ANNUAL REPORT & READER 2017

NEW HARVEST

EDITOR-IN-CHIEF
ERIN KIM

ART DIRECTOR & DESIGN
ROXANA BAZGONEH

LOGO DESIGN
TENNIS

CONTRIBUTING PHOTOGRAPHERS
TRICIA RUBIO, ERIN KIM, ISHA DATAR,
JESS KRIEGER, MARIE GIBBONS,
NATALIE RUBIO, SANTIAGO CAMPUZANO,
SCOTT ALLAN, ANDREW STOUT

CONTACT
HELLO@NEW-HARVEST.ORG

**FIND US ON TWITTER, FACEBOOK,
AND INSTAGRAM @NEWHARVESTORG**

**NEW HARVEST
154 GRAND ST. NEW YORK, NY, 10013**

NEW HARVEST IS A REGISTERED 501(C)(3) NON-PROFIT ORGANIZATION IN THE UNITED STATES OF AMERICA. CONTRIBUTIONS TO NEW HARVEST ARE TAX-DEDUCTIBLE TO THE EXTENT PERMITTED BY U.S. LAW.

NEW HARVEST'S TAX IDENTIFICATION NUMBER IS 20-1425438.

© 2018 NEW HARVEST INC.

TABLE OF CONTENTS

LETTER FROM OUR EXECUTIVE DIRECTOR

WHY CELLULAR AGRICULTURE?

MISSION

OUR AUDITED 2017 FINANCIALS

LETTER FROM OUR RESEARCH DIRECTOR

PROJECT CATALOGUE

HOW NEW HARVEST SPENDS ON RESEARCH

RETREATS

THE FELLOWSHIP EXPERIENCE

LETTER FROM OUR COMMUNICATIONS DIRECTOR

2017 MOMENTS

SELECTED WRITINGS

SPECIAL THANKS

A LETTER FROM OUR EXECUTIVE DIRECTOR

Reviewing the material for our annual report is always such a rewarding activity, and 2017 - my fifth (!) year as New Harvest's Executive Director - was a special look back.

I would say the theme of 2017 for New Harvest was "growing up". We levelled up our science prowess with the onboarding of our Research Director, Dr. Kate Krueger; our Fellowship program increased to six scientists in five universities across the US, UK, and Canada; held our second annual New Harvest cellular agriculture conference; we brought Caleb Harper of the MIT Open Agriculture Initiative onto our board of directors; we launched a new seed grant program; we developed our research processes, introducing new structures for openness and collaboration among the scientists that we support; and we welcomed 142 new donors to our community. And those were just some of the highlights!

My fifth year leading New Harvest was also an awakening that the field of cellular agriculture was also growing up and out, on its own. The early days, when New Harvest was the single nerve center of all cellular agriculture, have passed, and now we have a branching network of individuals, companies, and organizations populating an emerging and exciting field. When I take the time to sit back and watch, it's incredibly rewarding to witness.

I am reminded of Carl Sagan's quote: "If you want to make an apple pie from scratch, you must first invent the universe"... the same is true of a cell cultured steak!

The growth of the field has strengthened my faith in New Harvest's work. Five years ago, I would have said that the number one limiting factor in cellular agriculture was funding. Today, I would say the limiting factor is skilled technical expertise. Cellular agriculture's interdisciplinary nature makes it difficult to find experts who have already been trained in the appropriate laboratory techniques, with the appropriate living cultures that cellular agriculture and cultured meat

research requires. Our focus on supporting groundbreaking science fills this gap. While conducting fundamental pre-competitive research, we are training the talent that will go on to become the technical founders, the CTOs, and the leading Principal Investigators of cellular agriculture in the future.

It's an exciting time, but it's still just the beginning.

I can only imagine how it must feel to be one of the 660 people who have donated to New Harvest since 2004. These are the visionary individuals who created the fertile ground that cellular agriculture is taking root in. These are the people who foresaw a world where we could grow food from cell cultures instead of from animals. When the day comes that we see cultured meat, milk, and eggs on store shelves, that "new harvest" will be thanks to them.

Isha

ISHA DATAR
EXECUTIVE DIRECTOR

WHY CELLULAR AGRICULTURE?

There is a loud global conversation taking place, about how to feed a growing population with limited planetary resources in the face of climate change.

The consensus is that a particular challenge lies in animal agriculture. Large-scale animal agriculture has put strains on our natural environment and is ground zero for antibiotic resistance and a number of viral epidemics. It's also incredibly resource intensive - we use 70% of all agricultural land for farmed animals. Raising animals for food undoubtedly feeds billions of people, but it's a system that is becoming ever more precarious as extreme weather and disease events become more frequent.

In addition to the industry reaching planetary limits in terms of resource use, industrial animal agriculture has also reached biological limits in terms of efficiency. We can't make chickens grow any bigger any faster; we can't keep pigs in pens any smaller; and we can't keep cows lactating any longer. We've optimized the use of animals as producers of animal protein about as far as we can, and it's still at the mercy of weather and disease.

There are many approaches to mitigating the animal agriculture problem. The most simple and obvious would be to reduce our consumption of animal products – but will we see a widespread behavioral change taking place fast enough to counter the steady growing global demand for meat, milk, and eggs? Others suggest alternatives – consuming insects, or plant-based substitutes for existing animal products. These are great ideas too.

But alongside these methods, we also need to be considering long-term solutions that open up our minds in the way that we that think about agriculture. We need to stretch our understanding, and the science of agriculture, beyond farming organisms – whole plants, whole animals – and rather towards farming the most basic units of life – cells. We want to usher in a new era of agriculture – cellular agriculture – founded on the principle of openness.

Cellular agriculture, a term that New Harvest coined in 2015, is the farming of agricultural products from cell cultures rather than whole plants or animals. This could take the form of milk brewed by microbes, omega-3s grown in algae, or meat cultured by muscle cells, for just a few examples.

It makes sense that we are moving towards more controlled, contained systems for producing proteins, fats, enzymes, and other ingredients and materials for human use. In fact, cellular agriculture is not brand new. For decades, we have been using cell cultures to produce pharmaceuticals (e.g., insulin), food enzymes, (e.g., microbial rennet for cheese making), food ingredients, (e.g., MSG), vitamins, (e.g., B12) and more (e.g., flavors, fragrances). And this doesn't count the thousands of years we've been using cell cultures for fermented foods and drinks.

What **is** new ground for cellular agriculture is the production of larger, commodity-level products like meat, milk, and eggs. For milk and eggs, this means scaling tried-and-true techniques normally used for the products mentioned above. For meat, this means groundbreaking discovery research.

What is fascinating is that for technology with so much potential, so few people are working on it. It isn't yet funded by government grants, and large companies don't appear to be pursuing this research on their own. Today, the scientific landscape is still limited to a sprinkling of non-profits, independent researchers, and startups.

We see this emerging field of research as an opportunity to do food science in the best way possible. For us, that means openly. We can inform the public on progress in the field as it develops. We can ensure that as many people as possible can gain access to the protocols, experiments, data, and results that are being developed along the way. We can provide open forums for the public to ask questions, learn about, and even participate in the science.

NEW HARVEST HAS THREE GOALS

The short-term goal is creating a viable, well-supported scientific community whose members are equipped to go on to start or join cellular agriculture laboratories in industry or academia.

The medium-term goal is the creation of open, public research that asks and answers fundamental scientific questions related to cellular agriculture. This is already underway with several projects in our portfolio, and we've created and shared protocols and cell cultures along the way.

The very long-term goal is a world where we have the option of choosing a variety of cellular agriculture foods that are produced in systems which may look reminiscent of the brewing industry. It's a vision of animal products like meat, milk, and eggs, being created in large stainless steel tanks. Every brewery, from that of a home brewer to a massive multinational brewery, could hold the potential to make unique products using special recipes and methods, all built on the same, basic, open technology that New Harvest is making possible today.

New Harvest is pushing these goals forward as a 501(c)(3) non-profit organization, funded to date by just under 700 people who want to see a world where the foods and materials which are sourced from animals today can instead be produced via cellular agriculture. When we see cultured milk, meat, and eggs on our dining tables, in grocery stores, or on space stations one day, it will be thanks to these pioneering individuals, who demonstrated the foresight to envision a world that escapes the absurdities of animal agriculture.

MISSION

NEW HARVEST'S MISSION IS TO ADVANCE BREAKTHROUGHS IN CELLULAR AGRICULTURE.

We work towards this mission through our primary activities of funding, supporting, and coordinating open research in this field. We then report on the advancement of these projects, and on cellular agriculture as a whole.

NEW HARVEST'S AUDITED 2017 FINANCIALS

GOOD NEWS: OUR RESEARCH PROGRAM IS SCALABLE!

This is the second year that New Harvest is categorizing and sharing the details of our expenses in a public forum. We care deeply about transparency in funding: not only does this help our donors understand where New Harvest earns and spends its money, it also keeps us proactively accountable. The numbers presented below are all contributions and expenses attributed directly to New Harvest.

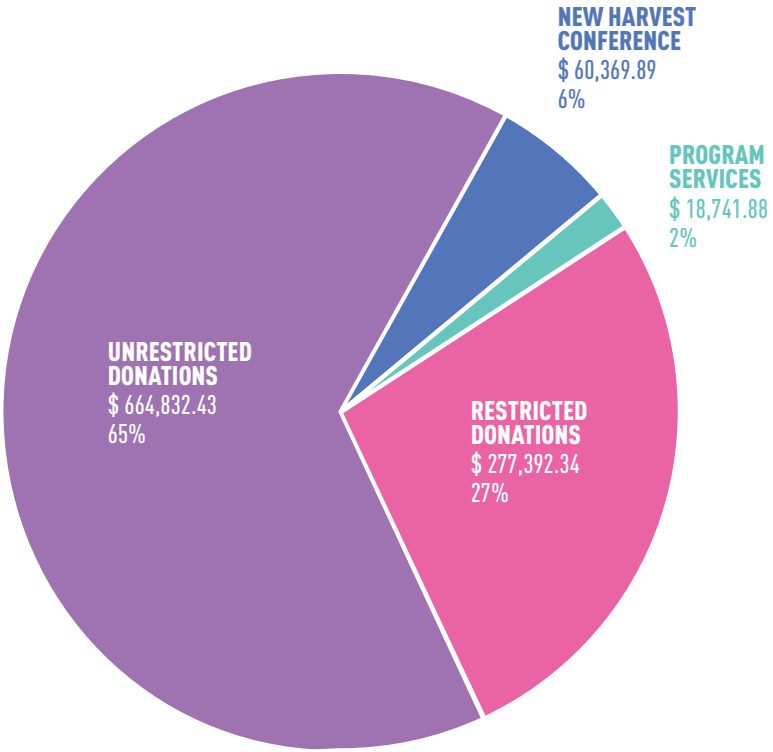
INCOME

In 2017, New Harvest's primary source of income was unrestricted donations from 225+ members of our donor community.

The secondary source of income was restricted donations, primarily for the New Harvest Fellowship Program.

New Harvest also earned income from ticket sales and sponsorship for the New Harvest 2017 conference; as well as in program service fees for speaking and consulting engagements

NEW HARVEST'S 2017 INCOME BY CLASS



EXPENSES

WE CATEGORIZED OUR EXPENSES INTO 5 CATEGORIES FOR 2017.

RESEARCH is New Harvest's largest expense. Expenses in this category include all grants given directly to funding academic research, plus the staffing and support (eg. retreats) required to manage our research effort. In 2017, $277,934 was given as grants for research, representing 77% of research program expenses. (By comparison, in 2016, $137,624 was given as grants, representing 67% of the research program expenses.)

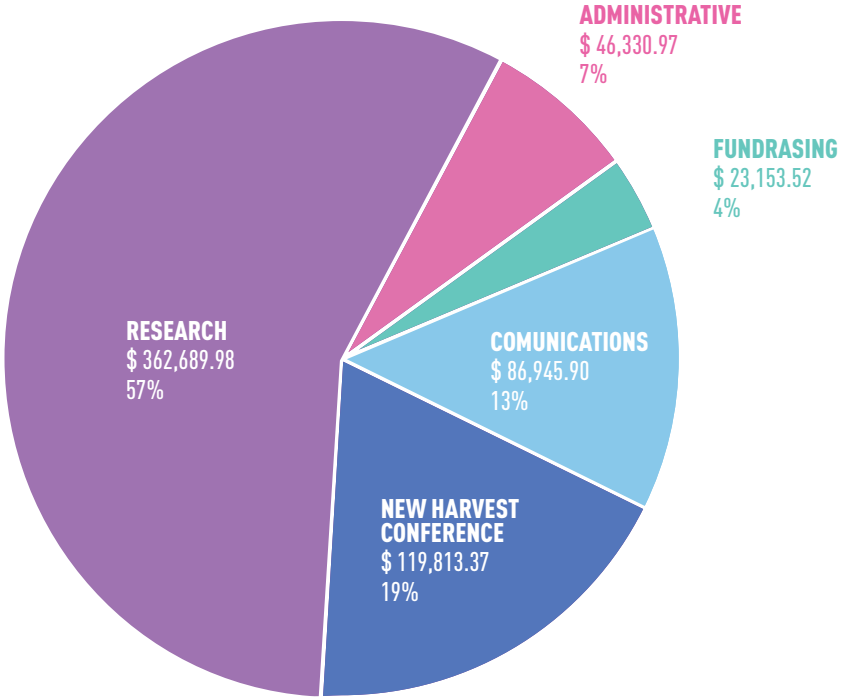
THE NEW HARVEST CONFERENCE is our annual event to showcase cellular agriculture. Expenses in this category cover all logistics required to plan and run the event, such as venue bookings, staffing, catering, and printing.

COMMUNICATIONS at New Harvest is an ongoing program, led by Communications Director Erin Kim. Expenses in this category include our generation of original content, outreach, and social media efforts, as well as any expenses incurred from New Harvest staff giving keynotes, lectures, and panel presentations to spread the word about cellular agriculture.

ADMINISTRATIVE expenses are those incurred by the general operations of New Harvest as an organization.

FUNDRAISING expenses are those incurred by any fundraising activity that New Harvest undertook throughout the year. With a team of three fulltime staff in 2017, every team member again found themselves working across multiple expense categories. As a result, payroll for each individual has been broken up by time commitment into the above five categories.

NEW HARVEST'S 2017 EXPENSES BY CLASS



A LETTER FROM OUR RESEARCH DIRECTOR

It's been some year!

In 2017, I defended my PhD thesis, moved to New York City, and joined the New Harvest team. During my first month on the job, I flew to NASA, where I heard first-hand from their scientists about the challenges of growing food in space – an issue that becomes more pressing as astronauts approach the Deep Space Gateway and journey toward Mars.

In August, I approved three New Harvest Fellowship candidates - Scott, Santiago, and Andrew - doubling our fellowship program, and adding expertise in plant-based scaffolding, food science, chemical engineering, and bioreactor design. In their short time at New Harvest thus far, they have already mentored undergrads, attended conferences, and T.A.ed courses. I couldn't be more pleased with their progress.

September brought our second fellowship retreat – my first meeting in person with our veteran New Harvest fellows Natalie, Marie, and Jess. It was wonderful to meet everyone in person – though I had been running weekly group meetings over Slack for almost six months, I hadn't yet had the chance to get to know these hard-working scientists. Their thoughtful self-reflection and ownership of our fellowship program is a valuable asset to our endeavor –their insights, critical feedback, and active participation have allowed us to improve our programming and recruiting efforts as we continue to grow our fellowship program.

Speaking at the New Harvest conference in October was another highlight of 2017. Discussing cell culture media and the challenges of serum replacement with our attendees and answering their insightful questions was one of this year's high points.

By November, it became clear to me that New Harvest needed a new type of funding – a means to fund short-duration projects to take ideas from concept to reality. This award, the New Harvest Seed Grant, funds teams pursuing open research and design projects of less than

6 months in duration and budgeted under $5,000 USD. Our first Seed Grant, awarded for bioreactor design, was directed by a veteran New Harvest Fellow, Jess Krieger. The bioreactor design came to life with the mechatronics skills of Han Zhang, Kyle Manke, and Yi Fan Chen under Jess's direction and bioengineering expertise. As the inaugural class of New Harvest Seed Grant recipients, Jess, Han, Kyle and Yi Fan set a strong example of what a group can do with short-term New Harvest support.

In December, I was invited back to Yale to speak on a career panel for my department. It felt like a homecoming – I was surprised to find myself speaking in the same room I defended my thesis earlier that year. That experience, and the year as a whole, have made me think deeply about the breadth of our endeavor, and the depth of work that remains in our field. There is much to be done, and a lot in the works for 2018.

My goals for the coming year include strengthening our commitment to open research in cellular agriculture. Through the addition of our Postdoctoral Fellowship Program and our Dissertation Award, and other programming currently in the works, we are poised to fund top talent in the critically neglected area of cellular agriculture. These, and other projects at New Harvest will help us continue to build a trained community of scientists and researchers poised to build the nascent cellular agriculture research community, and equip them with the tools they need to perform cutting-edge research.

Kate

KATE KRUEGER
RESEARCH DIRECTOR

PROJECT CATALOGUE

THIS IS AN OVERVIEW OF THE PROJECTS FUNDED BY NEW HARVEST IN 2017.

[redacted]

JESS KRIEGER – VASCULAR TISSUE ENGINEERING AND BIOREACTOR DESIGN OPTIMIZATION

PROJECT DATES:
JUNE 2017 - MAY 2020

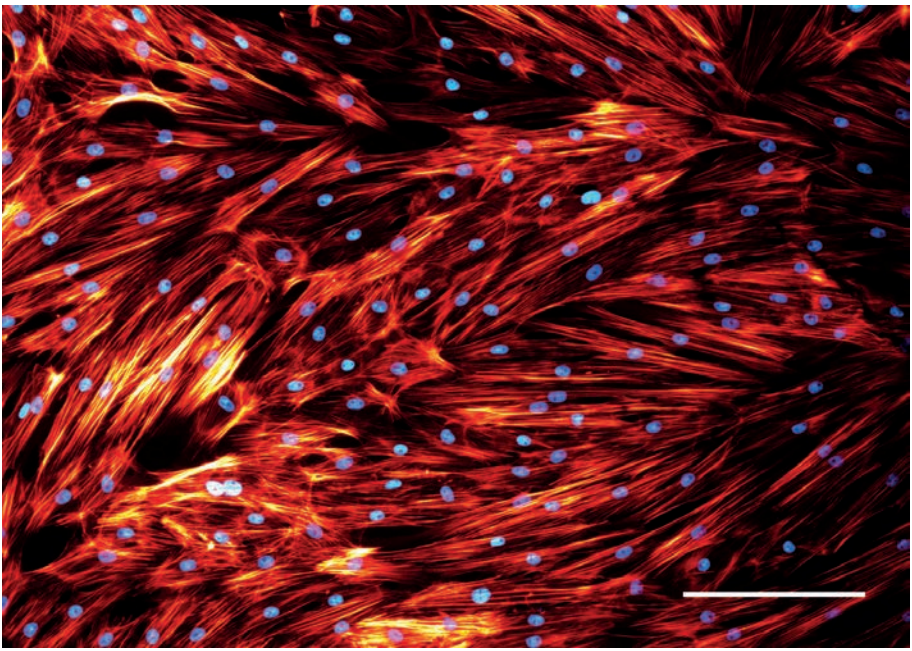
FUNDS FROM NEW HARVEST:
$130,760 USD

SUPERVISOR:
DR. MIN-HO KIM

PROJECT LOCATION:
KENT, OHIO, USA; KENT STATE UNIVERSITY

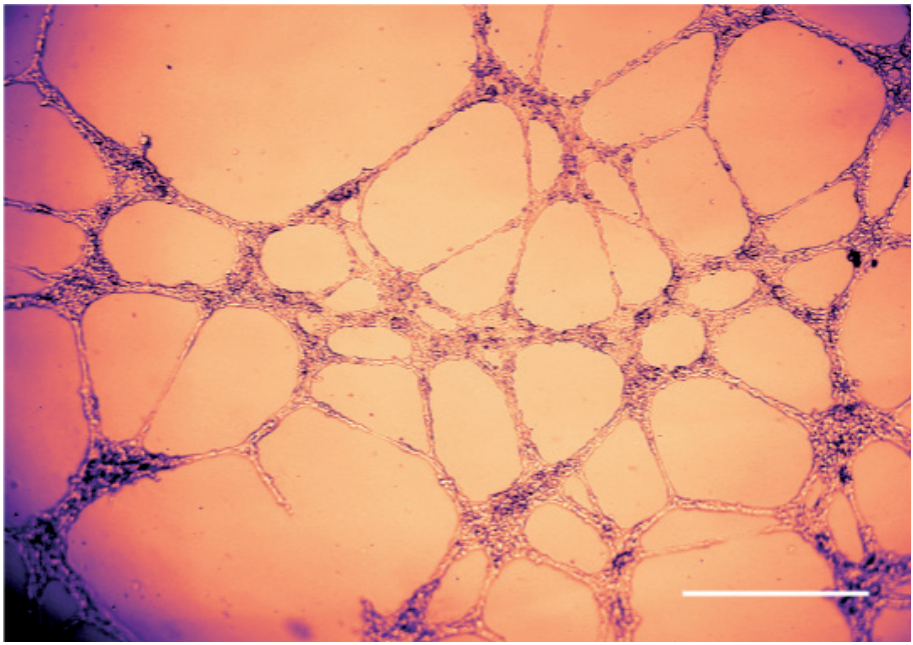
Jess (BSc, Biology, Kent State University) received her first New Harvest grant in fall of 2017 to conduct basic cultured meat research, looking at the prohibitive costs of production and finding cost-effective solutions, as well as using 2D cell culture and 3D tissue culture to inquire into how we can grow bigger and better muscle while retaining the taste and texture of meat harvested from livestock. With New Harvest funding, Jess was able to continue her work on porcine cells and vasculature through 2017. She also advanced to candidacy for her PhD! Additionally, Jess utilized her expertise in bioreactors to lead the first New Harvest seed grant, and submitted her paper on Transforming growth factor beta (TGF-β1) to the open journal Peer J.

Cultured pork fibroblasts



A microscopic photo of cultured pork fibroblasts (the connective tissue that produces collagen) -- Jess produced these in the lab!

Bovine aortic endothelial cells



In the summer of 2017, Jess began initial angiogenesis research (on the formation of new blood vessels from pre-existing ones) to investigate the ability of farmed animal blood vessel cells to create new vessels. This image shows bovine aortic endothelial cells (BAECs, aka blood vessel cells from cows) beginning to form such a network in vitro!

[redacted]

NATALIE RUBIO – CUSTOMIZATION OF ANIMAL-FREE BIOMATERIALS FOR 3D MUSCLE FASCICLE CULTURE

PROJECT DATES:
JUNE 2016 - JUNE 2019

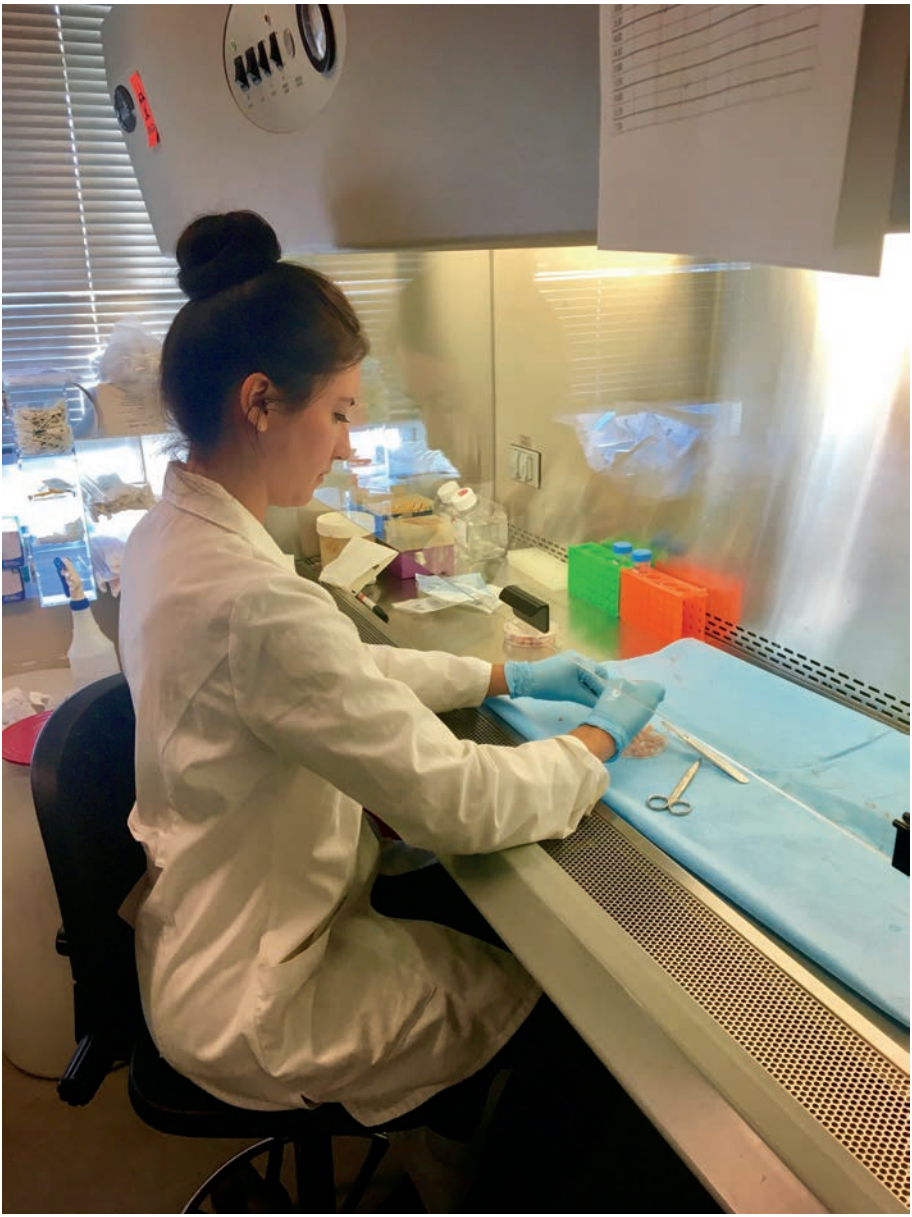
FUNDS FROM NEW HARVEST:
$167,067 USD

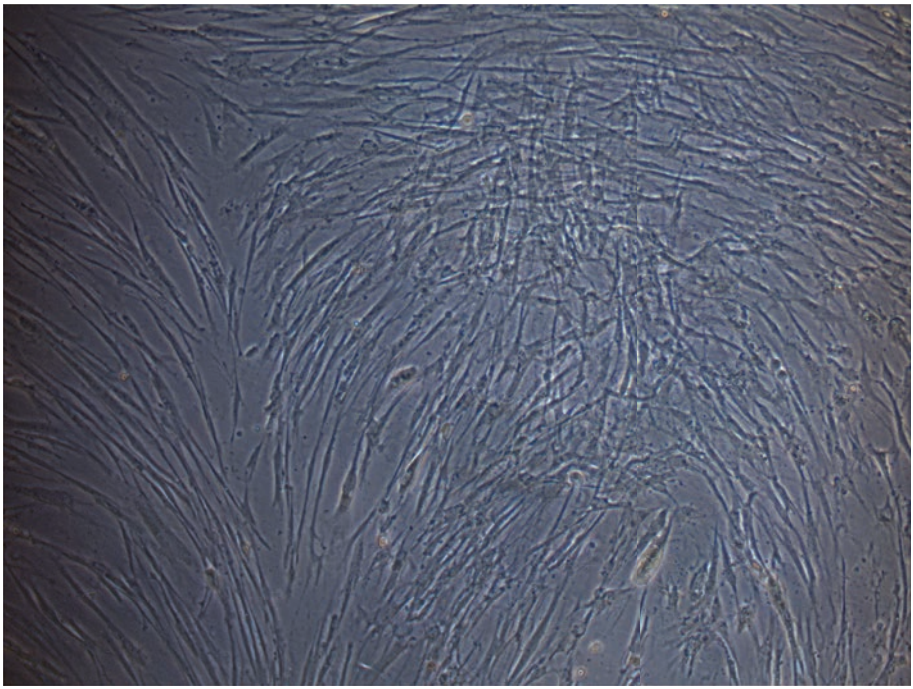
SUPERVISOR:
DR. DAVID KAPLAN

PROJECT LOCATION:
MEDFORD, MASSACHUSETTS, USA;
TUFTS UNIVERSITY

Natalie (BSc, Chemical and Biological Engineering, University of Colorado Boulder) entered into the second year of her PhD at Tufts in 2017, exploring the use of biomaterials to mimic the role of connective tissue in cultured meat. Natalie is working under the supervision of Dr. David Kaplan at the Tissue Engineering Research Center (TERC), which specializes in tissue engineering beyond medical applications, so it is the perfect place for biofabricated foods to develop. TERC is an NIH-supported initiative that focuses on functional tissue engineering through a systems approach to integrate the key elements of tissue engineering: cells, scaffold, and bioreactors. Through her research at TERC, Natalie is learning to assess the nutrition and behavior of the cells she is working with. She presented on this work at the 2017 New Harvest conference in a talk about scaffolds. She also mentored two undergrad students and a high school student in the summer of 2017.

[redacted]





(Above)
A microscopic photo
of turkey cells cultured
by Natalie at Tufts.

(Left page)
Natalie preparing samples
at the culture hood.

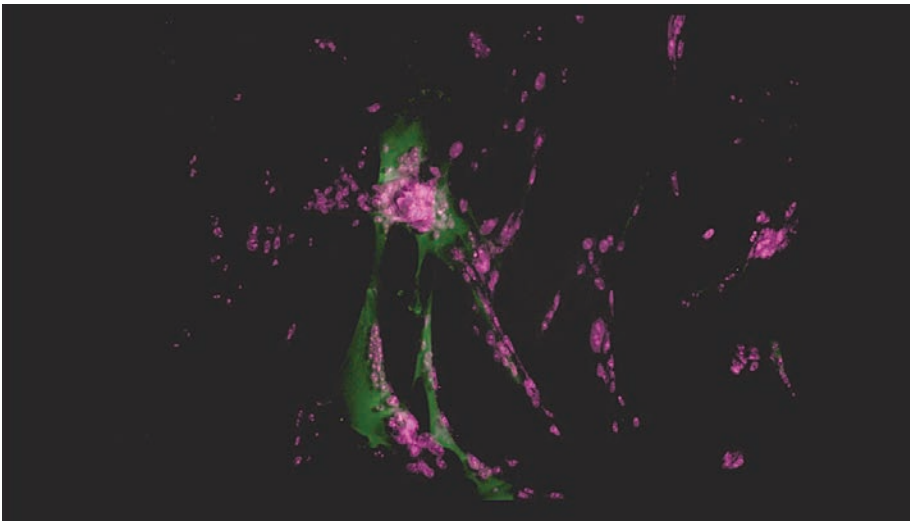
PROJECT DATES:
APRIL 2016 - MAY 2018

SUPERVISOR:
DR. PAUL MOZDZIAK

FUNDS FROM NEW HARVEST:
$106,100 USD

PROJECT LOCATION:
RALEIGH, NORTH CAROLINA, USA;
NORTH CAROLINA STATE UNIVERSITY

A microscopic photo taken by Marie, showing partially differentiated cultures of turkey myospheres. Marie used MF20 for the green staining and PI (nuclear) staining for the pink. (see below)



MARIE GIBBONS – MASS PRODUCTION OF CULTURED AVIAN MUSCLE CELLS

2017 saw Marie (BSc, Zoology, North Carolina State University) enter into the final half of her New Harvest Fellowship, continuing her research on In Vitro Avian Myoblast Suspension for Mass Scale Production and Consumption in the course of her Master's studies at North Carolina State University. Marie's research project was supervised by Dr. Paul Mozdziak, an expert in animal cell culture techniques, transgenic animal production, and muscle biology. Marie spent her summer as a visiting student in Dr. David Kaplan's lab in Boston, working alongside New Harvest Research Fellow Natalie Rubio. She presented on some of her research at the 2017 New Harvest conference in the fall, where she also exhibited a turkey cell on jackfruit scaffold "nugget" prototype!

Marie with her hybrid turkey cell on jackfruit scaffold "nugget'

[redacted]

SCOTT ALLAN – CULTURED MEAT BIOPROCESS DESIGN

PROJECT DATES:
OCTOBER 2017 - OCTOBER 2021

FUNDS FROM NEW HARVEST:
£75,200 GBP

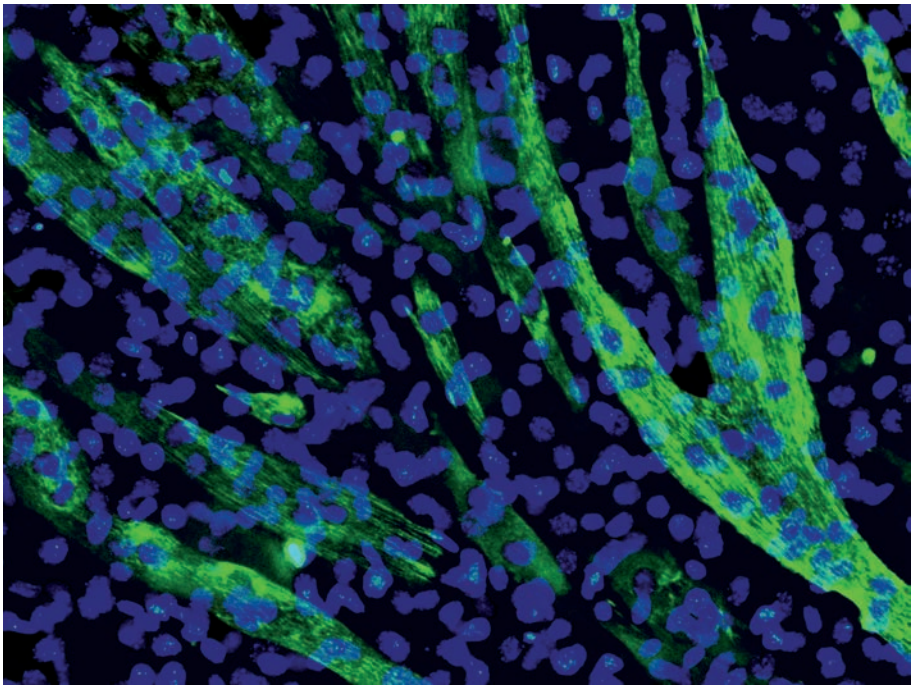
PROJECT LOCATION:
RALEIGH, NORTH CAROLINA, USA;
NORTH CAROLINA STATE UNIVERSITY

SUPERVISOR:
DR. MARIANNE ELLIS
(SENIOR LECTURER IN BIOCHEMICAL ENGINEERING; UNIVERSITY OF BATH),

DR. PAUL DE BANK
(SENIOR LECTURER IN PHARMACY & PHARMACOLOGY; UNIVERSITY OF BATH),

& MR. ILLTUD DUNSFORD
(FARMER, AGRI-FOOD CONSULTANT AND OWNER OF CHARCUTIER LTD)

Scott Allan (MEng, Chemical Engineering, University of Bath) is a chemical engineer by training (he worked in the oil and gas industry prior to his time at New Harvest) who began his New Harvest Fellowship in the fall of 2017. He is currently working towards a MRes (Masters in Research) and PhD at the University of Bath, and his New Harvest-funded research seeks to determine the parameters for cultured meat production in large scale bioreactors, including reaction kinetics (how quickly muscle cells will grow, divide, and mature), transport phenomena (how nutrients will enter the cells, how waste products exit), mass transfer limitations (the efficient flow of media over cells), and metabolic stoichiometric requirements (what the inputs (food) and outputs (waste products) of cultured meat production will be). Since he began his project, Scott has also been developing his skills in animal cell culture, beginning with C2C12 (mouse) cells.



(Above)
A microscopy of differentiating C2C12 (mouse) cells, cultured by Scott

(Left page)
Scott getting set up in the lab

[redacted]

SANTIAGO CAMPUZANO – PLANT-BASED SCAFFOLD MATERIALS

PROJECT DATES:
SEPTEMBER 2017 - AUGUST 2020

FUNDS FROM NEW HARVEST:
$184,500 USD

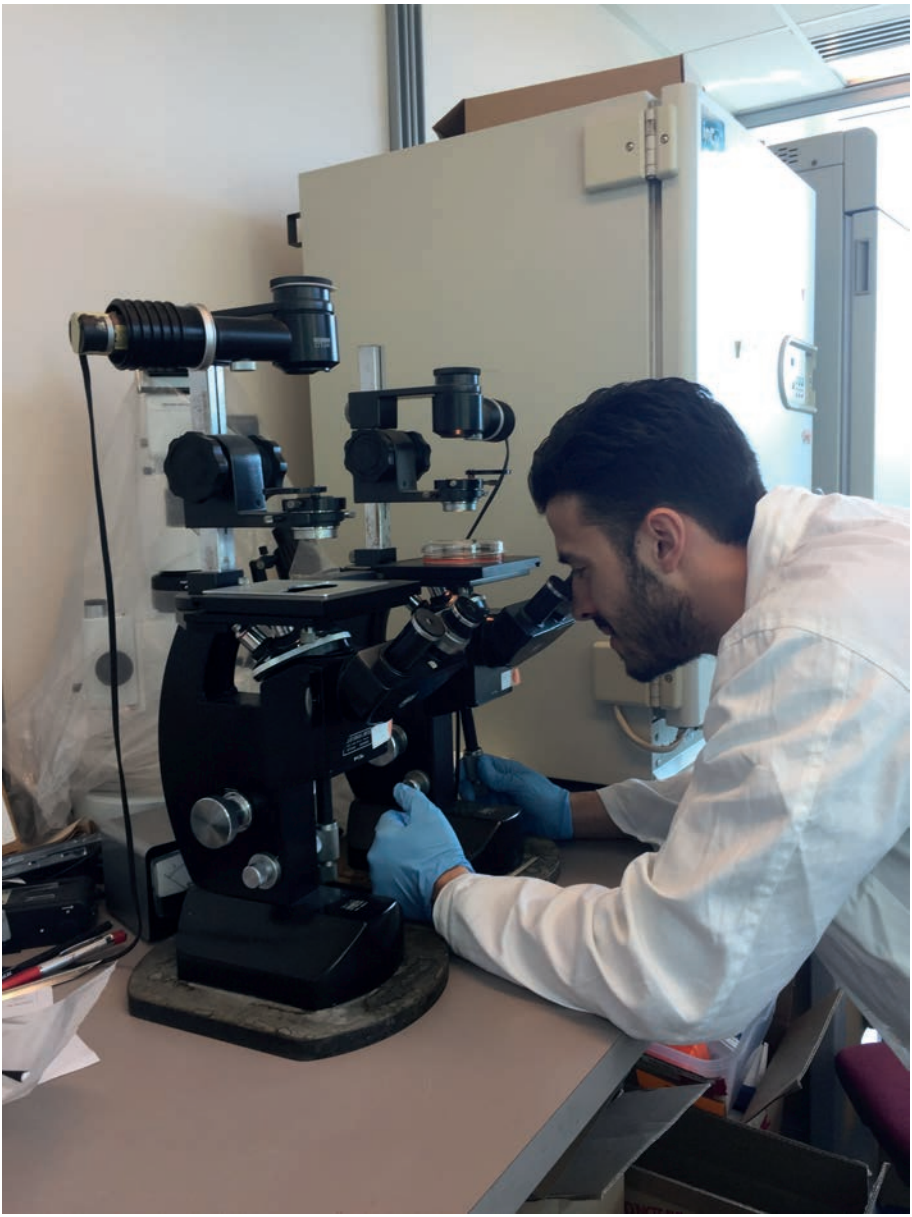
PROJECT LOCATION:
OTTAWA, CANADA; UNIVERSITY OF OTTAWA

SUPERVISOR:
DR. ANDREW PELLING
(CANADA RESEARCH CHAIR AND
PROFESSOR, DEPTS OF PHYSICS
AND BIOLOGY; UNIVERSITY OF OTTAWA)

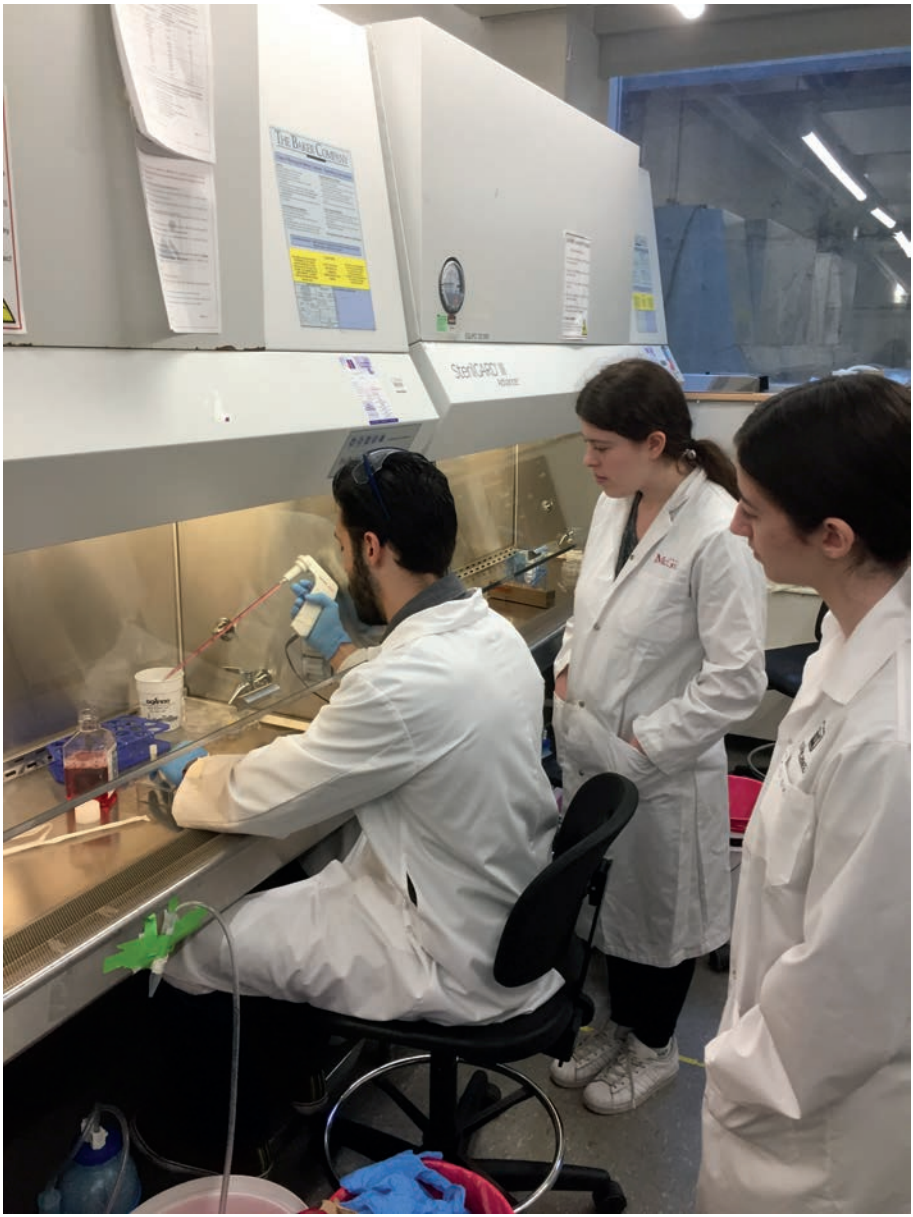
THIS PROJECT IS BEING MADE POSSIBLE THANKS TO THE PHILANTHROPIC SUPPORT OF INVIVO GROUP AND THE SCOTT AND CYAN BANISTER FREEDOM FUND.

A longtime member of the New Harvest scientific community, food scientist Santiago Campuzano (BSc Food Science, University of British Columbia) officially joined our team of Research Fellows in September 2017. He moved across Canada from Vancouver, British Columbia to join the Pelling Lab at the University of Ottawa, where he began his Master's research by studying bacterial cellulose as a natural scaffold material. Since then, he has moved on to experiments using various types of plant scaffolds (including mushrooms and celery, for example), using plant cells as scaffolds for muscle cells to adhere to.

The Pelling lab has previously demonstrated that apple-derived cellulose can act as an ultra-low cost and efficiently produced scaffold material. The Pelling lab's apple scaffold prototype was able to support 3D culture of mammalian cells, promote cell invasion and proliferation, and retain its shape and mechanical properties for several months in culture. As an organic, plant-based fibre, cellulose is one of the most abundant, sustainable, and easily sourced biomaterials on earth (it can be found in plant barks and leaves).



Santiago at the microscope



Santiago supervising two undergrad students
at the University of Ottawa

[redacted]

ANDREW STOUT – ENGINEERING MUSCLE CELL DEVELOPMENT VIA EXTRA-CELLULAR CUES

PROJECT DATES:
SEPTEMBER 2017 - 2020

FUNDS FROM NEW HARVEST:
$227,264 USD

SUPERVISOR:
DR. DAVID KAPLAN

PROJECT LOCATION:
MEDFORD, MASSACHUSETTS, USA;
TUFTS UNIVERSITY

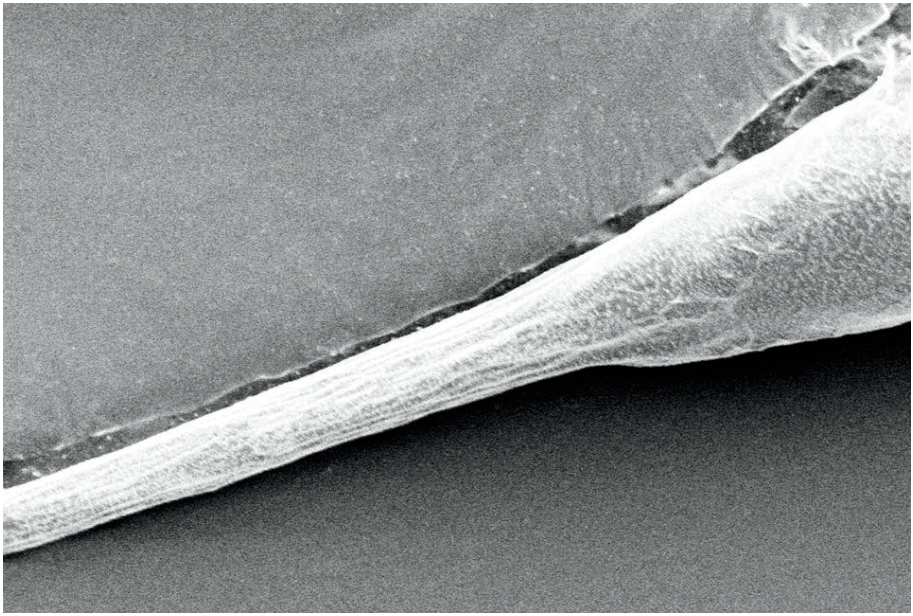
Bioengineer Andrew Stout (BSc Materials Science and Bioengineering, Rice University) began his New Harvest Research Fellowship in the fall of 2017. Andrew was already quite the veteran in cellular agriculture, having interned (twice!) in Dr. Mark Post's lab at Maastricht University on the first cultured beef hamburger, as well as having done a stint at the cell ag startup Geltor in San Francisco. For his New Harvest-funded doctoral research, Andrew is examining controlled, switchable differentiation of skeletal muscle in vitro through cell line and matrix engineering.

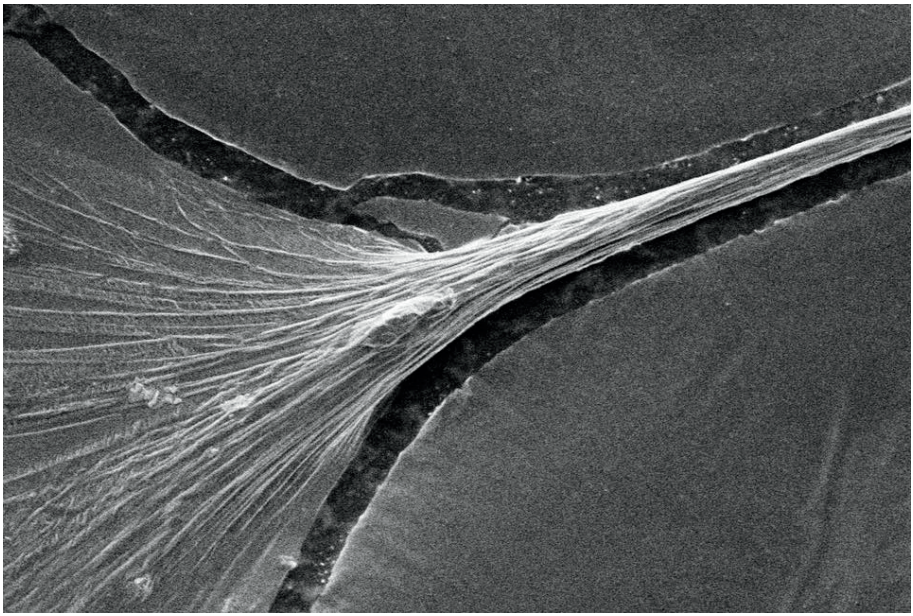
In essence, cultured meat involves directing tissue engineering towards the large-scale production of animal muscle. There are two phases of growth in cell culture: proliferation and differentiation. Proliferation is where cells increase in number but remain stem-like; differentiation is where cells no longer multiply but mature into muscle fibers. There are challenges in keeping a cell population multiplying in vitro while also maintaining their ability to differentiate into muscle cells, which affects scalability and end product quality control.

Andrew's research aims to understand what scalable factors regulate the myogenic (muscle) pathway, to engineer improved platforms for cultured meat production.

Andrew joined New Harvest Fellow Natalie Rubio at Dr. David Kaplan's lab at Tufts University, marking the first time (of hopefully more to come!) that we have had more than one Fellow working out of the same lab, under the same supervisor.

Andrew at the culture hood





These scanning electron microscopy (SEM) images show an extremely up close view of the alginate/chitosan fibers that Andrew is working with as a potential cultured meat scaffold material. He's aiming to get the animal cells to stay alive and spread while fully encapsulated within the fibers, so that a structure similar to muscle fibers can be achieved.

[redacted]

THE NEW HARVEST SEED GRANT

During Kate's first month on the job, she received an email from an undergraduate engineering student at the University of British Columbia, Han Zhang. He had an interesting background, ranging from optogenetics research to cloaking technologies, and a concrete request – support on a bioreactor project for his senior capstone design project.

New Harvest didn't have a mechanism in place for supporting stand-alone projects without a fellow at the time, but Kate connected Han with New Harvest Fellow Jess Krieger anyway, thinking they'd have a productive conversation. A few months later, Jess requested to mentor Han on his project using schematics she had already designed. This collaboration seemed like the right place for project funding – Jess had an idea that she wanted to execute, and Han was looking for a project mentor – they only needed a relatively small amount of funding to cover the cost of raw materials.

Jess and Han submitted their application, and New Harvest created a program to fund similar short-term projects in the future.

As a result, we launched the New Harvest Seed Grant program in fall 2017 as a new funding category: a one-time disbursement of up to $5,000 USD, for fixed projects lasting up to six months. The deliverables of any Seed Grant project must remain open and unpatented, with open licensing encouraged.

SCALABLE MODULAR BIOREACTOR DESIGN FOR CULTURED MEAT PRODUCTION

Our first seed grant was awarded for a multi-phase project aimed at designing and building a scalable, modular bioreactor prototype for cultured meat production, to be used in a lab setting. This novel bioreactor will be modular in that cells can be grown on trays with self-contained fluid circuits which can easily be switched out if goals change. The bioreactor is particularly scalable because all fluid circuits are driven by a single peristaltic pump head. Thus, the number of trays can be increased simply by adding more trays, without the need for additional pumps and complex tubing circuits.

To maximize the chances of the tissues surviving and growing, the bioreactor environment must be carefully controlled. Key bioreactor environmental parameters are temperature, CO2 levels, humidity, and fluid flow rate. For this early prototype, only flow rate and temperature control will be implemented.

Phase I of this project was made possible via New Harvest Seed Grant. Once completed, the bioreactor will undergo testing for subsequent in vitro tissue experiments.

NEW HARVEST SEED GRANTEES:
HAN ZHANG, YI-FAN CHEN & KYLE MANKE

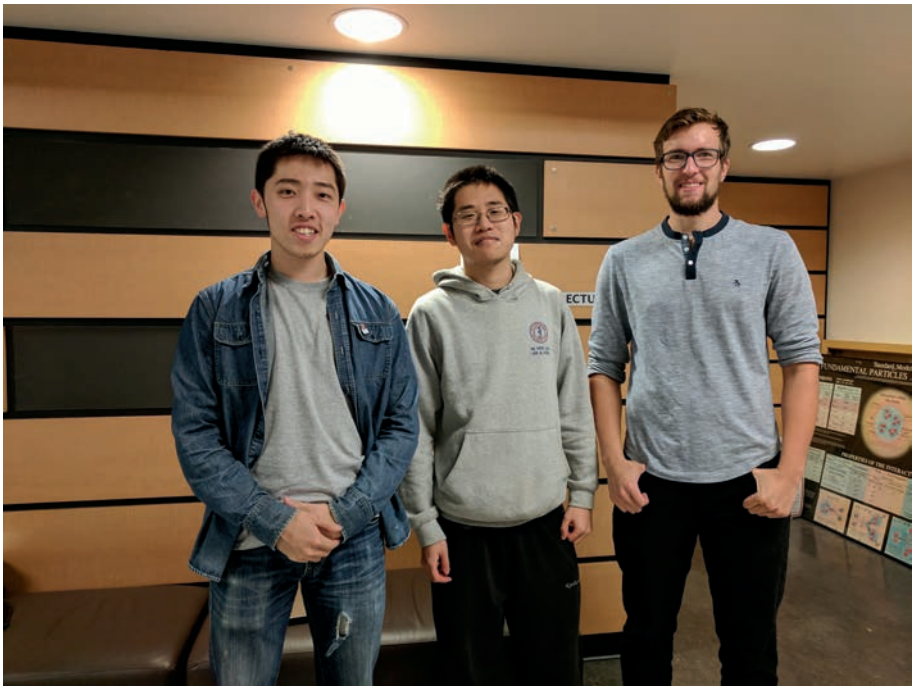
PROJECT LOCATION:
FACULTY OF APPLIED SCIENCE, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, CANADA

PROJECT START DATE:
OCTOBER 2017

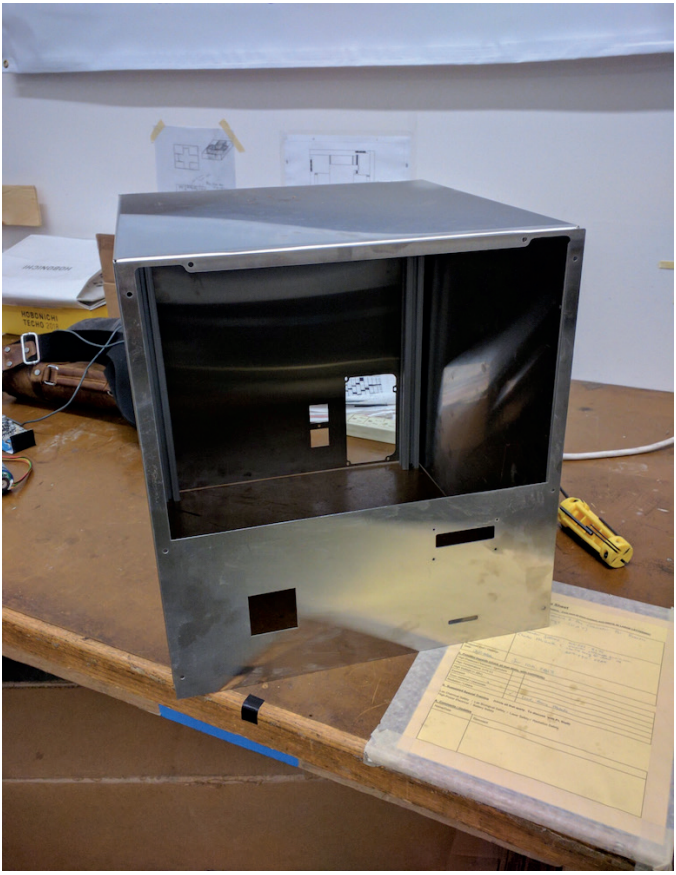
PROJECT DURATION:
4 MONTHS

PROJECT COST:
$2,700 CAD

THIS PROJECT WAS DESIGNED AND MANAGED BY NEW HARVEST FELLOW JESS KRIEGER



The UBC seed grant team: Yi-Fan, Han, and Kyle



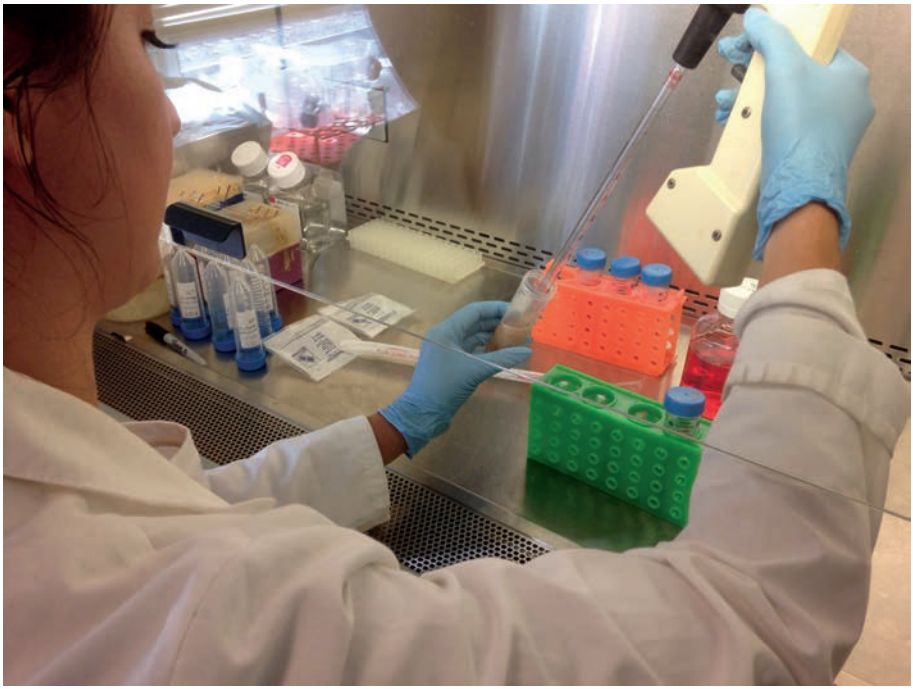
Parts for the bioreactor prototype were cut and assembled from scratch...

The prototype -
almost complete!

HOW WE SPENT ON RESEARCH IN 2017

We shared this look into how we make our research funding decisions in order to help prospective donors make a more informed decision to give.

At the beginning of every month, we send out an update to everyone who has donated to New Harvest—in any amount—within the past year.



New Harvest Research Fellow Natalie Rubio in the lab at Tufts University

As a result of a donor feedback survey, in September 2017 we began sharing some year-to-date fundraising figures so donors could get a sense of our organization's financial picture.

We also thought it would be helpful to explain how we fund research at New Harvest.

MULTI-YEAR PROJECTS ARE FUNDED AT 6-MONTH INTERVALS

The research proposals received by New Harvest involve a four-party combination of:
1) an academic supervisor,
2) a graduate student (the prospective New Harvest Research Fellow),
3) an institution at which the research will take place
4) a proposed project focused on advancing cellular agriculture.

Most projects are at least two years long. The exception are small seed grants for projects of less than 6 months and for amounts of less than $5000. Our first seed grant was given in November 2017, and we aim to give more of these in coming years.

In addition to being supervised by a designated supervisor at their respective university, New Harvest Research Fellows also receive guidance and academic support from New Harvest's Research Director, Kate Krueger.

Despite the projects being at least two years long, we disburse funds to the university in six month intervals. This allows us to observe the progress of the research, engage with the supervisor and student on a regular basis, and to ensure that the supervisor/student/institution/project combination is moving forward appropriately.

Since 2015, New Harvest has supported nine multi-year projects. In total, this is represented in $939,660 of research funds that are slated to be disbursed by New Harvest by 2021.

NEW HARVEST RESEARCH FELLOWSHIP PROGRAM FUNDS DISBURSED AND SLATED FOR DISBURSMENT, 2015-2021		
YEAR	AMOUNT DISBURSED	AMOUNT SLATED FOR DISBURSMENT
2015	$66,500	-
2016	$137,624	-
2017	$196,080	-
2018	-	$227,769
2019	-	$210,016
2020	-	$88.012
2021	-	$13,659
TOTALS 2015-2021	$400,204	$539,456

These numbers are purely funds dedicated to grants—they do not include any staffing or overhead costs for running our Research Program. These numbers also do not include any research that New Harvest decides to fund after the time of publication.

We have always reported how much New Harvest has disbursed in research grants in the past, but we have not previously reported how much we are slated to spend in the coming months and years.

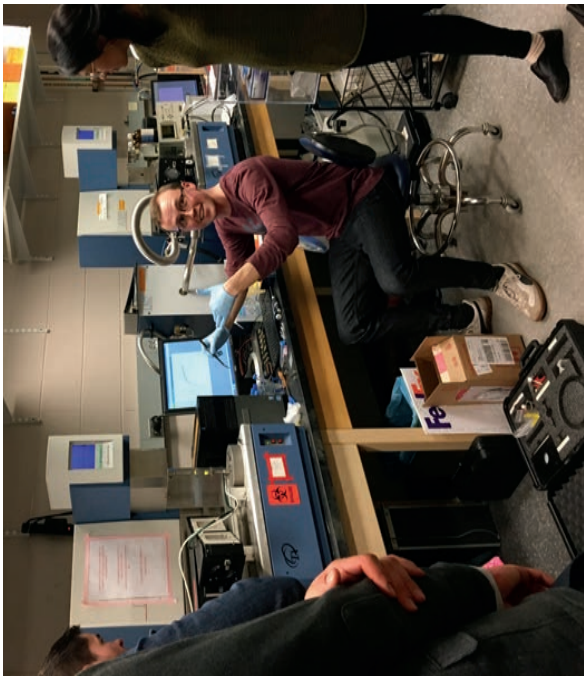
Our goal was to raise $1,000,000 in 2017 - a goal that we were thrilled to have exceeded. This will enable us to continue our commitments to our ongoing research projects, while also scouting for more.

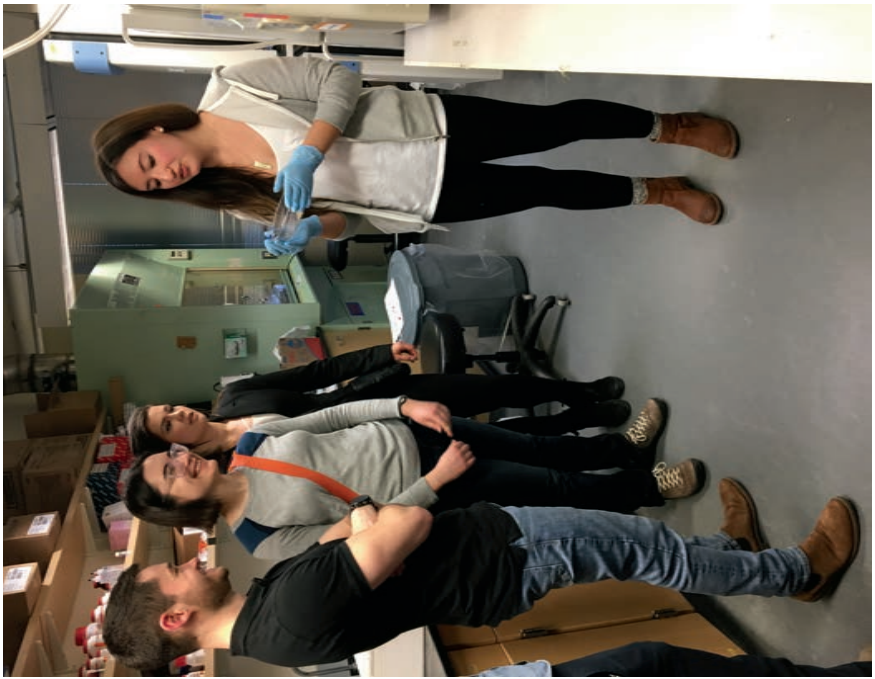
RETREATS

The New Harvest Research Fellowship program was launched in 2015, and over the next two years, it grew from a single researcher to an international, interdisciplinary team of six. As the team expanded both in terms of location and in the number of Fellows, Erin proposed the idea of hosting regular retreats to bring together the remote team for technical skills-sharing and troubleshooting sessions in the lab, as well as valuable face time and team-building. Grad school in any discipline comes with a number of challenges, and being among the first cellular agriculture researchers in the world - let alone academia - can be an especially isolating experience. Today, much of the growing cellular agriculture community still remains quite spread out geographically speaking, and for cultured meat scientists especially, it can be difficult to find other academics who may share interest or have relevant expertise in a particular area. This is such a new field of science that there are not yet any University-level courses, degree programs, or textbooks in existence, and published, peer-reviewed academic papers still remain few and far between.

In an interdisciplinary field like cellular agriculture where, for example, it would be helpful (but not necessarily a likely scenario) for a researcher with an engineering background to be familiar with certain principles of animal cell culture, it is crucial for Fellows to be able to communicate with one another on scientific topics which cross disciplinary lines. In addition to the weekly "Fellow Up" remote technical meetings led by Kate, we thought that these bi-annual retreats for New Harvest Fellows would be a great way to bring the team together, establishing connections between the researchers, and fostering collaboration and exchange of ideas.

We held the first of these retreats in Ottawa in the spring of 2017, followed by a September 2017 retreat in NYC. New Harvest staff and fellows alike have found these retreats to be an invaluable resource, and an invigorating event to look forward to every six months.





THE FELLOWSHIP EXPERIENCE

WHAT DO FELLOWS THINK ABOUT THE NEW HARVEST EXPERIENCE?

We regularly seek out feedback from our Fellows about their experience of the New Harvest Fellowship: what aspects are working well for them; as well as what could be improved. Here is some of the anonymized data we collected from the most recent fellow satisfaction survey.

How has your experience as a New Harvest Fellow impacted your graduate student experience?

6 responses

- It's been great to have a group to talk with that easily picks up on all of the implications of the work without having to describe it in the same way that I feel I need to with medical researchers - the shared context enriches the conversation a lot! Also, the sense of community and place and shared vision is a great motivator, and a great support network to feel good about this all, even when the research is tough:)
- great to have a support system!
- it has been great. I always feel the support from the fellows and Nh team. It also gives me the opportunity to discuss research outside of the lab group, including protocols and experiments. Adding on, i get to receive feedback on my approach-experimental design
- It's definitely enhanced my experience. I'm empowered to do the research of my dreams and connected with others who share my goals. There is additional technical/research support from the group that I can't always get from people in my lab. The fellowship has provided me with professional development opportunities that members of my cohort don't experience, and there are some extra perks like getting to travel more.
- It has made it possible!
- In a very positive light, it is great to be a part of the New Harvest community and have people who are genuinely interested in the same area of research as you

WE ALSO INVITED THE NEW HARVEST RESEARCH FELLOWS AND THEIR PRINCIPAL INVESTIGATORS TO SUBMIT STATEMENTS IN THEIR OWN WORDS ABOUT THE IMPACT OF RECEIVING THEIR RESEARCH GRANTS FOR CELLULAR AGRICULTURE.

"When I first started working with New Harvest as a volunteer in 2014, the organization served as motivation to finish my engineering degree, knowing I could apply my skills to an impactful field of work. Last year, New Harvest awarded me the opportunity to start my graduate degree in cellular agriculture at Tufts University, an opportunity that would have been next to impossible to secure without their network and financial support. Today, as I am almost two years into my program, New Harvest means having a community of support as I struggle through day-to-day challenges in the lab. I rely on our Research Director, Kate, as well as my other research fellows to help me refine project ideas and troubleshoot experiments. New Harvest has provided me with a sense of purpose and the beginning of a meaningful and always exciting career. I am incredibly grateful for their support and the confidence they give me to pursue our shared goals.

-NATALIE RUBIO
PhD candidate, Tufts University

"As an environmentalist and animal lover, I struggle with conventional meat production due to its unsustainable practices. I always had a feeling that there had to be a better way: If nature can "manufacture" tissues, then why can't we? Throughout my food science degree, I wanted to get involved in cellular agriculture. Unfortunately, most universities don't offer classes or programs aimed at developing animal products without animals. On the last year of my undergraduate degree, I submitted a thesis aimed at the applications of bacterial cellulose in cellular agriculture. My thesis was highly commended, due in large part to the collaboration with New Harvest.

Now as a proud New Harvest Research Fellow, I am pursuing an MSc under Andrew Pelling. I feel extremely privileged to call myself a New Harvest Research Fellow, and will be forever thankful for the opportunity. Not only has it opened doors, it allows to me do the research that I dreamed of doing. Projects such as the one taking place at the Pelling Lab would only be possible thanks to generous donors to New Harvest.

-SANTIAGO CAMPUZANO
Master's student, University of Ottawa

"After learning about the devastating effects that the animal agriculture industry has on climate change environmental destruction, in vitro meat became my dream in 2010. For many years, I tried navigating through the research funding world with this hope in mind. Unfortunately, because there is no obvious funding agency tailored to the study of in vitro meat, it's been very tough to advance this field. That was the case until I met New Harvest! Their team has done an incredible job providing guidance and opportunities to advance my research.

One of New Harvest's greatest strengths is that it's run on donations from people who fund the change they want to see in world. With support from donors, we can protect all life on earth by making cellular agriculture a reality. I'm so proud to be part of this team and I couldn't be doing what I love without New Harvest! Together we're making the world a better place.

-JESS KRIEGER
PhD candidate, Kent State University

"I have long been engaged in research in tissue engineering for regenerative medicine, and understand that the principles of tissue engineering hold promise in advancing cellular agriculture. The generous support from New Harvest has allowed me to make steps towards researching cellular agriculture to produce bioengineered meat. I believe that the future of cellular agriculture depends highly on successful research that can make major technological breakthroughs, enabling the production of cost-competitive cultured meat. Since New Harvest is the only funding source to initiate such research efforts, donations to New Harvest will greatly advance the future of cellular agriculture, which will eventually transform traditional agricultural technologies.

-DR. MIN-HO KIM
Principal Investigator to Fellow
Jess Krieger at Kent State Universityy

"Having worked in the oil and gas industry, I felt compelled to turn my hand to research in the area of sustainability. The funding from New Harvest has allowed me to conduct my PhD research specifically on cultured meat, an area I am extremely passionate about! As a chemical engineer, my research is on the design of a bioreactor for scale-up, a necessary step to take cultured meat from the lab to a financially viable product that can one day be commercially available. Cultured meat has the potential to battle so many of the challenges facing livestock farming today; ranging from population growth increasing the demand for food, to negative impacts on the environment such as greenhouse gas emissions and water use. In my opinion cultured meat will address these challenges and make a massive contribution towards a sustainable future.

The science of cellular agriculture fills me with hope for the future, and New Harvest has empowered me to play an active role in contributing to the advancement of this amazing field. The concept of cellular agriculture used to feel like science fiction, but discovering New Harvest has opened my eyes to the revolutionary work already being carried out to make it a reality.

The idea of growing meat and other animal products in a lab without the need to sacrifice animals is awesome and a reality that New Harvest is helping pioneer. Donating to New Harvest is a great way to invest in our future and thanks to generous donations, New Harvest is able to support my PhD research in cultured meat at the University of Bath in the UK.

-SCOTT ALLAN
MRes and PhD candidate, University of Bath

"What New Harvest means to me is written in the mission statement: to establish the field of cellular agriculture. For me, 'field' is the operative word. The common aim of Cell Ag—of activists, scientists, philanthropists, or investors—is, in a word, lofty. It is one that no single entity will bring to bear in its entirety. Rather, it will rely on a set of players who are diverse in their methods, opinions, and contexts. In other words: a field.

New Harvest's commitment to this idea is amazing. No matter when that avidly-sought 'first product' hits shelves, the mission of Cell Ag won't be finished in a year, or two, or fifty. It will instead be an continuing, challenging, and changing process. Because of this, New Harvest's dedication to a bottom-up, holistic, product-patient approach—where foundational research and openness are king—is essential for the field's long-term growth.

So, to all past donors, and to everybody who is considering donating this year: thank you. The opportunity to work with New Harvest has been exciting and enriching to the extreme, and it's through donations like yours that it's possible. I can't say how grateful I am for your support!

-ANDREW STOUT
PhD candidate, Tufts University

"For three years we've been carrying out theoretical bioprocess design for the scale up of cultured meat, mainly through undergraduate student projects, but with no sustained research due to lack of funds. We believe we have determined the key steps to realising affordable large scale culture, the first being to design an efficient scalable bioreactor that is supplied with the correct amount of media. This sounds obvious, but there is no literature in the public domain that provides the level of detail on the stoichiometry of muscle cell expansion and differentiation, that can be found for already-commercial cell types. Having Scott Allan, a New Harvest Fellow, work on the bioreactor design means we can now take the first step to making our scale up concept happen!

-DR. MARIANNE ELLIS
Principal Investigator to Fellow
Scott Allan at the University of Bath

A LETTER FROM OUR COMMUNICATIONS DIRECTOR

In all my years in cellular agriculture, I can't remember a time when things at New Harvest were anything but super exciting, and yet we continue to see that bar being raised to new heights.

Throughout 2017, our field collectively saw increased media coverage, more startups entering the scene, many more voices joining in on the conversation, and more international engagement than ever before. The growth in the number of active players in cellular agriculture in particular was a very welcome and timely development for New Harvest. It coincided with a palpable increase in the public understanding of what cultured meat is, why we are pursuing it, and the possibilities - as well as, importantly, the challenges - surrounding it.

Over time I've noticed that there is slightly less of a need for us to go into the basics of cellular agriculture, freeing up space and time to go right into more "meatier" (pardon the pun) and more nuanced content.

We also began to see some commentary take on a slightly more critical tone. And this makes perfect sense: as more people gain a deeper understanding of cultured meat and cellular agriculture, more nuances, questions, and differing viewpoints will undoubtedly arise, and ultimately make for a more robust field and industry. This was one of many reasons why I felt it was so important to make a rather bold move and invite more of what were previously (and perhaps still are) the "unusual suspects" - meat eaters, current meat producers, and professionals from the meat industry - to speak at and attend our 2017 conference. I think it's absolutely critical to the future success of this field to be inclusive of and collaborate further with these groups. And it has been wonderful for us to have our invitations to connect be received with as much warmth and open-mindedness as we've encountered. I'm very much looking forward to more of this type of inclusion, and seeing how these new relationships open doors for cellular agriculture in the future.

In stepping up my public speaking engagements with New Harvest over the past year, I was thrilled to find our honest, scientifically grounded communications approach being received particularly well in the international communities where Isha and I were invited to share our work in 2017: countries like Sweden, Dubai, The Netherlands, and our old stomping grounds in Canada. Our international outreach efforts helped to generate further interest in our work abroad, and drew in a number of new donors.

Some recurring and deeply meaningful feedback that I received throughout 2017 is how much of a trusted authority New Harvest has become in this space. Once the science is proven, consumer trust will be the most critical factor in the future success of cultured meat and cellular agriculture, and it is something that is not easily earned - and yet all too easy to lose. Being truthful in our messaging and discerning in our media and speaking engagements may not always be the "sexiest" choice or lead to the most attention-grabbing headlines, but for us it is proving to pay off where it will really matter most in the long run. Maintaining our position as a longstanding, trusted authority in the field of cellular agriculture is something that will always remain at the top of my mind as our work continues in the years to come.

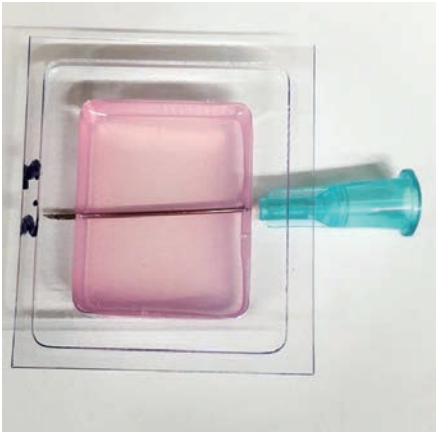
I love that we're becoming a more refined, seasoned organization, and the various new directions that New Harvest is heading in. We are maturing to a point where we can make bolder moves, push the conversation to new places, audiences, and into greater depth, and diversify the field in a truly impactful way. And that makes me more hopeful and excited for the future of New Harvest, and the field as a whole, than ever before.

erin

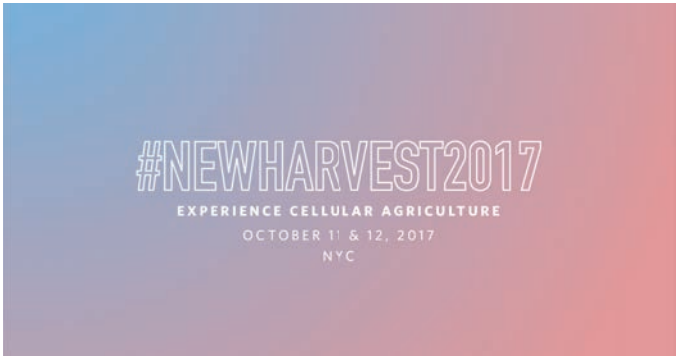
ERIN KIM
COMMUNICATIONS DIRECTOR

2017 MOMENTS

A LOOK BACK AT SOME OF OUR FAVORITE MEMORIES FROM 2017!



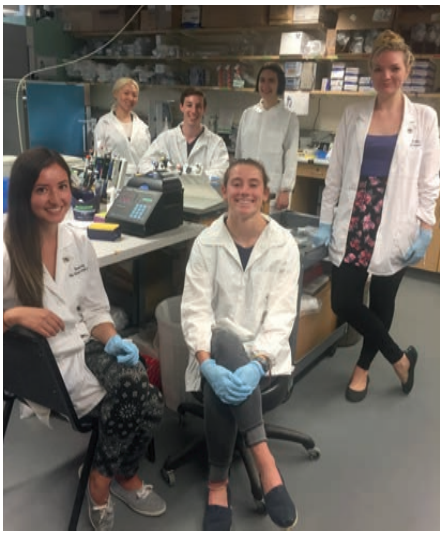
THIS QUICK SNAP TAKEN BY JESS KRIEGER IN THE LAB (SHE WAS TESTING IF AN ACELLULAR COLLAGEN GEL WOULD RETAIN A HOLLOWED SHAPE, HENCE THE NEEDLE) INSPIRED SOME OF THE VISUAL ELEMENTS OF THE NEW HARVEST 2017 CONFERENCE. WE LOVED THE JUXTAPOSITION OF THE PINK GEL AND THE BLUE PLASTIC ATTACHED TO THE NEEDLE.



A SIMILAR LIGHT PINK AND BLUE ENDED UP BEING USED AS THEME COLORS IN SOME OF THE 2017 CONFERENCE DESIGN.

ISHA ADDRESSING THE CROWD AT THE ON CUE CONFERENCE IN BOSTON

A PHOTO OF THE STAGE AT THE WORLD GOVERNMENT SUMMIT IN DUBAI, JUST BEFORE ISHA GAVE HER TALK!



ERIN AND KATE WITH THE TUFTS SUMMER '17 CREW: NEW HARVEST FELLOWS NATALIE AND MARIE, AND SUMMER STUDENTS ANDREW AND NETA

ISHA AND KATE AT NASA. NEW HARVEST WAS INVITED TO LEAD A 2-DAY WORKSHOP ON OPEN SOURCE FOOD PRODUCTION IN SPACE!

GREATER NEW YORK

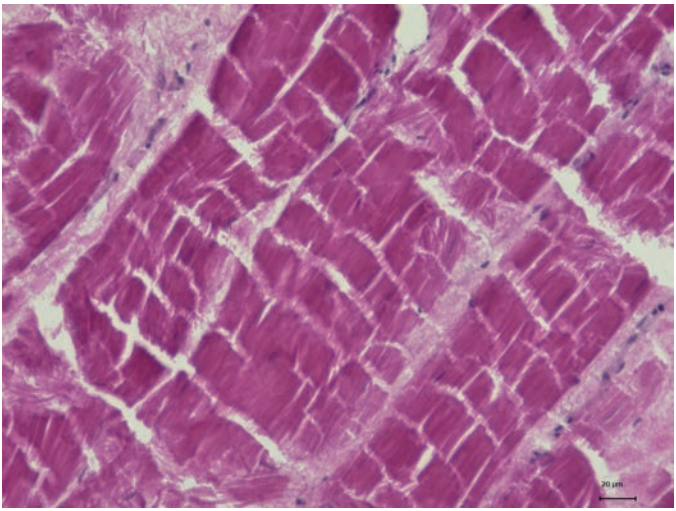
Charitable Sleuths Put Their Money Where It Counts

Cuomo Marks LaGuardia Progress

Industrial Tenants Feel Squeeze on Long Island

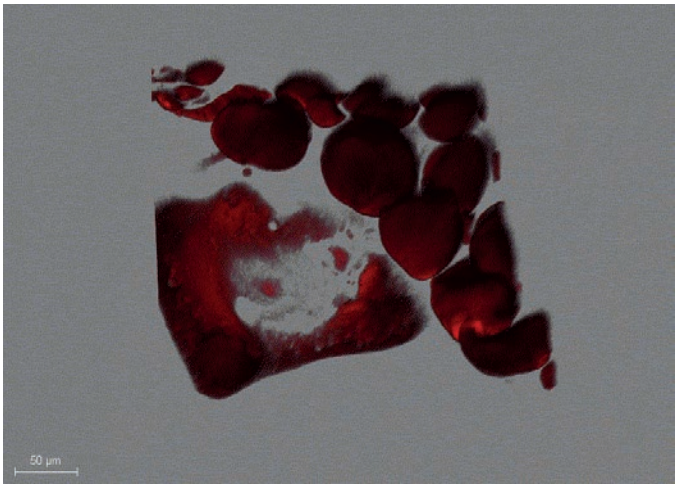
A SHOUTOUT TO NEW HARVEST IN THE WALL STREET JOURNAL, IN A STORY ABOUT THE NYC EFFECTIVE ALTRUIST COMMUNITY

ERIN AND NATALIE IN A MAJOR THROWBACK TO THE SUMMER OF 2014 (SPOT THE VINTAGE NEW HARVEST TOTE!)



EVER WONDERED WHAT CONVENTIONAL MEAT LOOKS LIKE UNDER A MICROSCOPE? THIS IS A SECTION OF H&E STAINED RAW TURKEY (NOT FROM CELL CULTURE) AT 40X MAGNIFICATION, PHOTOGRAPHED BY NEW HARVEST FELLOW NATALIE RUBIO

ERIN TALKING ABOUT THE FUTURE OF FOOD ON FOODABLE TV WITH FELLOW FOOD FUTURIST MIKE LEE



A 3D CARS MICROSCOPY SHOWING PORK LIPID (FAT) STRUCTURE, TAKEN BY KAPLAN LAB COORDINATOR MARTIN HUNTER AT TUFTS UNIVERSITY!

#NEWHARVEST2017 CONFERENCE CREW! MEERA, MORGAN, ERIN, ISHA, KATE, AND KRISTIN

OUR TOP 9 INSTAGRAM POSTS FOR 2017

SELECTED WRITINGS

New Harvest Research Director Kate Krueger presents on "Medium 101"

ICYMI: HERE'S A RECAP OF #NEWHARVEST2017 - *BY JASON WEISS*

New Harvest volunteer Jason Weiss' account of the two days of talks, exhibits, and networking at the New Harvest 2017 conference.

As guests streamed into Pioneer Works in Red Hook, Brooklyn, the renovated brick and timber building matched a recurring theme at the 2017 New Harvest Conference: progress that respects history. Beginning at the registration desk, guests were reminded of this inspiring theme— instead of a throw-away badge, the hosts opted for a reusable ribbon. While getting coffee, they were greeted with an exhibition of researchers, startups, and biohackers eager to share their latest progress. Conversation flourished as experts, entrepreneurs, journalists, students, and a mishmash of professionals and enthusiasts exchanged ideas and made new friends.

The first presentations came directly from New Harvest, which funds research by several fellows on the various building blocks of cultured meat. The subjects included cell lines, scaffolds, medium, and bioreactors. While followers of New Harvest and cultured meat were likely familiar with some of the material, the opportunity to listen to the fellows themselves about their latest progress was electrifying. The audience also heard presentations from New Harvest's Research Director and a principal investigator to a fellow, Dr. Marianne Ellis. What was striking about each presentation was how deftly the speakers could connect to guests entirely unfamiliar with cultured meat. Additionally, the sli.do used for questions allowed guests to submit anonymous questions in case you felt shy. Some questions requested more technical details, some about where additional funding should be spent, and others focused more on the excitement—had researchers tried tasting the meat they had grown? What meat were attendees most excited for? (The clear winner: bacon!)

The audience adjourned for a vegan lunch—provided with recyclable cutlery and compostable paper products. While there were tables for eating, the feel was more of a party where guests could walk around and mingle with each other. Some chose to network in the garden just outside, others spent more time speaking with exhibitors—a few of which had samples of their own food products. The flow between the talks on stage and the exhibition booths, plus the several breaks throughout the two days of the conference provided ample opportunity to have meaningful conversations while also meeting plenty of people.

Guests enjoy the plant-based lunch served at #NewHarvest2017

Oron Catts on "Nobodies' Food"

The next block of presentations focused more on the relationship between meat and society, first with a look at history. Dr. Ben Wurgaft journeyed through the evolution of meat from its origins in hunting through husbandry techniques to grow more, and tastier meat, to the current effort towards growing meat without animals. Oron Catts followed this reflection with a presentation on his work with tissue engineering that challenges how we think about meat and several other tissues when they come from "nobody" (as in, no animal).

After a break, the conference continued with a panel of farmers and cultured meat producers, discussing challenges like achieving the flavor of traditional meat, and how to reconcile how cultured meat appears poised to disrupt traditional meat. The tissue engineers expressed optimism about their ability to achieve the flavor, while the farmers felt optimism towards smaller farm operations persisting beyond the advent of cultured meat. The panel prompted questions from the audience about GMO use, intellectual property rights, and the relationship between people and animals in the future.

Yuki Hanyu of The Shojinmeat Project and Integriculture Inc. closed off the first day of the two-day event

The final presentation of the day stunned much of the audience. After hearing from researchers and entrepreneurs about their progress toward creating a cultured meat product using specialized equipment, Dr. Yuki Hanyu took the stage to share how he managed to culture meat using inexpensive equipment and household items—at one point explaining how he used a culture medium based from a sports drink! He then went on to share how he has taught high school students to grow their own cultures, and his plans to continue teaching even younger students. While the quantity of meat produced with these methods is relatively low, Dr. Hanyu is working toward an open-source community of culture scientists. He has shared his methods online so anyone can try it. His rationale was that by including more people in cultured meat we can broaden the conversation about the best way to make it. The first day wrapped-up with extra networking, fueled with drinks and vegan snacks.

Jesse Wolff of International Flavors and Fragrances giving a talk on how we experience taste

The second morning of the conference focused on the practicality of putting cultured meat on the market, considering challenges of taste, regulation, and communication. It started with Jesse Wolff, who had a vial of roast chicken fragrance for every guest. With his instruction, the aroma of the exhibition hall was transformed into a banquet hall. His presentation was a reminder that texture and flavor must be kept in mind as choices are made developing cultured meat. Vince Sewalt and Isha Datar followed with a conversation on regulation. Cultured meat is a tricky thing, since FDA regulates food products, but USDA regulates farm animals, and therefore meat, while fish remains with the FDA. Isha and the audience picked through Vince's mind about what is GRAS, or "generally recognized as safe", how that might work for cultured meat, and the best precedent to set for future progress.

Vince Sewalt and New Harvest Executive Director Isha Datar in a conversation about regulatory pathways for cellular agriculture food products

The audience enjoyed a break to speak with more exhibitors, and perhaps for some Soylent to satisfy any hunger brought on by the roast chicken experience. They returned to a presentation by Jack Bobo about how to communicate science in the market. He helped the audience through examples of good communication, examples of communication failure, and called attention to the many ways cultured meat is currently described, encouraging to focus less on the why and more about building trust from consumers.

#NewHarvest2017 attendees enjoying the exhibits and tasting experiences at the conference

The final presentation of the morning combined visionary Mike Lee with food product expert Mary Haderlein. To help imagine what cultured meat in the future could look like, Mike and his team designed a speculative Chinese takeout restaurant in the year 2038. They created a menu where a customer would have a choice between traditional and cultured meats for classic dishes. Even more, the specials on the menu allowed the audience to envision a cost difference between traditional specialties and the cultured variety, like bird's nest soup—or how about shark fin? Mary explained the steps ahead to put cultured meat on the market, exploring with the audience ways to ease its emergence—perhaps in collaboration with a chef.

Rebecca White of Qualitas Health giving a talk on algae farming

After lunch, the final afternoon moved away from cultured meat and toward a mix of developments in cellular agriculture. Algae farmer Rebecca White explained the benefits and potential of algae like spirulina as a food product, and the audience explored its potential for use in cultured meat, which was identified as a potential medium on the previous day. The topic drew some extra attention for some of the exhibitors who were focused on algae food products and cultivation. Lauri Reuter shared his experience culturing fruit cells from different plants, prospecting on the potential of culture techniques to access flavors that are expensive or otherwise inaccessible for commercial use.

Finally, Kevin Chen presented the use of fermentation to produce medicinal cannabinoids, explaining how the production capability of fermentation can vastly outproduce current growing methods. He had no samples to offer, but you couldn't blame the audience for asking!

The conference closed with an impromptu open-mic for anyone attending to introduce themselves and any cellular agriculture-related initiatives they were involved with. The speakers ranged from startups announcing recruitment and new products, to a representative of an agriculture coop, to a writer focused on bringing conversations about cultured meat to more people.

New Harvest 2017 was an invigorating experience. It brought together luminaries in the field and like-minds from all over the world, and in combination with the initiative to make changes, it's nearly impossible to walk away without optimism toward the challenges ahead.

JASON WEISS IS AN ENGINEER FOCUSED ON HOW TO DO THINGS BETTER. DURING NEW HARVEST 2017 HE SERVED AS A VOLUNTEER, WITH A HAND IN SETUP, PRESENTATIONS, AND BREAK-DOWN. HE FOUND NEW HARVEST VIA A SEARCH ON MEAT ALTERNATIVES.

- NEW HARVEST BLOG

Published November 7, 2017

THE NAS REPORT ON HOW TO REGULATE FUTURE BIOTECHNOLOGY PRODUCTS IS OUT.... NOW WHAT?

- BY VINCE SEWALT

The long-awaited NAS report on Future Products of Biotechnology was released March 9, 2017 (available at: http://www.nap.edu/download/24605)

It's a thoughtful product of some very sharp minds mostly from academia—and as such, it is a good academic perspective on identifying and characterizing risks relative to current and future biotechnology products. The report also provides a good first step of encouragement toward the US regulatory agencies to exchange more information, collaborate where needed, and establish one single entry point for future biotechnology products.

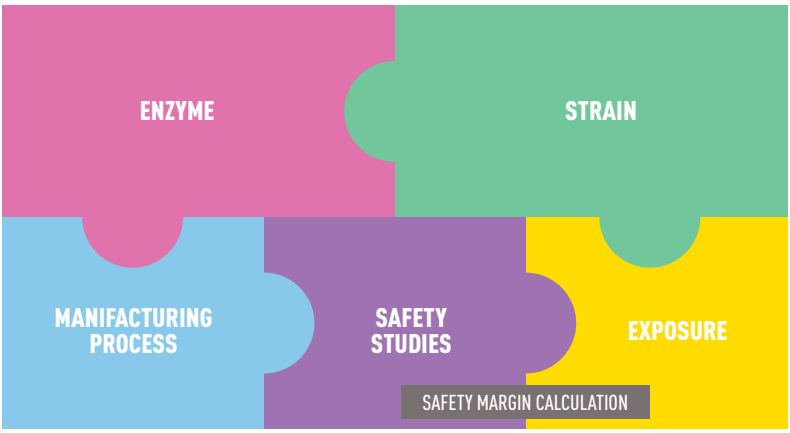
Not to diminish the value of the final report or the stature of the scientists who authored it, but it falls a bit short incorporating some of the direct input from industry regulatory scientists and US regulatory policy makers, something the committee set out to do with the information gathering sessions last summer. As such, the impact of the report will remain largely academic, unless this report can be a stepping stone to more.

Better incorporation of industry stakeholder input (ranging from DIY, to start-ups and non-profit entities such as New Harvest, to large companies) and from various highly engaged institutions, think tanks, and other NGOs, would have provided a richer perspective. And the report seems to have generated a few some misconceptions....

For example, the report mentions "Future biotechnology products may include an additional array of new products that may not fit within existing policies. Examples would be synthesized foodstuffs produced directly in industrial and fermentation facilities without the intermediation of plants or animals (such as egg-white protein produced from GE yeast) ....." The 'existing policies' refer to the designation of food ingredients as Food Additives by the US FDA, unless they are Generally Recognized as Safe (GRAS).

Although the initial assertion is correct, the example chosen (egg-white protein produced from GE yeast) is not.

Proteins produced with the aid of safe microbes such as yeast perfectly fit the GRAS designation, as elaborated in a recent publication [i], supported by well-established safety evaluation methodology for food enzymes produced with genetically engineered microbes [ii], and over 100 successful GRAS Notices filed with FDA for microbial enzymes!



[i] Sewalt et al., 2016. The Generally Recognized as Safe (GRAS) Process for Industrial Microbial Enzymes. Industrial Biotechnology 12(5), 295–302. http://online.liebertpub.com/doi/pdf/10.1089/ind.2016.0011 (open access)

[ii] Pariza and Johnson, 2001. Evaluating the Safety of Microbial Enzyme Preparations Used in Food Processing: Update for a New Century. Regulatory Toxicology and Pharmacology 33, 173–186.

Elements of an enzyme GRAS determination. From Sewalt et al., 2016. Courtesy Mary Ann Liebert, Inc. publishers (http://online.liebertpub.com/doi/pdf/10.1089/ind.2016.0011—open access)

The publications assert that the safety of any microbially-produced protein depends on **1)** the history of safe use of that protein in food, and **2)** the proven safety of the production organism.

Although a person's intake of a dietary protein such as yeast-produced egg albumin or milk protein, for that matter, will be considerably higher than that of an enzyme, the general safety of both **1)** egg or milk proteins and **2)** yeast as a production organism have both been well-established. Moreover, modern engineering techniques allow for minor adjustments to the protein sequence such that hypo-allergenic versions of these proteins can be generated if needed, enabling their consumption by individuals who are allergic to these otherwise highly nutritious proteins.

Further, when describing microbially-produced proteins it is imperative to use correct terminology, as the choice of words **"produced from"** implies a crude preparation from which the yeast production organism has not been removed or potentially a process by which the protein is extracted from yeast. Neither is correct. The correct choice of words for proteins secreted by yeast and other microbes is **"produced with"**, which indicates that the production organism is physically removed from the protein product. This is essential as the regulatory status in some jurisdictions (e.g., EU and Brazil) differs between these 2 types of preparations, with only the former being subject to GMO authorization and labeling.

Instead, the committee may have intended to point out that some animal products produced without animals (such as **cultured meats**) do not fit any of the current policies.

This is what Isha Datar of New Harvest presented in the 3rd public meeting in San Francisco. Interestingly, cultured meats don't easily fit any of the current regulatory categories regardless of whether the cultured cells have been genetically engineered. Although it is well possible that future versions of cultured meat may be perfected with the aid of genetic engineering, current prototypes are not. Cultured meat produced from cell lines that are genetically engineered would be considered an 'open release' product as opposed to proteins produced in contained fermentation. The point that Isha made in the public hearing: traditional oversight over meat processing by USDA (which

largely focuses on carcass processing hygiene) would not apply, and neither would the regulatory category of food additives under purview of the FDA as cultured meat is a whole food. It is such conundrums that we were hoping the committee would address, or, at the very least, that the committee would point at existing safety assessment protocols as being appropriate for cultured meat as also elaborated in a recent Science Magazine Interview [iii].

Which brings me to the most important point, which I also presented to the NAS committee [iv] in the same public meeting: that any evolving regulatory framework that aims at keeping up with evolving technology needs to evolve itself, leveraging knowledge building to set new 'safe baselines' rather than starting safety assessments anew every time an improved variant is put forth to the regulatory agency. Current examples include the Tier 1 exemption by the US EPA, the GRAS designation, and the concept of Safe Strain Lineage, which allows reliance on pre-existing safety data to finalize a risk assessment, without unnecessary sacrifice of test animals.

Although exempt designations and concepts exist, they are not necessarily embraced by the regulatory agencies or leveraged efficiently enough for start-ups to benefit from, and navigating the regulatory maze can be arduous.

[iii] http://www.sciencemag.org/news/2016/08/lab-grown-meat-inches-closer-us-market-industry-wonders-who-will-regulate

[iv] Managing risks of using microbial biotechnology in containment. Presentation to NAS Study Panel of Future Products of Biotechnology (https://vimeo.com/173789952).

From that perspective, establishing a single entry point as recommended by the NAS committee may be a good first step, although it requires focused execution with short turnaround times to avoid prolonging the process even further beyond today's. It is now up to the regulators to come together and seriously work together, while letting go of the silos erected between agencies or even between programs within one agency.

- NEW HARVEST BLOG

Published March 21, 2017

President Reagan pardons turkey in 1983
(Source: Wikimedia Commons)

IF LAB-CULTURED MEAT WAS AS CHEAP AS ANIMAL MEAT *- A SPECULATIVE FUTURE ENVISIONED AND WRITTEN BY ZOE LEAVITT*

WASHINGTON—November 29, 2031—The protesters wore feathers. Outside the White House gates, a group of roughly 40 men and women dressed in turkey costumes hoisted streamers and placards with alliterative slogans, protesting the president's landmark decision on this year's Thanksgiving Day.

In a first, the president chose to forgo the traditional Thanksgiving turkey pardoning in favor of a ceremony for lab-cultured meat.

The White House press secretary described the decision as "a major step forward for human and animal welfare." Conservative YouTube star Jerry Flynn called it "a spit in the face of our Founding Fathers," while the White House chief of dining called it simply "delicious." As the president and her family sat down for this most unusual Thanksgiving meal of artificially grown turkey, the American public was deeply divided.

"We're on the right side of history today," said Adam Lamprelli, co-founder and CEO of UMeat, who provided the White House with its entrée. "So often we think: What choices could we have made that would have steered the world in a more positive direction? We're facing one of those defining moments today in cultured meat, and I think we can be proud of our decision."

FROM LAB TO FORK

Cultured, laboratory-grown meat—also termed synthetic meat, clean meat or"Frankenmeat," depending on the speaker's preference—represented over 50 percent of all U.S. pork, turkey, chicken and beef sales for the first time this year. The first public cultured meat tasting took place back in 2013 among a team of Dutch scientists, who'd poured $330,000 into the effort. By 2016, U.S. startup Memphis Meats managed to reduce production costs to $18,000, a price point that convinced new donors and companies that cultured products might be viable.

In late 2017, the Bill & Melinda Gates Foundation, which previously funded plant-based artificial meat companies like Impossible Foods, invested $120 million into cultured meat research, and soon meat giants like Yum! Brands Tyson Foods and McDonald's began funding animal-free product development.

Regulations also helped, not always intentionally. While President Donald Trump undermined first lady Michelle Obama's anti-obesity initiatives, his administration inadvertently supported cultured meat development. As the Trump administration passed laws forbidding the forced labeling of genetically modified ingredients, food producers increased their biotech investments.

Following the Gates Foundation investment, scientists announced a major breakthrough. A research group in Switzerland successfully grew a batch of cultured meat using photosynthetic algae as a serum instead of the previously used fetal bovine serum, the blood of fetal cows. The new method was cheaper, more scalable and more palatable to the public.

"After the algae breakthrough is when you really saw private companies getting into the space," said Mark Rojas, a partner at the biotech investment company Revolve, which backed several algae companies. "Everyone was looking for the next big thing, the next VRLife or FitTrack, and culturing had the potential to totally transform the consumer space. I mean, look at every ridiculous place Silicon Valley was hurling money and then look at cultured meat in comparison—talk about disruptive."

Prices continued to fall. By 2019, the (then) hip new Manhattan restaurant Camera debuted a cultured meat burger for $11, the cheapest dish on its menu.

PIG FLU CRISIS

Despite positive initial reviews, cultured meat was still a niche product in gourmet stores or aisle displays at Whole Foods;

Source: Wikimedia Commons

marketing efforts had yet to convince the public. That all changed with the pig flu outbreak of 2024.

"Nearly 1,000 people died from this new strain of flu," said Kathleen Dixon, head of the Washington Medical Center, who led the efforts to reform the use of antibiotics in livestock following the outbreak. "We were able to trace the outbreak back to an industrial pig farm in Virginia. Pork sales plummeted by something like 80 percent that year, and the scare pushed people toward cultured meat."

Within a few months, restaurant chain Chipotle announced it would use only cultured meat. McDonald's—which suffered its own contaminated beef scandal, in China, where 1,500 people were hospitalized—launched a range of cultured meat dishes globally. Now we see cultured meat everywhere, from corner stores in cattle country to, today, the White House.

GOOD FOR PEOPLE AND THE PLANET?

Cultured meat brings both individual and societal benefits, advocates say. Medical research shows it is healthier than conventional animal meat, decreasing heart disease, cholesterol and some cancers, including colon cancer.

With cultured meat, one size need not fit all. Companies like EatMe and Meattery offer over 20 varieties of turkey breast and 30 of beef, each with unique nutritional profiles geared toward different consumer segments.

Years ago, you might choose between 90 or 96 percent lean ground beef at the grocery store. Today, one can wander through aisles full of products like the Meattastic Vitamin B booster burger, Iron Maiden iron-enhanced beef for women and dozens more targeting everyone from diabetics to those worried about bad breath. Top restaurants are even starting to trademark their own bespoke meat formulations.

From a public health perspective, animal-borne diseases like mad cow disease are now no longer a global concern. Even flu incidence declined. Previously, pigs and birds were incubators for some of humanity's most virulent flu outbreaks, such as the H1N1 swine flu of 2009 and the pig flu of 2024. With fewer farms in the U.S. today, diseases have fewer launch points from which to spread.
"Cultured meat deserves a spot in public health history alongside the vaccine and the anti-tobacco movement," said Dr. Ellis Mercer, professor of global health policy at Stanford University.

Others aren't so sure. "It may be grown in a lab, but it's still meat," said Michelle Li, who runs the vegan advocacy group 100 Carrots. Activists believe cultured meat gives us a crutch to avoid thinking about what they view as the healthiest solution for human bodies: eliminating meat from our diets altogether. Be it animal-based or synthetic, meat still has more cholesterol than vegetables.

Cultured meat is not without its drawbacks—the production process has high electricity costs—but this is more than offset by the massive reductions in agricultural water usage. With the water savings achieved, the U.S. hasn't yet had to resort to the sort of widespread water rationing some scientists predicted would occur in the early 2020s.Environmentalists have led reforesting efforts in some out-of-use farms, and greenhouse gas emissions have dropped. And the avoidance of so much animal suffering is incalculable. But as today's White House protests show, not everyone supports it.

STRANGE ALLIANCES

Cultured meat faces an intense backlash, unsurprising for a product that takes aim at the heart of an American mythos: replacing the fertile range and vast expanses of cattle land with a fluorescent-lighted laboratory and the sterile clink of test tubes.

The White House demonstrators included a curious collection of protesters not used to being on the same side, from third-generation farmers and anti-genetically modified organism naturalists to animal rights advocates, who believe cultured meat doesn't go far enough. Not since the anti-alcohol movement of the 1910s—which counted both suffragettes and the Ku Klux Klan among its supporters—has a

Source: Wikimedia Commons

protest attracted people from such different ends of the ideological spectrum.

"I think the press knocked us a little bit in our early days," said UMeat CEO Lamprelli. "Just enough people came out of the woodwork with a niece, or old roommate, or Facebook friend's sister's cousin who'd gotten sick from cultured meat that some started to take them seriously. Of course, all the evidence shows cultured meat is actually more healthy."

A broader critique concerned cultured meat's impact on jobs. Along with manufacturing automation and artificial intelligence, lab-cultured meat has contributed to economic inequality, eliminating thousands of farming and trucking jobs in favor of a smaller number of highly educated biotech workers. For years, the government propped up the agricultural sector, providing subsidy after subsidy in a Sisyphean effort, from subsidizing farmers' insurance to reviving a platform for direct farmer payouts. But the loss of jobs continued as people moved toward cultured meat.

The corn and soy industries also struggled as the need for livestock feed declined. In a move unnoticed by most consumers, corn and soy producers began marketing heavily to add more soy and corn syrup to other food products, to make up for their losses in livestock feed. "If there aren't cows to eat it, pass it on to the customer," said one anonymous source close to the industry. The pharmaceutical industry flailed as well—previously, 80 percent of U.S. antibiotics went to livestock. Despite lobbyists' best efforts, these industries have shrunk significantly since the early 2000s.

While pundits frequently blame cultured meat for the decline in agricultural employment, in reality the farming industry was already shrinking. Automation and robotics likely eliminated the most farm jobs.

"Pundits attacked the immigration boogeyman and the AI boogeyman, and then suddenly cultured meat became the new punching bag," said Stanford's Mercer.

Some meat producers did fight back. The industry consolidated, as it became harder for small farmers to compete, while big meat producers launched new, smaller "craft" brands, aiming to bring a sense of nostalgia and authenticity to traditional meat. Some of the craft brands positioned their old-fashioned, hand-raised, animal-based meat as a luxury item, driving their prices up even as the sector contracted.

But for all the opposition, cultured meat, once a scientific curiosity, has become mainstream. For some, it's even winning the war for our taste buds.

"A juicy, medium-rare burger with a hint of spice already included?" said White House head chef Cara Wilhelm. "What could be better?"

- PRO JOURNO DAVOS 2017

Published January 16, 2017

FROM PETRI DISH TO PROTEIN

SCIENCE TO SINK YOUR TEETH INTO: BIOLOGICAL SCIENCES ALUMNA REIMAGINES THE FUTURE OF MEAT WITH CULTURED ANIMAL PRODUCTS.

BY KATIE WILLIS
for University of Alberta Faculty of Science
Contours alumni magazine on May 15, 2017

ISHA DATAR ('09 BSC)

When Isha Datar gave her first public talk in 2012 on the concept of cultured, lab-grown meat, she was greeted with laughter. "It certainly wasn't the reaction I expected," Datar explains from her office in New York City. "And while there are still a lot of questions about cellular agriculture, the disbelief isn't as prevalent anymore."

Cellular agriculture is the process of developing animal products-such as meat, milk, and eggs-from cell cultures in the lab, rather than using animals and factory farming. So, is your hamburger coming from a test tube? Not yet, says Datar. But it's not completely out of the question either.

"We can't deny that factory farms are feeding the world," says Datar. "Alternative food sources will simply lessen our reliance on that one source. This will be a great thing, because the density and number of animals that we are dealing with on factory farms is reaching global limits."

And while the idea of cultured animal products--or cellular agriculture--may make some uncomfortable at first, the potential benefits are huge, including moving toward more safe, secure, and sterile systems of producing animals products around the world. Epidemic viruses, like avian flu and mad cow disease, could become a thing of the past--not to mention potentially mitigating the massive environmental impact associated with factory farming.

"Throughout history, there are lots of examples of how alternatives arise. Consider alternative energy sources like solar and wind power," explains Datar. "Alternative food sources, like alternative energy sources, would simply become part of a portfolio of options for people who are interested in trying them."

There are many other aspects to consider, ranging from the need to develop sustainable food sources in space to concerns about climate change and the environment.

Now the Executive Director of New Harvest, a non-profit organization that supports research and development in the field of cellular agriculture, Datar knows that introducing all audiences to the idea

of cellular agriculture is important. "Everyone eats, so everyone is relevant."

EARLY INSPIRATION

Born and raised in the Canadian prairies, Datar is a self-declared foodie and meat lover. So, when the opportunity to combine her love of science and interest in food arose in the fourth year of her undergraduate degree in the University of Alberta's Faculty of Science, she leapt at the chance.

In 2009, after seeing a poster for a graduate-level meat science course, Datar enrolled and began to learn how the worlds of science and agriculture intersect. The course, offered through the Faculty of Agricultural and Life Sciences, introduced students to the concept of animal products without animals, or cellular agriculture.

"You can talk about food with absolutely anyone, but you can't necessarily discuss protein synthesis pathways with everybody," explains Datar. "It was a little bit like taking a popular science course, and it really drew me in. It was at that point that I, consciously or unconsciously, decided that I wanted to be a part of it."

The final assignment was a research paper on the future of meat. Naturally, being the only student with a biotechnology background, Datar wrote about cellular agriculture and cultured meat. It was then that she found New Harvest, a non-profit organization centered around this very idea. Datar contacted then-director and founder Jason Matheny to ask for feedback on her assignment. To her surprise, he replied connecting her to a group of researchers she had written about, with advice to publish the paper.

"I had to write back to him to tell him that I was just an undergrad student," laughs Datar. "I was so thrilled. People weren't asking how old I was or what lab I worked in. They were simply reading my research and offering their feedback and suggestions. It was an impromptu peer review by people who treated me as a peer."

The paper, "Possibilities for an in-vitro meat production system," was published in Innovative Food Science and Emerging Technologies in January 2010, and still holds its own in today's literature on cellular agriculture.

NEXT STEPS

After completing a master of science in the biotechnology program at the University of Toronto and an internship as policy assistant with GlaxoSmithKline, Datar returned to New Harvest on January 14, 2013 taking over from Matheny as Executive Director and sole employee.

"Going it alone was challenging," explains Datar. "I often asked myself, 'When my laptop is closed, does this organization even exist?'"

It did exist, as it turned out. Datar's first year at the helm of New Harvest was spent on community building and uniting people with a common interest in cellular agriculture. And in 2014, things came together in way she had never expected.

"THIS WAS A GREAT YEAR, BECAUSE PEOPLE STARTED TO REALIZE THAT CELLULAR AGRICULTURE WASN'T JUST THEORETICAL, FUTURISTIC STUFF" – ISHA DATAR

In conjunction with community partners and spearheaded by Datar, New Harvest started two San Francisco-based companies--Muufri, now known as Perfect Day, and Clara Foods. Muufri produces milk from yeast cultures, and Clara Foods produces egg whites from the same. While New Harvest did not have enough money to fund the start-ups on their own, they sourced funds through two accelerator programs--IndieBio in San Francisco and the Synthetic Biology Accelerator in Ireland.

"This was a great year, because people started to realize that cellular agriculture wasn't just theoretical, futuristic stuff," says Datar. "We were able to show that it was possible, and in the near term. The year 2014 put us on the map for donors and philanthropists and has been instrumental in making us what we are today."

IDENTITY SHIFT

Navigating the influx of funds has been challenging, Datar explains. With many more interested individuals and groups, and an employee base of two (with the addition of longtime volunteer Erin Kim in 2016), New Harvest needed to make some deliberate decisions about where they wanted to fit in the world of cellular agriculture.

"It has been a steady incline for New Harvest for the last few years," explains Datar. "We had to ask ourselves a lot of questions. Where exactly do we fit? What is our role? How do we want to position ourselves at this crossroads?"

The answer, it turned out, was to return to Datar's love of science and discovery in the world of academia.

"MANY ISSUES WITH FOOD TECHNOLOGY TODAY ARISE FROM A LACK OF TRANSPARENCY. WE WANT TO TALK ABOUT THE RESEARCH AS IT'S HAPPENING IN AN ACCESSIBLE WAY."

"We've decided to focus on funding academic research and developing the discovery side of cellular agriculture for the time being," says Datar. "Nonprofits are a crucial part of the discovery process. They do the early-stage research and development that is too expensive or too exploratory for private companies to do in-house. They fund the early academic research that lays the foundation for everything that comes after."

Fast forward to 2017, where under the direction of Datar, New Harvest is doing just that. Now in a financial position to fund and conduct open-source, academic research, New Harvest provides financial support to research groups to get a start in the world of cellular agriculture by funding their first projects, prototypes, and milestones in the creation of animals products without animals. From here, the recipients will be better positioned to attract funding from other sources, putting themselves on the map, so to speak, much like New Harvest itself in 2014.

"We want to focus on academic research so that results can be published publicly, for anyone to read," says Datar. "Any person who is interested in this field should be able to read about what we're doing, how we're doing it, and what materials we are using. Many issues with food technology today arise from a lack of transparency. We want to talk about the research as it's happening in an accessible way."

The first project began in 2015 through King's College London and has grown to four different academic partnerships across the globe. New Harvest plans to fund many more academic research projects in the coming months and years.

FUTURE FOCUS

"The thing that keeps me motivated is that we're on the cutting edge of something," says Datar. "This field is fragile, and it needs people to keep things moving and pushing the work forward. Cellular agriculture continues to innovate upon itself in the same way that all agriculture has."

New Harvest unites a diverse collection of people interested in bettering the planet. Cellular agriculture is inherently interdisciplinary. Whether a scientist, entrepreneur, chef, or just someone interested in what they eat and where it comes from, New Harvest provides a wealth of information and resources about cultured animal products.

Datar also wants people to know that cellular agriculture is more than purely utilitarian: it's also culinarily-minded. While many may think the work is simply about feeding as many mouths as possible in the most efficient way, cultured animal products present many interesting culinary opportunities.

"I love food and trying new things," says Datar. "At every instance where I have the chance to do so in my work, I'm reminded how real cellular agriculture is. We're not just selling an idea. We are creating things --real food-- and we are moving research and food science forward."

As for what's next, Datar says the thing that keeps her engaged is working with the donor population that makes New Harvest possible.

"I love the fact that we are a charity and have inspired people from around the world with our cause," explains Datar. "Their goodwill makes this happen. It is very motivating that these people believe in the same idea that we do, and they trust us to try and make it happen. Serving that donor population is something that keeps me going."

"New Harvest is at the intersection of so many motives that will better our world. And we're about creating the solution to many issues at once. So we start there, presenting the solution. All of these issues and problems are secondary."

Isha Datar (left) and Erin Kim ('16 JD), communications director at New Harvest, visit Sag Harbor, N.Y., home of New Harvest donor, hedge fund manager, and art collector Adam Sender (right).

SPECIAL THANKS

ROXANA BAZGONEH
DAVID CHUCHUCA
PATRICIA RUBIO
JASON WEISS
ZOE LEAVITT
VINCE SEWALT
KATIE WILLIS
JOHN ULAN
JESS KRIEGER
MARIE GIBBONS
NATALIE RUBIO
SCOTT ALLAN
ANDREW STOUT
HAN ZHANG
SANTIAGO CAMPUZANO

AND LAST BUT CERTAINLY
NOT LEAST -
TO EACH AND EVERY ONE
OF OUR 694 DONORS.