# TAKING MIZZOU IDEAS TO MARKET

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July 2019 - December 2020



Economic Development





Curators' Distinguished Professor Tom Spencer began his role as interim vice chancellor in January 2021. He also serves as scientific director of NextGen Precision Health and continues to conduct research in reproductive and developmental biology.



## Laying the Groundwork for Future Breakthroughs

hrough interdisciplinary collaborations among researchers at the University of Missouri, the UM System and global institutions, Mizzou continues to make its mark in the research space. Often, these discoveries lead to the commercialization of products, which is supported by the robust economic development ecosystem at Mizzou, and this booklet recognizes those achievements.

Our faculty, students and staff are at the core of early-stage innovations that can be patented, licensed and further developed in commercial settings. In FY20, Mizzou signed 48 license and option agreements with industry partners and was issued 22 U.S. patents, generating revenue for both faculty and the institution. In fact, during the last three years, MU's licensing income totaled more than \$20 million. Faculty inventors and their departments receive a portion of this revenue; the university's portion is reinvested in education and upgrading our research and technology infrastructure, sowing the seeds for future breakthroughs.

In the Office of Research and Economic Development, we're using data analytics to grow our resources while closely reviewing our programs to strategically meet MU's goals. In essence, we're expanding our services in a purposeful manner so that you can continue to produce exciting advancements in life sciences and agriculture, engineering and health sciences, among other fields.

Congratulations to all recipients listed here. As we celebrate these milestones with you, we are keeping an eye on the future of the institution and the impact we have on the citizens of Missouri, the nation and the world. I hope you will share your ideas for growing our research enterprise at muresearch@missouri.edu.

Sincerely.

Thomas E. Spencer Interim Vice Chancellor for Research and Economic Development

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Most people think economic development is an office in Jesse Hall that doesn't impact them, according to Bill Turpin, associate vice chancellor for economic development.



"The fact is, we are running entrepreneurial programs for students, faculty and staff; recruiting industry partners to sponsor research and license the rights to MU innovations; and providing business development expertise and resources," Turpin said.

Bill Turpin



Turpin and his team are focused on making Mizzou a more effective economic driver for the state by collaborating across disciplines to encourage more innovation and entrepreneurship, technology advancement and industry partnerships.

Lisa Lorenzen

In January, the MU Research Reactor signed an exclusive <u>multi-year agreement</u> with Advanced Accelerator Applications International, a Novartis company, to provide a key

ingredient for cancer therapeutics.

"The magic happens when we find industry partners with goals that align with Mizzou's goals," Turpin said. "We work with companies like Novartis to bring new drugs to market because it is a long, expensive process that universities can't afford."

Faculty and staff who participate in commercialization activities are making important direct and indirect contributions to the strength and vitality of MU's research and economic development missions.

The <u>Technology Advancement Office</u>

(TAO), led by Assistant Vice Chancellor Lisa Lorenzen, evaluates and protects faculty innovations, but the university relies on entrepreneurs and industry to help translate them into products, jobs and businesses.

"The process starts when TAO receives an Invention Disclosure Form," Lorenzen said. "My staff and I look forward to finding creative solutions to bring those innovations to the marketplace, where Mizzou can make a real difference for Missourians and beyond."

The university received \$12.4 million in FY20 from companies licensing the rights to its intellectual property. Recent examples include a <u>gene therapy</u> to treat hearing loss, a <u>mobile app</u> for behavioral health researchers and a <u>screening technology</u> for autism. Turpin's team also is focused on growing industry-sponsored research, which he sees as an essential part of MU's plan to increase research expenditures. Currently, there are 231 industry partners funding research at Mizzou. For example, the university has multiple projects with Roche Diagnostics, including improving cancer case review efficiency using the <u>NAVIFY® Tumor Board</u>. Turpin thinks the NextGen Precision Health initiative will generate even more opportunities.

Better supporting MU faculty and staff involved in the commercialization process is another priority. This year, Turpin's team produced a guide for employees interested in starting a company based on Mizzou research, and they are working to better coordinate services through Lab 2 Market contacts and programs.

Most new jobs will need employees who are able to innovate and think entrepreneurially. That's one reason Turpin also is focused on preparing students by establishing the Griggs Innovators Nexus in the MU Student Center with donor support.

"We need to teach students how to thrive in a culture of innovation," Turpin said. "We want them to be able to question the status quo, propose solutions to make things better, take risks and understand that failure is part of the process."

## University resources for faculty innovators

#### Mizzou Lab 2 Market

is a network of contacts, programs and services available to inventors navigating the multifaceted commercialization process. lab2market.missouri.edu

#### A startup guide that

includes requirements and resources is available for employees interested in founding a company based on MU research. <u>tao.missouri.edu/</u> <u>commercialization\_guide</u>

## The Mizzou Venture Mentoring Service

surrounds the most promising MU-affiliated startup companies with confidential and trusted volunteer business mentor teams. mizzouvms.missouri.edu

#### Missouri StartupTree

is an online community and global platform for UM innovators and entrepreneurs. Recruit collaborators for business ventures and projects. Connect with mentors and investors plus find resources and programs. missouri.startuptree.co

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#### July 2019 – December 2020

Arun Agrawal Hasanain Osamah Al-Sadr Jella An Amer Avdagic Gary Baker Breanne Baker Bimal Balakrishnan Jonathan Bath Eduardo Beche Anthony M. Belenchia Christi Bergin David Beversdorf Will Bezold Rebecca A. Bliss Chantelle C. Bozynski Jonathan Breedlove Jeffrey Bryan Chandrasekar Bysani Prasad Calvam Ashley C. Campbell Alessandra Cecchini Chiswili Yves Chabu Si Nian Char Pengyin Chen Shi-Jie Chen Yangyang Chen Shiyou Chen Yi Cheng Gary Francis Clark Michael Wayne Clubb James L. Cook Cristi R. Cook Dawn D. Cornelison Damon Coyle Melissa Crisel Xiaobing Cui Joshua Dakota Erin A. Dannecker

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Charles M. Darr Dongsheng Duan Cornel Duta Tojin Eapen David Echelmeyer Ahmed Sherif El-gizawy Reza Espanani Bradley J. Ferguson Ricardo Figueroa-Vicenty Jennifer Foster John Michel Gahl Shubhra Gangopadhyay Keshab Gangopadhyay Abilash Gangula Alexander Garnov Rvan Gettler Sean P. Goggins Camilo R. Gomez Jeremy Gonzalez Sheila A. Grant David Alan Grant Aaron D. Gray Joseph Griffin Li-gun (Andrew) Gu Trent M. Guess Dean P. Hainsworth Jamie B. Hall Benjamin Hansen Ian Michael Heck Xiao Heng Dena Higbee Guoliang Huang Hu Huang Heather Hunt Olivia C. Ivanov William A. Jacoby Soumen Jana Urmeka T. Jefferson Brad D. Jeffries

Juan Ji Robert L. Kallenbach Xunlei Kang Raghuraman Kannan Kattesh V. Katti Kavita K. Katti Ramesh Khanna Eric T. Kimchi Senthil R. Kumar Keiichi Kuroki James Laffey Nathaniel E. Larm Predrag Lazic Emily Leary Anton Lennikov Teresa E. Lever Huijie Li Guangfu Li Jinpu Li Riging Li Jun Li Jian Lin Chris L. Lorson John D. Lydon Hongbin (Bill) Ma Wenjun Ma Xuewei Ma **Richard Ma** Sundararajan Mahalingam Raghav Male Matthew R. Maschmann Cherian Joseph Mathai Brian David Maurer Susan C. McKarns Grace Margaret-Eleanor Meers Tejas R. Mehta Clinton Meinhardt Rajiv R. Mohan

Harold Moore Wesley Moore Aaron B. Morton Azlin Mustapha Hussein Nassar Cuong X. Nguyen Henry Thien Nguyen Huy Nguyen Peter Norgard Valentina O'Donnell Roland Oruche Xiufang Pan Nickie J. Peters Michael J. Petris Ferris Michael Pfeiffer Mihail Popescu Randall S. Prather Elizabeth Prenger Sara Prewett Santhoshkumar Puttur Randy Scott Rector Bethany K. Redel Hariharan Regunath John David Robertson Madhu Sudhana Saddala Andrew Scaboo Rod Schlotzhauer **Kyle Schweser** Steven S. Segal Stewart Wayne Selves Julie Semon Vinit Shanbhag James Grover Shannon Abhilasha Sharma Krishna Sharma Justin Sigoloff Kamlendra Singh Scotty Lee Smothers Colten Snider

Thomas E. Spencer Swati Srivastava Gary Stacey Minviluz Bing Stacey Kevin F. Staveley-O'Carroll Aaron M. Stoker Honamin Sun John J. Tanner Velaphi Thipe Kai Tian Jeffrey K. Uhlmann Anandhi Upendran Mariola Usovsky Caixia Wan Fang Wang Pengtao Wang Murphy Ward Glenn Washer Kevin D. Wells Zhengyan Weng Carlos Wexler Kristin M. Whitworth Brad W. Willis Kim S. Wise Guangfu Wu Quinton Wyatt Dong Xu Xianjin Xu Xiaojun Xu Xianchen Xu Yadong Xu Zheng Yan Bing Yang Matthias J. Young Yongping Yue Dong Zhang Sicheng Zhang Yi Zhang Xiaogin Zou

## MU INVENTORS-WITH U.S. PATENTS

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### **ANIMAL & PLANT BIOTECHNOLOGY**

#### Genetically modified swine resistant to the porcine reproductive and respiratory syndrome virus (Patents 10.405.526 & 10.827.730)

PRRS-resistant pigs have been developed and are being commercialized. PRRS is a viral disease that causes reproductive failure and respiratory tract illness leading to widespread death in herds, costing the swine industry billions annually.

MU inventors: Randall S. Prather, Kevin D. Wells and Kristin M. Whitworth

#### Method to develop high oleic acid soybeans using conventional sovbean breeding techniques (Patent 10.774.337)

Non-GMO soybean germplasm that produces seeds with higher oleic acid percentage serves as an important source of oil for industry and healthier diets.

MU inventors: Kristin Bilyeu, Jeong-Dong Lee, Anh Tung Pham and James Grover Shannon



#### Supplement for cultivation of mammalian embryos (Patent 10.485.584)

This semen preservation technique increases efficiency of livestock artificial insemination, a necessity for increased meat production. MU inventor: Peter Sutovsky

### **COMPUTER SOFTWARE**

#### User identity authentication using

visual storytelling (Patent 10,467,400) A software methodology for authenticating a user based on the user's knowledge and gaze tracking, adding security for highly sensitive information.

MU inventors: Hongfei Cao, Matthew Klaric, Chi-Ren Shyu and Jeffrey K. Uhlmann



## **DEVICES & TOOLS**

#### Continuous-wave ultrasound measurement system (Patent 10,697,875)

The first device for noninvasive measurement of viscoelastic properties opens up a number of new applications, such as process control in the food and beverage industry and other manufacturing areas.

MU inventors: Nilesh Salvi and Jinglu Tan

#### Controlled laser light delivery method for dermatological procedures (Patent 10,456,198)

This method eliminates the air gap between the handpiece and skin that delivers laser light to the target tissue, reducing the likelihood of injury to patients undergoing tattoo removal or other dermatological procedures. MU inventors: Randy D. Curry, Nicholas J. Golda, Beniamin Samuel Goldschmidt. John Andrew Viator and Paul James Douglas Whiteside

#### Device to objectively measure laryngeal adductor reflex (Patent No. 10,542,911)

Delivers air pulses to the vocal cords at varving pressure and duration, improving the ability of clinicians to objectively diagnose and treat airway abnormalities, such as dysphagia, vocal cord dysfunction and neurological disorders. MU inventors: Cameron Hinkel and Teresa Lever

#### Endoscopic-enabled tongue depressor and mouth gag (Patent 10,512,394)

This device combines a tongue depressor and mouth gag with attached endoscope to enable simpler, one-handed direct imaging of surgical sites in the upper airways for routine procedures, improving visibility and freeing clinicians from holding a mirror to indirectly visualize the site.

Surgical tool, Patent 10,512,394

#### MU inventors:

Eliav Gov-Ari and Alexander Madinger

#### Instrument-assisted soft tissue mobilization tool (Patent 10.434.032)

This ergonomic, therapeutic physical therapy tool is designed to treat different tissue types and areas of the body while allowing clinicians the flexibility to hold it comfortably. MU inventors: Jonathon Buehler, Katherina Chen, Jaya Ghosh, Teresa Graff, Brett Hayes, Ellie Koehly, Yaw Sarpong and Roger de la Torre

#### Instrument to close fascia during laparoscopic surgery (Patent 10,548,580)

This lightweight instrument simplifies suturing of the deep facia and peritoneum in the anterior abdominal wall following arthroscopic surgery. MU inventors: Java Ghosh, Ellie Koehly, Yaw Sarpong and Roger de la Torre

## **DIAGNOSTICS & DETECTION**

#### Photoacoustic flow cell technology (Patent 10.859.536)

This device detects analytes, such as cancer cells, based on their acoustic response to laser exposure.

MU inventors: Benjamin Samuel Goldschmidt, Kvle Rood and John Andrew Viator

#### Rhodol fluorophores for near-infrared imaging (Patent 10,675,364)

These stable, water-soluble molecules for research and disease detection can be targeted to specific cell biomarkers and activated without producing radiation. MU inventor: Timothy Glass



### **ENGINEERING SOLUTIONS**

#### Ambient vibration energy-harvesting device (Patent 10,447,135)

A compact cantilever beam converts low-frequency ambient oscillations into high frequency vibrations that are efficiently converted into electrical power. MU inventors: Mahmoud Almasri and Nuh Sadi Yuksek

#### Energetic nanocomposite materials for defense applications (Patent 10,336,661)

Nanothermite and functionalized graphene self-assembled mixtures increase mechanical strength, impulse and reactivity while decreasing sensitivity to electrostatic discharge. MU inventors: Stephen W. Chung, Keshab Gangopadhyay, Shubhra Gangopadhyay, Clay S. Staley and Rajagopalan Thiruvengadathan

#### Energy production from spent nuclear reactor fuel (Patent No. 10,373,723)

Neutron energy released by spent fuel nuclear control rods is converted into light energy and then to electricity by photovoltaic cells.

MU inventors: Robert V. Tompson Jr. and Mark A. Prelas

#### Fabrication method for atomic batteries (Patent 10.706.983)

This method is a safe microfabrication process to mass produce batteries that are activated by exposure to radiation. MU inventors: John Michel Gahl, Jae Wan Kwon and Bradley Ryan Nullmeyer

#### Magnetic diode (Patent 10,403,810)

This first-of-its-kind, solid-state magnetic diode is able to conduct and block electricity, which can increase the lifetime of a battery up to a hundredfold. MU inventors: Ashutosh Dahal, Deepak Kumar Singh and Brock Summers

#### Manufacturing method for multilaver nanograting (Patent 10,490,679)

Nanostructures fabricated using soft lithography enhance the fluorescence detection of biological and chemical species a hundredfold in fluorescence and surface-enhanced Raman spectroscopy. MU inventors: Sagnik Basuray, Sangho Bok, Biyan Chen, Keshab Gangopadhyay, Shubhra Gangopadhyay, Sheila A. Grant, Cherian Joseph Mathai. Samiullah Pathan and Aaron J. Wood



#### Optically controlled semiconductor switch (Patent 10.790.405)

A power device activated using this electrooptic switch will turn on more guickly, use less power and operate at higher frequencies and temperatures.

MU inventor: Randy Curry

#### Radiolytic electrochemical generator (Patent 10.566.638)

Similar to how a battery converts chemical energy to electrical energy, this new device converts radiation energy to electrical energy. MU inventors:

Jae Wan Kwon and Baek Hvun Kim

### Thermal exchange system for livestock

Magnetic diode, Patent 10,403,810

## barns (Patent 10.537.089)

This technology reduces fuel costs,

enables cleaner air, and mitigates disease transmission in a commercial poultry barn by exchanging heat between internal waste air and outdoor air.

MU inventors: Tingsheng (Tennyson) Xu and Yunsheng (Shawn) Xu



MU is a member institution in the National Academy of Inventors and established Mizzou's chapter in 2015 to promote and foster innovation on campus.



## **THERAPEUTICS & TREATMENTS**

#### Aryl and heteroaryl amides for use as anti-proliferative, anti-thrombotic and anti-viral agents (Patent 10,851,096)

This series of small molecule therapeutic compounds is used to treat breast cancer and non-small cell lung cancer. *MU inventor: Kamlendra Singh* 

## Inhibitors of Hepatitis B virus targeting capsid assembly (Patent 10.759.774)

This small molecule targets the hepatitis B capsid to reduce the spread of HPV infections.

*MU inventors: Andrew D. Huber and Stefan Sarafianos* 

## Nanoparticle immunoconjugates for cancer detection and treatment (Patent 10,548,989)

These nanoparticles with conjugated antibody fragments are joined to a chemotherapeutic drug for improved targeting of cancer. *MU inventor: Thomas P. Quinn* 

## Nanoplatform for delivery of cancer therapeutics (Patent 10,426,842)

Enables simultaneous delivery of biologic and small molecule drugs in combination with small interfering RNA (siRNA) to treat cancer and other diseases.

MU inventors: Raghuraman Kannan, Srikar Raman, Dhananjay Suresh and Anandhi Upendran



Nanoplatform, Patent 10,426.842

## Gene therapy for spinal muscular atrophy (Patent 10,472,630)

This gene therapy treatment enables the production of the survival motor neuron (SMN) protein that is deficient in infants with spinal muscular atrophy, an often-fatal neuromuscular disease.

MU inventors: Christian Lorson and Erkan Yakub Osman



Engineered genes, Patent 10,351,611

## Preventative gene-therapy treatments for muscular dystrophy (Patent 10,351,611)

MU researchers have engineered mini- and micro-dystrophin genes to restore function to skeletal and cardiac muscles in patients with this debilitating disease. *MU inventors: Dongsheng Duan, Yi Lai, Yongping Yue and Junling Zhao* 

## **Treatment for bacterial infections** (Patent 10,441,588)

MU researchers have identified novel small-molecule antibacterial compounds that reduce bacterial virulence factors while making them less likely to induce antibiotic resistance.

MU inventors: Feng Qi and Hongmin Sun

#### Tech Transfer's Ultimate Impact:

The public benefit from academic research discoveries that reach the market and jobs and businesses that result from the development and sales of those products.



MU joins colleagues from 193 United Nations member states recognizing World Intellectual Property Day every April 26. It's a prime opportunity to celebrate the originality and creativity of our faculty and staff innovators.

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## INNOVATORS WITH TECHNOLOGIES OPTIONED TO A COMPANY

Option agreements provide companies with a limited time period to obtain a license to use MU innovations. Options gives industry partners an opportunity to validate a technology, or "try it on," before committing to a licensing agreement.

Adeyemi O. Adedeji, Ramak R. Amjad, Roger Clayton Fales, Christopher A. Foote, Sagar Gupta, Hsin-Yeh Hsieh, Shibu Jose, Raghuraman Kannan, Kattesh V. Katti, Luis Martinez-Lemus, Chung-Ho Lin, Soumavo Mukherjee, Jaume Padilla, Srikar Raman, Stefan Sarafianos, Mason Schellenberg, Kamlendra Singh, George C. Stewart, Dhananjay Suresh, Anandhi Upendran, Ajit Prakash Zambre and Kim S. Wise

## MU INNOVATORS WITH COMMERCIAL AGREEMENTS

#### July 2019 – December 2020

## INNOVATORS WITH TECHNOLOGIES LICENSED TO COMPANIES

Hadi Ali Akbarpour, Filiz Bunyak, Kannappan Palaniappan, Rengarajan Pelapur, Mahdieh Poostchi, Raphael Viguier and Rui Wang (*advanced drone surveillance technologies*)

Sagnik Basuray, Kunai Bhatnagar, Sangho Bok, Biyan Chen, Peter Cornish, Keshab Gangopadhyay, Shubhra Gangopadhyay, Arnab Ghosh, Sheila A. Grant, Venumadhav Korampally, Cherian Joseph Mathai, Drew Edwin Menke, Avinash Pathak, Samiullah Pathan and Aaron Wood (*noninvasive*, *ultra-sensitive*, *low-cost molecular detection system to diagnose tuberculosis and other infectious diseases*)

Kristin Bilyeu, Jeong-Dong Lee, Anh Tung Pham and James Grover Shannon (*new methods to develop high oleic acid soybeans using conventional breeding techniques*)

Pengyin Chen, Michael Wayne Clubb, Melissa Crisel, Henry Nguyen, Stewart Wayne Selves, James Grover Shannon and Scotty Lee Smothers (soybean varieties: S11-20337GT, S13-10590C, S13-1955C, S14-15138GT, S14-15146GT, S14-9017GT, S15-10434C, S15-17812C, S16-16641GT)

Gary Francis Clark (cancer immune-based therapy for veterinary medicine) Joan R. Coates and Gary S. Johnson (*diagnostic test for canine degenerative myelopathy*)

Joshua Dakota, Erin Grannemann, Clinton Meinhardt, Melissa Goellner Mitchum, Xiaofan Niu, Andrew Scaboo and Dennis Yungbluth (soybean variety SA13-2699)

Dongsheng Duan, Arkasubhra Ghosh and Yongping Yue (gene therapy for hearing impairments and balance disorders)

Alexander Garnov, John D. Lydon and John David Robertson (*new process for making lutecium, the radioactive element in a radiopharmaceutical treatment for a type of stomach cancer*)

Aaron Gray, Marjorie Skubic, Seth Sherman and Erik Edward Stone (knee joint angle measurement during landing and jumping for diagnosing susceptibility to injury)

Luke Guerdan, Zachary Kipping, Siyang Liu, William Maxwell Morrison, Connor Rowland, Yi Shang, Timothy J. Trull and Weiliang Xia (software to track effectiveness of mental health interventions)

Giovanna Guidoboni (a mathematical model for interpreting data generated in a ballistocardiogram)

Christy Hutton (mental health first responder training materials)

Roli Kargupta, Sachidevi Puttaswamy and Shramik Sengupta (*detection of early-onset sepsis*) Chris L. Lorson and Erkan Osman (gene therapy for spinal muscular atrophy)

Judith H. Miles, Dinalankara M.R. Dinalankara and Gang (Gary) Yao (a device to measure pupillary light reflex in infants and toddlers)

James Grover Shannon, David A. Sleper and James Allen Wrather (*soybean varieties S05-11482 and S06-4649RR*)

Hongmin Sun (anti-microbials to treat multi-drug resistant bacteria)

Kim S. Wise (antibodies to detect two different mycoplasma bacteria in quality control testing)

## FIRST SALES OF PRODUCTS USING MU TECHNOLOGIES

Canine degenerative myelopathy diagnositc test (Joan Coates and Gary Johnson)

Software system to track mental health interventions (*Siyang Liu, Yi Shang and Timothy Trull*)

Soyleic<sup>™</sup> soybeans (Kristin Bilyeu and Grover Shannon)

Soybean varieties S05-11482, S064649RR, S12-4718, SA13-1385, S11-20242C, S14-9017GT, S14-15146GT, S13-2743, S13-3851, S14-15138GT, SA13-1363, SA13-1310 and SA14-9653 (Andrew Biggs, Pengyin Chen, Michael Clubb, Melissa Crisel, Joshua Dakota, Clinton Meinhardt, Henry Nguyen, Xiaofan Niu, Stewart Selves, Andrew Scaboo, Grover Shannon and Scotty Smothers)

## Startups created with MU-licensed technologies

#### Plasmonic Diagnostics

Offers a noninvasive, ultra-sensitive, low-cost molecular detection system to diagnose tuberculosis and other infectious diseases.



#### **Shift Pharmaceuticals**

Uses a precision medicine approach to develop drugs for patients with genetic neuromuscular diseases, including spinal muscular atrophy and Charcot-Marie-Tooth disease.



**TigerAware** — Offers a cross-platform software system that makes it easier for researchers to collect mood, substance usage and other data in real time from individuals using an app on their smart phones.



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