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 $32.8 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,

Mark A. McIntosh
MU Vice Chancellor for Research and Economic Development
Licensing, Options and Startups in FY2019

MU INVENTORS WITH TECHNOLOGIES LICENSED TO A COMPANY

<table>
<thead>
<tr>
<th>Name</th>
<th>Inventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laila Al-Khashti</td>
<td>Medicine for premature infants, cellular respiration in neural stem cells</td>
</tr>
<tr>
<td>Mitchell Allen</td>
<td>Technology for the detection of cancer biomarkers</td>
</tr>
<tr>
<td>Ramak R. Ajmad</td>
<td>Novel methods for the treatment of long-term chronic inflammation</td>
</tr>
<tr>
<td>Jerry L. Atwood</td>
<td>Automated methods for improving the efficiency of biological systems</td>
</tr>
<tr>
<td>Andrew B Higgins</td>
<td>Medical devices for the treatment of cardiovascular diseases</td>
</tr>
<tr>
<td>Pengyin Chen</td>
<td>Plasmonic materials for optical applications</td>
</tr>
<tr>
<td>Michael Wayne Clubb</td>
<td>Antiviral compounds for the treatment of viral infections</td>
</tr>
<tr>
<td>Joan R. Coates</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
</tr>
<tr>
<td>James L. Cook</td>
<td>Techniques for the production of biofuels</td>
</tr>
<tr>
<td>Melissa Crisel</td>
<td>Methods for improving the efficiency of solar cells</td>
</tr>
<tr>
<td>Randy Curry</td>
<td>Advanced materials for energy storage</td>
</tr>
<tr>
<td>Joshua Dakota</td>
<td>Biocompatible materials for medical applications</td>
</tr>
<tr>
<td>Dongsheng Duan</td>
<td>Novel methods for the production of pharmaceuticals</td>
</tr>
<tr>
<td>Roger Clayton Fales</td>
<td>Nanotechnology for the detection of biomarkers</td>
</tr>
<tr>
<td>Kevin Gillis</td>
<td>Methods for improving the efficiency of renewable energy systems</td>
</tr>
<tr>
<td>Timothy Glass</td>
<td>Advanced materials for the development of new technologies</td>
</tr>
<tr>
<td>Erin Grannemann</td>
<td>Methods for the detection of rare diseases</td>
</tr>
<tr>
<td>Maria Haag</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
</tr>
<tr>
<td>Christy Huitton</td>
<td>Methods for improving the efficiency of biological systems</td>
</tr>
<tr>
<td>Gary S. Johnson</td>
<td>Nanotechnology for the detection of biomarkers</td>
</tr>
<tr>
<td>Raghuraman Kannan</td>
<td>Novel methods for the treatment of diseases</td>
</tr>
<tr>
<td>Timothy Klaim</td>
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<tr>
<td>Yi Lai</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
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<tr>
<td>William R. Lamberson</td>
<td>Methods for improving the efficiency of renewable energy systems</td>
</tr>
<tr>
<td>Justin Le Tourneau</td>
<td>Novel methods for the detection of biomarkers</td>
</tr>
<tr>
<td>Teresa E. Lever</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
</tr>
</tbody>
</table>

STARTUP COMPANIES CREATED WITH MU-LICENSED TECHNOLOGIES

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<th>Name</th>
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<td>Intelligent Respiratory Devices LLC</td>
<td>Technology for the detection of cancer biomarkers</td>
</tr>
<tr>
<td>OncoGen LLC</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
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<tr>
<td>Peridot Films LLC</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
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<tr>
<td>Plasmadigm LLC</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
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<td>Quetza LLC</td>
<td>Nanotechnology for the detection and treatment of cancer</td>
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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 are used to study the development, progression and treatment of diseases and strategies for tissue and organ transplant.
Patent 10,058,079: MU inventors Randall S. Prather and Ko In 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 10,080,573 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 embryo transfer points.
Patent 10,190,093: MU inventors Ko In 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, specifically Heterodera schachtii, are a major pest in U.S. crop yield losses. Genes have been identified that provide resistance to nematodes in soybean, potato and other valuable crops.
Patents 10,231,583 and 10,246,722: MU inventors Melissa Sopelkiewicz, Amy Replogle and Janjung Wang
Patent 10,294,489 and 10,070,614: MU inventors Pramod Prather, Kevin D. Wells and Kristin M. Whitworth

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 Guerrier Shannon, Joaing-Dong Lee and Ahn 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

Peptide-based compounds for melanoma therapy
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 10,263,426: MU inventor Yinbin Mao

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 10,019,399 and 10,179,796: MU inventors Satish S. Jalasatig, Marion Frederick Hawthorne and Alexander V. Savron

Cholesterol biosynthesis inhibitors
As agents to treat tumors
A repurposed small molecule targets the cholesterol biosynthesis pathway for the treatment of cancer.
Patent 10,143,939: MU inventors Ryan M. Tucker, Yuan Liang, Xiaoqiong Zou, Sam Z. Glintzer and Sheng-You Huang

Gold multicomponent nanomaterials
Gold nanoparticles with cancer targeting, imaging and therapeutic properties are used to diagnose and treat EGFR-expressing cancer.
Patent 10,317,400: MU inventors Raghuveer Kannaman, Ajit Zambre and Anandhi Upendran

Heart-disease therapy targeting KCNQ channels
Channels control heart mechanotransduction, and inhibition of KCNQ channels treats heart disease or epilepsy.
Patent 10,064,842: MU inventor Xiaoqiong Zou

A treatment for Q fever
Veterinarians, farmers, and others who work with livestock can receive this biologic treatment against the lipo polysaccharide of Coxiella burnetii, which causes Q fever, a worldwide zoonotic infection.

Nocturnal gastrointestinal disorder treatment
Administration of buffered proton pump inhibitor controls nocturnal gastric acid disorders.
Patent 10,045,973: MU inventor Jeffrey G. Phillips

Pain management using novel carboxylate-based sodium channel blockers
Demonstrates how carboxylate-based sodium channel blockers can treat acute pain.
Patent 10,202,906: MU inventors George P. Krocke, Yula Sevyugin and Marion Frederick Hawthorne

Therapeutics & Treatments

Device focuses muscle conditioning on the eccentric motion for improved strength building.
This weightlifting machine enabling independent control of concentric and eccentric (weight lowering) rather than concentric (weight lifting) motion for improved strength building.
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This weightlifting machine enabling independent control of concentric and eccentric (weight lowering) rather than concentric (weight lifting) motion for improved strength building.
Patent 10,202,906: MU inventors George P. Krocke, Yula Sevyugin and Marion Frederick Hawthorne

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 10,288,246: MU inventors: Marjorie Sulcik, Marilyn J. Rantz, Mihal Popescu, Shuang Wang, Isaac J. Sliger, Dana A. Zhang, Diana F. Wright and James M. Keller
Patent 10,080,513: MU inventors: Erik Edward Stone, Marjorie Sulcik, Marilyn J. Rantz and Mihal Popescu

A nonthermal, plasma gas device for dental treatments
Surface heat treatment of device uses cold atmospheric plasma to improve the clinical performance, durability and longevity of dental fillings, crowns and other procedures.
Patent 10,217,977: MU inventors: Guoqiong Yu and Hao Li

High-resolution 3D tissue imaging using optical polarization trクトography
This medical imaging platform visualizes early tissue 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 10,131,045: MU inventors: Gang Yao, Dongsheng Duan and Yuango 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.

Impendence 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.

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 orthochondral 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: Ferns 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 10,227,027: MU inventors: Ashok Rau, John Rayburn, Orr Hadass and Nicholas Ryan Smith

Thermally driven heat pump
This heat pump includes a low-temperature evaporator for evaporating cooling fluid to reduce 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 unmanned aterial systems.
Patent 10,082,770: MU inventors: Jae Wan Kwon, John David Robertson and Tungtseewa Wacharrasri

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 X-ray optical cavities.

Low-temperature production of zinc oxide nanowire
These high-quality nanowires can be grown virtually anywhere at a reduced cost for use in photovoltaics, piezoelectric devices and other applications.
Patent 10,126,111: MU inventors: Jae Wan Kwon and Baek Hyun Kim

Nanogap-grating devices with enhanced optical properties
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 10,171,500: MU inventors: Jae Wan Kwon and Baek Hyun Kim

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Patent 10,171,500: MU inventors: Jae Wan Kwon and Baek Hyun Kim

Nanopore-facilitated single molecule nucleic acid detection
Diagnostic platform provides sensitive and selective detection and quantification of nucleic acids for applications in agriculture, food safety and personal health.
Patent 10,273,527: MU inventors: Li-Qun Gsu, Yong Wang and Kai Tian

Fluorescent chemical sensors for biological amines
This fluorescent chemical sensor enables the detection and visualization of select neurotransmitters in tissues and fluids.
Patent 10,350,673: MU inventors: Timothy Glass, Kevin Gillis and Kenneth Hette

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 10,901,177: MU inventors: Azlin Mustapha and Prashant Singh

ENGINEERING SOLUTIONS

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.

Manufacturing multilayer nanograting structures
This is an improved fabrication method for making nanogap-grating devices.
Patent 10,103,357: MU inventors: Shubhra Gangopadhyay, Sangho Bok, Samulahl Pathan, Chiranj Joseph Mathai, Sakinig Basuray, Khashab Gangopadhyay, Biyan Chen, Sheila Grant and Aaron Wood
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.


A nonthermal, plasma gas device for dental treatments
Surface Heat 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: Giorgos Yu and Hao Li.

High-resolution 3D tissue imaging using optical polarization tractography
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Nocturnal gastrointestinal disorder treatment
Administration of buffered proton pump inhibitor controls nocturnal gastric acid disorders.


Bacterial-based diagnosis of cancers
This correlated microbial ecological fingerprint method can detect a broadened range of cancerous tumors present in a sample.


Manufacturing multilayer nanograting structures
This is an improved fabrication method for making nano-grating devices.

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

“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.”

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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,

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

Fiscal Year 2019

Office of Research and Economic Development
University of Missouri
research.missouri.edu

Cover: Image of a cell membrane