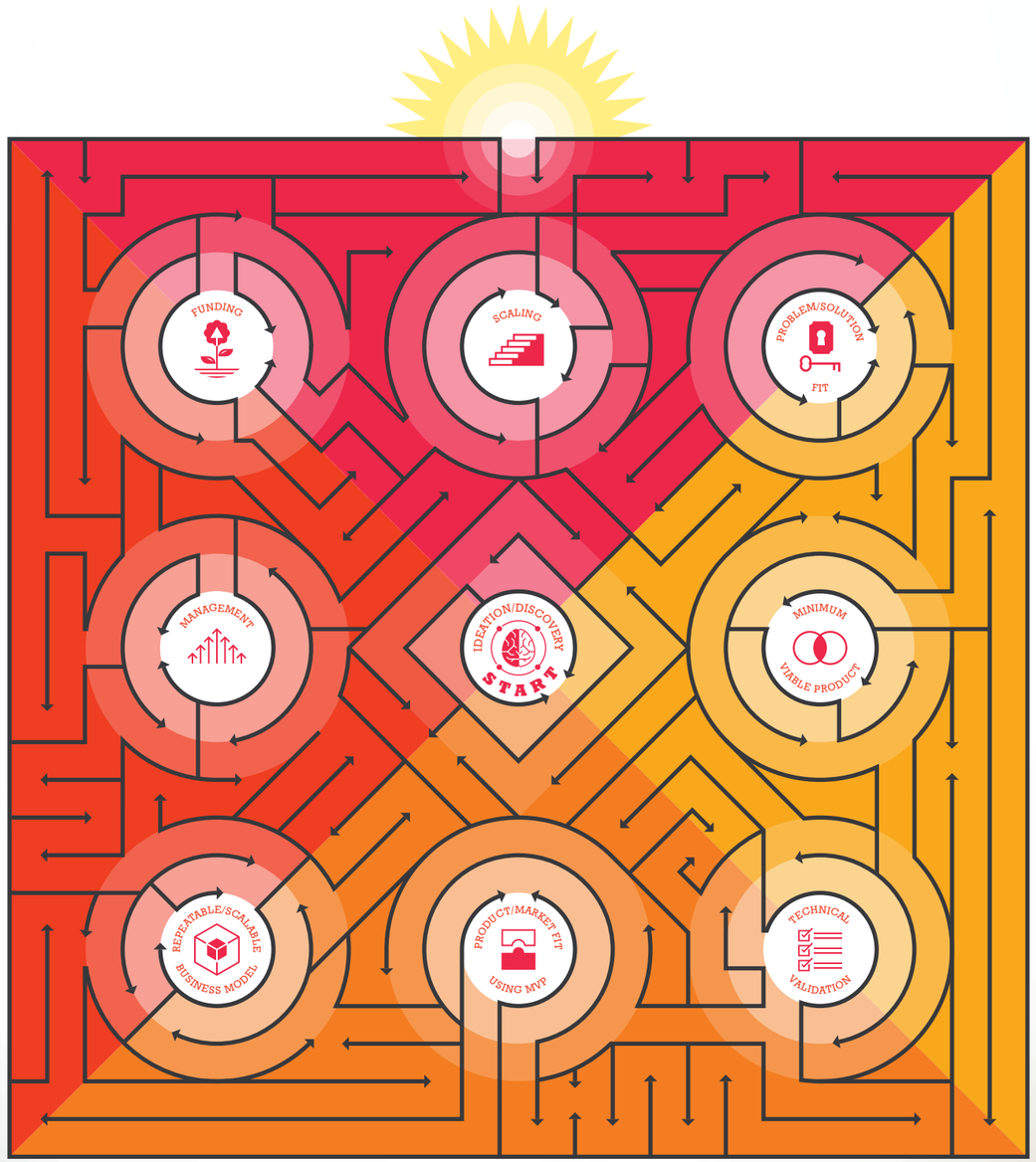
Technology & Venture Commercialization

2015 ANNUAL REPORT

PATH TO COMMERCIALIZATION

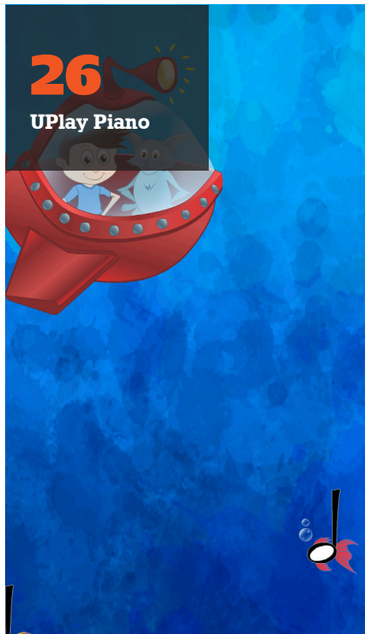
Milestones


FUNDING
SCALING
PROBLEM/SOLUTION
FIT
MANAGEMENT
IDEATION/DISCOVERY
START
MINIMUM
VIABLE PRODUCT
REPEATABLE/SCALABLE
BUSINESS MODEL
PRODUCT/MARKET FIT
USING MVP
TECHNICAL
VALIDATION

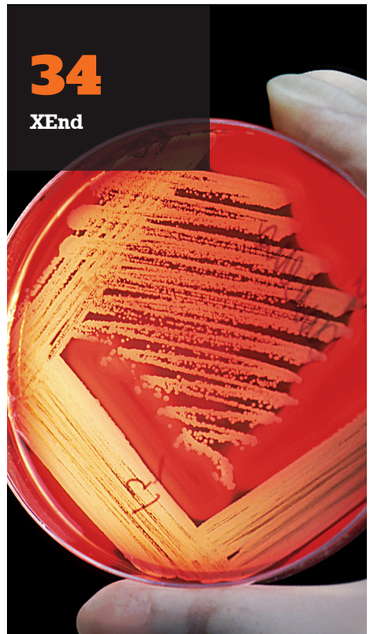
4-13 YEAR IN REVIEW

14-21 FEATURED ARTICLES

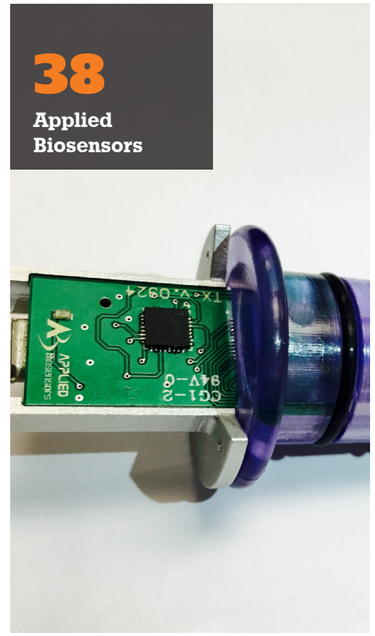
22-29 FEATURED ARTICLES

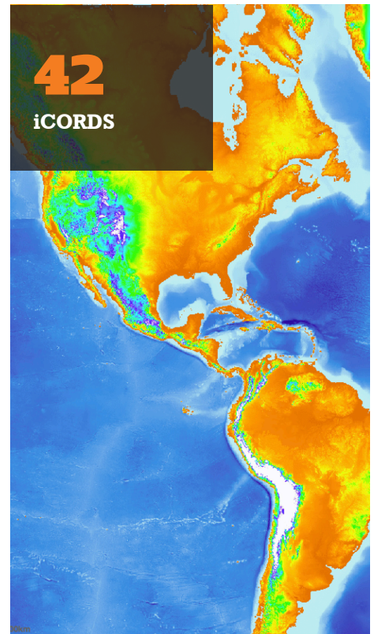


30-37 FEATURED ARTICLES

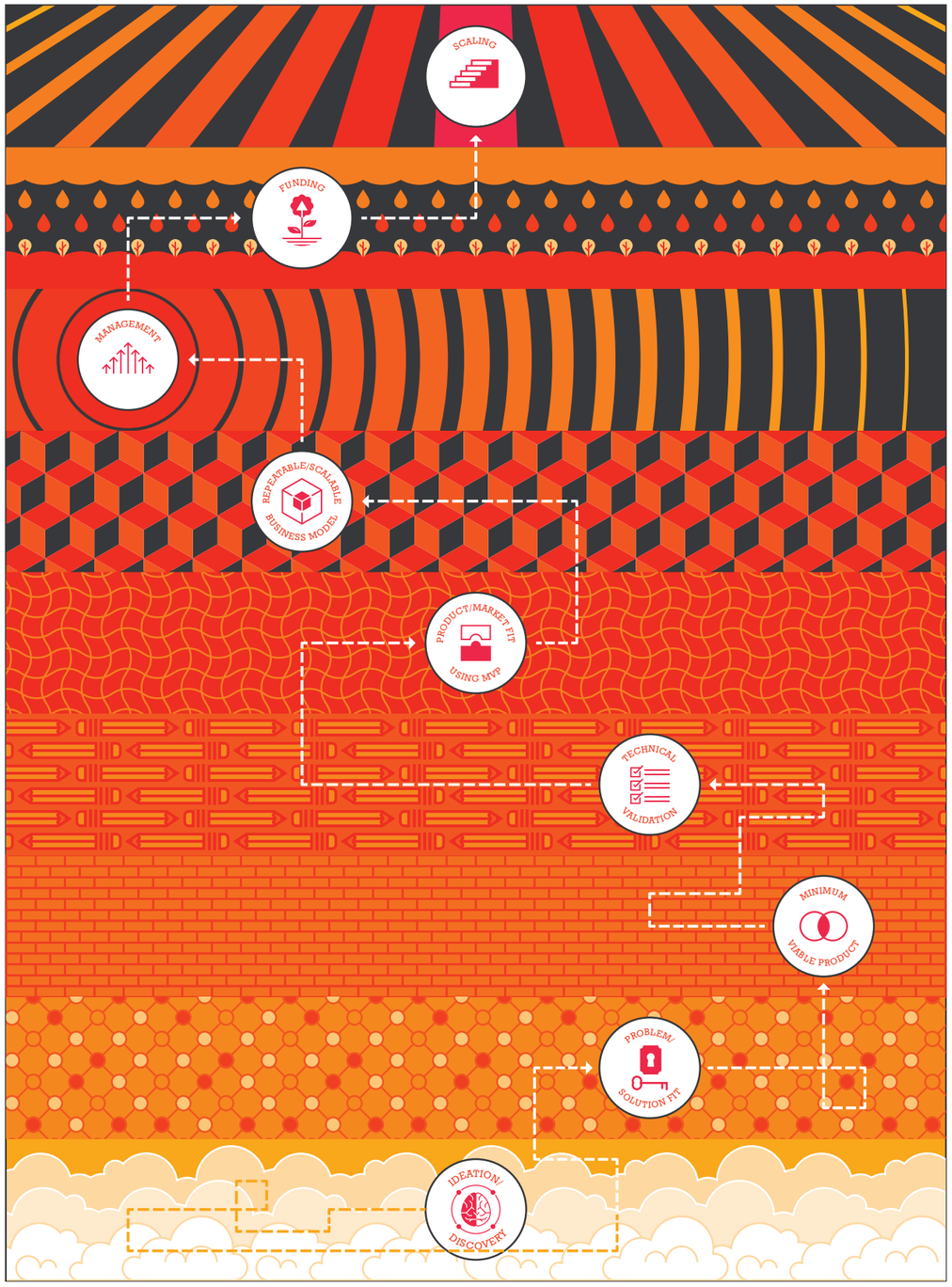


38-45 FEATURED ARTICLES





46-47 YEAR IN REVIEW CLOSING



2015: A Year of Milestones

Technology and Venture Commercialization (TVC) has been proudly serving the University of Utah's inventive faculty and researchers since 1968. During this time, we have evolved from a traditional technology transfer office into a national leader in commercialization and innovation. The jobs and companies created by the University's commercialization efforts have made the University a catalyst for economic development in Utah. This success, however, has not been coincidental. The effects we benefit from today are a direct result of achieving a series of planned commercialization milestones set and accomplished by the University of Utah's rich innovation ecosystem (for more information visit www.utah.edu/innovate). As each milepost was marked, it contributed to and enriched the overall impact of this innovation ecosystem.

Advancing Through Milestones

While the success of commercializing University technology has brought substantial economic growth to the community and tens of millions of dollars back to the University, the majority of this success has come from only three percent of the University's technologies. While this percentage is actually *higher* than average in the technology transfer industry, it is not a number we are satisfied with. It is also important to consider that the overwhelming majority of the University's commercialization returns have come from its spinouts rather than technologies licensed to existing companies. In an effort to double our returns percentage, we are focusing our efforts on helping the University's spinouts accomplish defined commercialization milestones. This includes helping them find qualified management, achieve technical mileposts, market their technologies, or to find funding, just to name a few. Achieving milestones adds additional value to a company and signals that it is one step closer to achieving its desired end goals.

Both the layered illustration to the left and the maze on the cover feature nine important milestones that the University's spinouts tend to progress through as they mature. Each of the featured articles in this report includes an icon indicating the current stage of that spin-out. For more information about these milestones, visit www.tvc.utah.edu/2015annualreport/milestones.php.

Meeting Milestones

As interim director of Technology and Venture Commercialization (TVC), I am honored to lead such a passionate and dedicated team. I began my journey at TVC in July 2011 as a business and technology development manager. In the spring of 2013, I was promoted to director of the engineering team. During this time, I became keenly aware of the milestones we have marked and of the progress we have made. I am grateful for the path that has been laid to help us achieve our future milestones. I believe that the seeds that have been sown over the last few years by our faculty, administration, employees, spinouts, and the work of our Commercialization Engine and Accelerator will lead to the attainment of not only our milestones, but those of our spinouts as well.

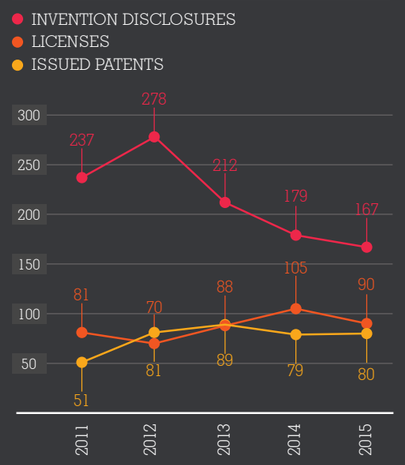
Finally, to our stakeholders, the University administration, employees, and the inventors who inspire us, I say thank you. Collectively, you are the power behind everything we do. We are proud of TVC's success, but are also keenly aware of the challenges that face us. Diversifying our portfolio by helping more of our spinouts advance will require focus and dedication. At the same time, we believe that challenging conditions offer great opportunities for growth. We are confident that with your support we will meet these milestones.

Sincerely,

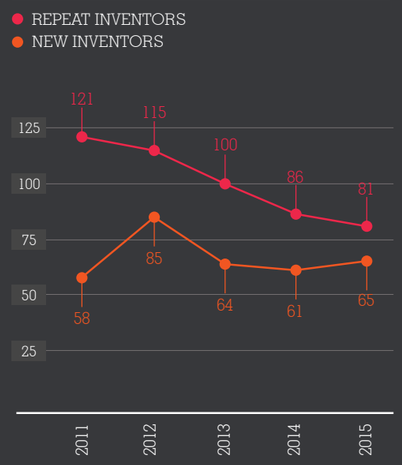
James E. Thompson
Interim Executive Director, TVC

2015 BY THE NUMBERS

DISCLOSURES, LICENSES & PATENTS

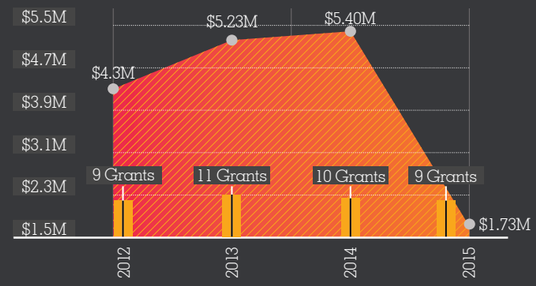


INVENTORS

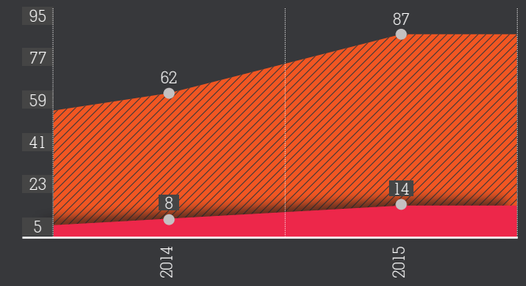


GOVERNMENT GRANTS

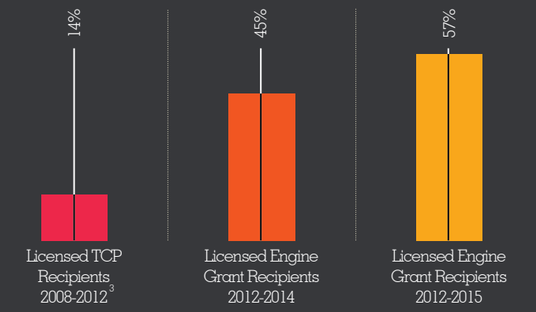
INCLUDES FEDERAL SBIR & STTR GRANTS
SECURED FOR UU SPINOUTS & TECHNOLOGIES



2-& 12-WEEK TVC RESPONSE TIME[2]

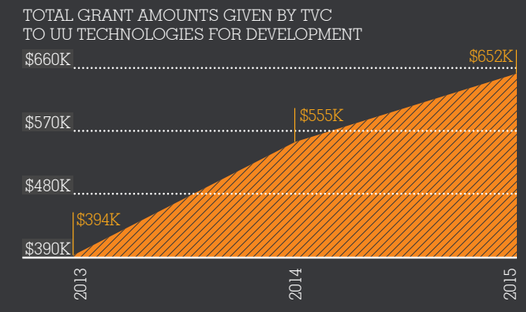


COMMERCIALIZATION ENGINE'S PERFORMANCE



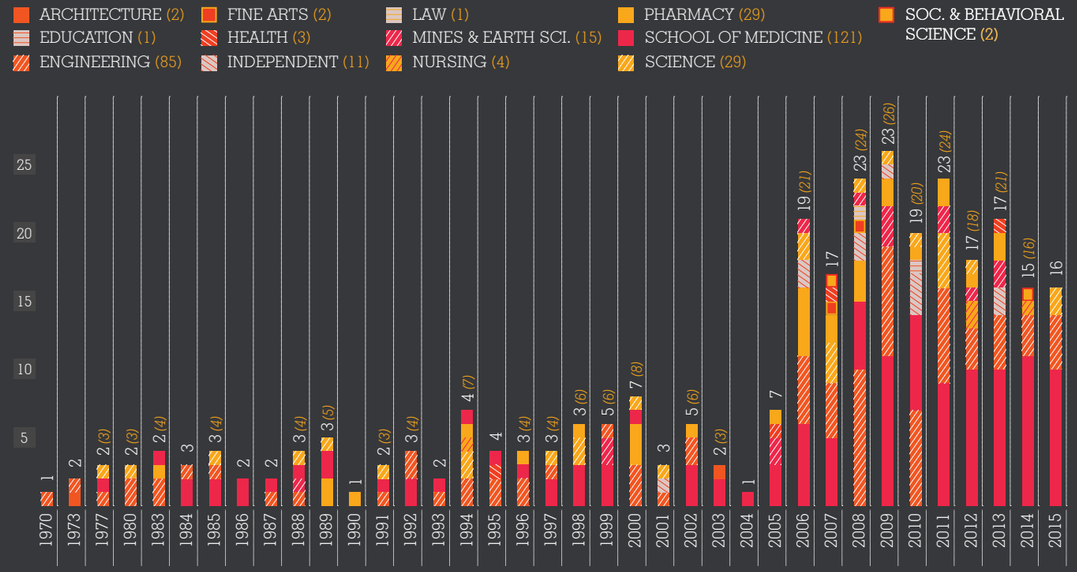
ENGINE INVESTMENTS

TOTAL GRANT AMOUNTS GIVEN BY TVC
TO UU TECHNOLOGIES FOR DEVELOPMENT



SPINOUTS BY COLLEGE [1]

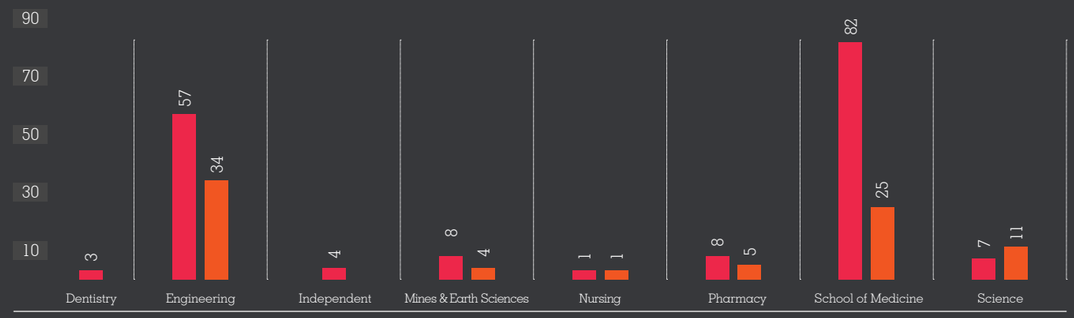
1970-2015



2015 DISCLOSURES & PATENTS BY COLLEGE

DISCLOSURES ISSUED PATENTS

INCLUDES THE COLLEGES OF THE PRINCIPAL INVESTIGATORS LISTED ON 2015'S INVENTION DISCLOSURES AND ISSUED PATENTS [4]



1. This chart lists the number of spinouts launched by year along with their college(s) of origin. The college of origin for each spinout was determined by the department(s) listed by the principal investigator (PI) on the invention disclosure form of each technology licensed to the spinout. Because many spinouts took licenses to multiple technologies, and because many of those technologies have different colleges of origin, the total number of spinouts (the white-colored numbers above the colored bars) does not always match the total number of colleges (the yellow-colored numbers in parentheses) each year.
2. TVC strives to meet with inventors within two weeks of invention disclosure to understand the disclosure and answer and ask questions. We then strive to meet with them again at 12-weeks (84 days) to discuss the path forward for their disclosed technology.
3. The Commercialization Engine program replaced the Technology Commercialization Project (TCP) in 2012.
4. There are three more invention disclosures in this chart than in the Disclosures, Licenses, and Patents chart due to the fact that the principal investigators (PI) on three disclosures listed two departments that each belong to a different college on their invention disclosure forms.

SPINOUTS LAUNCHED SINCE 1970

The U has been successful at creating spinout companies—especially in recent years. Below are spinouts by fiscal year with notation for status.

- A Active
- I Inactive
- Q Acquired
- C Acquired but active with name at the time of acquisition

2015	
4DQC	A
6S Medical	A
Bastion Biologics	A
Clinacuity	A
IDbyDNA	A
Madra Learning	A
Majelco	A
NanoSynth Materials & Sensors	A
Origyn	A
ProMD	A
Safe Blade	A
Solefire	A
StreamDX	A
T3S Technologies	A
uBiota	A
Veritas Medical	A
2014	
ApopTx	A
Behavioral Health Strategies	A
Episona	A
Javali	A
Medvantage Corporation	A
NeuroCircuit Therapeutics	A
NeuroVersity	A
Orriant	A
Progenitor Life Sciences	A
Recursion Pharmaceuticals	A
Sentius Technologies	A
Symptom.ly	A
Tactical Haptics	A
Techcyte	A
Xenocor	A
2013	
Active Desk	A
Applied Biosensors	A
Arapeen Medical	A
ASHA Vision	A
CIRJ	A
Curza Global	A
Molecular Cloud	A
Navigen Endo-Shield	I
Ore to Metal Technologies	A
Proactive Memory Services	A
Resolution Applications	A
SimplicityMD Sharps	I
SimplicityMD Solutions	A
Synoptic	A
University Innovation Services	I
Verus Mobile Security	A
Vettore	A
2012	
Add-it	A
Creative Medical Health	A
DecipherGenX	I
Falgatter Technologies	A
iBiologics	A
Lazarus Medical	A
Lone Star Thiotherapies	A
MultiFunctional Imaging	A
Navillum Nanotechnologies	A
Pecten Technologies	I
PRONTO International	A
Salarius Pharmaceuticals	A
Utah Medical Solutions	A
Vaporsens	A
Veristride	A
Visus	A
Voyant Biotherapeutics	A
2011	
AvanSci Bio	A
Axon Optics	A
Beijing Great Sun Biotech	I
CB Bioenergy	A
Cell Reader	I
CoNextions	A
Domain Surgical	A
e-Sens	A
Elute	A
Espira	A
Granite Mountain Technologies	A
HOT Water Global	I
Innoception Technologies	A
Knudra	A
MacCure	I
Perfect Vision	A
Seismic Option Safety Systems	I
SymbioCellTech	A
Telomere Diagnostics	A
TransViragen	A
US Bioremediation	I
Xandem	A
XEnd	A
2010	
7Revolutions	I
Brickell Biotech	A
Converus	A
F2 Solutions	A
Fay Financial Engineering	I
G6	I
iVeena Delivery Systems	A
Kayak Biosciences	I
KickStart	A
Predictive Medical	I
RedSpan	I
Salt Lake Biosciences	I
Seasonal Energy	I
Sfida Biologic	I
Short Solutions	I
Solan	A
Veritract	A
Versalion Pharmaceutics	I
Vutara	Q
2009	
Accendo	A
Blackrock Microsystems	A
Branching Tree	I
Energence	I
Ergonomic Tool Development	I
H2OTEQ	I
Headwaters Clean Carbon Serv.	I
Honde Environment	I
Integratech Proteomics	I
JSK Therapeutics	A
Marrek	A
Metallosensors	I
Miracotech	I
Nanomedic	A
Optema	I
Oscilla	I
Purple Energy	I
RNA Biosciences	I
Sci-U	I
Sera Prognostics	A
TheraRenal	I
TheraTarget	A
Wastewater Compliance Systems	A
2008	
Advanced Signal Detection	I
Akadi	I
Allegro Diagnostics	Q
BabyJock	I
BioEnergenix	A
Catheter Connections	A
Celux Scientific	I
Epitel	A
Geo Mind	I
GlycoMira Therapeutics	A
Heavystone Laboratories	A
I2S Engineering	I
Nano-Oxides	A
Nanonc	A
PFO Technologies	Q
Philotek	I
Rigalya Pharma	I
RU Ready	A
Surfagen	I
Trapeze Media Solutions	I
ViroPan	A
VisTrails	A
Wasatch Nanopore Sensors	I
2007	
Bioclassifier	A
BioFuels Development Corp	I
Boulder Technology Devel. Labs	I
Central Logic	A
Clear Carbon Solutions	I
ContraDyn	I
Image Technologies	A
Larada	A
LV Partners	Q
Navigen	A
nFocus	I
Osteoseek	I
PowerMems	I
Polevault Media	A
RayScale	Q
Rescue Medical Systems	A
Thermimage	I
2006	
AlloCure	I
Carbylan Biosurgery	I
Exeven V	I
Fuels Development Group	I
Glycosan Biosystems	Q
Heightened Technologies	I
Intan Technologies	A
Intellivis	I
LifeScan	I
LiveWire Innovation	A
Neuroadjuvants	A
Respiris	Q
SentrX Animal Care	A
TechnoImaging	I
Vestan Medical Imaging	A
Visual Share	A
Wasatch Microfluidics	A
Xapio	I
Zicthus	I
2005	
Globalmatics	I
Goldfinger	I
Lineagen	A
MedAnalytics	A
Milcin Therapeutics	I
N-ERGY	I
Sentrx Surgical	Q
2004	
Coherex Medical	A
2003	
Applied Medical Visualizations	A
Q Therapeutics	A
2002	
Amirsys	A
Hydra Biosciences	I
Versa Power Systems	Q
Visual Influence	Q
Wyoming Research Innovations	I
2001	
Sensicore	I
Tramontane	A
Universe Partners	I
2000	
Acionт	A
Allvivo Vascular	A
Attensity Corporation	A
ParSciTech	I
Pharmanex	Q
Salus Therapeutics (Genta)	I
Sonic Innovations	I
1999	
Fiore Automation	I
MedQuest Products	Q
Mineral Technologies	I
TheraDoc	I
ThermaCom	I
1998	
Echelon Biosciences	C
Spectrotek	I
Zars	Q
1997	
Cyberkinetics	Q
Manticore Pharmaceuticals	Q
Signature Immunologics	I
1996	
Cimarron Software	C
Rosetta Inpharmatics	Q
Viewpoint Manufacturing	I
1995	
Diacor	I
ErgoWeb	I
Handtronix Corporation	I
Process Instruments	A
1994	
BioCentrex	I
Cognetix	I
ENECO	I
Innovative Caregiving Resources	I
1993	
HerediLab	I
PartNet	C
1992	
Cardiowest Technologies	I
InfaBloc	I
Myriad Genetics	A
1991	
BioFire Diagnostics (Idaho Tech.)	C
Femtoscan	I
1990	
MicroMath	I
1989	
MacroMed	Q
Parvus Corporation	I
TheraTech	Q
1988	
Darbick Instructional Software	I
J. Bunger & Associates	A
Tepnel Lifecodes	Q
1987	
A.D.A.M.	Q
Evans & Sutherland	Q
1986	
Anesta	Q
NPS Pharmaceuticals	Q
1985	
DataChem Lab	I
Rocky Mountain Research	Q
Techniscan Medical Systems	I
1984	
ARUP	A
Engineering Geom. Systems	Q
Medtronic Gastro/Uro	I
1983	
Datex-Ohmeda	I
Sarcos	Q
1980	
Bunnel	I
Ceramatec	A
1977	
FFFractionation	Q
Iomed	Q
1973	
Advanced Composite Materials	A
Metals Manufacturing	I
1970	
TerraTek	Q

TECHNOLOGY COMMERCIALIZATION MILESTONES AT THE U

1968 — **Patent and Product Development Department Launches.** The U's technology commercialization office is created under its first name, the Patent and Product Development Department.

1970 — **The University of Utah Research Foundation (UURF) Forms.** The UURF is created in April 1970 with the purpose of promoting, conducting, encouraging, and facilitating research, development, and dissemination of knowledge, and the application of knowledge.

1970 — **TerraTek Launches.** TerraTek, the U's first spinout company, is founded by Wayne S. Brown, dean of the College of Engineering. Schlumberger acquired TerraTek in 2006.

1977 — 

IOMED (formerly Motion Control) Launches. U-spinout IOMED manufactured drug delivery systems developed by Stephen C. Jacobsen, distinguished professor of mechanical engineering, et al., that were used to treat acute local inflammation in the physical and occupational therapy, and sports medicine markets.

1980 — **Ceramatec Launches.** U-spinout Ceramatec is founded by Ronald Gordon and Abraham Sosin, professors of materials science and engineering. The company performs advanced research and development of ceramic material technologies.

1982 — 

Jarvik-7 Heart Transplant. Robert Jarvik, a physician at the U, begins development of the Jarvik-7, the world's first permanent artificial heart in the late 1970s. Surgeons at the U successfully transplant Jarvik-7 into a patient in December 1982.

1985 — **Department Shares Begin.** The Patent and Product Development Department institutes department shares as a method for encouraging invention disclosures.

1986 — 

Anesta Launches. U-spinout Anesta develops a successful product called Actiq, a breakthrough treatment for cancer pain based on the company's patented oral transmucosal system. The product is derived from the research of Theodore Stanley, professor of anesthesiology, et al.

1986 — **Patent and Product Development Department Becomes the "Technology Transfer Office" (TTO).**

1986 — 

Mallinckrodt Pharmaceuticals Licenses Technescan MAG3. Technescan MAG3 is used to image the kidney and to assess renal perfusion. This novel compound developed by Alan R. Fritzberg, associate professor of radiology, et al., provides better imaging of the kidney.

1986 — **NPS Pharmaceuticals Launches.** Hunter Jackson and Tom Parks launch U-spinout NPS Pharmaceuticals. Both are research scientists in the U's School of Medicine studying the biological effects of spider venom.

1987 — **The Technology Transfer Office Becomes Financially Self-Sufficient.** In the years following, the office not only remains self-sufficient, it contributes millions of dollars back to the U.

1991 — **BioFire (formerly Idaho Technology) Launches.** U-spinout Idaho Technology is started in the corner of an Idaho potato equipment facility based on technology developed by Carl Wittwer, professor of pathology, et al.

1992 — **Myriad Genetics Launches.** U-spinout Myriad Genetics is formed by Mark Skolnick, professor emeritus of medical informatics, et al., as one of the first genomic companies with the vision of elucidating the role genes play in human disease and using this critical information to improve patient healthcare by developing novel molecular diagnostic products.

1997 — **Technology Innovation Grant Program Launches.** The Technology Innovation grant program (later renamed the Technology Commercialization Project [TCP]) becomes the first grant the U gives to researchers seeking to further develop commercializable technologies.

2000 — **Cephalon Purchases U-Spinout Anesta for $444 million.**

2000 — **Pharmanex Launches.** Pharmanex develops technologies based on the research of Werner Gellerman, professor of physics, that can detect and map certain chemical substances in the skin. The U-spinout, later purchased by NuSkin, expanded its products under Pharmanex.

2005 — **Technology Transfer Office Becomes the Technology Commercialization Office (TCO).**

2005 — **Technology & Venture Development (TVD) Forms.** TCO is removed from the Office of the Vice President for Research and placed under the newly created TVD. This office is formed to support the many commercialization activities taking place across campus.

2005 — **Emphasis on Launching University Spinouts Begins.**

2006 — **Start of the Virtual Incubator Projects Grants (VIP) & Micro-Grant Programs.**

2007 — 

Entrepreneurial Faculty Scholars (EFS) Forms Under Glenn Prestwich.

2011 — **Commercialization Engine Develops.** The TCP, VIP, and Micro-Grant programs are subsumed by the newly formed Commercialization Engine.

2012 — **Technology Commercialization Returns to the Office of the Vice President for Research.**

2012 — **Emphasis on Driving Value Into Spinouts and U Technologies Begins.**

2013 — **Technology Commercialization Office Becomes Technology & Venture Commercialization (TVC).**

2013 — **BioMérieux Purchases U-Spinout Biofire for $450M.**

2013 — **Launch of 2-Week and 12-Week Faculty Meetings at TVC.**

2014 — **The U Celebrates 105 Technology Licenses, Highest Number in Its History.**

2015 — **Shire Acquires U-Spinout NPS Pharmaceuticals for $5.2B.**

ACQUISITIONS EXPAND U'S INFLUENCE

The recent acquisitions of U-spinouts NPS Pharma and AvanSci Bio add to a growing list of U-spinouts that have been purchased by major corporations in recent years.

NPS Pharmaceuticals

In January 2015, Irish drug company Shire acquired NPS Pharmaceuticals—a U-spinout that provides treatments for rare disorders—for an all-cash purchase of $5.2 billion, making this acquisition the largest in the U's history.

NPS Pharmaceuticals was founded in 1986 by Hunter Jackson, Ph.D., executive chairman of U-spinout Navigen and Tom Parks, Ph.D., vice president for research and professor of neurobiology and anatomy. Both were research scientists in the U's School of Medicine studying the biological effects of spider venom. Today, NPS Pharmaceuticals focuses on therapeutics aimed at improving the quality of life for patients with rare diseases such as Short Bowel Syndrome (SBS), Hypoparathyroidism, and Autosomal Dominant Hypocalcemia (ADH).

AvanSci Bio

In December 2014, the world's largest biotech company, Roche Diagnostics, acquired all products associated with U-spinout AvanSci Bio's microdissection technologies. This transaction includes its Millisect™ instrument, a device for removing tissue samples from microscope slides, along with all of its associated instrumentation, software, and consumable resources.

AvanSci Bio

Katherine Geiersbach, M.D., assistant professor of pathology, developed the original technology behind Millisect™ at the U. While working in molecular oncology, Geiersbach became frustrated by the need for a device that could be more precise than scraping slides by hand. With applications in clinical and research pathology as well as histology laboratories, the technology's primary use is to bolster precision in genetic testing for cancer mutations.

Expanded Impact

"These acquisitions, along with BioMérieux's $450 million purchase of U-spinout BioFire (formerly Idaho Technology) in 2013, demonstrate the growing influence and impact the University's 265+ spinouts are having in the market," states Parks. "The University is creating technologies and companies that are generating interest from some of the largest businesses in the world."

BE A PART OF BUILDING COMPANIES AT THE U

- **Lead Company Strategy**
- **Explore Investment Opportunities**
- **Provide Technical Product Guidance and Assistance**

Amazing innovations and technologies are being created at the U. A potential cure for type 1 diabetes is being developed; a new, radical method for heating homes will soon be available; antibiotics that kill superbugs like MRSA are being fast-tracked by the FDA; and engine exhaust is being turned into reusable power, to name just a few.

Technology and Venture Commercialization (TVC) is charged with bringing these and other novel inventions to market and into the hands of customers. We have launched over 190 companies in the last 10 years to accomplish this. However, this success depends on an active and engaged community of subject matter experts, investors, and executives like you. TVC has learned that success depends on receiving support from people who have experience in every field and discipline. This support means giving advice and guidance to the teams behind the U's groundbreaking technologies. Even a short conversation about a topic you know well could help guide the development of an innovative technology down the correct path more quickly and into the lives of those who need it.

We Know How to Start Them; Come Help Us Run Them!

Simply fill out our Commercialization Engine profile form by visiting the link below. We will then contact you and employ your unique experience in helping to guide the development of U technologies.

www.tvc.utah.edu/tco/engine_committee_events.php

The Commercialization Engine

The Commercialization Engine is a value-adding process through which all University inventions pass after disclosure to TVC. Its goal is to take early-stage technologies through a process of de-risking and transform them into life-changing and productive applications. This is accomplished by thoroughly understanding inventions, finding their value, determining their market fit, acting on feedback from potential customers, protecting IP, creating a strong business model, identifying milestones, and executing an acceleration plan.

TVC has incorporated many of the latest entrepreneurial ideas and texts from thought leaders around the world into the Engine and molded them to work in a university setting.

The goal of the Engine is to have a team and a plan in place ready to raise the first round of professional investment for a new spinout or for the technology to be licensed to an established company.

Learn more at: www.tvc.utah.edu/tco/engine.php

LINEAGEN

Changing Autism Spectrum Disorder's (ASD) Diagnostic Odyssey

While never confirmed, it has been suspected that such leading figures as Michelangelo, Andy Warhol, Mozart, Albert Einstein, and Isaac Newton each had a type of autism spectrum disorder (ASD).[1] ASD is an umbrella term for a range of neurodevelopmental disorders that impair an individual's ability to communicate and interact with others. ASD tends to encompass diagnoses of autism, Asperger syndrome, a range of childhood disintegrative disorders, and various pervasive development disorders.

According to the Centers for Disease Control and Prevention (CDC), ASD affects approximately 1 in 68 children.[2] Parents with one child with ASD will have a 2 to 18 percent chance of having a second child with the condition. In the case of identical twins where one has been diagnosed with ASD, the other will be affected roughly 36 to 95 percent of the time.[3] Nearly half (46 percent) of ASD children are reported to have average to above average intellectual ability.

Concurrent Conditions

While ASD has long been characterized by communication impairments, in many cases children with the disorder will also have concurrent conditions such as epilepsy, cardiac anomalies,

"Due to recent advances in genetic analysis, we can now identify potentially life-threatening conditions early on through genetic testing and then treat them. This is important because identifying a condition early leads to better management and better outcomes."

—Michael Paul, CEO, Lineagen

problems with movement and balance, and/or learning difficulties. Myriad studies have shown that these conditions, in conjunction with ASD, often have an underlying genetic cause. "This link is important," explains Michael Paul, Ph.D., CEO of U-spinout Lineagen. "Knowing the genetic basis changes treatment, often dramatically. Due to recent advances in genetic analysis, we can now identify potentially life-threatening conditions early on through genetic testing and then treat them. This is important because identifying a condition early leads to better management and better outcomes."

FirstStep^{Dx}PLUS®

Lineagen was born from the research of Distinguished Human Genetics Professor Mark Leppert, Ph.D., at the U. The company has been at the forefront of accessible genetic testing for ASD and other forms of developmental delay since its founding in 2005. Lineagen's mission is to accelerate and enhance the diagnostic evaluation of medical conditions so that the best possible outcomes can be achieved for patients and their families. Their primary product, FirstStep^{Dx}PLUS®, is a customized genetic testing service for individuals with ASD and other developmental disorders. This non-invasive test can identify underlying genetic conditions that provide physicians and families with necessary information for more educated decision-making regarding treatment.

How FirstStep^{Dx}PLUS® Works

FirstStep^{Dx}PLUS® utilizes chromosomal microarray analysis (CMA), a technique that screens a patient's entire genome looking for "blips" or irregularities within. The irregularities

Michael Paul, CEO, Lineagen

Sets of Lineagen's FirstStepDX Plus product

A patient having a FirstStep DX Plus cheek swab

A DNA microarray

that CMA searches for are usually duplicated or deleted chromosomal segments, known as copy number variants (CNVs), associated with ASD and other developmental disorders. According to Lineagen, CMA is a vital first genetic test after someone has been diagnosed with ASD because it is roughly three times more effective at spotting genetic variants than other clinical methods. The company's customized CMA platform is also unique in that it is the only test on the market that includes additional technology to detect genetic variants shown to be associated with autism spectrum disorder (ASD), including the most recently identified ones.

Families who use the FirstStep^{Dx}PLUS® test are often delighted to learn that needles are never involved. Lineagen solicited feedback from its customers and learned that blood draws and injections are often traumatic affairs for their children with autism. Because of this feedback the company uses a cheek swab rather than a needle to gather DNA samples. "It didn't hurt; it only took a couple of minutes," explains Angela Guerin, mother of a son with autism. "It was so easy to do. It doesn't matter what your diagnosis is, whether it's a yes or a no, or a positive or a negative, knowing an answer is helpful."

After Lineagen receives the cheek swab sample from the family the results are provided to the physician in three to four weeks. "Our genetic counselors then interpret the results, package them into an easy-to-understand report with both a physician and family section, and send it to the physician to share with the family," explains Paul. If, for example, a test for a two-year-old child identifies a mutation associated with Angelman syndrome (a serious disorder usually associated with a variant in the maternally inherited copy of chromosome 15), that child's physician, as well as the family, will be able to properly prepare for and treat the likely oncoming of seizures later in that child's life.

FirstStep^{Dx}PLUS® is currently reimbursed by most insurance companies and can be ordered by a physician by contacting Lineagen. Approximately 3,000 people have been tested thus far and the company has grown over 200 percent year over year. Roughly $12.2 million in new capital has been raised recently and Paul and his team are adamant that the same vision that catapulted them into forming Lineagen—a sincere desire to help children with autism and their families—is alive and well today and the impetus for future growth.

Nanoxene painted on a tile

PRODUCT/MARKET FIT USING MVP

LIFE-E

Changing the Way Homes are Heated

A growing number of homeowners today are turning to the comfort of radiant floor heating to warm their homes. Unlike the more common forced air systems, radiant heating uses electromagnetic waves to heat objects and people, not the air. These objects absorb the energy from the infrared radiation and emanate heat to other objects in an energy efficient manner. Traditional radiant heating works through either hydronic systems (pipes carrying a warm liquid) or electric systems embedded in or under the floor. While radiant heat is a comfortable alternative to forced hot air, existing methods require expensive and time-consuming installations and often provide uneven heat under areas where pipes and wires cannot be installed.

Life-E

Life-E is a U-spinout created to commercialize the invention of Feng Liu, Ph.D., professor of materials science and engineering at the U, who developed a new, more affordable, adaptable, and lightweight radiant heating product he named Nanoxene. In contrast to other forms of radiant heating, installation is as simple as laying down thin sheets of Nanoxene and connecting them to a power source.

The Creation of Nanoxene

Nanoxene is an electrothermal coating made up of advanced multicomponent, multidimensional nanocomposite materials. Once attached to a source of power, the lightweight film instantly heats and offers even, tunable coverage (i.e., its temperature can be easily and rapidly changed from 30C to 150C), unlike the warm and cold

patches associated with traditional radiant heating pipes and wires. And, because it is painted on thin flexible sheets that can be cut to fit, every crevice is covered and heated.

Nanoxene is highly adaptable and can be used on a variety of surfaces including ceramics, wood, paper, various polymer films, and even cloth. When applied to soft surfaces, Nanoxene bends and folds. One of the main components of Nanoxene is graphene, an advanced material that has received a lot of press over the last few years for its size, versatility, strength, and excellent ability to conduct electricity and heat.

Promising Applications

Nanoxene can be adapted for a wide range of applications beyond heating homes, including heated driveways and sidewalks, airplane de-icing, and heated clothing. Nanoxene's electrical conductivity can be made several orders higher than most conventional conducting films, with power conversion efficiency from electricity to heat close to 100 percent, simply because the coating does not require metal flakes which traditionally carry the charge.

Liu is excited about the future of Life-E. "We were recently awarded a grant from the U.S. Army to use Nanoxene to heat portable tents," Liu explains. "Nanoxene will weigh much less than current heating methods such as stoves, will provide more even and comfortable heating for the troops, and will be easier and faster to disassemble."

The applications of Nanoxene seem endless. While the heating costs will be comparable to other forms of radiant heat, Life-E will give homeowners far more control through instant zone heating that can be tweaked with apps for smartphones and tablets. Nanoxene is also a green material, containing no harmful or poisonous elements.

The Future of Life-E

Life-E has moved beyond lab samples to manufacture testing. Their goal is to get their first line of product up and running in the winter. Once the heated tents for the Army are complete, Life-E will move on to residential radiant heat, and then ultimately to de-icing applications. With plans to build a manufacturing facility, Life-E expects to reach $2.5 million dollars in revenue in its first year.

Simple Installation

Compared to its competitors, installing Nanoxene is easy. Installers simply need to lay down a sheet of Nanoxene, place Gyp-Crete over it, and then install their chosen floor covering (e.g., tile, carpet, wood, etc.).

Easily Powered and Customizable

In addition to being powered by a home's standard power supply, Nanoxene can also be powered by either a 240V AC or a 12V DC car battery. Homeowners will also be able to do spot heating, meaning one section of a room will be able to be hotter than another.

Lightweight and Portable

A condition of the Army SBIR grant that Life-E received for heating portable tents requires that both the portable tent and the heating unit system be 250 pounds or less and be deployable in under 15 minutes, a requirement that Life-E expects to easily meet due to Nanoxene's ultra lightweight and ease of use.

From left: Chao Hui, Feng Liu, Andrew Merrell, and Ninghai Su

LAYING DOWN A NEW KIND OF RADIANT HEAT

FUNDING

IVEENA

Eliminating Eye Injections & Post-Surgery Eye Drops

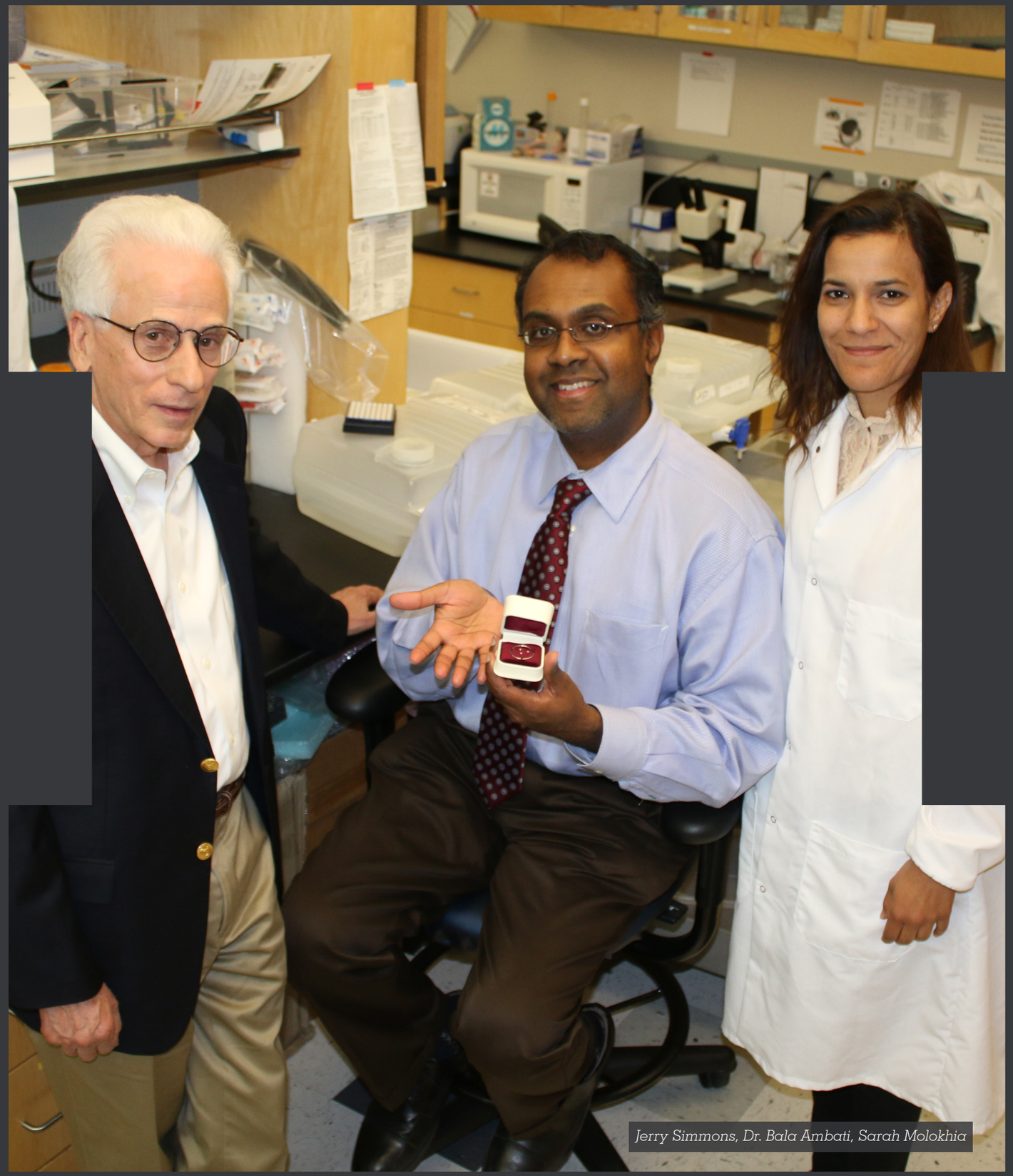
According to the National Eye Institute, over half of all Americans will develop a cataract by age 80,[4] a staggering figure that illustrates why cataract surgeries are the most frequently performed operation in the world.

In a normal eye, a clear lens helps to focus light or images on the retina. Once light passes through the lens and hits the retina it is changed into nerve signals, which are subsequently sent to the brain as images. If the lens is cloudy, due to a cataract, the image one sees will be blurred.

The most common cataract surgeries are done with a small incision where the cataract is removed and replaced with a man-made lens, also known as an intraocular lens. Post-surgery patients are prescribed eye drops, with most receiving three different types. These drops need to be administered in distinct intervals over multiple durations. "Following this regimen can be tricky," explains Bala Ambati, M.D., Ph.D., M.B.A., professor of ophthalmology at the U's Moran Eye Center and president and founder of iVeena Delivery Systems. "Compliance rates with eye drops post-surgery are only about 45 percent." Failing to follow the post surgery regimen of eye drops can lead to inflammation and costly subsequent ophthalmological interventions.

Eliminating Post-Cataract Surgery Eye Drops

This low level of patient compliance led Dr. Ambati to search for potential solutions only to discover that there was nothing on the market that effectively addressed post-surgery compliance



Jerry Simmons, Dr. Bala Ambati, Sarah Molokhia

issues. Sensing an opening, Dr. Ambati began experimenting with methods that would significantly boost compliance. Ultimately he realized that 100 percent compliance could only be achieved without patients having to do anything.

This realization led Dr. Ambati to develop his Bioerodible Dexamethasone Implant (BDI). This breakthrough device is designed to completely eliminate the need for eye drops post-cataract surgery. It is implanted in the back of the eye during cataract surgery and delivers drug doses to both the front and back of the eye. It only needs to release a fraction of the amount of drugs that eye drops contain because it is implanted in the area where the drugs are needed most: the area behind the eye's lens. After the drug has been delivered over anywhere from two to six weeks (depending on how complex the cataract case is), the product safely degrades by hydrolysis.

"The ability to eliminate eye drops and painful eye injections will significantly help millions of people who have cataract surgeries and millions of others struggling with macular degeneration, diabetic retinopathy, or glaucoma."

—Beth Drees, Dir., Health Sciences Team, TVC

iVeena's BDI device

Cataract surgery

Dr. Bala Ambati, President and Founder, iVeena

The Ophthalmologist: The Power List 2015 Top 40 Under 40

In 2015 *The Ophthalmologist* magazine ranked Dr. Bala Ambati as the number one up-and-coming individual in ophthalmology. The selection process involved nominations from fellow ophthalmologists followed by a rigorous judging process.

From the publication:

"[Dr. Ambati] holds the distinction of being the world's youngest person to graduate from medical school – at the age of 17 – and since specializing in ophthalmology, has gone on to receive many awards, including the Ludwig von Sallmann Clinician-Scientist Award from the ARVO Foundation in 2014, and in 2013, the Troutman-Véronneau Prize from the Pan-American Association of Ophthalmology. Asked why he chose the career that he did: 'At four, I was burned on both legs and underwent three surgeries in three months. Seeing the doctors and nurses was formative, and a love for biology flowed into medicine.' He devotes several weeks per year to volunteer work, including overseas missions with ORBIS, a nonprofit organization with a Flying Eye Hospital, and he hopes to support the opening of an eye clinic in India too.

....

And [Dr. Ambati's] advice to those wishing to succeed? 'Stand in the shoes of patients, students, mentors, staff, family, and colleagues. Give back in research, service, teaching, or policy.'"[5]

iVeena Moving BDI to Market

U-spinout iVeena was formed in 2010 to commercialize the BDI device. "We have completed in vivo studies on 65 New Zealand white rabbits, all of whom were successfully implanted with the device," describes Dr. Ambati. "The device both successfully treated post-cataract inflammation and reduced retinal thickening in the rabbits."

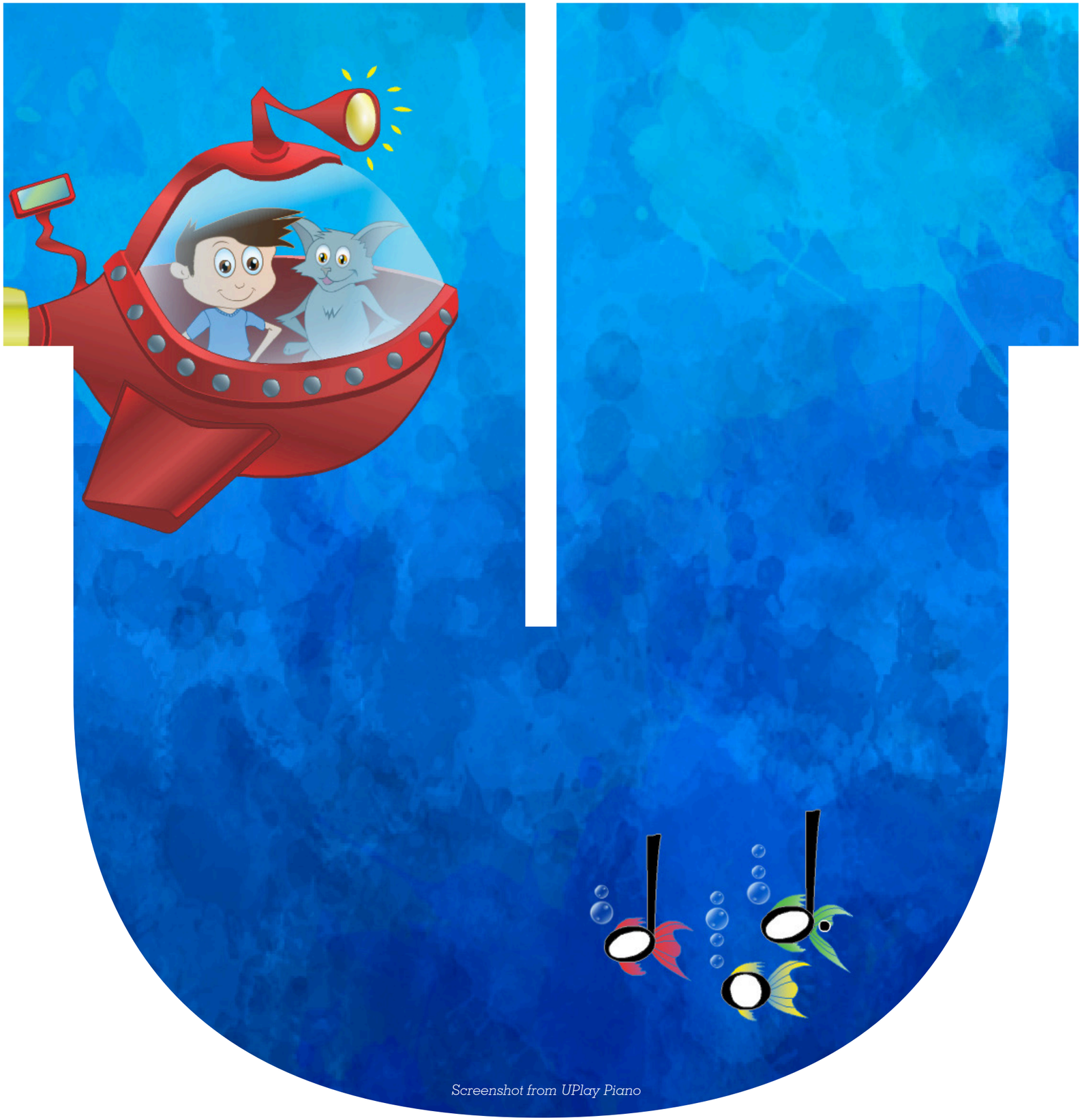
iVeena is now planning to move into Phase 1 clinical trials. Following these and subsequent FDA approval, the company expects BDI to be a major breakthrough within the larger ophthalmological community. iVeena's CEO, Jerry Simmons, explains that in addition to the patient benefit of not having to take eye drops post-cataract surgery, the estimated savings to the government for BDI on both eye drops and post-surgery complications will be approximately $270 million annually. This is because Medicare pays for 55 percent of cataract surgeries and their subsequent regimen of eye drops. At a price point of around $200, iVeena estimates that it will be saving the government approximately $140 per eye.

An Experienced Leader

Simmons' recent arrival was a calculated move by Dr. Ambati to bring on a tested leader to advance the company beyond early preclinical trials. "We had gone as far as we could in the lab," explains Dr. Ambati. "We needed to bring on an experienced leader who could move our products to market." A seasoned large and early-stage pharmaceutical veteran, Simmons brings a wealth of experience to iVeena having spearheaded two IPOs and several successful corporate transactions.

In addition to BDI, iVeena is developing three additional products. As with its lead product, BDI, iVeena's other products are each designed to eliminate the need for eye drops or eye injections for various, targeted conditions.

"iVeena's pipeline of products is truly innovative and disruptive," explains Beth Drees, director of the Health Sciences team at TVC. "Although each product is still early, the ability to eliminate eye drops and painful eye injections will significantly help millions of people who have cataract surgeries and millions of others struggling with macular degeneration, diabetic retinopathy, or glaucoma."



Screenshot from UPlay Piano

UPLAY PIANO

A Unique & Interactive Web-Based Piano Curriculum for Children

"Music gives a soul to the universe, wings to the mind, flight to the imagination, and life to everything." A seemingly infinite choice of genres and styles corroborates this prescient quote by Plato. Yet, the number of children who might have the benefit of understanding this observation is in jeopardy. Recent studies show that participation in the performing arts by middle school-aged students has been in decline since 1991. According to a report commissioned by *Child Trends*, "Participation [in the performing arts] drops significantly among older students, with only 37 percent of tenth-graders and 39 percent of twelfth-graders participating in 2011."[6] Partly because of this decline in youth participation, piano stores are increasingly closing across the US as children choose to participate in other activities.[7]

The Benefits of Music

This decline in performing arts participation has been a cause of concern for some as the benefits of engagement, particularly with music, are well documented. During the early 1990s, researchers Frances Rauscher and Gordon Shaw demonstrated that listening to specific Mozart piano sonatas boosted spatial reasoning skills.[8] Similarly, a decade later E. Glenn Schellenberg found small increases in the IQs of six-year-olds who were provided piano and voice lessons.[9] Many other studies have produced similar results.

Bridging Technology and Classical Piano

"In 2004, I walked into my first undergraduate class, watched as my professor tested out a few dry erase markers, quickly wrote her name on the whiteboard, and then began handing

out the syllabus," comments Lindsey Wright, D.M.A., inventor and founder of UPlay Piano. Four years later, Wright sat down in her first graduate class, opened up her MacBook Pro and took notes as her professor lectured from a PowerPoint slideshow.

Wright realized that in four short years the conduits with which to deliver and receive academic instruction had substantially evolved. Instructors were adapting their teaching methods to the experiences and expectations of their students. *Why not extend this to music*, she thought?

While working concurrently as a group piano instructor for a music store, Wright decided to develop a PowerPoint curriculum to supplement the instruction her piano class was receiving. Over the following month she noticed her students picking up key concepts at a much quicker pace. In the face of declining youth interest in music participation, Wright had found a potential solution.

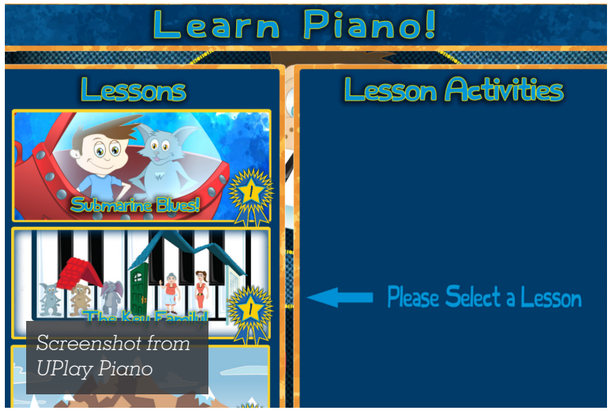
"Because children use computers, iPhones, and tablets, there was a noticeable opportunity for us to reach them at their level. We decided to create our own web-based, educational piano software that would engage students who are accustomed to living in a digital generation," Wright explains.

UPlay Piano

Wright helped develop UPlay Piano, a new web-based piano curriculum. A critical component of the software is the use of stories. Research informed her that a stimulating lesson framed in an entertaining story could enhance learning. "Online storybooks have multiple benefits," Wright explains. "Students may not always remember what you say, but they might remember if they can see it or try it. The visual, aural, and interactive components of online stories can help a child make sense of what they are learning, and ultimately, improve their ability to retain that information."

Each of UPlay Piano's 30 chapters will include five modules: an animated story, a demonstration, an interactive "play" element that challenges users with musical games, a practice session, and a final test for reinforcement. Wright wanted the practice and final test sections to be interactive. "Students need to be able to practice and they can only do that on a piano," she explains. So using funds from TVC's Engine funding program, Wright, along with the UPlay team

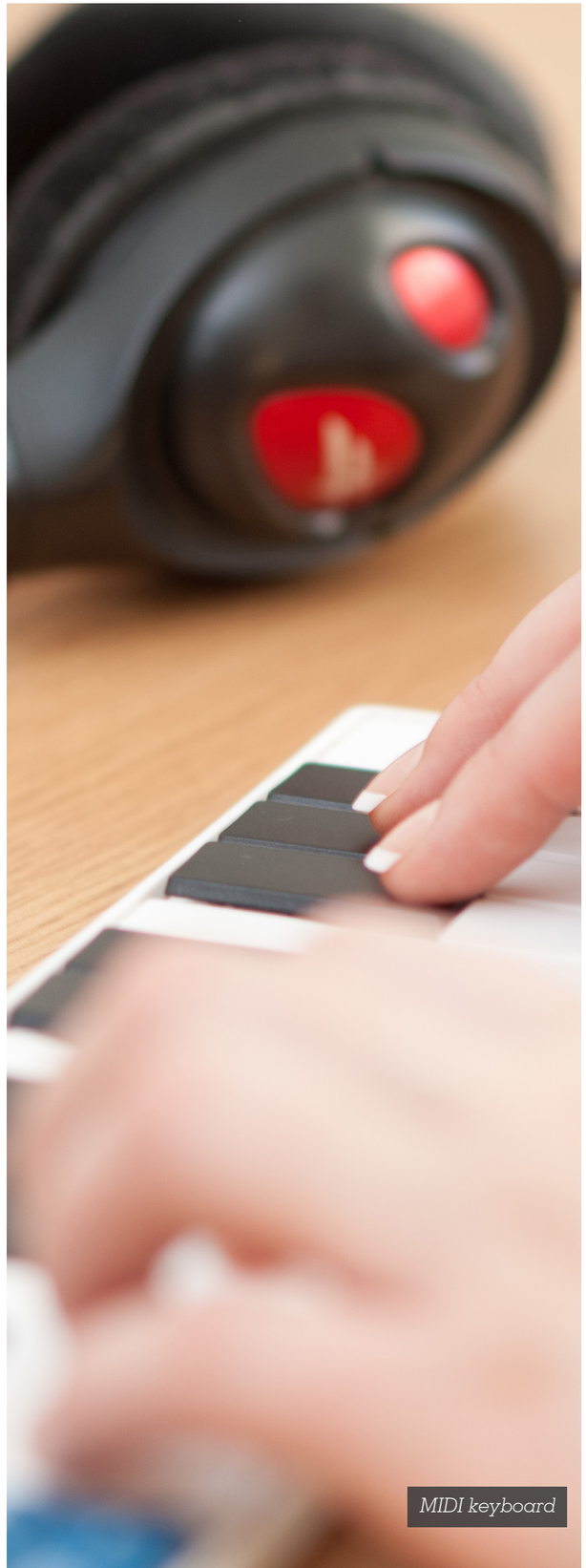
Lindsey Wright, co-founder, UPlay Piano



Screenshot from UPlay Piano

"Lindsey and her team have developed something that can have a dramatic impact on music education and make high-quality piano instruction accessible to thousands of children at an affordable price."

—Troy D'Ambrosio, Director, Lassonde Entrepreneur Institute



MIDI keyboard

at the U's School of Music commissioned the Entertainment Arts and Engineering (EAE) program at the U to develop software that would recognize and interact with MIDI keyboards (electronic pianos). Students can now use the MIDI keyboard of their choice and the online program will recognize it.

Wright believes that these elements, while crucial for student engagement, are only maximized when instructors or parents are involved. As such, the software will also contain a powerful backend database for administrators that will track student progress. These progress reports will show student names, usernames, grades, levels, when they last logged on, how many activities they've completed, and the amount of time it took each student to complete each lesson.

Results

As part of her doctoral dissertation, Wright compared the progress of elementary-aged students who were using UPlay as part of the U's Piano Outreach Program with students who were also in the program, but not using the software. Over the course of three weeks, she noticed a remarkable difference in student comprehension and retention. "These observations were made after using a drafted version of UPlay," explains Wright. "Imagine the affect it will have when UPlay is complete! Students were excited to discuss the stories they had read, and were eager to share what they had learned. The experience was both exciting and revealing."

Commercialization Plans

UPlay Piano will be subscription-based through an app or available online. The company is hoping to engage piano teachers who will recommend the product as a supplement to their lessons and as a way to encourage children to play piano. The company will also sell the product to schools while the funding for the MIDI keyboards that are used will likely come from grants.

Direct competitors at the moment are few and Wright's next milestones before a formal launch is the complete development of 30 lessons and the development of a more comprehensive database tracking function for instructors. Utilizing the beta version of UPlay, the UPlay team has already observed that instruction designed at the "student's level" has the power to engage. This is exciting news for the aspiring musician in all of us.

FUNDING

RECURSION PHARMA

Revolutionizing Drug Discovery

U-spinout Recursion Pharmaceuticals made waves in the drug industry in 2014 for announcing that they would develop 100 drugs in 10 years. The skepticism surrounding this claim comes primarily from the fact that such a number would be a major achievement for even the largest of the Big Pharma companies, let alone a new U spinout.

Despite the criticism, the company defends this number: "We're going to bring 100 existing drugs to the market for a new indication," explains Christopher C. Gibson, Ph.D., inventor, co-founder, and CEO of Recursion. "These are drugs that have already undergone successful safety trials but failed for their initial purpose. By partnering with large pharmaceutical companies who posses many such drugs, we'll also draw on their extensive capabilities to conduct and finance the clinical trials. So the more accurate description will be that we will develop 100 repurposed treatments in 10 years."

Gibson explains that such a claim has only been made possible because of recent advances in technology, particularly technology that Recursion has adapted to biotechnology or cultivated itself: "We have developed advanced algorithms and disease modeling techniques that will allow us to significantly scale drug repurposing," he explains. "These advances allow us to bypass the traditional drug discovery model and turn drug discovery into a data-science problem. We no longer need to understand how a disease works; we just need to know its cause, which in the case of genetic diseases is now often clear. Our approach allows us to rapidly identify new ways to use old drugs to treat the disease."

Traditional Treatment Development

The traditional route for finding an effective drug treatment for a disease begins by first spending years studying the biological mechanisms behind it. Once an understanding of the disease is achieved, drug candidates are developed

and tested. When a lead compound has been chosen, the drug enters a costly, time-consuming process in which it is tested in a lab, then in animals, and then in humans in multiple phases. Altogether, the journey takes roughly 10-15 years and costs tens of millions to billions of dollars. By the time this rigorous protocol has been exhausted, 95 percent of these medicines will have been found to be ineffective for their intended purpose, never making it to market.

Focusing on Orphan Diseases

The high cost of developing therapeutics is a major reason why most pharmaceutical companies focus their efforts on conditions that affect a large number of people. Simply put, to recoup development costs and turn a profit, the cost of drugs needs to be spread out over a broad population to make it affordable, otherwise the cost per person would be too great.

This system has meant that hundreds of millions of people suffering from 5,000+ rare genetic diseases, also known as orphan diseases, have been mostly ignored by the industry until the last few decades. "There will often be too few patients for any one rare disease to justify the cost of a traditional drug discovery program," explains Gibson.

But as Dean Li, M.D., Ph.D., CSO for the U Health Sciences, and co-founder of Recursion, explains, "When you say that rare diseases are truly rare, as a group they're not rare at all. We're talking about 10 percent of our population. The question is, how do you actually begin to view that population as a group that you can effectively develop medicines for?"

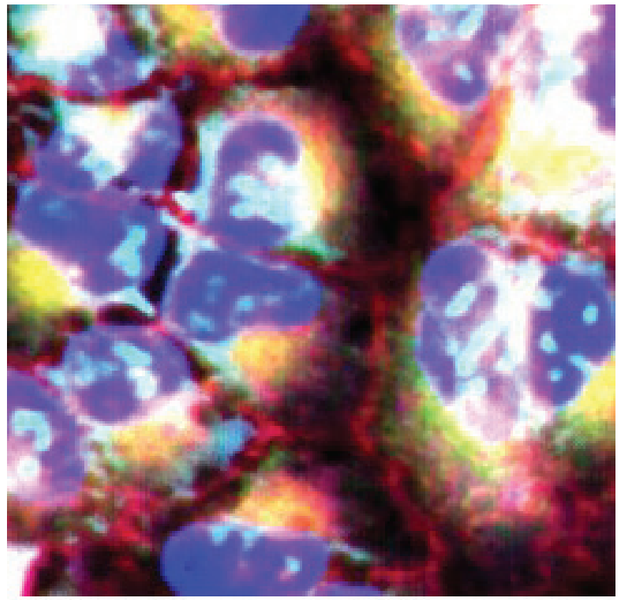
The answer to this question is the driving force behind Recursion. Thousands of people with orphan diseases are told each year that there is nothing that can be done for them. Recursion believes that it can cost effectively and expeditiously develop drug treatments for rare genetic disorders. "Our model and our focus on rare disease may allow some repurposed drugs to hit the market in one to two years, rather than the traditional 10 to 15," Gibson explains.

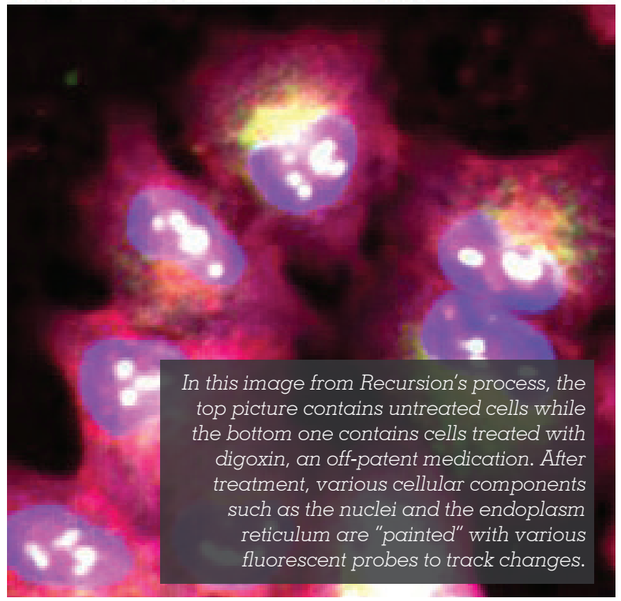
The Recursion Model

In response to the deficiencies of the traditional path to drug discovery, Recursion looks for known drugs and shelved pharmaceutical assets that could be recycled as possible treatments for rare genetic diseases. With their novel drug-screening platform, the company combines experimental biology and bioinformatics in a massively parallel system to quickly and efficiently identify treatments for multiple orphan diseases. They can simultaneously study many diseases and thousands of potential treatments by combining microfluidics on the experimental side and advanced algorithms on the data side.

Gaelle Mercenne, research scientist and laboratory manager, Recursion

Chris Gibson, co-founder and CEO, Recursion





In this image from Recursion's process, the top picture contains untreated cells while the bottom one contains cells treated with digoxin, an off-patent medication. After treatment, various cellular components such as the nuclei and the endoplasm reticulum are "painted" with various fluorescent probes to track changes.

Han Han, director of robust data, Recursion

Partnering with Big Pharma

Large pharmaceutical companies own most of the shelved assets Recursion intends to use. "These companies would like to see the billions of dollars they spent on these medicines not to go waste," explains Gibson. "If we can identify ways to monetize these drugs, the partnership will be a win-win for everyone involved – especially patients."

"Not only is this an opportunity for new drugs to enter the market, it's also a chance to help millions of people with orphan diseases who have never had any hopeful options before."

"When you say that rare diseases are truly rare, as a group they're not rare at all. We're talking about 10 percent of our population."

—Dean Li, MD, Ph.D.,

Blood cultures

TECHNICAL VALIDATION

XEND

Ending Needle-Caused Infections

While attending an ophthalmology meeting in New Orleans five years ago, Randall Olson, M.D., CEO of the John A. Moran Eye Center and professor and chair of the Department of Ophthalmology and Visual Sciences, was intrigued by the persistent chatter surrounding eye infections. His colleagues were discussing the fact that roughly 1 in every 2,000 eye injections results in an infection, with total loss of vision an all-too-common outcome. Chances worsen the more one receives shots, particularly if they have a complex retinal disease such as age-related macular degeneration that routinely requires them.

The risk of contamination from injections is lowered when proper procedures are followed but can never be completely eliminated due to bacteria that lurk at the point of needle entry. "Antiseptics simply do not kill all of the surface bacteria present," explains Olson. "There are many microscopic cracks and crevices for harmful bacteria to hide in, such as on the skin or on the surface of the eye. It's not as smooth as you might think."

Removing harmful bacteria from the skin prior to an injection is vital because when needles puncture the surface they take

a small amount of that tissue with them into the patient. The bacteria not removed on this skin-core with an antiseptic or anesthetic enter the bloodstream. If the injection is made in areas more susceptible to infections such as the eye, spine, or joint spaces—or if the patient has a weak immune system—there is an increased risk of that patient acquiring a needle-caused infection.

The XEnd Needle

After returning home from the New Orleans conference, Olson searched for potential solutions to this problem. He was surprised to find very little on the market or in development. This absence led him to develop his own solution: an anti-infective hypodermic needle. In 2011, U-spinout XEnd was established to commercialize this new medical device. The needle, which has undergone significant iteration, promises to greatly reduce needle-caused contamination.

Olson's device is actually made up of two needles, an outer and inner one. Unlike standard needles, the outer needle does not take skin-cores with it as it penetrates the skin. It is also covered with a key anti-infective film made up of FDA-approved materials that repel bacteria from puncture areas rather than kill or inhibit them. Once inside the skin, the inner needle follows through, allowing the healthcare worker to either inject medicine or draw blood. The only contact with the skin comes from the outer needle; the inner needle remains 100 percent free from surface contact.

Proof of Concept

To test the needle's effectiveness a proof of concept test was recently completed on cadavers. "Cadavers have a large amount of bacteria on them and were perfect for this kind of test," explains Andy Raguskus, XEnd's CEO. In the study, the XEnd needle was injected in one unsterilized arm while a standard, sterile needle was injected in the other unsterilized arm. Out of 100 samples, 24 of the standard needles registered bacterial contamination. XEnd needles recorded zero percent contamination rates, a result that astounded both Olson and Raguskus.

Targeting False Positives

Although Dr. Olson originally designed the XEnd needle for intraocular injections, later research showed that its impact could be multiplied if

Randall Olson, founder, XEnd and CEO, John A. Moran Eye Center

The XEnd needle

The Moran Center

"Every needle puncture carries risk of infection. If live human trials are as successful as our cadaver study, XEnd will likely experience rapid growth."

—Andy Raguskus, CEO, XEnd

it were also used in blood cultures. Roughly 18-million blood culture tests are ordered annually in the U.S.[10] Of these, approximately three percent yield a false positive, meaning that bacteria not present in the patient's blood were identified in a grown culture.[11]

Patients with false positive blood cultures often undergo unnecessary and expensive antibiotic treatments, lab tests, and hospitalizations.[12] Studies have estimated the cost of an inpatient stay stemming from a false positive at between $2,889 and $8,720.[13] Altogether, false positive blood cultures cost the U.S. healthcare system approximately $4 billion each year.[14] The treatment procedures also lead to an increase in antibiotic resistance and even patient morbidity.[15]

According to the *College of American Pathologists Today*, reducing false positives from five percent to one percent would save individual hospitals anywhere from $400,000 to $4.1 million, depending on the institution's size and current false positive rate. Moreover, neither insurance companies nor Medicare/Medicaid pay for infections contracted within a hospital, so the need to eliminate them has become a high priority.

A Veteran CEO to Lead the Company

To satisfy this need and move the needle to market more rapidly, Olson brought on serial entrepreneur and veteran CEO Andy Raguskus to lead the company. Raguskus successfully led Sonic Innovations, a hearing aid company, as it became the 17th largest company in Utah and the sixth largest global hearing company in the world. He was also named "Utah Entrepreneur of the Year" in 2001 by Ernst & Young, CNN, *USA Today*, and NASDAQ.

Next steps for XEnd are to conduct live human trials in conjunction with ARUP as part of its process to obtain approval from the FDA. They will then approach two or three of the larger hospital chains and conduct a trial program. "Every needle puncture carries risk of infection," Raguskus explains. "If live human trials are as successful as our cadaver study, XEnd will likely experience rapid growth."

PRODUCT/MARKET FIT USING MVP

APPLIED BIOSENSORS

Enabling Growth in the Bioprocessing Industry

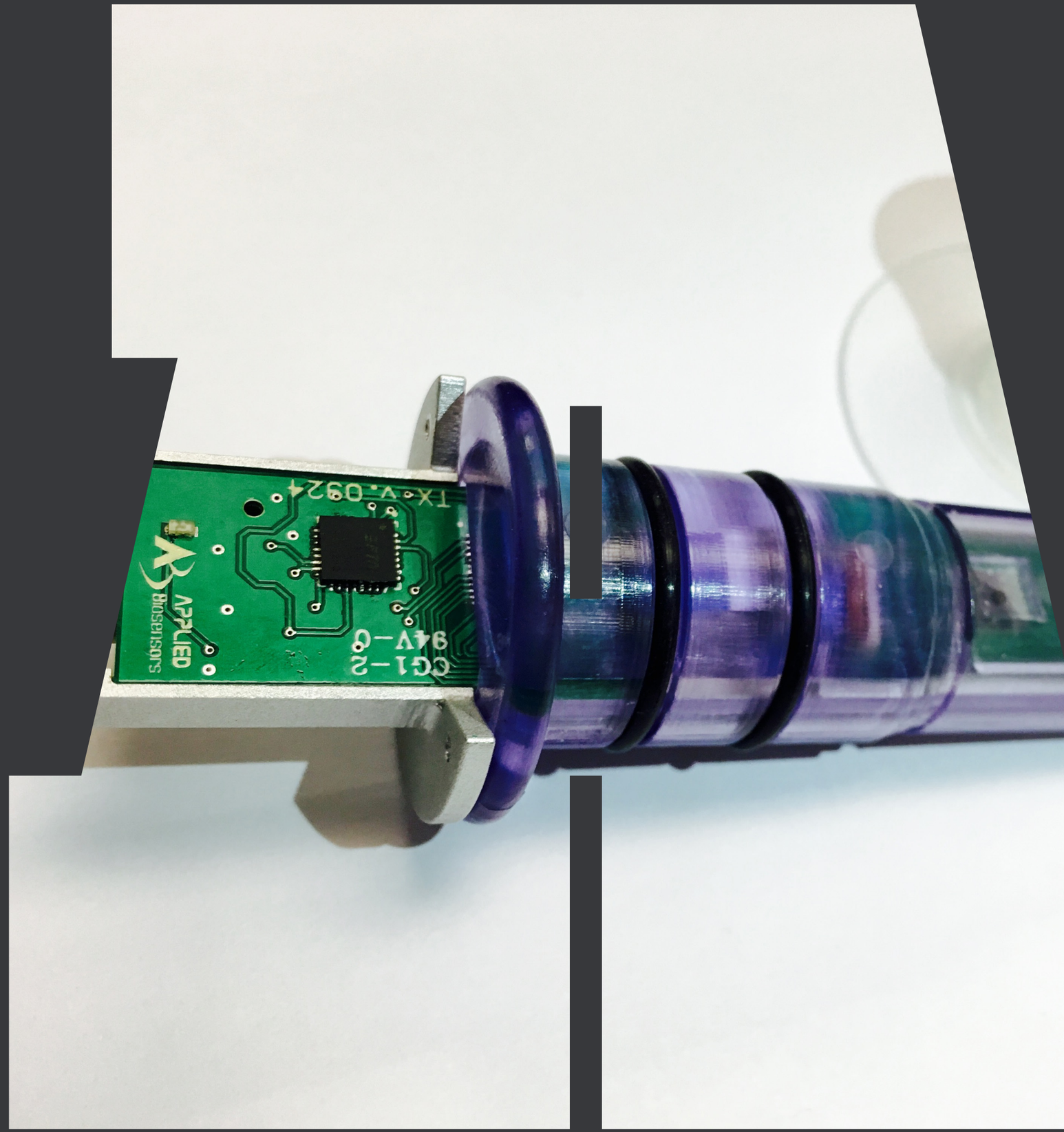
A growing percentage of pharmaceutical drugs on the market today are biologics, medicines grown from living cells in bioreactors. A bioreactor is, in essence, an enclosed brewing system that supports a biologically active environment where microorganisms make complex molecules, including biologic drugs.

For much of the history of modern drug making such biologics have been grown in giant, sophisticated steel-based bioreactors that cost millions of dollars and nearly the same amount to maintain and operate. Between each batch of drugs considerable cleaning, sterilization, and validation steps must be meticulously performed. Such downtime has become a major bottleneck in the biopharmaceutical industry. The time lost between each batch significantly lowers the number of batches of drugs these multi-use bioreactors can produce. The downtime and cost is multiplied when cross contamination takes place from failure to properly sterilize, a problem that is estimated to occur around five percent of the time.

Eliminating the cost, time, and risk of contamination associated with these cumbersome processes has been the driving force behind the rapid growth of single-use technologies in this industry over the last 10 years. Unlike their multi-use competitors, single-use bioreactors are often small, mobile, inexpensive, and pre-sterilized. They are significantly reducing overall expenses and speeding up the time it takes drugs to get to market.

Lack of Disposable Sensors

The adoption of single-use technologies has, however, encountered its own significant bottleneck in recent years: the lack of disposable sensors. Bioreactor sensors are what give biomanufacturers the ability to measure what is taking place in a bioreactor. Analytes such as pH, glucose, and lactic acid are monitored through these sensors in an effort



to maintain consistent process performance. "The relative lack of single-use sensors in the market is one of the factors limiting the growth and adoption rates of single-use technologies," explains Prashant Tathireddy, Ph.D., research associate professor of electrical and computer engineering at the U, and founder and CTO of U-spinout Applied Biosensors. "Customers who purchase single-use bioreactors are having to sterilize and reuse available sensor probes, and perform off-line sampling for most analytes, which defeats the purpose of contact-free, sterile, single-use technologies."

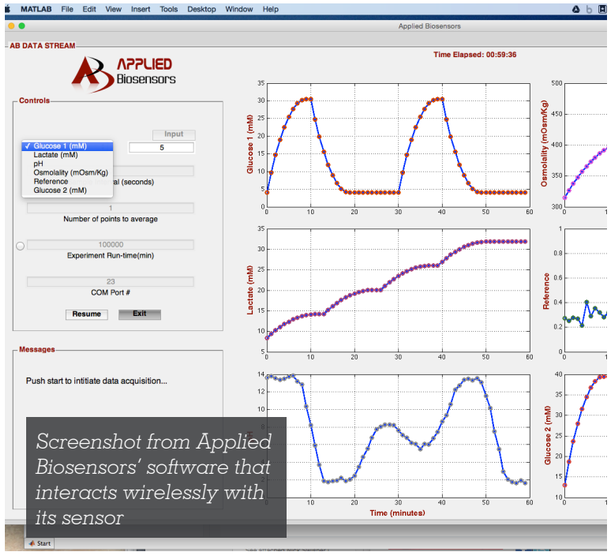
Current classical methods for measuring most analytes involve removing samples from the bioreactor and then performing measurements using expensive laboratory equipment. "This approach," Tathireddy explains, "suffers from several drawbacks: it only provides intermittent values and it increases the risk of bioreactor contamination."

Applied Biosensors' Single-Use Sensor

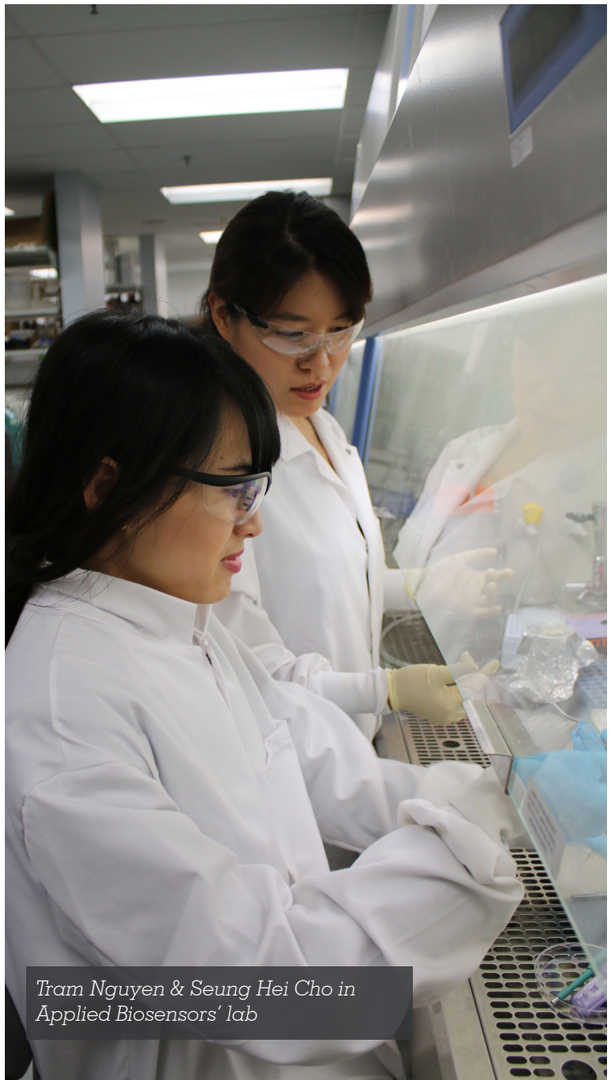
Tathireddy is confident that the sensor Applied Biosensors developed, AB Sense, will eliminate this major bottleneck. This inexpensive, single-use sensor can monitor multiple new analytes simultaneously and in real-time, something its competitors cannot achieve. It is able to do this because it is compartmentalized like a pie with each piece containing a hydrogel made sensitive to a specific analyte. This design eliminates the need for the biomanufacturer to have multiple sensors and perform off-line measurements.

AB Sense is able to monitor multiple analytes largely because of the special hydrogels it uses. Developed by Jules Magda, Ph.D., professor of chemical engineering at the U, these hydrogels are made up of smart polymers that respond in a dramatic way to slight changes in their environment. "For example, if the concentration of glucose increases in the environment the polymer network swells," Magda explains. "When the concentration goes down, it de-swells." The sensor detects these often minute changes by monitoring the magnetic field produced by magnetic particles embedded in the hydrogels. When the polymers change in volume, the magnetic field changes as well, which directly correlates to the concentration of the chemical being measured.

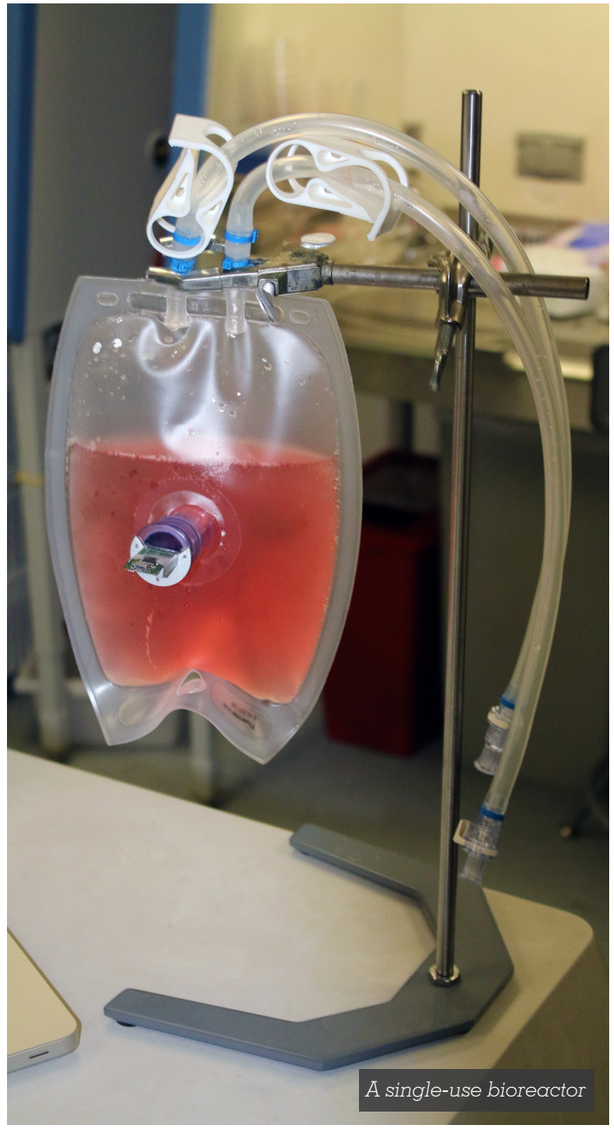
Measuring changes in the magnetic field enables continuous monitoring. With the long-lasting biocompatible hydrogels on the inside of the bioreactor, the electronics are



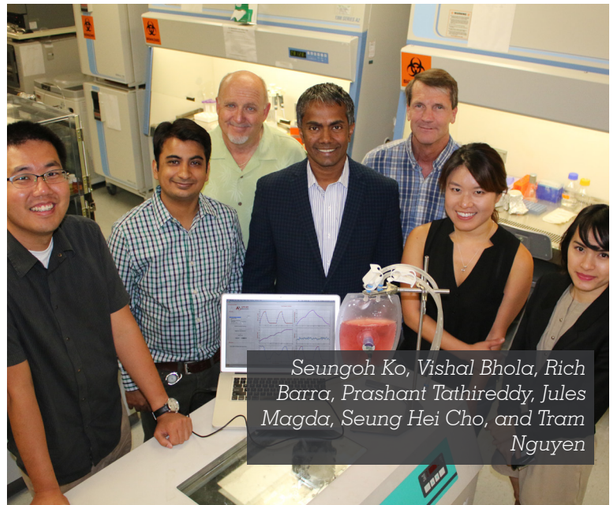
Screenshot from Applied Biosensors' software that interacts wirelessly with its sensor



Tram Nguyen & Seung Hei Cho in Applied Biosensors' lab



A single-use bioreactor



Seungoh Ko, Vishal Bhola, Rich Barra, Prashant Tathireddy, Jules Magda, Seung Hei Cho, and Tram Nguyen

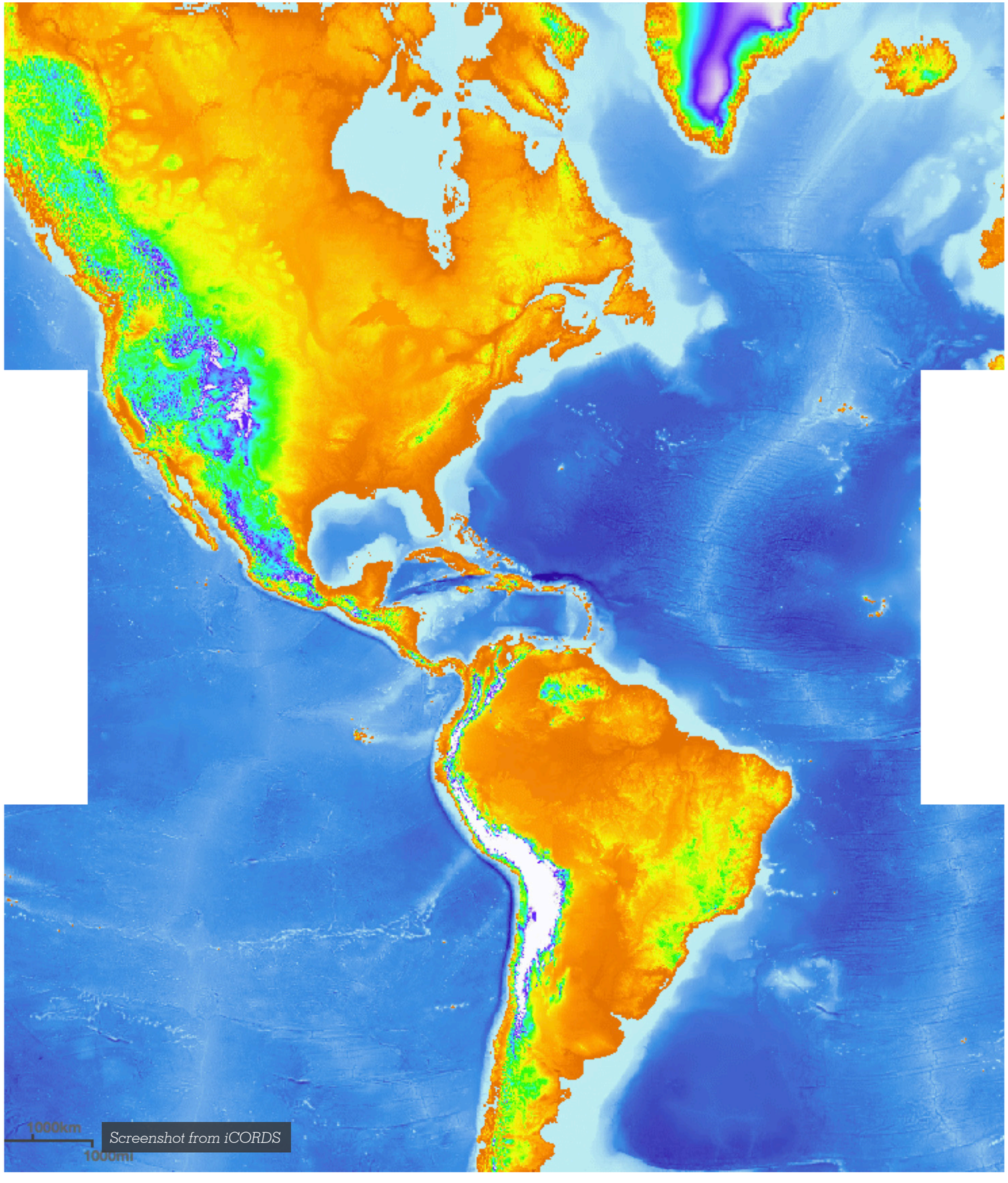
attached as long as needed to the outside and are thus never in contact with the medium. The electronics also transmit data wirelessly and continuously to process control systems, completely eliminating the need to take samples intermittently. "This benefit," explains Rich Barra, Applied Biosensors' CEO, "is very important to the industry because the production of biologics depends entirely on the process in which they are made." Drug consistency, quality, and purity must remain highly stable from batch to batch and the only way this can be achieved is through extensive control of the environment inside the bioreactor. Even the slightest of adjustments in the manufacturing process can result in dramatic, costly, and unacceptable changes to the drug. Continuous and accurate monitoring provided by AB Sense will significantly reduce the risk of such setbacks from occurring.

Moving to Market

Barra anticipates having a commercially-ready product available on the market in 18 months. This, he explains, can't come soon enough for the industry: "We have talked to 15 big companies in this space and from these conversations we know that there is considerable demand for quality disposable probes and sensors like ours. They are the final item needed for having a fully disposable operation."

"The relative lack of single-use sensors in the market is one of the factors limiting the growth and adoption rates of single-use technologies"

—Prashant Tathireddy, Ph.D.



Screenshot from iCORDS

FUNDING

iCORDS

Mitigating the Risk of Oil Exploration

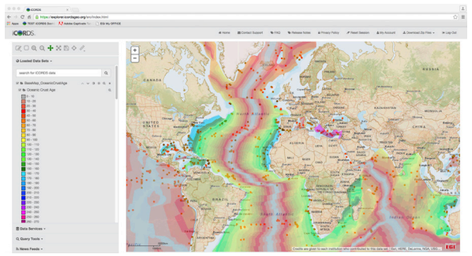
Drilling for oil and gas is an expensive endeavor. A dry well represents wasted time and significant financial loss for oil companies. With low crude oil prices, today's oil exploration companies require relevant, consolidated, high quality geoscientific data in order to make smart drilling decisions.

Raw geoscientific data, largely obtained through various academic and governmental sources, includes hundreds of terabytes of geochemical, sedimentological, paleontological, chronostratigraphic, and geophysical data. This massive amount of data is cumbersome, expensive, and time-consuming for oil companies to gather and analyze, illuminating the industry need for greater access to curated data.

"Geoscientists in the oil and gas industry spend a surprising amount of time gathering data," explains Raymond Levey, Ph.D., director of the Energy and Geoscience Institute (EGI) at the U. "Often 60 percent of their time is spent collecting data, leaving only 40 percent of their time for analyzing it. We want to dramatically reduce the data collection time for our clients so they can make better-informed decisions faster."

In response to this market need—and at the request of industry partners—EGI developed and recently launched iCORDS, an easy-to-use cloud-based knowledge platform that facilitates interactive access to both proprietary EGI data and curated publicly available data. iCORDS' early clients provided feedback on how the software should structure searches and what data would be most relevant.

Varun Gowda, chief technology officer at EGI, explains, "The iCORDS solution has two key technologies: data curation driven by large-scale data science and interactive web-based exploration. We have developed efficient scripts and processes for harmonizing disparate geoscientific data sources into a single, unified database. And we have created a scalable, web-based exploration platform for accessing and exploring geoscientific data."



Today iCORDS is in use by over 50 global exploration teams including ExxonMobil, Shell, and Chevron. Using iCORDS to explore their particular geographic focus, geoscientists can interactively sift through terabytes of raw data, including four decades worth of scientific research compiled by EGI.

"What used to take geoscientists months to discover, now takes just a few minutes with iCORDS," explains Gowda.

The Future of iCORDS

Given the key role it plays in the exploration process, iCORDS is currently securing Series A financing in order to ensure its success and long-term profitability.

Although the cost of drilling a well will continue to be an expensive endeavor, iCORDS will significantly mitigate the exploration risk for the oil and gas industry.

A Partnership Driven By Data and Powered By Science

Over the last four decades, EGI's integrated science, research, and global expertise has delivered $750 million in research. iCORDS is now curating and integrating those results, linking them with global raw data and exposing them to industry through a visual, search-driven platform for exploration scientists.

De-Risking Deepwater Exploration with Geoscientific Data

Through a visual and secure interface, iCORDS accelerates the decision-making process while minimizing risk and delivering more successful exploration and production results. By streamlining the discovery of information, data is transformed into basin insights and opportunities.

Raymond Levey and Varun Gowda

The iCORDS Advantage

With a focus on data curation and aggregation, iCORDS empowers exploration teams to extract full data value and fuel the ability to quickly discover and evaluate regional plays worldwide.

BRINGING DATA TO SEARCH

TVC Star Award

The TVC Star Award was established in 2011 to recognize and honor individuals who have made a significant contribution in the promotion and enhancement of technology commercialization at the U. The impetus behind its creation was to acknowledge the fact that the U's faculty and researchers are the key ingredient for success at TVC.

2015 Recipient: Stacy Bamberg

"Since our initial engagement with Stacy Bamberg, Ph.D., professor of mechanical engineering, it has been apparent that the U has been gifted with a highly skilled researcher. Her academic accolades and growing list of honors and awards, coupled with the fact that she's a graduate of both MIT and Harvard, showcase her talents. TVC has been nothing but impressed and privileged to work alongside Bamberg and the company she founded, U-spinout Veristride.

It is rare to have an individual who can bridge the gap between academia and commercialization so well, but Bamberg has done so in stride. From being awarded an SBIR Phase 1 and 2 for her research and development efforts, to her recent successful fundraising pursuits, Bamberg continuously impresses those she engages with. As a brilliant and dedicated engineer, she has taken on extensive risk to pursue her passions and guide her research to market in order to impact individuals' lives."

-Natan Chetrit, TVC Business and Technology Development Associate

PREVIOUS TVC STAR AWARD RECIPIENTS

Name	Position
Florian Solzbacher	Director, Center for Engineering Innovation
James U. Jensen	Founding Partner, ClearWater Law and Governance Group
Nassir F. Marrouche	Exec. Director, CARMA Center and Assoc. Prof., Internal Medicine
Greg M. Jones	Associate Director, Scientific Computing and Imaging Institute
Darin Furgeson	Asst. Professor, Pharmaceutics and Pharmaceutical Chemistry
Robert Hitchcock	Associate Professor, Bioengineering

2015 SPINOUTS

Over 185 companies have been launched from U technologies in the last ten years, and more than 265 since 1970. These diverse companies range from the fine arts to pharmaceutical chemistry. The following companies are some of the newest created at the U:

1. 4DQC
2. 6S Medical
3. Bastion Biologics
4. Clinacuity
5. IDbyDNA
6. Madra Learning
7. Majelco
8. NanoSynth Materials & Sensors
9. Origyn
10. ProMD
11. Safe Blade
12. Solefire
13. StreamDX
14. T3S Technologies
15. uBiota
16. Veritas Medical

To read more about these spinouts, visit: http://tinyurl.com/oofj2ky.

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