

Fiscal Year 2019

MIZZOU innovates

MU's Entrepreneurial Ecosystem Elevates Research



Building interdisciplinary collaborations among researchers at Mizzou, the network of universities in the University of Missouri System, outside institutions and industry partners is key to leveraging our discoveries. Commercialization of products is also supported by the robust ecosystem at Mizzou that supports the entrepreneurial spirit while building the crucial ties to businesses that enhance and elevate discoveries and bring them to market — products that tackle the grand challenges facing Missourians, the nation and the world.

Our faculty, staff and students are at the heart of early-stage innovation at Mizzou, and this booklet recognizes this year's inventors. Together with our Technology Advancement Office, MU innovators work to promote discoveries from bench to marketplace and into the hands of consumers.

As the senior research administrator for MU, it is my role to ensure that researchers are in the best possible positions to produce exciting advancements in life sciences and agriculture, engineering, and health sciences among other fields. I also

endeavor to spark innovation through the development of collaborations and partnerships creating the collisions necessary among researchers and innovators that help produce marketable technologies.

In 2018, Chancellor Cartwright set the ambitious goal of doubling the university's research funding over five years. Just over a year and a half later, we've announced that our grants from federal funders as well as business and industry investments have contributed to an increase in grant funding of \$48 million over the previous fiscal year.

Additionally, Mizzou experienced a 29% increase in grant proposals totaling more than \$1 billion. These increases will provide the revenues that will increase research output and boost economic development in the region and state. MU's research enterprise as a whole remains robust. Internal research investments and extramural funding support generated more than \$210 million in research expenditures in FY2019. Newly awarded dollars, most coming in the form of highly competitive grants from agencies such as the National Institutes of Health and the National Science Foundation, also saw solid year-over-year gains.

Research initiatives and funding generate faculty innovations, some of which are licensed, patented and further developed in commercial settings. In FY19, Mizzou signed 61 license and option agreements with companies and was issued 40 U.S. patents. In fact, during the last three years, MU's licensing income totaled more than \$12.8 million. Faculty inventors receive a portion of this revenue along with their departments. Mizzou's portion is reinvested in education and in upgrading our research and technology infrastructure, thus laying the groundwork for future breakthroughs.

We are making great strides to maximize the investments the citizens of Missouri make in our land grant, AAU institution. I hope you will share your ideas for growing our research enterprise at umcresearch@missouri.edu.

Sincerely,

A handwritten signature in black ink that reads "Mark A. McIntosh". The signature is fluid and cursive.

Mark A. McIntosh
MU Vice Chancellor for Research and Economic Development

LAUNCHING MIZZOU TECH

The MU Office of Research and Economic Development welcomes Lisa Lorenzen, Assistant Vice Chancellor, Technology Advancement Office (TAO). Lorenzen, who joined the Mizzou family in September 2019, is leading university efforts to leverage the commercial potential of faculty research innovations (often called tech transfer).

Lorenzen most recently served as both executive director of the Iowa State University Research Foundation and director of the Office of Intellectual Property and Technology Transfer at Iowa State.

“Lisa has 20 years of experience in many aspects of economic development, especially in academic commercialization and industry partnerships,” said Mark McIntosh, vice chancellor for research and economic development. “Her background in plant sciences as a computational biologist for Pioneer Hi-Bred International combined with her contract negotiation skills and ability to manage multimillion-dollar research collaborations will greatly enhance the tech transfer process at MU.”

*TAO professionals work
at the interface of
science, business and patent law.*

At Mizzou, TAO professionals manage more than 800 early-stage innovations in different stages of development and collaborate with faculty, companies, entrepreneurs and investors to develop and transform them into products, jobs and businesses.

Lorenzen oversees the assessment of MU inventions for marketability; the process for securing intellectual property protection, such as patents and copyrights; and the negotiation and execution of license agreements that allow companies to access university-owned innovations. In FY2019, companies optioned or licensed 103 different technologies, generating \$6.6 million in revenue for MU.

“This position is the perfect opportunity to combine my strong commitment to technology transfer with my passion for industry relations and economic development,” Lorenzen said. “Facilitating deal making for intellectual property agreements and negotiating creative solutions that enable research collaborations with industry are at the core of what I enjoy most about this field.”

Before working in tech transfer, Lorenzen directed industry relations and economic development programs for Iowa State. She earned a bachelor’s degree and a doctorate in genetics from ISU.

“Under Lisa’s leadership at Iowa State, the number of inventions that faculty disclosed rose 40%, and license agreements increased by 33%,” said Bill Turpin, interim associate vice chancellor for economic development. “We look forward to her expertise on Mizzou’s economic development leadership team.”



Did You Know?

The UM System has made the list of “Top 100 Worldwide Universities Granted U.S. Utility Patents” annually since the National Academy of Inventors and the Intellectual Property Association began publishing it in 2013.

MU Inventors With U.S. Patents Issued in FY2019

ANIMAL & PLANT BIOTECHNOLOGY

Immune-cell-deficient, transgenic, cloned miniature pig

Transgenic pigs (SCID) are used to study the development, progression and treatment of diseases and strategies for tissue and organ transplants.

Patent 10,058,079: MU inventors Randall S. Prather and Kiho Lee

Genetically modified swine resistant to the porcine reproductive and respiratory syndrome virus

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. PRRS-resistant pigs have been developed and are being commercialized.

Patents 10,080,353 and 10,091,975: MU inventors Randall S. Prather, Kevin D. Wells and Kristin M. Whitworth

Artificial activation of unfertilized mammalian oocytes, or egg cells

An approach for more efficient livestock cloning that yields more live births with the same number of in vitro embryo transfers.

Patent 10,190,093: MU inventors Kiho Lee and Randall S. Prather

Sperm stimulating additive

This semen preservation technique increases efficiency of livestock artificial insemination, a necessity for increased meat production.

Patent 10,070,889: MU inventors Peter Sutovsky and Young-Joo Yi

Transgenic plants resistant to cyst nematodes

Cyst nematodes cause \$1 billion annually in U.S. crop yield losses. Genes have been identified that provide resistance to nematodes in soybean, potato and other valuable crops.

Patents 10,231,383 and 10,246,722: MU inventors Melissa Goellner Mitchum, Amy Replogle and Jianying Wang

Patents 10,294,489 and 10,070,614: MU inventors Pramod Kaitheri Kandoth and Melissa Goellner Mitchum

High oleic acid soybeans using conventional breeding techniques

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

Patents 10,087,454 and 10,329,576: MU inventors James Grover Shannon, Jeong-Dong Lee and Anh Tung Pham

Bacillus-bacteria-based delivery and production system for bioparticles, proteins and small molecules

This bacterial platform for enzyme expression is used to deliver enzymes for advances in agriculture, contaminant bioremediation, biofuel production, vaccine development and more.

Patent 10,081,790: MU inventors George C. Stewart, Brian M. Thompson and Chung-Ho Lin

THERAPEUTICS & TREATMENTS

Peptide-based compounds for melanoma cancer imaging

Cyclic peptides that bind to melanocyte-stimulating, hormone-producing melanoma allow clinicians to image and detect noninvasively and treat melanomas and their metastatic spread.

Patent 10,265,425: MU inventor Yubin Miao

Borane compounds for cancer treatment

This inexpensive chemical process enables commercial production of boron compounds that can be used in Boron Neutron Capture Therapy (BNCT) for treatment of invasive, malignant cancer tumors.

Patents 10,059,599 and 10,179,795: MU inventors Satish S. Jalisatgi, Marion Frederick Hawthorne and Alexander V. Safronov

Cholesterol biosynthesis inhibitors as agents to treat tumors

A repurposed small molecule targets the cholesterol biosynthesis pathway for the treatment of cancer.

Patent 10,143,686: MU inventors Salman M. Hyder, Yayun Liang, Xiaoquin Zou, Sam Z. Grinter and Sheng-You Huang

Gold multicomponent nanomaterials to detect and treat cancer

Gold nanoparticles with cancer targeting, imaging and therapeutic properties are used to diagnose and treat EGFR-expressing cancer.

Patent 10,317,400: MU inventors Raghuraman Kannan, Ajit Zambre and Anandhi Upendran

Heart-disease therapy targeting KCNQ channels

Small molecule therapy for the modulation of KCNQ channels treats heart disease or epilepsy.

Patent 10,064,842: MU inventor Xiaoquin Zou

A treatment for Q fever

Veterinarians, meat processors, farmers, and others who work with livestock can receive this biologic treatment against the lipopolysaccharide of *Coxiella burnetii*, which causes Q fever, a worldwide zoonotic infection.

Patent 10,233,233: MU inventor Guoquan Zhang

Nocturnal gastrointestinal disorder treatment

Administration of buffered proton pump inhibitor controls nocturnal gastric acid disorders.

Patent 10,045,973: MU inventor Jeffrey O. Phillips

Pain management using novel carborane-based sodium channel blockers

Demonstrates how carborane-based sodium channel blockers can treat acute pain.

Patent 10,202,406: MU inventors George R. Kracke, Yulia Sevryugina and Marion Frederick Hawthorne

DEVICES & TOOLS

Activity analysis, fall detection and risk assessment

An integrated sensor network and associated risk assessment algorithms alert caregivers about changes in an elderly person's gait and activity patterns, possible indicators of physical and cognitive health problems.

Patent 10,188,295: MU Inventors: Marjorie Skubic, Marilyn J. Rantz, Mihail Popescu, Shuang Wang, Isaac J. Sledge, Rainer Dane A. Guevara, Elena F. Wright and James M. Keller; Patent 10,080,513: MU inventors Erik Edward Stone, Marjorie Skubic, Marilyn J. Rantz and Mihail Popescu

A nonthermal, plasma gas device for dental treatments

Surface treatment device uses cold atmospheric plasma to improve the clinical performance, durability and longevity of dental fillings, crowns and other procedures.

Patent 10,299,887: MU inventors Qingsong Yu and Hao Li

High-resolution 3D tissue imaging using optical polarization tractography

This medical imaging platform visualizes early tissue fiber abnormalities at the cellular level in skeletal muscles, nerves, teeth, cartilage, heart muscles and blood vessels, which enables diagnosis and prediction of diseases, such as coronary artery disease associated with an increased risk of heart attack.

Patent 10,133,045: MU inventors Gang Yao, Dongsheng Duan and Yuanbo Wang

Rapid detection of sepsis and other bacterial infections

Detects sepsis in biological fluids in 24 to 36 hours by using high frequency electricity to measure the change in capacitance of growing bacteria.

Patent 10,273,522: MU inventors Shramik Sengupta and Sachidevi Puttaswamy

Impedance sensor for bacteria detection

This biosensor array can rapidly detect and quantify bacteria at low concentrations from surface swabs taken at places like hospitals and food processing plants.

Patent 10,274,492: MU inventors Mahmoud Almasri, Shibajyoti Ghosh Dastider, Shuping Zhang, Majed El Dweik, Nuh Sadi Yuksek, Ibrahim Jasim and Jiayu Liu

Tissue storage and preservation

This tissue preservation system more than doubles the storage time and increases the total viability of orthopedic grafts and tissues used in bone and tissue transplants, leading to more successful surgeries and increasing the supply of available grafts.

Patent 10,039,277: MU inventors James L. Cook and Aaron M. Stoker

Tapered osteochondral allograft device

This orthopedic medical device creates a tapered bone and cartilage implant for the knee with a matching joint cavity that reduces surrounding tissue damage and improves surgery outcomes.

Patent 10,080,570: MU inventors Ferris M. Pfeiffer, Aaron M. Stoker and James L. Cook

Weightlifting machine enabling independent control of eccentric and concentric movements

Device focuses muscle conditioning on the eccentric (weight lowering) rather than concentric (weight lifting) motion for improved strength building.

Patent 10,220,239: MU inventors Adam Rau, John Rayburn, Orr Hadass and Nicholas Ryan Smith

DIAGNOSTICS & DETECTION

Nanopore-facilitated single molecule nucleic acid detection

Diagnostic platform provides sensitive and selective detection and quantitation of nucleic acids for applications in aquaculture, agriculture and human health.

Patent 10,273,527: MU inventors Li-Qun Gu, Yong Wang and Kai Tian

Fluorescent chemical sensors for biological amines

This first demonstration of small molecule fluorescent sensors enables the detection and visualization of select neurotransmitters in fixed and live cells.

Patent 10,222,390: MU inventors Timothy Glass and Kenneth Hettie; Patent 10,330,673: MU inventors Timothy Glass, Kevin Gillis and Kenneth Hettie

Detection of multiple bacterial species in biological or food samples

A rapid, accurate and low-cost PCR-based assay screens for bacterial contamination in food and antibiotic-resistant bacteria in medical samples.

Patent 10,190,177: MU inventors Azlin Mustapha and Prashant Singh

ENGINEERING SOLUTIONS

Thermally driven heat pump

This heat pump includes a low-temperature evaporator for evaporating cooling fluid to remove heat.

Patent 10,101,059: MU inventors Hongbin Ma and Peng Cheng

High energy-density atomic micro battery

This lightweight, long-life nuclear micro battery is designed for use in micro electromechanical systems.

Patent 10,083,770: MU inventors Jae Wan Kwon, John David Robertson and Tongtawee Wacharasindhu

Separation of chemically pure osmium from metal mixtures

Improved process separates osmium from production byproducts. Osmium can be used as a target for the production of radioisotopes in cyclotrons or reactors.

Patent 10,087,503: MU inventors Leonard Manson III, Stacy L. Wilder, Hendrik P. Engelbrecht and Cathy S. Cutler

Low-temperature production of zinc oxide nanowire

These high-quality nanowires can be grown on virtually any substrate at a reduced cost for use in photovoltaics, piezoelectric devices and other applications.

Patent 10,128,111: MU inventors Jae Wan Kwon and Baek Hyun Kim

Nano-gap grating devices with enhanced optical properties

This technology allows users to view single molecules using a relatively inexpensive microscope instead of a costly confocal microscope.

Patent 10,073,200: MU inventors Shubhra Gangopadhyay, Venumadhav Korampally, Sagnik Basuray, Kunal Bhatnagar, Avinash Pathak, Arnab Ghosh, Drew Edwin Menke, Cherian Joseph Mathai, Peter Cornish, Keshab Gangopadhyay and Aaron Wood

Manufacturing multilayer nanograting structures

This is an improved fabrication method for making nano-gap grating devices.

Patent 10,103,357: MU inventors Shubhra Gangopadhyay, Sangho Bok, Samiullah Pathan, Cherian Joseph Mathai, Sagnik Basuray, Keshab Gangopadhyay, Biyan Chen, Sheila Grant and Aaron Wood

Licensing, Options and Startups in FY2019

MU INVENTORS WITH TECHNOLOGIES LICENSED TO A COMPANY

Laila Al-Khashti
Mitchell Allen
Ramak R. Amjad
Jerry L. Atwood
Andrew Biggs
Pengyin Chen
Michael Wayne Clubb
Joan R. Coates
James L. Cook
Melissa Crisel
Randy Curry
Joshua Dakota
Dongsheng Duan
Roger Clayton Fales
Kevin Gillis
Timothy Glass
Erin Grannemann
Maria Haag
Christy Hutton
Gary S. Johnson
Raghuraman Kannan
Timothy Keim
Yi Lai
William R. Lamberson
Justin Le Tourneau
Teresa E. Lever

Chris L. Lorson
Clinton Meinhardt
Yubin Miao
Melissa Goellner Mitchum
Henry Thien Nguyen
Jarrod Nichols
Xiaofan Niu
Stephen Christian Rozier
Andrew Scaboo
Stewart Wayne Selves
James Grover Shannon
Kamlendra Singh
David A. Slepser
Scotty Lee Smothers
Aaron M. Stoker
Jay J. Thelen
Anandhi Upendran
Lakmini Wasala
James Allen Wrather
Yajin Ye
Yongping Yue
Dennis Yungbluth
Habib Zaghouani
Ajit Prakash Zambre
Le Zhang

STARTUP COMPANIES CREATED WITH MU-LICENSED TECHNOLOGIES

Intelligent Respiratory Devices LLC is developing a technology solution that learns from each patient to automatically control oxygen in premature and low-birth-weight infants. *MU inventors: Ramak R. Amjad, Roger Clayton Fales and Timothy Keim*

Oncogen LLC is a biotechnology company developing breakthrough targeted therapeutics for cancer. Its proprietary nanoparticle platform delivers chemotherapeutics to tumors with unprecedented precision; thus, increasing treatment efficacy and decreasing overall toxicity. *MU inventors: Raghuraman Kannan, Anandhi Upendran and Ajit Prakash Zambre*

Peridot Films LLC holds the license and copyright for the independent feature film *Peridot* about an Apache man in eastern Arizona. *MU inventor: Stephen Christian Rozier*

Plasmadigm LLC is a company that will commercialize self-confining atmospheric plasmas. The technology was funded by the Office of Naval Research at MU and then spun off for advanced applications. *MU inventor: Randy Curry*

Quetza LLC is an educational technology company focused on developing data-driven, highly interactive and engaging software applications for the animal sciences. *MU inventors: Maria Haag, William R. Lamberson and Justin Le Tourneau*

MU INVENTORS WITH TECHNOLOGIES OPTIONED TO A COMPANY

Syed Barizuddin
Sagnik Basuray
Kunal Bhatnagar
Sangho Bok
Biyan Chen
Gary Francis Clark
Peter Cornish
Reza Espanani
Keshab Gangopadhyay
Shubhra Gangopadhyay
Arnab Ghosh
Xiaofen Gong
Sheila A. Grant

William A. Jacoby
Venumadhav
Korampally
Cherian Joseph
Mathai
Drew Edwin Menke
Avinash Pathak
Samiullah Pathan
Valery A. Petrenko
Thomas P. Quinn
George P. Smith
Aaron J. Wood
Xiaoqin Zou

What's New for Faculty Entrepreneurs

Missouri StartupTree is the UM System's new online community and global platform for innovators and entrepreneurs. Recruit collaborators for business ventures and projects. Connect with mentors and investors. Find resources and programs. Join at missouri.startuptree.co.

The **Commercialization Concierge Program** is a free service that includes a needs assessment, personalized plan and continued assistance. Apply at missouri.startuptree.co/discover/applications

The **Fast-Track Express License** includes predefined terms and conditions that streamline contract negotiations and are favorable for UM inventors who wish to obtain the rights to their innovations for a new startup company. More at umurl.us/elg

MIZZOU TECH ADVANCEMENT

FY2019 IMPACT

WHY US?

MU has medicine, veterinary medicine, agriculture and engineering on the same campus along with the nation's only NIH-funded university rat and swine centers and the most powerful university research reactor in the U.S.

WHAT WE OFFER

- Faculty expertise
- Licensable innovations
- State-of-the-art instrumentation
- Research and business infrastructure

\$210+ million

spent annually on scientific research

850+

total MU technologies

89

new invention disclosures filed, FY19

69

U.S. patent applications filed, FY19

40

U.S. patents issued, FY19

61

license & option agreements executed, FY19

\$6.6 million

gross licensing income generated, FY19

35%

of U.S. issued patents are licensed

20%

of active technologies are licensed

\$35.2 million

in income generated from 244 different technology license & option agreements, FY15-19.



Office of Research and Economic Development

University of Missouri

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Cover: Image of a cell membrane