his research interests focus on how plant and microalgal genetics can be harnessed to develop disruptive technologies that can accelerate sustainable development of the energy sector.

ANDREW DOUGLAS
Andrew is the creator of URBAN FARM, founded to research and demonstrate alternative DIY food growing methods for localised food security. Andrew designs and builds urban agricultural projects for local communities, businesses and educational institutes for the purpose of healthy food production, neighborhood revitalisation and community engagement. In 2013, Andrew and the URBAN FARM team built Europe's first fully upcycled rooftop farm installation in Dublin's inner city. Andrew hopes that through cultivating a network of urban farmers and creating alternative DIY food projects there will be social changes that will improve the livelihood and livability of our city spaces.

ABOUT SCIENCE GALLERY

WHAT IS SCIENCE GALLERY DUBLIN?

In 2008, a car park in a forgotten corner of Trinity College Dublin was transformed into a living experiment called Science Gallery. Through a cutting-edge programme that ignites creativity and discovery where science and art collide, Science Gallery Dublin encourages young people to learn through their interests. Since opening in 2008, over two million visitors to the gallery have experienced thirty-seven unique exhibitions ranging from living art experiments to materials science and from the future of the human race to the future of play. Science Gallery Dublin develops an ever-changing programme of exhibitions and events fuelled by the expertise of scientists, researchers, students, artists, designers, inventors, creative thinkers and entrepreneurs. The focus is on providing programmes and experiences that allow visitors to participate and facilitate social connections, always providing an element of surprise. Science Gallery Dublin is kindly supported by the Wellcome Trust as founding partner, and by 'Science Circle' members—Deloitte, ESB, Google, ICON, NTR Foundation, and Pfizer. Science Gallery Dublin receives support from programme partners Intel Ireland, The Ireland Funds and Bank of Ireland. It also receives government support from the Department of Arts, Heritage and Gaeltacht and Science Foundation Ireland. Science Gallery Dublin's media partner is *The Irish Times*. For more information visit: **dublin.sciencegallery.com**

ABOUT THE GLOBAL SCIENCE GALLERY NETWORK

In 2012 the Global Science Gallery Network was launched with the support of Google.org, and the aim of establishing eight university-linked galleries worldwide by 2020. Based on the model pioneered at Trinity College Dublin, the Network is set to take the Science Gallery mission global. The first new gallery will open in London in 2017, followed by galleries in Melbourne and Bengaluru (Bangalore) in 2018. The development of the Network is being driven by Science Gallery International, a non-profit headquartered in Dublin that is also charged with touring Science Gallery exhibitions worldwide. Exhibitions from Dublin have now toured to twelve locations internationally, reaching more than 400,000 people in science and art centres across the globe. For more information visit: **international.sciencegallery.com**

SCIENCE GALLERY

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PACCAR

An Roinn Post, Fiontar agus Nuálaíochta Department of Jobs, Enterprise and Innovation

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SCIENCE GALLERY DUBLIN IS PART OF THE GLOBAL SCIENCE GALLERY NETWORK PIONEERED BY TRINITY COLLEGE DUBLIN

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