

Leading Discovery: URC Contributions to the Life, Medical and Health Sciences

A Report from the
University Research Corridor

Spring 2017



EXECUTIVE SUMMARY

Overview

- Approximately one in eight Michigan jobs are in the life, medical, and health sciences, and this sector is an important stabilizing force for the state's economy.
- URC institutions conducted over \$1.2 billion in academic R&D in the life, medical, and health sciences in 2015, accounting for 95 percent of the state's total.
- Operating throughout the state, URC institutions have more than three million patient care visits each year and perform tens of thousands of surgeries.
- Forty-two percent of the state's practicing physicians attended a URC medical school.
- URC institutions are a primary source of talent in the life, medical, and health sciences producing 44 percent of the state's degrees in these fields and higher shares for more advanced degrees. The URC ranks first in talent production among peer university clusters.
- URC institutions have been averaging a new start-up company every other month in the life, medical, and health sciences over the past five years.



Economic Importance of the Life, Medical, and Health sciences



The life, medical, and health sciences represent a broad array of disciplines that generally involve the biology and health of people, plants, and animals. These fields, especially when the provision of medical care is included, make up an important and growing part of Michigan's economy. Approximately 533,000 Michiganders were employed in one of these sectors in 2015, representing approximately one in eight jobs. Between 2011 and 2015, the sector added 21,000 jobs, with growth of 4.2 percent. While this growth is slower than the overall economy during this period, this slower growth is misleading. Michigan's economy is still recovering from the sharp employment declines that occurred in the 2000s, a decline that the life, medical, and health sciences did not experience. Compared to its 2000 level, employment in the life, medical and health sciences is up 18.9 percent, while overall Michigan employment is still down 9.3 percent.¹ The ability of the sector to grow while the rest of Michigan's economy was contracting represents an important stabilizing force for the economy.

Michigan's bioscience industry is a subset of the life, medical, and health sciences that excludes the delivery of medical care. This subset represents the portion of the sector more focused on export industries, making it an important driver of economic growth.

Michigan's bioscience industry:

- Employed 44,277 people in 2014, ranking Michigan 13th highest among states
- Generated venture capital investments of \$666 million between 2012 and 2015, ranking 18th highest among the states
- Boasts high-paying jobs, with workers in this sector earning an average annual wage of \$83,482, 74 percent higher than Michigan's average private sector wage (\$48,054). (TEconomy Partners LLC and Biotechnology Innovation Organization 2016)

Research



There are few places in the world with the capacity to do the types of research that occur at the URC. URC researchers tackle big problems—like infant mortality, cancer, ALS, and Alzheimer's disease. Leading researchers working at world-class facilities can do

amazing work, and these researchers get results. The URC has conducted groundbreaking and historically important medical research—developing blockbuster drugs like Cisplatin, the “penicillin of cancer drugs,” creating the first mechanical heart used during surgery, and playing a key role in polio vaccine field trials.

The future for research in the life, medical and health sciences includes tackling challenges related to aging, cancer, genetic disorders, health disparities and food supply safety. Technological advances on the horizon and being studied today include treating individuals according to their unique genetic code through precision medicine, using 3D printing for biological mechanisms, and utilizing information technology to collect, analyze and inform healthcare treatment and behavior. And the frontier will require integrative approaches to make interdisciplinary connections that lead to real-world solutions, such as examining the interplay between environmental impacts and the health of plants, animals and humans.

Important research continues, including developing the next generation of antibiotics and cancer drugs and using bioengineering for targeted drug delivery, wearable sensors, advanced prosthetics and more. For example, WSU researchers recently discovered a simple and inexpensive way to screen expectant mothers at risk for preterm birth, and a corresponding noninvasive, low-cost treatment that reduces the chances of preterm birth in half. This breakthrough can make a meaningful impact on communities like Detroit that struggle with high infant mortality rates. U-M researchers have found a drug that may reduce the metabolic response that often keeps dieters from being successful, a finding that may prove important in treating diabetes. MSU researchers recently discovered a chemical compound and potential new drug that may reduce the spread of melanoma by up to 90 percent. With 76,000 new cases of this disease in the U.S. each year, this drug could save thousands of lives. Researchers at the URC institutions are working collaboratively on many projects, bringing the collective strengths of the universities together to address big questions like the impact of the environment on children's health.

Researchers are also leveraging new technologies to develop innovative treatments, such as U-M's recently created bronchial splint, made for a toddler using a 3-D printer. WSU uses high-performance computing to create humanlike models to test vehicle safety. Researchers at MSU are working on developing implantable brain-machine interfaces that allow the control and communication of prosthetic devices (e.g., robotic limbs) with neurons through

¹ PSC calculations using data published by the U.S. Department of Labor's Quarterly Census of Employment and Wages.

an individual's brain signals. These types of biomedical engineering projects that bring together engineering and medical know-how represent an exciting new research frontier.

The URC institutions' research facilities in the life, medical, and health sciences are truly world-class. MSU's Veterinary Diagnostic Laboratory helps protect the public by ensuring the health of animals in Michigan and beyond, helping to counter threats like avian influenza and West Nile virus. U-M scientists at the Taubman Medical Research Institute are seeking cures for common and debilitating diseases and conditions. There is also currently research at Taubman to identify drugs to make chemotherapy more effective and to prevent diabetes-related kidney damage.

Health policy research occurring across the URC universities is helping reduce health disparities and ensure that the best medical care is available to all citizens. WSU's Integrative Biosciences Center (IBio) is a good example of this work. IBio is a research facility in Detroit dedicated to eliminating the health disparities for city residents. Researchers study environmental sciences, bio and systems engineering, heart disease, obesity, and other health ailments that plague Detroiters. Research occurring there will help Detroiters and people living in similar communities across the country.

The variety and scale of research being completed across the URC can be difficult to fully comprehend. With \$1.2 billion in academic research and development (R&D) in the life, medical, and health sciences occurring at the URC institutions in 2015 and \$6.2 billion occurring over the last five years, the URC is one of the top research centers in the world.

Medical Care



For most people, the medical sciences are the most easily recognized of the life, medical, and health sciences. The URC's presence in Michigan medical care is expansive and diverse. Combined, the diversity of what the URC universities offer in terms of medical training, research, and the delivery of care has a profound impact on the state, as well as the world. Whether Michiganders and their families are facing a devastating health crisis or just need basic care, URC university clinics, hospitals, and specialty medical centers are often the place they turn to for treatment.

Combined the URC institutions have more than three million patient care visits each year. They perform tens of thousands of surgeries, serve more than 100,000 patients in emergency rooms, and are a leading provider of many types of specialized care.

Providing care for this many people takes a large and talented workforce, and the URC is a vital source of much of this talent. From 2011 to 2015, 45 percent of the medical science degrees awarded in Michigan were awarded by URC universities. The URC's presence is particularly notable in the education of physicians, with 54 percent of dentistry degrees, 99 percent of Doctor of Medicine degrees, and 100 percent of all degrees in osteopathic and veterinary medicine awarded by URC schools. Many of these medical doctors stay in the state; forty-two percent of the state's practicing physicians attended a URC medical school (Public Sector Consultants 2013).

The depth and breadth is impressive at Michigan Medicine, the academic medical center of the University of Michigan. It is one of the largest healthcare complexes in the world, encompassing U-M's medical education, research, healthcare, and patient care entities. With approximately 1,200 residents training in their area of specialty, U-M Medical School has the fourth-largest residency program in the United States. U-M's advanced facilities and clinicians make it a destination for medical care, much like the Mayo and Cleveland Clinics.

MSU's offerings are distributed and diverse including its College of Human Medicine, College of Osteopathic Medicine and its College of Nursing. The MSU College of Human Medicine was one of the nation's first community-based medical schools, and has been partnering with local communities to deliver care since 1964. It has a presence in communities from Flint to the Upper Peninsula. MSU's focus on community-based clinical training has translated to 4,000 physicians in Michigan communities that hold clinical faculty appointments and volunteer their expertise to educate MSU medical students, nurses and residents.

MSU's College of Osteopathic Medicine has sites in East Lansing, Clinton Township, and Detroit. Nearly 85 percent of its 2016 entering class were Michigan residents and two-thirds of the college's graduates remain in Michigan, making it an essential source of physicians for the state. The college attracts more funding from the National Institutes of Health than any other osteopathic college.

The WSU School of Medicine's urban setting gives the program a competitive advantage in attracting students seeking to play a role in urban care and to help address health disparities. Nearly all WSU medical students are engaged in the community and participate in outreach programs, such as volunteer work at free medical care clinics throughout the city of Detroit. WSU physicians provide world-class medical care in the university's many affiliated partners. WSU doctors diagnose and treat some of the most complex medical cases in the state, bringing the newest technology and latest medical advancements

From 2012 to 2016, the URC had the following results relating to the life, medical, and health sciences:

1,348 inventions reported
by researchers
380 U.S. patents issued



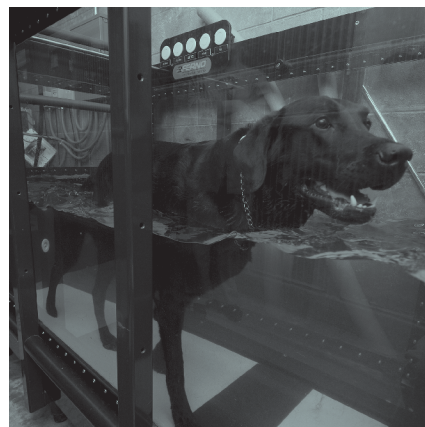
433 new license
agreements
32 new startup
companies



\$142 million in
royalties earned



With \$1.2 billion in
academic R&D in these
sectors occurring at the
URC institutions in 2015,
the URC is one of the top
research centers in the
world.



to patients. These physicians, leaders in their respective fields, conduct groundbreaking research and help make WSU one of the nation's top medical universities. In addition to their clinical practice and research, WSU doctors train Michigan's future physicians, instructing 1,200 medical students and 900 hospital residents annually, many of whom stay in Michigan to practice medicine.

The URC is also home to many specialized medical facilities. WSU partners with the Barbara Ann Karmanos Cancer Center, with every basic science researcher and clinician at the center a member of the WSU faculty. U-M's C.S. Mott's Children's Hospital provides specialized healthcare not offered elsewhere in the state to newborns, children, and pregnant women, who are cared for in the Von Voigtlander Women's Hospital, which shares a floor with the C.S. Mott Children's Hospital. MSU's Veterinary Medical Center, a teaching hospital, provides world-class care to large and small animals, supporting agriculture and caring for companion animals.

Peer University Clusters



Michigan is competitive nationally in the life, medical, and health science fields because of the URC, which brings in virtually all the state's academic research dollars and awards most of the state's advanced degrees. The URC represents a cluster of high-power research universities, and it often benchmarks itself against the seven other leading university clusters from around the nation. These clusters are in Northern California, Southern California, Illinois, Massachusetts, North Carolina, Pennsylvania, and Texas.

The URC ranks first among the eight university clusters in terms of the importance of each cluster to its respective state, with virtually all of Michigan's academic R&D expenditures in the life, medical, and health sciences (95 percent) occurring at the URC. In terms of total academic R&D spending in the life, medical and health sciences, the URC ranks fourth among these prestigious clusters. Looking at state totals (more than just clusters), Michigan ranks 11th among all 50 states in total academic R&D expenditures (NSF n.d.b). That the URC is responsible for 95 percent of all academic R&D in the state in the life, medical and health sciences speaks to the value of the cluster to the competitiveness of the state as a whole.

The URC is an important source of talent in the life, medical, and health sciences; it ranks first in degrees awarded in these fields among the eight university clusters with 44,422 graduates from 2011 through 2015. The URC also ranks first among the leading university clusters in the number of bachelor's, master's, and medical doctor degrees awarded.

Looking just within the state of Michigan, the URC awards 44 percent of life, medical, and health sciences degrees at the bachelor's degree level or higher as well as 49 percent of master's degrees and 83 percent of PhDs.

Michigan is a national power in the life, medical, and health sciences, and the URC is responsible for the state's competitiveness. The URC brings in the research dollars that support much of the state's cutting-edge research, and it trains the researchers that make Michigan attractive to employers, investors, and federal agencies supporting research.

Technology Commercialization



Technology commercialization is an important outcome of the university research process, and the life, medical, and health sciences represent a significant share of this process at the URC. Technology commercialization refers to taking discoveries and inventions out of the lab and bringing them into the real world. However, moving a new drug or invention from the lab to the market can take years of expensive additional research. The technology commercialization processes at URC universities help find the ways to extend the research to make this happen by protecting intellectual property through patents and copyrights, finding partners to fund additional research, helping to license technologies, and helping to launch new startup firms.

From 2012 to 2016, the URC had the following results relating to the life, medical, and health sciences:

- 1,348 inventions reported by researchers
- 380 U.S. patents issued
- 433 new license agreements
- 32 new startup companies
- \$142 million in royalties earned

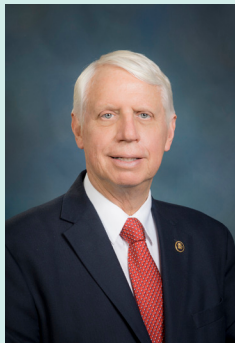
These totals represent an average pace of 22 new inventions reported by URC researchers in the life, medical, and health sciences each month. In addition, over this period the URC institutions averaged six patent awards and seven license agreements each month, and a new startup company was formed roughly every other month. Life, medical, and health sciences startups accounted for 40 percent of all URC institution startups from 2012 to 2016. The life, medical, and health sciences generated \$142 million in royalties, over 80 percent of the royalty income earned over this period.





Strong Presence and Impact on Michigan

The institutions of the University Research Corridor (URC), one of the nation's leading university clusters, are changing lives through groundbreaking research, talent development, and innovation. Some of the most impactful and ambitious research underway at URC schools is focused on challenges in the life, medical and health sciences. This research advances global scientific discovery while generating a significant contribution to the state's economy. It also fosters unique levels of collaboration and partnership among key business, government and community leaders.



Jim Haveman

"In the past 10 years, the URC has made significant contributions to the medical and health science marketplace in both Michigan and across the country," said Jim Haveman, retired Director of Community Health for Governor Engler and Governor Snyder. "Much of the universities' funding focuses on addressing crucial health issues [seen across the nation], and we are especially fortunate for the URC's interminable commitment to

and support of community and mental health efforts in our state."

Community health has been a significant focus for all URC schools for many years. WSU research and advocacy on health disparities in urban areas is helping diverse populations gain better access to care and achieve better outcomes. Michigan Medicine at U-M has a global reputation as a leader in patient care, research and education. The MSU College of Medicine has locations across the state,



Michael Jandernoa

focused on delivering primary and specialty care while providing clinical training for Michigan's future physicians. Overall, the URC is increasing research and development expenditures, making discoveries that improve everyday life, and advancing innovations from concept to marketplace.

"The URC is an incredible asset for our industry, state, and citizens in terms of the scale of

R&D conducted at its universities in critically important areas, such as biomedical engineering, bio-agriculture, veterinary medicine, pharmacology and health disparities," said Michael Jandernoa, Former Chairman of the Board and CEO of Perrigo Company. "Medical and healthcare discoveries with the potential to improve and save lives position Michigan as a top state for innovation in the life, medical and health sciences."

The URC's focus on specialized medical services and research, across multiple sectors, has led to productive collaborations with a variety of world-class healthcare providers, such as the Barbara Ann Karmanos Cancer Institute and Mott Children's Hospital. The MSU Veterinary Medical Center partners with private practitioners across the state, sharing resources and knowledge. In addition to partnering with established institutions, the URC is helping create future industries by bringing new innovations to the marketplace through licensing or patent activity. During the past several years, the URC institutions have developed and expanded entrepreneurial incubators, as well as services and programs to assist with business formation, planning and growth. These services—along with the relationships the universities have fostered nationally and around the world—contribute to the successes of startups.



Mina Sooch

Mina Sooch, President, CEO and board member of Gemphire Therapeutics; former CEO, co-founder and principal of Apjohn Ventures; and prior member of a number of private, public and VC industry boards, stated, "As a serial entrepreneur and venture investor based in Michigan since 2000, I've experienced first-hand the innovation-rich environment provided by the presence and accessibility of the URC that

enables Michigan's life sciences sector to thrive, attract venture investment, and create opportunities for business and job growth. Apjohn Ventures has made investments in a number of companies founded on a university technology licensed from a URC institution or that were university startups, including RenaMed Biologics, CytoPherx, and ProNAi Therapeutics."

With over \$1.2 Billion in research and development expenditures on an annual basis the URC is a research juggernaut. Each day thousands of researchers and clinicians come to work committed to discovering treatments and/or cures which will impact the lives of Michiganders, and people around the world.

“The University Research Corridor showcases Michigan’s world class universities, economic competitiveness, and scientific breakthroughs being made every day in our state,” said The Honorable Debbie Stabenow, U.S. Senator from Michigan. “This innovative partnership is creating jobs, fostering relationships with all types of businesses, from our largest corporations to smallest entrepreneurial businesses, and driving innovation in all sectors of our economy. The impact of the Corridor on healthcare has been especially important in pushing boundaries of medical science to improve people’s health and medical care.”

The URC produces medical talent on a grand scale, conferring more medical degrees than any other university cluster in the nation, educating 92 percent of the medical doctors who graduate each year in Michigan. Additionally, these universities operate or partner with hospitals that treat the highest level of trauma as well as those with the greatest need for specialization, ultimately drawing patients from across the nation and around the globe. The impact of the

URC’s medical education can be felt every day, from urban cores to rural community clinics.

“The University Research Corridor helps make Michigan a leader in granting medical degrees and educating highly-qualified nurses and doctors with specialized knowledge and skills,” stated Brian Peters, CEO of the Michigan Health and Hospital Association, the statewide leader representing



Brian Peters



Debbie Stabenow

Michigan’s community hospitals. “Michigan hospitals are equally invested in graduate medical education of physician residents. Taken together, these efforts make Michigan a national leader in growing and retaining physician talent, which is critical to ensuring healthy, vibrant communities.” Medical talent produced by the URC continue to develop and deliver effective and innovative treatments that promote physical and mental wellness. Competing with the nation’s top university research clusters, the URC attracts billions of dollars in national funding for R&D, which not only leads to life-saving discoveries, but also supports a robust entrepreneurial environment in the life sciences.

The net effect of the URC in the life, medical and health sciences can be measured in many ways, from lives saved to dollars invested to jobs created. At the same time, what cannot be fully measured – but nevertheless appreciated – are the new moments, new chances and new hopes that URC research, and its results, offers so many every day. This collective benefit continues to grow every year with every new inspiration and novel innovation, strengthening our state, our nation and our world in the process.



OVERVIEW

What are the Life, Medical, and Health Sciences?

The URC, which consists of MSU, U-M, and WSU, represents the largest research universities in Michigan and ranks as one of the nation's top university clusters. The URC leads Michigan in the areas of talent production, academic research, and economic development. The URC plays an important role in the life, medical, and health sciences. These sectors include a broad array of disciplines—including agriculture, biology and bioengineering, medical and health sciences, veterinary medicine, and more. The URC has a deep connection with these fields as a leading research cluster, key source of talent, deliverer of care, and economic driver.

The URC's work in these areas touches the lives of Michiganders in many ways. Findings from URC research save lives and change the world. Work in these sciences helps find cures for debilitating diseases, develops new pharmaceuticals for both humans and animals, increases the security of the food supply, and improves the health and quality of life for Michiganders in many other ways. URC

research brings substantial federal dollars to Michigan's economy. Finally, URC institutions deliver care to residents across the state through regional hospitals and clinics and specialized medical centers. Many of Michigan's medical practitioners, particularly physicians, were educated at URC medical and nursing schools.

The life, medical and health sciences represent a broad array of disciplines. These disciplines are related to and overlap with one another, which can lead to some confusion. In general, these fields all involve the biology and health of people, plants, and animals. The disciplines include agriculture, biology, medicine, and related fields like bioengineering. The medical sciences include the study and practice of diagnosis, treatment, and prevention of disease in humans and animals. Researchers focus on individual patients, and include activities such as clinical trials. The health sciences study the application of scientific knowledge to practical and clinical practices that serve to maintain and improve the health of people and animals. The focus of researchers is at the community level, and includes things like vaccination practices and policies to help prevent disease.

The life, medical, and health sciences play an important role in diversifying Michigan's economy. The sector also helps to stabilize the economy. During the long downturn



of the 2000s, the life, medical, and health sciences sector steadily added jobs, while the rest of Michigan's economy, weighed down by a decline in the manufacturing sector, steadily lost jobs. Michigan's downturn would have been much worse without the growth of the life, medical, and health sciences sector.

Throughout this report, the life, medical, and health sciences are presented together, because there is so much overlap between the three categories. The life, medical, and health sciences can also be divided into the following categories:

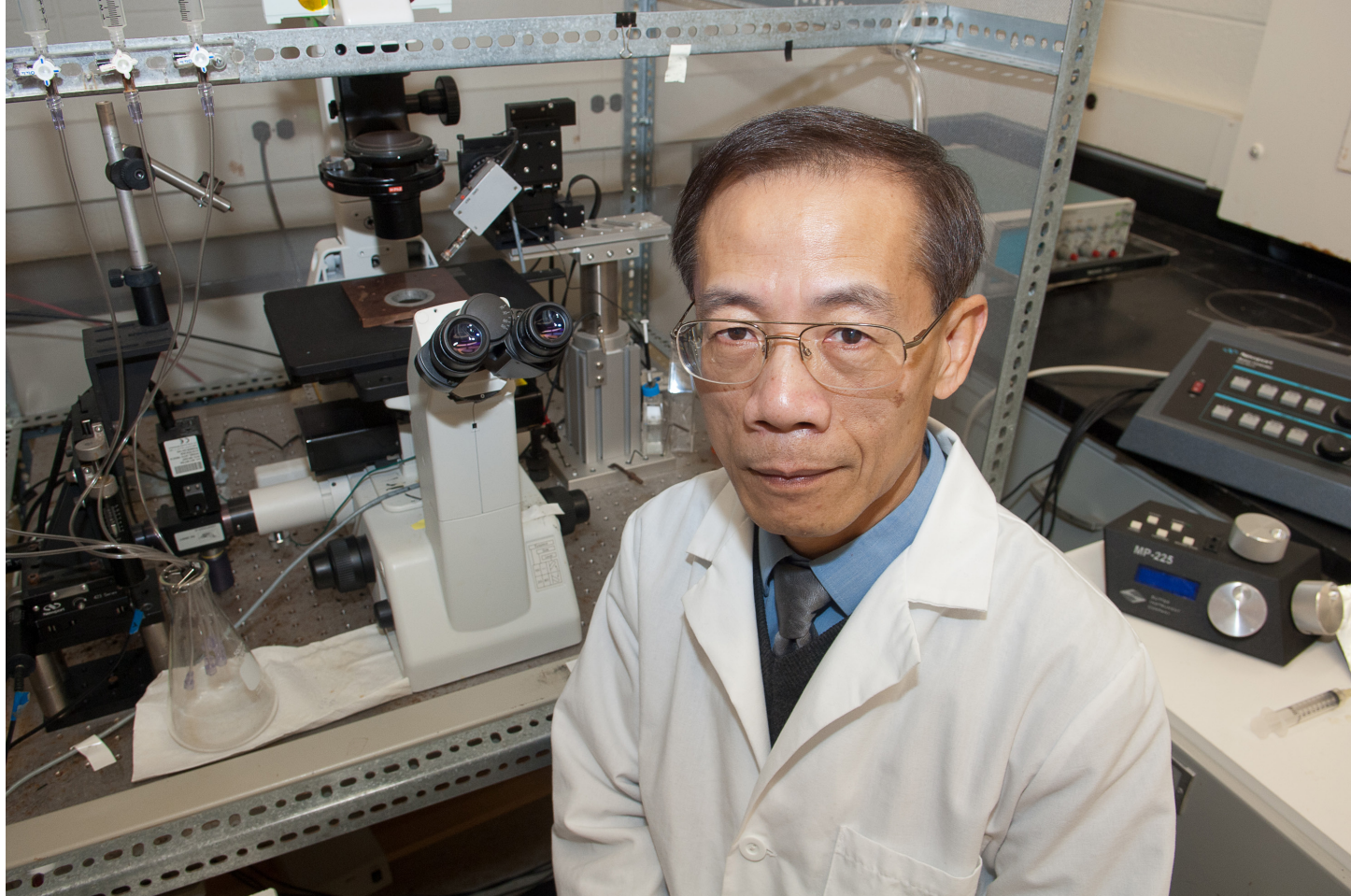
- Agricultural sciences
- Bioengineering and biomedical engineering
- Biological sciences
- Medical sciences
- Psychology
- Other life sciences

The agricultural sciences deal with food and fiber production and processing. Included in this category are soil cultivation, crop cultivation and harvesting, animal production, and

the processing of plant and animal products for human consumption and use (Ekstrom et al. 2016). The biological sciences are the study of living things, while bioengineering is the application of engineering principles to biological systems and biomedical engineering applies engineering principles to healthcare. Finally, psychology is the study of the mind and human behavior.

The URC examined the life sciences in a 2009 report, on which this report builds (Sallee, Doe, and Anderson).² It includes the URC's important role in delivering healthcare services to the people of Michigan, something that was outside the scope of the original report, and it takes a deeper dive into the important research occurring at the URC universities. This new report coincides well with the tenth anniversary of the URC, since its origins date back to 1998, when the institutions decided to join forces to leverage their collective expertise as part of Michigan's Life Sciences Corridor.

² The URC's 2009 life sciences report did not include in its industry definition primary healthcare services delivered in physician's offices, hospitals, and clinics. Since these services are included in the definitions used in this report, the figures reported in this report are not directly comparable to the 2009 report.



RESEARCH

Overview

Science advances through the collective effort of researchers who learn from one another and build on one another's work, and there are few places in the world that conduct the breadth and depth of life, medical, and health science research that occurs at the URC universities. Their large concentration of top researchers creates a community and environment in which groundbreaking discoveries can be made. URC research and discoveries in the life, medical, and health sciences often have a direct, practical impact on people's lives. For example, the URC is finding ways to decrease infant mortality. It is also working to find cures and treatments for cancer, Alzheimer's disease, ALS, and many other devastating diseases. Engineering research is helping to improve the quality of prosthetic limbs and internal organs and structures. Agricultural research is helping to increase crop yields and improve the security of the food supply. URC researchers are working to address disparities in health outcomes and the availability of care. Some URC research creates significant economic benefits from patents, licensing, and successful startup companies, which yield funds that can be used to support additional research. The URC completes \$1.2 billion in life, medical, and health science research each year.

URC researchers are collaborating across institutions to leverage their respective expertise to help solve big problems. The Environmental Influences of Child Health and Outcomes (ECHO) study is a good example of this type of work. This NIH-funded project leverages the

collective expertise of the URC to study factors influencing child health, including investigators from U-M School of Public Health and Institute for Social Research, WSU Center for Urban Responses to Environmental Stressors, and MSU College of Human Medicine. This research builds on previous collaborative research the URC supported for the National Children's Study, and is helping to determine how to best address important issues like autism spectrum disorder, low birth weight, and childhood obesity.

Historically Important Research

Through the decades, URC research has led to cures that have saved countless lives. Ground-breaking anti-cancer therapy Cisplatin was developed 50 years ago at MSU. Known as the "penicillin of cancer drugs," Cisplatin was one of the first widely prescribed and highly effective cancer drugs (MSU Innovation Center June 2016), and it has changed the outlook of some cancers from a near death sentence to a highly treatable disease. For example, testicular cancers, which affect approximately 8,700 men in the United States each year, used to have a survival rate of just 10 percent, but Cisplatin—combined with early detection—has raised that rate to close to 100 percent (American Cancer Society 2016). Cisplatin has also helped lower the rates of death from cervical, lung, head and neck, bone, and ovarian cancers.

Cancer research at WSU helped to synthesize a new class of drugs to advance cancer treatments, including the discovery of azidothymidine (AZT) in 1964. AZT, which was developed as an anti-cancer drug, was the first drug approved for the treatment of HIV infection and AIDS (WSU School of Medicine 2012). AZT has been demonstrated to decrease the mortality and frequency of opportunistic infections in people with AIDS or AIDS-related complex (Fischl et. al. 1987).

U-M played an important role in the development of the polio vaccine. U-M professor Thomas Francis Jr. led the field trials that demonstrated the vaccine's effectiveness. More than 1.8 million children participated in the study, and 100 U-M staff and faculty participated in the trials. The announcement that the vaccine was "safe, effective, and potent" was made at U-M's Rackham Auditorium and broadcast on closed-circuit television to 54,000 physicians across the United States (U-M Alumni Association 2015).

WSU surgeon Dr. Forest Dewey Dodrill was the first to use a mechanical heart pump on a patient. Dr. Dodrill and his medical team worked with a group of scientists and engineers at the General Motors Research Laboratories to develop the Dodrill-GMR Mechanical Heart. In 1952, this mechanical heart was first used successfully during

surgery. Some form of heart-lung machine is now used in more than one million open heart operations around the world each year (GM Heritage Center 2015).

The URC has also made important breakthroughs in agriculture. In 1873, MSU botany professor W.J. Beal helped to develop hybrid corn, which doubled the yield of corn plantings at the time (MSU n.d.). In the 1930s, MSU professor G. Malcolm Trout was credited with helping to make homogenized milk feasible by linking the processes of pasteurization and homogenization in production. He also worked closely with the dairy industry to develop new processes to make cheeses, yogurt, and other products (New York Times 1990). MSU's Veterinary Diagnostic Laboratory plays an important role in Michigan and nationally in identifying, tracking, and addressing emerging animal and public health issues. The facility works with public health officials to address important topics like avian influenza, West Nile virus, and chronic wasting disease (MSU Diagnostic Center for Population and Animal Health 2009).

Current Research and Future Outlook

URC researchers continue to push for solutions to a wide range of pressing medical and health problems, like Alzheimer's disease, ALS, cancer, and more. One of the best illustrations of the URC's commitment to address complex health problems is in the area of reducing infant mortality. In 2016, a WSU study on preterm birth (birth before 37 weeks of pregnancy) was published in *Nature Medicine*, a premier biomedical research journal. Preterm birth affects up to one in every six births in the United States, and is the number one cause of infant death and is a contributor to many long-term illnesses. A WSU School of Medicine team of researchers discovered how a type of a mother's immune cells (B lymphocytes) can help avoid inflammation-triggered preterm birth. After performing various studies on animals, the researchers filed a patent for this potential therapeutic approach, working closely with WSU's Technology Commercialization Office (WSU Division of Research 2016).

Through the NIH-funded Perinatology Research Branch (PRB), WSU researchers recently discovered a simple and cost-effective way to screen expectant mothers for potential risk of preterm birth. Women are screened with a simple ultrasound; their risk is identified based on the length of their cervix. Prescribing progesterone to at-risk women can cut the chances of early delivery in half, and the treatment is noninvasive and low-cost.

A recent study by an MSU professor in reproductive



Saving Lives, One Test at a Time

"The rate of infant mortality in Detroit has been unacceptably high for too long," said Detroit Mayor Mike Duggan.

The loss of a child is devastating and the leading cause of infant death is premature birth. According to the March of Dimes, Michigan's preterm birth rate in 2015 was 9.9 percent, exceeding the national average of 9.6 percent. The rate of preterm birth in Detroit was even higher, but now groundbreaking research at Wayne State University (WSU) has the potential to dramatically decrease the number of preterm births, saving lives and reducing complications.

Focusing on factors that contribute to infant mortality, such as premature birth, WSU researchers recently developed a simple and cost effective technique based on research showing preterm births are more frequent among women with a short cervix. This research was conducted by the Perinatology Research Branch (PRB) of the Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health (NICHD/NIH) located at the Wayne State University School of Medicine and the Detroit Medical Center in one of the few NIH research facilities located outside Bethesda, MD.

Screening pregnant women with a simple ultrasound test and treating those who are at risk for preterm delivery with an inexpensive and noninvasive hormone gel can reduce the chance of early delivery in these women by nearly half. Requiring no new procedures, nor long-term drug development trials, the two-step process has been implemented since its discovery for immediate and lasting impact.

The findings come from collaborative research work at over 40 medical centers worldwide, led by Roberto Romero, M.D., chief of the PRB and principal investigator on behalf of NICHD/NIH. WSU served as the lead center in the trial, under the direction of Sonia Hassan, M.D., associate dean for Maternal, Perinatal and Child Health.

As a result of this work, Michigan's Infant Mortality Reduction Plan of 2012 and 2016 included universal cervical screening and vaginal progesterone therapy for women as a strategy for lowering the risk of preterm birth. Screening is part of the Make Your Date™ Detroit program, an initiative started at Wayne State University by Dr. Hassan and supported by a coalition of civic leaders and medical experts working to help expectant mothers in Detroit deliver healthy, full-term babies.

A leading partner of the initiative, Detroit Mayor Mike Duggan said, "The Make Your Date program is doing great work helping expectant mothers bring their babies to full-term and giving them the best chance possible at a healthy start to life."

Since its start in 2014, Make Your Date™ Detroit has made a positive difference in the lives of mothers and babies, reducing premature birth by implementing evidence-based strategies through education, collaboration and partnerships with health care systems, universities and other established programs in the Detroit area. Efforts to implement the two-step screening and treatment process, key elements of the initiative, continue across the state.



physiology found that providing women with a follicle-stimulating hormone, something commonly prescribed during in vitro fertility treatments, can reduce live birth rates, a finding counter to what many believed (Research at MSU n.d.). The MSU College of Human Medicine administers the nation's only training grant in perinatal epidemiology and the nation's largest ongoing epidemiological study of the biopsychosocial origins of preterm delivery.

U-M researchers recently found that the children of women who are obese are twice as likely to die during the first year of their life as children of women who are viewed as "normal weight." This discovery suggests that reducing obesity in women may be a way to reduce overall infant mortality rates (U-M Human Growth and Development n.d.). U-M researchers also recently found that higher cigarette taxes can lead to a lower infant mortality rate. In research done jointly with Vanderbilt University, U-M researchers found that every \$1 increase in the tax on a pack of cigarettes was associated with 750 fewer infant deaths each year (Michigan Medicine 2015).

URC researchers are at the forefront of developing the next generation of pharmaceuticals. U-M researchers at the Life Sciences Institute have found that Amlexanox, an asthma drug that is currently off patent, reduces obesity, diabetes, and fatty liver in mice. Amlexanox can help reduce the metabolic response that often makes it difficult for dieters to successfully lose and keep off weight. While the results of the research on mice is exciting, researchers have not yet determined if humans will respond to the drug in the same way. However, given that 29 million people in the United States have diabetes, this drug has the potential to provide significant benefits to many people (Michigan News 2013).

Researchers at WSU are working to develop the next generation of antibiotics. The project will study aminoglycoside antibiotics (AGAs) that have long been used as potent broad spectrum antibiotics. AGAs are susceptible to resistance, and have severe side effects. WSU researchers are working to develop new AGAs that do not suffer from resistance and have less severe side effects. This work is critical to help address new cases of drug-resistant bacteria, which are becoming a major global health crisis (WSU College of Liberal Arts and Sciences 2016).

Researchers from MSU's College of Osteopathic Medicine have made a significant breakthrough in discovering a chemical compound, and potential new drug that reduces the spread of melanoma by up to 90 percent. Melanoma is the most dangerous form of skin cancer, and approximately 76,000 new cases of melanoma are diagnosed in the United States each year. The disease is frequently fatal because it can quickly spread throughout the body. The

compound reduced the migration of melanoma cells by 85 to 90 percent and greatly reduced tumors in the lungs of mice that had been injected with human melanoma cells. Most people who die from melanoma die because the disease has spread, and this compound has the potential to significantly increase the survival rate (Research at MSU n.d.b).

Advances in technology and bioengineering have created opportunities for new ways to address disease and injuries. Researchers at U-M have saved the lives of multiple babies suffering from restricted or collapsed airways. Doctors and biomedical engineers created a bronchial splint using a CT scan and 3-D printer. Prior to the insertion of the splint, the children stopped breathing on a frequent basis. (Michigan Medicine, U-Michigan Engineering 2013).

Researchers at MSU are working on developing implantable brain-machine interfaces that allow the control and communication of prosthetic devices (e.g., robotic limbs) with neurons through an individual's brain signals. This provides a new therapy to restore motor control in patients suffering some severe disabilities, such as spinal cord injury and stroke (MSU College of Engineering n.d.).

WSU's College of Engineering's Advanced Human Modeling Laboratory uses high-performance computing to model humans from head to toe. The modeling being done in this lab is helping to improve vehicle safety, and is being used by the U.S. Army to help prevent blast-related brain injuries (WSU College of Engineering n.d.).

At MSU, researchers are helping to rid the world of devastating diseases like Zika and dengue. Through the Sun Yat-Sen-Michigan State University Joint Center of Vector Control for Tropical Disease, an MSU researcher created a "mosquito factory" in Guangzhou, China, where lab technicians breed mosquitoes infected with bacteria that prevent them from transferring deadly viruses to humans (Josuka 2016). The infected male mosquitoes are released into the wild, where they mate with female mosquitoes, rendering them sterile, and preventing disease transmission. This work has led to additional funding to build a second mosquito factory in Yucatan, Mexico, extending MSU's work and impact (Research at MSU n.d.c).

Mental Health

In many ways, mental health is as important as physical health. Untreated mental health issues can have significant negative consequences for individuals, their families, and society at large. As many as one in four people has symptoms of a mental health illness. The URC plays a major role in mental health research and treatment in Michigan. The universities conduct research, train practitioners, and

treat patients. The scope of the work done by the URC is broad, and this section contains a sample of the many types of mental health work done by the universities.

The mission of U-M's Depression Center is to "detect depression and bipolar disorders earlier, treat more effectively, prevent recurrences and progression, counteract stigma, and improve public policy." The center brings together researchers from more than 30 disciplines to research the causes and consequences of depression and improve the quality of life of those affected and their families (U-M Depression Center 2016).

In 2016, WSU was awarded a five-year grant from the National Institute of Mental Health for schizophrenia research. Schizophrenia can impair learning and memory. Researchers at WSU will explore the underlying mechanisms of learning and memory in patients with schizophrenia from the perspective of brain plasticity, function, and network dynamics (WSU School of Medicine September 9, 2016).



"In the past 10 years, the URC has made significant contributions to the medical and health science marketplace in both Michigan and across the country. Much of the universities' funding focuses on addressing crucial health issues [seen across the nation], and we are especially fortunate for the URC's interminable commitment to and support of community and mental health efforts in our state."

Jim Haveman

Retired Director of Community Health for Governor Engler and Governor Snyder

Researchers at MSU are conducting a four-year study known as the SPIRIT Trial, or Suicide Prevention for at-Risk Individuals in Transition. The study looks to reduce suicides among recently released jail detainees. The study will follow 800 recently released detainees from Michigan and Rhode Island. Each is randomly assigned to the current standard practice of care or a newer intervention strategy. The study's author notes that one in 34 people in the United States is

currently involved with the justice system, so addressing the heightened rate of suicide among recently released inmates is extremely important (MSU n.d.b).

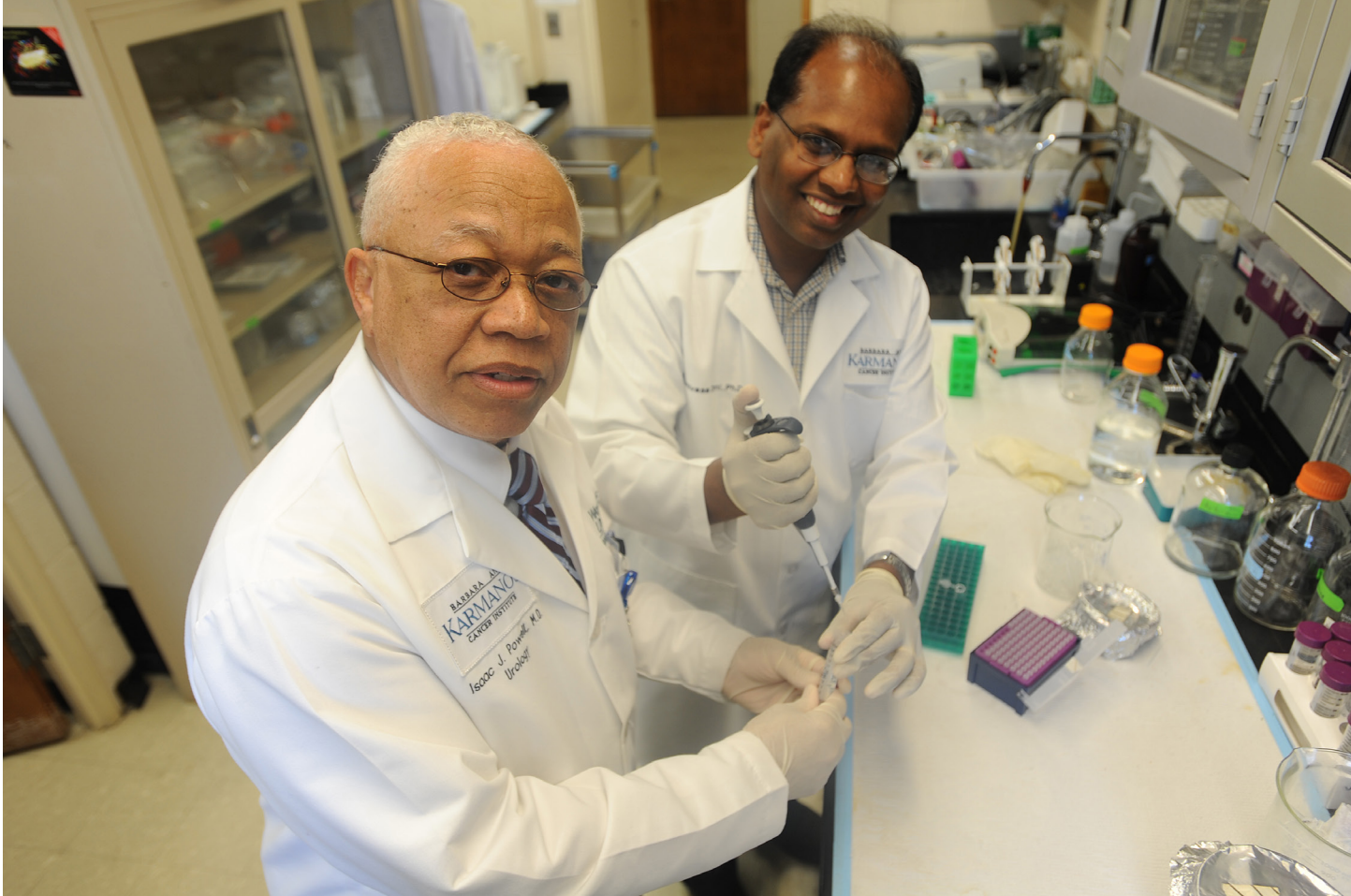
WSU has provided advanced training in infant mental health through the Merrill Palmer Skillman Institute (MPSI) for Child and Family Development. Infant mental health involves a child's social and emotional development from birth through age three (Zero to Three 2017). MPSI offers a dual degree in infant mental health. This degree prepares clinicians, educators, and researchers for research and practice. Graduates have a good understanding of both research and clinical work with infants and families (MPSI n.d.).

U-M's Molecular and Behavioral Neuroscience Institute (MBNI) started as the U-M Mental Health Research Institute, which opened in 1955. U-M opened the Institute to help psychologists and psychiatrists explain mental illness in scientific terms. The MBNI has interdisciplinary teams who have made important discoveries about brain functions, mental health, and the factors that influence human behavior (U-M Department of Psychiatry 2016).

MSU annually holds a mental health conference for Muslims, the largest annual conference for Muslims in academic settings. The eighth annual conference was held in 2016; it focused on opiate addiction. The conference covered a range of topics, such as addiction training for imams, and helping communities address individuals who are affected by traumatic events, which can potentially be related to their status as refugees.

Health Policy

The URC's research role is not just in groundbreaking agriculture and medical discoveries, but also bridging the life, medical, and health sciences with public policy. Policy research helps to reduce health disparities and ensure that high-quality care reaches vulnerable populations. MSU's Institute for Health Policy's mission is to improve the health status of Michigan residents through research, policy analysis, education, and outreach, and support of quality improvement activities (MSU Institute for Health Policy 2016). U-M's Institute for Healthcare Policy and Innovation is focused on addressing today's healthcare policy challenges. Its work is focused on four key areas: evaluating healthcare reform, improving the health of communities and reducing disparities, driving greater value in healthcare, and innovating in the delivery of healthcare. The Institute's mission is to improve the quality, safety, equity, and affordability of healthcare services (U-M Institute for Healthcare Policy and Innovation 2017).



All three universities provide graduate-level education in public health—either through separate schools or through programs in their schools of medicine. The researchers and graduates of these programs work at the intersection of healthcare and public policy. For example, MSU professor Harold “Woody” Neighbors is working on developing community-based interventions with a focus on improving the health outcomes of black men. He is creating the Man Up Man Down Research Program, which will emphasize three areas: research on chronic disease management, community outreach and health engagement, and transdisciplinary (public health and medicine) research training for students from underrepresented populations (MSU Division of Public Health n.d.).

WSU professor Dawn Misra is studying the social and biomedical disparities in perinatal outcomes, which may help explain the increased risks to infants born to poor and minority women (WSU School of Medicine 2016). U-M Professor Nicholas Bagley is an attorney studying healthcare law with a focus on Medicare and the Affordable Care Act (ACA). His current research is focused on legal issues surrounding the implementation of the ACA. He is also working on alternate ways of regulating private health insurance in a post-ACA environment, including potentially

applying a public utility model to manage healthcare (U-M Institute for Healthcare Policy and Innovation 2017b).

Clinical trials

The URC institutions are major participants in clinical trials. Between 2011 and 2015, the URC universities either sponsored or participated in 1,185 clinical studies, representing close to one-third of those occurring in Michigan during this time. Clinical trials can be interventional or observational. In interventional studies, participants receive a specific medical intervention such as a drug, device, or procedure. In an observational study, the study group is observed as opposed to receiving a specific intervention. For example, children may be observed to help determine the impact of physical activity on obesity. Eighty percent of the clinical trials in which the URC institutions participated in were interventional.

These clinical trials provide significant benefits. They provide Michigan citizens, who choose to volunteer, the opportunity to participate in studies that contribute to medical knowledge. Before a treatment or drug can be put into widespread use, it often must first be vetted

through the clinical trial process. Clinical trials afford some participants the opportunity to receive a direct medical benefit by providing access to innovative care, procedures, or pharmaceuticals that are not yet widely available. Finally, having important research include groups in Michigan helps provide the research base to ensure that treatments are effective for everyone and minimize future health disparities.

Research Facilities

Some of the world's leading research facilities are located within the URC. These facilities bring together top researchers and world-class laboratories to produce innovative research in the life, medical, and health sciences. Some examples of these facilities are presented below.

Taubman Medical Research Institute

The Taubman Medical Research Institute is housed in the A. Alfred Taubman Biomedical Science Research Building on the medical campus of U-M in Ann Arbor. The mission of the institute is to "provide the university's finest medical scientists the freedom, resources, and collaborative environments they need to push the boundaries of medical discovery, to produce breakthroughs in the cures and treatment of disease, and ultimately alleviate human suffering" (A. Alfred Taubman Medical Research Institute 2011). In short, the institute focuses on practical results and works with medical doctors with active practices who also direct their own research laboratories.

The scientists at the Institute are seeking cures and treatment for common and debilitating diseases and conditions. Research includes helping to prevent kidney damage resulting from elevated glucose levels in diabetes patients, investigating ways to prevent blood clots to find therapies to treat strokes and heart attacks, and identifying drugs that can make traditional chemotherapy ten times more effective.

Integrative Biosciences Center (IBio)

WSU's IBio Center is a facility designed to foster collaboration and a flexible team science approach to research located on a previously abandoned 2.7-acre city block in Midtown Detroit. The facility hosts over 400 individuals with 200,000 square feet of lab and clinical space. Dedicated to studying and eliminating the many health disparities that plague Detroit's residents, IBio houses faculty researchers with expertise in environmental sciences, bio and systems engineering, heart disease, diabetes, obesity, asthma, and biobehavioral health, as well as clinicians from the Henry Ford Health System, which has located its bone and joint research center on the first floor. The hope is that discoveries

made at IBio can apply not only to the surrounding Detroit community, but other urban areas as well.

WSU recently announced that it was creating the Center for Translational Science and Clinical Research Innovation, and that it would be located at IBio. The Center will consolidate existing resources and work more closely with the community to improve health care. Among the components of the new Center is the Center for Community Engagement and Health, which will work to facilitate the activities of the community, university, government, and nonprofit organizations. The Center will also include Clinical Research at One Wayne which will serve as a central contact point for coordinating industry-funded research, budgets, contracts, and trial designs (Nagl 2017).

Bio Engineering Facility

In late 2016, MSU opened its new 130,000-square-foot Bio Engineering Facility, which brings together dozens of researchers from across the campus. The building will house faculty scientists from the Colleges of Engineering, Human Medicine, and Natural Science. The facility will also house the new Institute for Quantitative Health Science and Engineering—an interdisciplinary research center devoted to basic and applied research. It will bring together the life sciences, engineering, information science, and other physical and mathematical sciences as well as biomedical engineering. The laboratories have an open-floor design to enhance collaborative research.

Research to be conducted at the facility includes developing models to help understand heart disease with the goal of developing more effective treatments, and developing and improving electrodes that can be implanted in the brain to better understand neurological function and treatments (MSU College of Engineering 2016).

C.S. Mott Center for Human Growth and Development and Perinatology Research Branch (PRB)

The C.S. Mott Center for Human Growth and Development is a basic research facility located on WSU's medical campus. The building houses the research laboratories of the Perinatology Research Branch of the National Institute of Child Health and Human Development (NICHD), the Implantation Laboratory of the Reproductive Biology and Medicine Branch, the WSU Genomics Facility, a Bioinformatics Center and a Systems Biology section. The C.S. Mott Center is working to foster basic and clinical biomedical research on reproduction and development (WSU School of Medicine 2016).

Attracted to the uniquely diverse population of Detroit, the expertise at WSU's Department of Obstetrics and



Busting Bacteria for a Safer Tomorrow

E. coli is a large, diverse group of bacteria often found in the intestines of humans and animals. While most strains are harmless, some can cause mild to fatal illnesses. *E. coli* has been widely associated with several foodborne illness outbreaks worldwide. In the United States alone, *E. coli* is responsible for approximately 100,000 illnesses, 3,000 hospitalizations, and 90 deaths annually.

One of the biggest challenges in the fight against *E. coli* is that its pathogens constantly evolve or acquire new characteristics that make them more resistant to antibiotics. In an evolutionary arms race at the molecular level, MSU is finding ways to protect people with new vaccines by forecasting how these pathogens will change. By maintaining a timely advantage, MSU researchers are equipped to develop the strategies needed to protect the world from the potentially devastating consequences of *E. coli*.

A recent study at MSU found that dairy cattle under stress from hot weather and energy loss from milk production were more likely to shed the Shiga toxin-producing *E. coli*, also known as STEC. Cattle are common carriers of STEC, and food or water contaminated with cattle feces is a common source of *E. coli* infections in humans.

The MSU study sampled more than 1,000 cattle from six dairy farms and five feedlots in Michigan.

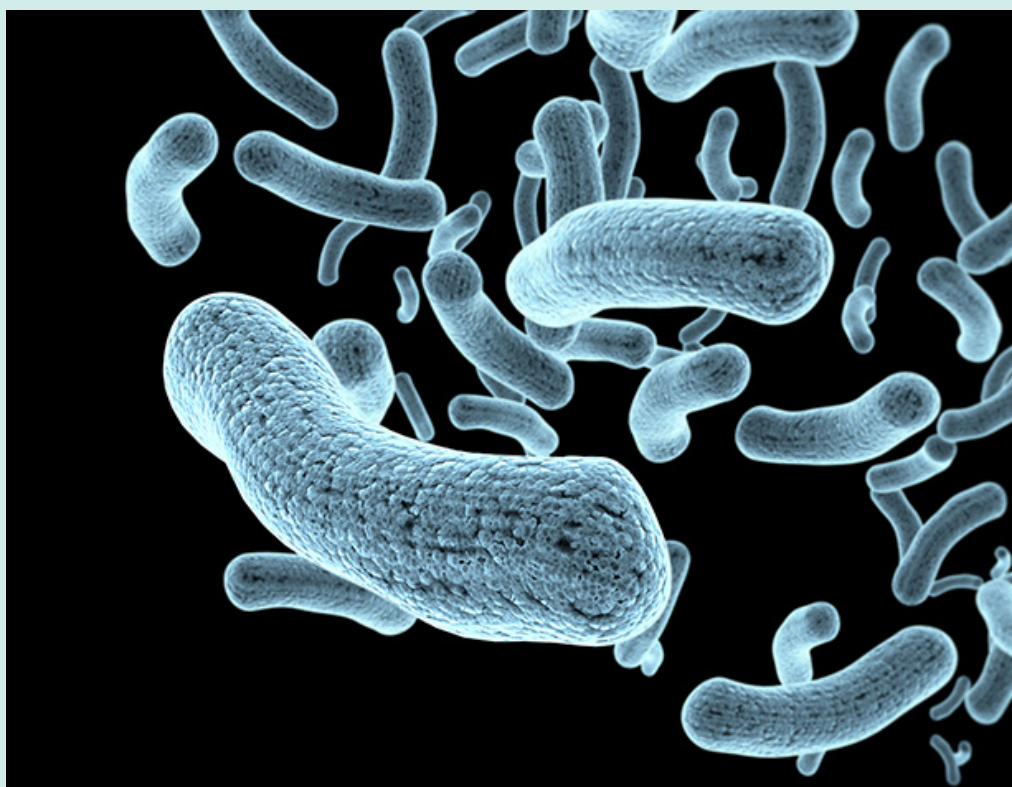
"Most importantly, our study involved cattle farmers who were willing to be involved in projects that help to improve the safety and quality of the food they produce," said Dan Grooms, MSU large animal veterinarian and a collaborator in the study.

"Reducing STEC colonization and shedding in cattle can decrease the likelihood of these bacterial pathogens from entering the food supply and causing foodborne infections in people," said Shannon Manning, MSU molecular biologist and principal investigator of the study. "By understanding

specific factors that increase the risks of STEC shedding in cattle, new management strategies, such as the isolation of high-risk animals, can be developed to limit transmission."

MSU researchers—including microbiologists, epidemiologists, animal scientists, veterinarians, farmers, and students—will continue to examine the diversity of different STEC strains that are shed and determine the rate at which animals acquire new STEC strains over time.

"We hope to assess how frequently individual animals acquire different types of STEC and determine which types are most commonly linked to disease in humans," Manning said. "It would have been extremely difficult to do this study without such a wide range of expertise."



This research occurs at MSU's Thomas S. Whittam STEC Center, and important national resources. MSU's STEC Center manages the national sampling of *E. coli* specimens. It serves as the repository for specimens, distributes sets of reference strains for use by investigators, and provides researchers with a standard reference collection of well-characterized strains and central on-line databases.



"The University Research Corridor showcases Michigan's world class universities, economic competitiveness, and scientific breakthroughs being made every day in our state. This innovative partnership is creating jobs, fostering relationships with all types of businesses, from our largest corporations to smallest entrepreneurial businesses, and driving innovation in all sectors of our economy. The impact of the Corridor on healthcare has been especially important in pushing boundaries of medical science to improve people's health and medical care."

U.S. Senator Debbie Stabenow

Gynecology, and the strength of WSU's hospital partners and the URC, the Perinatology Research Branch (PRB) is one of only a handful of NIH research facilities located outside Bethesda, Maryland. Housed at Hutzel Hospital, the PRB is focused on clinical and basic research in perinatal medicine in an effort to reduce infant mortality and physical disabilities, promote healthy pregnancy outcomes, and improve the healthcare of mothers and children. Having this NIH facility is a major asset to Southeast Michigan and the state providing Michiganders and Detroiters with access to the doctors and researchers on the cutting edge of treatments and strategies for improving pregnancy outcomes. Since its inception, the PRB has made many groundbreaking discoveries, including the identification of several DNA variants that predispose African Americans to a high rate of preterm delivery (WSU School of Medicine 2017).

AgBio Research Centers

MSU has 13 outlying research centers and several on-campus facilities that provide growers, natural resource managers, and commodity groups with critical information they need to remain viable and competitive in the global economy (MSU 2015). For example, the Clarksville Research Center hosts research on small fruits and fruit trees; research at the 440-acre site includes variety development, integrated

pest management, and new pruning practices to make production more profitable, efficient, and environmentally friendly (MSU 2015b). The Upper Peninsula Research and Extension Center, established in 1899, serves as a center for crop and livestock research for the U.P. Research topics include grass-based beef finishing, utilization of cover crops, hoophouse farming, season extension, and soil health. Outreach efforts focus on expanding producer knowledge of local food systems and developing market opportunities (MSU 2015c).

North Campus Research Complex

In 2009, U-M purchased a 2.2 million-square-foot office complex from Pfizer when the company ended operations in Ann Arbor and turned it into the expansive North Campus Research Complex, or NCRC (Woodhouse 2014). The NCRC provides space for U-M research teams to address major challenges, including new approaches to treating heart disease and targeted cancer therapies. Biointerface (BI) research includes those from engineering, science, and medical fields working in advanced materials, nanotechnology, microfluids and cell engineering to foster breakthroughs in the diagnosis and treatment of disease. An example of BI research is creating cutting-edge biomaterials to guide tissue regeneration, and developing novel mechanisms to deliver complex drugs to hard-to-reach places such as cancer cells for prolonged periods of time to maximize therapeutic efficacy (U-M Biointerfaces Institute 2014).

Veterinary Diagnostic Laboratory (VDL)

The VDL at MSU, formerly known as the Diagnostic Center for Population and Animal Health, has a mandate to protect the public by ensuring the health of animals in Michigan and the nation. The VDL helps identify and track emerging animal and public health issues. One of its first major efforts was to help the state cope with the discovery of human exposure to a fire retardant chemical that had been accidentally mixed with cattle feed. The center currently works with government officials to research and counter threats from things like avian influenza, bovine tuberculosis, and West Nile virus. The VDL handles 220,000 cases each year (MSU Diagnostic Center for Population and Animal Health 2009).

Life Sciences Institute (LSI)

U-M's LSI is an interdisciplinary science unit working to advance life science research. The LSI is housed in a 230,000-square-foot open-laboratory design building. It hosts the Center for Chemical Genomics, Center for Structural Biology, Center for Stem Cell Biology, and the Center for the Discovery of New Medicines. The LSI houses

faculty from a variety of life science disciplines who work collaboratively toward “a tangible impact on human health, longevity, and well-being (U-M LSI 2016).” LSI scientists explore the most fundamental biological and chemical processes of life.

Grand Rapids Research Center

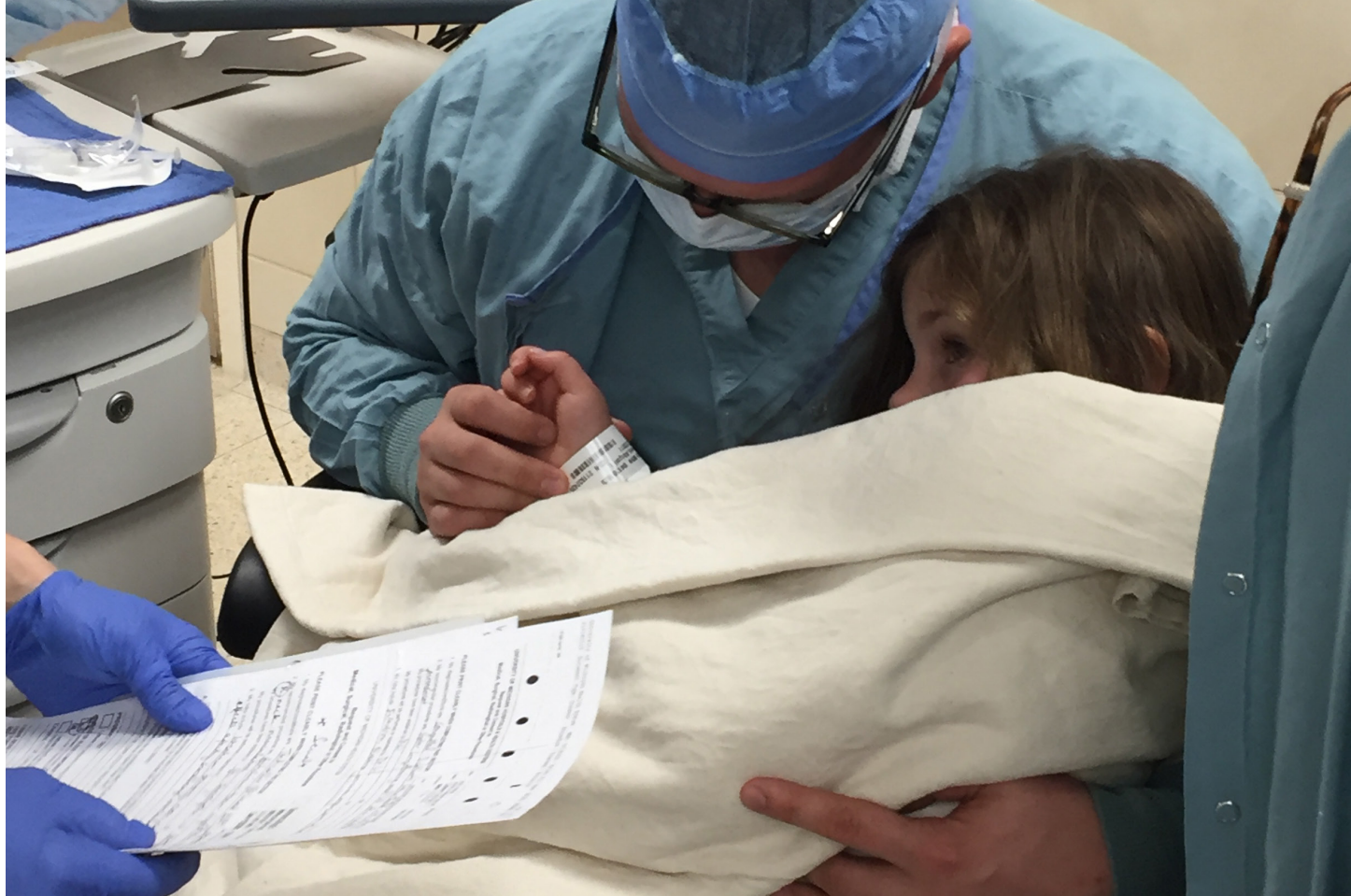
The MSU Grand Rapids Research Center is slated to open in the second half of 2017 and, when fully occupied in future years, will house up to 44 medical research teams. Areas of scientific study will include Parkinson’s disease, Alzheimer’s disease, pediatric neurology, autism, inflammation, transplantation, cancer, genetics and women’s health and reproductive medicine. Until it opens, MSU researchers are working at the nearby Van Andel Research Institute and at space made available by Grand Valley State University (GVSU). This facility is part of a long-run strategy of MSU partnering with GVSU and the Van Andel Research Institute to support new NIH funded researchers recruited to the Grand Rapids area.

- 1. WSU**
Schizophrenia research
- 2. U-M**
Kellogg Eye Center
- 3. MSU**
Throat and mouth cancer treatment
- 4. WSU**
Autoimmune disease vaccine research
- 5. MSU**
Cardiovascular disease research
- 6. U-M**
Heart transplant
- 7. WSU**
Lung cancer screening
- 8. WSU**
Leukemia treatment
- 9. MSU**
Type 1 diabetes management
- 10. U-M**
Brain Controlled Prosthetic Arm

- 11. WSU**
Orthopaedic surgery
- 12. U-M**
Kidney transplant
- 13. WSU**
Colorectal cancer screening
- 14. U-M**
Rheumatoid arthritis research
- 15. MSU**
Melanoma treatment research
- 16. U-M**
Sports injury treatment
- 17. MSU**
Prosthetic limb team
- 18. MSU**
Small Animal Clinic

Research from Head to Toe (and Beyond)





MEDICAL CARE

Overview

For most people, the medical sciences are the most easily understood of the life sciences because they have such a direct impact on our day-to-day lives. The medical sciences include the study and practice of diagnosis, treatment, and prevention of disease in humans and animals. Researchers focus on individual patients, and research includes activities such as clinical trials. The URC plays a critical role in the medical sciences—spanning education, research, and patient care.

The URC's presence in medical care is expansive and diverse, and each institution plays a unique role—for example, each URC institution has a distinctive approach to medical education. Combined, the diversity of what URC institutions offer in terms of educating health professionals and researchers, delivering patient care, and conducting research has a profound impact on human and animal health—both across Michigan and around the world.

The URC's presence includes the world-class academic medical center at U-M, now known as Michigan Medicine. Michigan Medicine, which encompasses U-M's medical education, healthcare research, and patient care is a leading medical complex and a destination for world class care. Michigan Medicine is one of the largest healthcare complexes in the world.

MSU played a trailblazing role in the development of one of the first community-integrated medical schools in the United States, and in veterinary education, most recently resulting in groundbreaking work to perform open-heart surgery on companion animals (MSU 2012). MSU's role in the medical sciences is distributed and diverse, with offerings through the Colleges of Human Medicine, Nursing, Osteopathic Medicine, and Veterinary Medicine.

WSU excels in its commitment to community outreach, finding creative ways to combine opportunities for hands-on training for health professionals with the healthcare needs of Michigan's diverse urban populations and conducting interdisciplinary research from prenatal to end-of-life care. Located in an enviable urban setting serving a uniquely important population, WSU School of Medicine is integrated within highly-specialized partner hospitals. It is targeted by students seeking opportunities to experience a wide-range of areas in medical care. Its location combined with its expertise and status as a national leader in health disparities research makes WSU a critical partner in medical research and clinical studies among its fellow URC institutions and universities and hospitals across the nation.

Training Medical Practitioners

The URC has been exceptionally important in the role of medical education. From 2011 to 2015, URC institutions awarded almost half of the medical science degrees in Michigan. Together, the URC institutions have a profound impact on educating not only doctors, but also other critical roles in medicine, including nurses, pharmacists, health workers, and researchers.

The URC's importance in training medical practitioners in Michigan is especially true when it comes to educating the most prestigious roles in medicine—physicians and dentists. A 2012 survey revealed that over 42 percent of the state's practicing physicians attended a URC medical school (Public Sector Consultants 2013). Compared with the rest of the country, Michigan is eighth in the nation for the number of medical school students it graduates (Kaiser Family Foundation 2017).

The URC's leading role in shaping medical education dates to 1875, when the University of Michigan Medical School discovered that one of several buildings that was being used as a hospital space was no longer sufficient, and decided that a new hospital should be built for medical school instruction. This decision made U-M the first medical school in the United States to build a university hospital for physician instruction. The Pavilion Hospital, as it was known, married architecture and public health—it was built of wood so that it could be burned to the ground if a contagion were

to occur (Tobin 2013).

Today, Michigan Medicine remains both an innovator and a destination for care. U-M Medical School is consistently ranked as one of the top medical schools in the country for training in research and primary care (U.S. News and World Report 2017). The Medical School is leading the way on initiatives to reform medical education to ensure it is adequately preparing doctors to deliver modern healthcare to patients. In 2014, the Medical School received a grant from the American Medical Association's Accelerating Change in American Medical Education Initiative to help formulate and implement a new curriculum for medical students (U-M Medical School 2014).

With approximately 1,200 residents training in their areas of specialty, U-M Medical School has the fourth-largest residency program in the U.S. (Greene 2014). The size and complexity of Michigan Medicine's hospitals and health centers allow U-M to offer physicians clinical training under faculty physicians in 105 accredited specialties, from primary care to highly advanced subspecialties.

The MSU College of Human Medicine (CHM) is one of the nation's first community-based medical schools, and has been partnering with local communities to deliver healthcare since its founding in 1964. With a presence in urban communities such as Flint, to rural towns in the Upper Peninsula, CHM was designed with a philosophy that emphasized clinical training in community hospitals. To implement this philosophy, the college formed a consortium of teaching hospitals in several Michigan communities, each with an assistant dean and staff of faculty coordinators for major medical specialties. In 1974, MSU developed a special program to address the healthcare needs of rural citizens in the Upper Peninsula. Students entering the College of Human Medicine who planned to serve a rural community upon completion of their medical training could apply to complete their clinical years in the Upper Peninsula. The headquarters for the College of Human Medicine is located in the college's Secchia Center in the downtown Grand Rapids "Medical Mile." The college has clinical campuses in Flint, Grand Rapids, Midland, Southeast Michigan, Traverse City, and the Upper Peninsula.

Today, the college's focus on community-based clinical training translates to nearly 4,000 physicians in Michigan communities that hold clinical faculty appointments and volunteer their expertise to educate CHM students and residents. Over its 30 years, MSU's Rural Medicine Program has led to an increase in physicians practicing in underserved areas, including the Upper Peninsula. Meanwhile, MSU's community/college collaborative model in urban areas played a central role in identifying elevated levels of lead in Flint's children leading to identifying the

water system as the source. In recognition of this emphasis on partnership with diverse communities, as well as efforts to improve healthcare across the state, CHM received the 2016 American Association of Medical Colleges (AAMC) Spencer Foreman Award for Outstanding Community Service (Jablrow 2016).



"The University Research Corridor helps make Michigan a leader in granting medical degrees and educating highly-qualified nurses and doctors with specialized knowledge and skills. Michigan hospitals are equally invested in graduate medical education of physician residents. Taken together, these efforts make Michigan a national leader in growing and retaining physician talent, which is critical to ensuring healthy, vibrant communities."

Brian Peters

CEO of the Michigan Health and Hospital Association

The MSU College of Osteopathic Medicine operates three sites to facilitate access and provide a variety of experiences—MSU's campus in East Lansing, Macomb University Center in Clinton Township and the Detroit Medical Center downtown. Its statewide campus system is one of the nation's largest graduate medical education consortia. The college collaborates with 47 hospitals and 31 Federally Qualified Health Centers throughout Michigan. In 2014-15 there were 1,752 physicians-in-training in 224 internship, residency and fellowship programs. Of its 2016 entering class, nearly 85 percent were Michigan residents and two-thirds of its graduates stay in the state to practice patient-centered care. The college attracts more funding from the National Institutes of Health than any other osteopathic college, a testament to the quality of its research.

The WSU School of Medicine and its faculty practice group, the WSU Physician Group, see and treat patients in hospitals and clinics throughout southeast Michigan. WSU physicians provide world-class medical care with the university's affiliated partners, including the Henry Ford

Health System, the Detroit Medical Center, the Barbara Ann Karmanos Cancer Institute, Crittenton Hospital Medical Center, the John D. Dingell VA Medical Center, St. Joseph Mercy Oakland, St. John Health and Beaumont Hospitals. These physicians, recognized as leaders in their specialties, conduct groundbreaking research and continuing education at Wayne State University, one of the nation's top medical universities.

WSU doctors diagnose and treat some of the most complex medical cases in the state, bringing the newest technology and latest in medical advancements to Michigan's largest population base. Their research brings them into partnership with that population because many studies rely on those very same patients, making WSU and its faculty physicians the experts in diseases and conditions endemic to the region. In addition to their clinical practice, they train Michigan's future physicians, instructing 1,200 medical students and 900 hospital residents annually. Most of those medical students remain in Michigan to practice medicine, addressing the state's shortage of physicians.

Nearly all WSU School of Medicine students are engaged in the community, and participate in outreach programs that aim to enrich their education by providing patient care and other services, such as volunteer work at free medical clinics throughout the city of Detroit (WSU 2016). The WSU School of Medicine partnerships and the immediate vicinity of the WSU School of Medicine and various nationally renowned medical institutions like the Henry Ford Health System afford students the opportunity to take advantage of learning at some of the best hospitals and with some of the most respected healthcare professionals in the United States. The WSU School of Medicine is the academic affiliate of the Barbara Ann Karmanos Cancer Institute, one of just 47 cancer centers designated by the National Cancer Institute.

URC institutions also educate professionals in other health areas, from nursing and other acute care to dentistry, pharmacy, public health, health promotion, and chronic care. U-M's School of Dentistry was founded in 1875. It has 15 programs and specialties, and is one of only two dental schools in Michigan. It has over 100 faculty members and more than 600 students. U-M and WSU have schools of pharmacy, the only schools of pharmacy in Michigan other than Ferris State University.

The URC institutions are leaders in training nurses. From 2011 to 2015, the URC awarded more than 5,200 degrees in nursing, over one-quarter of the nursing degrees conferred in Michigan at a bachelor's level or higher over this time-period. Efforts such as MSU's totally online registered nurse (RN) to bachelor of science in nursing (BSN) program and accelerated 15-month program to allow

students who already have a degree to earn their BSN help those already in the workforce move into nursing. This is especially significant as the nursing profession grapples with a shortage of workers and educators, as well as a changing healthcare landscape.

The URC institutions play a particularly important role in nursing research and training nurses with advanced degrees. From 2011 to 2015, the URC institutions awarded half of the state's master's degrees in nursing, one-third of the PhDs in nursing and three-quarters of the doctor of nursing degrees.³ The schools are also committed to clinical excellence and are national leaders in nursing research. Nursing school students and faculty at the URC institutions research pressing healthcare challenges including cancer, chronic illnesses, and helping those with specific health challenges.

Delivery of Medical Care to Patients

Building on their roles in medical education and research, URC institutions also provide medical care to Michigan residents through a variety of hospitals, clinics, and specialized medical centers.

The MSU Health Team—the faculty practice for MSU's two medical schools and its nursing school—occupies an important niche in the Greater Lansing market as one of the region's largest medical practices. The Health Team offers primary care and specialty healthcare services to the greater Lansing community through over 260 physician faculty and clinicians, including care in specialty pediatrics, radiology, neurology, and surgery (MSU 2017). Under MSU's community-based model, both of MSU's medical schools maintain residency programs at each Lansing hospital system, with the allopathic program more closely aligned with the Sparrow Health System and the osteopathic program aligned with McLaren Greater Lansing (Tu et al. 2011). The impact of the MSU Health Team on the Greater Lansing community includes:

- Approximately 191,586 patient visits each year to the team's primary and specialty care locations
- Nearly 24,450 routine and life-saving surgeries each year (MSU 2017)

MSU Health Team clinicians and physicians are also impacting lives and communities by working collaboratively with other providers to bring advanced healthcare to the Greater Lansing region. This includes a partnership with Sparrow Hospital to launch an epilepsy monitoring unit

in 2011, and an interventional neurology stroke service in 2013. The MSU Health Team also provides trauma surgeons for Sparrow Hospital's Trauma Center and neonatologists for its Neonatal Intensive Care Unit. MSU CHM also hosts two NIH-funded epidemiology research training programs that are investigating problems associated with drug dependence. The college also administers the nation's only program project grant in neurohumoral control of veins in hypertension. MSU leads research on precision medicine, an approach that looks to maximize the effectiveness of disease treatment and prevention by considering an individual's variability in genes, environment and lifestyle (Research at MSU n.d.d).

At U-M, Michigan Medicine gets high marks on national surveys on patient care, reaching patients in every county in Michigan (U.S. News and World Report 2017). The reputation, size, and scope of what Michigan Medicine offers makes U-M a world-renowned destination for care, not to mention a major economic driver in Washtenaw County. Michigan Medicine has a \$3.7 billion operating budget, and employs over 26,000 people, including 1,800 physicians and 4,900 nurses. These health professionals practice across a series of facilities, including three hospitals, approximately 40 health centers, and 120 outpatient clinics throughout the state of Michigan (U-M Patient Care). In fiscal year 2016, patients seeking care at U-M made 2.5 million visits to its hospitals, health centers and clinics. U-M had over 50,000 surgical cases, 1,200 survival flight missions, and 104,000 emergency room visits.

WSU also has an important impact on patient medical care in the state of Michigan. With 2,000 physicians, the WSU Physician Group (WSUPG) is the largest nonprofit multispecialty group of practicing physicians in southeast Michigan, offering patients both primary and specialty care (WSU 2011). The WSUPG has eight clinical hospital affiliates spanning a broad variety of specialty care hospitals, and serves more than one million patients each year.

Specialized Hospitals

URC institutions are also home to some of the world's leading specialized hospitals. Many healthcare providers look to these specialized facilities to not only develop and deliver high-quality care, but also to provide efficient, focused services to patients.

Located in the Michigan Medicine health complex in Ann Arbor, the C.S. Mott Children's Hospital is a pediatric hospital that provides newborns, children, and women with specialized healthcare, including services that are not offered elsewhere in the state of Michigan—such

3 A doctor of nursing degree is a clinically focused degree, while a PhD in nursing is a research focused degree.

Timeline of Select URC Milestones in the Life, Medical, and Health Sciences

1869

WSU | Joseph Ferguson, M.D becomes the first African-American graduate of Detroit Medical College, established in 1868. He is the first African American in Detroit (and most likely in Michigan) to earn a medical degree.



1959

U-M | U-M's School of Public Health launches the Tecumseh (Michigan) Community Health Study, a longitudinal epidemiological study that transforms scientific understanding of chronic diseases and tests the concept of herd immunity.

1998

U-M | U-M professor Mark Burns heads a multidisciplinary team that creates miniature "laboratory on a chip" kits to analyze DNA samples.

2001

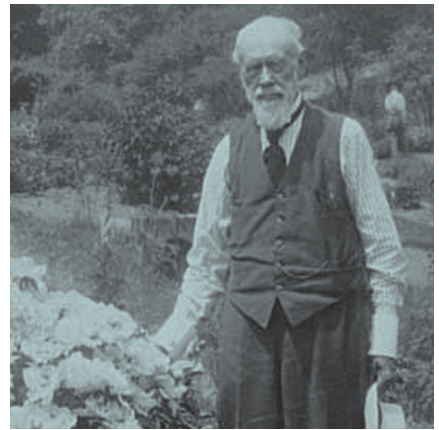
U-M | U-M establishes the Comprehensive Depression Center, the first of its kind—devoted entirely to bringing depression into the mainstream of medical research, translational care, education, and public policy.

1869

U-M | U-M opens the first university-owned medical facility in the United States. The 20-bed hospital is in the residence of a former professor, and has no wards or operating rooms.

1877

MSU | MSU professor William J. Beal performs the first documented genetic crosses to produce hybrid corn, dramatically increasing the yield.



1934

U-M | U-M scientists Pearl Kendrick and Grace Eldering begin testing a new vaccine for pertussis, or whooping cough. The vaccine works, all but ending the scourge of whooping cough deaths. They later combine shots of diphtheria, whooping cough, and tetanus into the single DPT shot children routinely receive today.

1943

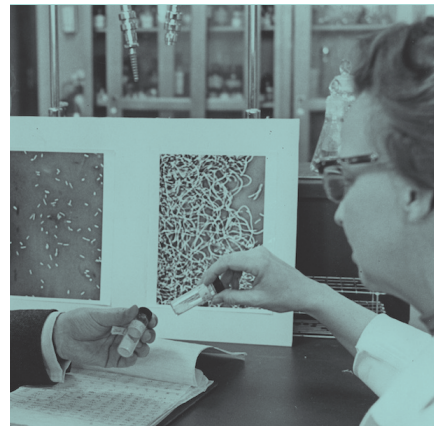
WSU | Marjorie Peebles-Meyer, M.D., graduates from WSU's School of Medicine, the school's first African-American female graduate. She also becomes the first African-American female resident and chief resident at Detroit Receiving Hospital.

1962

WSU | WSU School of Medicine researcher Dr. Morris Goodman discovers chimpanzees and gorillas are more closely related to humans than to each other.

1974

MSU | In response to an unprecedented number of cattle deaths on farms throughout Michigan and to assist the state in the management of PBBs, MSU establishes the Veterinary Diagnostic Laboratory.



2011

WSU | WSU researcher Dr. Sonia Hassan develops a test identifying mothers at high risk for preterm birth. Treating these high-risk mothers with progesterone cuts the risk of early delivery in half.

MSU | MSU opens a radio-pharmacy on campus to streamline access to nuclear imaging agents created at an MSU cyclotron. This change means improved access to patients needing advanced imaging.



1888

MSU | The Michigan Agricultural Experiment Station—now MSU AgBioResearch—is created after the passage of the Hatch Act, which calls for a nationwide network of agricultural experiment stations.

1898

U-M | U-M professor Moses Gomberg synthesizes the compound tetraphenylmethane, which includes an “organic free radical”—a highly reactive collection of atoms. In doing so, Gomberg becomes the founder of radical chemistry, central to the understanding of everything from polymerization to atmospheric reactions.

1913

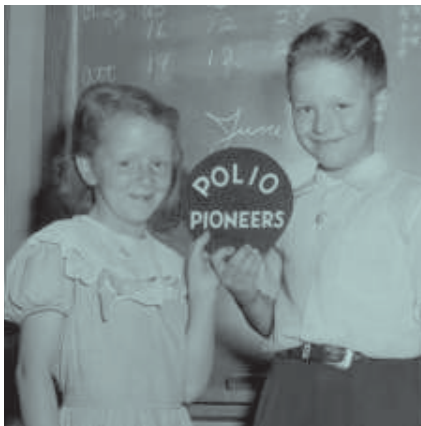
U-M | U-M's Dr. Aldred Warthin becomes one of the first researchers to establish that cancer can be hereditary.

1929

MSU | MSU dairy pioneer G. Malcolm Trout links the processes of pasteurization and homogenization, helping to make homogenized milk feasible.

1952

WSU | WSU's Dr. Forest Dewey Dodrill is the first to use a mechanical heart to operate on a patient. The operation reroutes blood around the heart, allowing the surgeon to repair damaged valves. The concept and practice are now standard and used more than one million times annually.



1955

U-M | U-M professor Thomas Francis Jr. concludes the two-year national field trials of the Salk polio vaccine, and on April 12, 1955, announces to the world that the vaccine developed by his former student Jonas Salk is “safe, effective, and potent.”

1978

MSU | The Food and Drug Administration approves the use of cisplatin, which greatly improves the treatment of testicular and some ovarian and colon cancers.

1987

WSU | WSU researcher Dr. Jerome Horowitz develops the first FDA-approved drug to treat AIDS patients. The discovery of using AZT to treat AIDS gives hope to millions of patients and their families.

1988

MSU | The longest running E. coli experiment creates a window into evolution in action.

1994

U-M | Under the direction of professor MaryFran Sowers, the U-M School of Public Health becomes a site for the Study of Women's Health Across the Nation (SWAN), a multisite longitudinal epidemiological study designed to examine the health of women during their middle years. Sowers' groundbreaking research in this and other studies helps transform women's health into a major discipline.



2014

WSU | WSU professor of surgery Anna Ledgerwood is named the first female president of the American Surgical Association. The ASA is the nation's oldest—and considered by many to be the most prestigious—surgical organization.

2015

MSU | MSU's Tropical Medicine Team discovers the cause of death to children from cerebral malaria.





The Age of Alzheimer's: URC Universities Team Up to Research Deadly Disease

Modern medicine has helped to double the average life expectancy over the past 150 years. Sadly, the risk of getting Alzheimer's increases with every year of age over 65, making innovative research and therapy solutions integral to fighting this deadly disease.

Alzheimer's is a relentless and fatal brain disease that affects one out of every ten people over the age of 65. The disease comes on gradually, killing brain cells and compromising an individual's ability to form new memories or hold on to old ones, process language, solve problems, regulate emotions, and perform basic motor functions. In the U.S. alone, more than five million Americans of age 65 and older have Alzheimer's disease. Currently, no disease-slowing therapies exist.



Thanks to a grant from the U.S. National Institutes of Health, the Michigan Alzheimer's Disease Core Center (ADCC) was launched to support URC universities in a collaborative effort to conduct a wide range of studies on Alzheimer's disease and other forms of dementia.

"This opportunity will leverage the combined clinical, research, and educational expertise of our three universities to tackle this devastating disease," said Scott Counts, Ph.D., associate professor of translational science and molecular medicine at MSU College of Human Medicine. "It will also allow us to improve access to care for families suffering from these conditions by providing more classes, information, and resources."

The ADCC will emphasize areas of research that are often overlooked. Alzheimer's disease is characterized by two kinds of accumulated protein deposits: plaques and tangles. Much of the present research in the field investigates beta-amyloid, the protein that forms the plaques. The Michigan ADCC will take a different focus.

"We'll focus on studies of the many non-amyloid factors contributing to disease because beta-amyloid, though unquestionably important in Alzheimer's, is already getting considerable attention," said Henry Paulson, U-M neurologist and director of the Michigan Alzheimer's Disease Center. "The goal of all this innovative research is to understand disease processes and develop better treatments for the various dementias."

Funding will also allow for deeper integration with geriatrics, movement disorders, and other programs across the three universities to develop new lines of research. For example, URC universities are working with the WSU Healthier Black Elders Center to advance the understanding of dementia in underrepresented minorities.

"The collaboration between Michigan's highest research universities and the integration of strong community outreach represents an enormous opportunity for the citizens of Michigan to benefit directly as they struggle to understand and intervene with people suffering with Alzheimer's disease," said Peter Lichtenberg, Ph.D., director of WSU's Institute of Gerontology and Merrill Palmer Skillman Institute, and ADCC co-core leader for training. "We are especially excited that this collaboration will extend the scientific and community engagement work on Alzheimer's disease in African Americans."

as the pediatric liver transplant program and the Fetal Diagnostic and Treatment Center. Of the ten pediatric specialties evaluated by a national ranking entity, the C. S. Mott Children's Hospital is consistently ranked among the nation's top children's hospitals in the nation in each of the ten (C.S. Mott Children's Hospital n.d.). The C. S. Mott Children's Hospital and Von Voigtlander Women's Hospital opened its first hospital wards for women and children over 100 years ago, and today provide patients with nearly 15,000 overnight hospital stays, over 12,000 operations, 338,000 outpatient visits, and over 4,000 births each year (U-M Health System August 2014).

Meanwhile, WSU researchers at the Barbara Ann Karmanos Cancer Institute are developing new ways to treat and cure cancers, providing patients with access to the latest, most promising treatments. Based in Midtown, the Karmanos Institute is a research center dedicated to the prevention, early detection, treatment, and eventual eradication of cancer. Karmanos is one of 47 cancer centers designated by the National Cancer Institute. It employs over 1,000 staff members, including 300 doctors and 100 researchers, and provides care for approximately 12,000 patients each year. Every Karmanos basic science researcher and clinician is a faculty member of WSU's School of Medicine (Karmanos Cancer Institute 2016).

Karmanos is conducting more than 800 cancer-specific scientific investigation programs and clinical trials, giving Michiganders access to the latest cancer treatments and cures. Karmanos emphasizes rapidly moving treatments from the laboratory into patient care. The institute has six cancer workgroups, representing a collaboration between lab scientists and clinicians who work with patients.

Uncompensated Care

The presence of URC institutions in communities across Michigan also means that they provide a tremendous amount of uncompensated care, serving as a safety net for patients without insurance or other options. Combined, the U-M Health System and WSU School of Medicine provide more than \$250 million in uncompensated care annually. Because MSU delivers care mostly through its hospital partners around the state, uncompensated care estimates are unavailable.

Veterinary Care

Patient care extends beyond human health. MSU's role in veterinary care combines animal health and human health to create approaches that seek to identify threats, including avian influenza, bovine tuberculosis, and West Nile virus. Leading the way in this work is MSU's Veterinary Diagnostic Laboratory (VDL)—one of the country's premier veterinary diagnostic labs, serving over 220,000 cases each year in all 50 states, and more than ten countries.

The VDL was established in the early 1970s in response to an unprecedented case of cattle deaths on Michigan farms. In 1974, VDL researchers worked with the State of Michigan to discover and then manage the inadvertent mixture of cattle feed with a toxic fire retardant—polybrominated biphenyls (PBBs). This work also led to the finding that humans who had consumed dairy products from cattle that ate this feed were also exposed to PBBs, a discovery that underscores the importance of state-of-the-art veterinary diagnostics in protecting not just animal, but human health (MSU Diagnostic Center for Population and Animal Health 2009).



Today, the VDL is a member of several networks that seek to protect both human and animal health, including state networks through the Michigan Department of Agriculture and Rural Development, and federal networks managed by the Centers for Disease Control (CDC), U.S. Department of Agriculture, and the Federal Drug Administration (FDA).

The MSU Veterinary Medical Center (VMC) provides specialized care to large and small animals. The VMC is a teaching hospital with specialized equipment and expertise that provides services to both companion and agricultural animals. MSU's College of Veterinary Medicine is ranked 12th in the nation by U.S. News and World Report (2017b).



THE ECONOMIC IMPORTANCE OF THE LIFE, MEDICAL, AND HEALTH SCIENCES

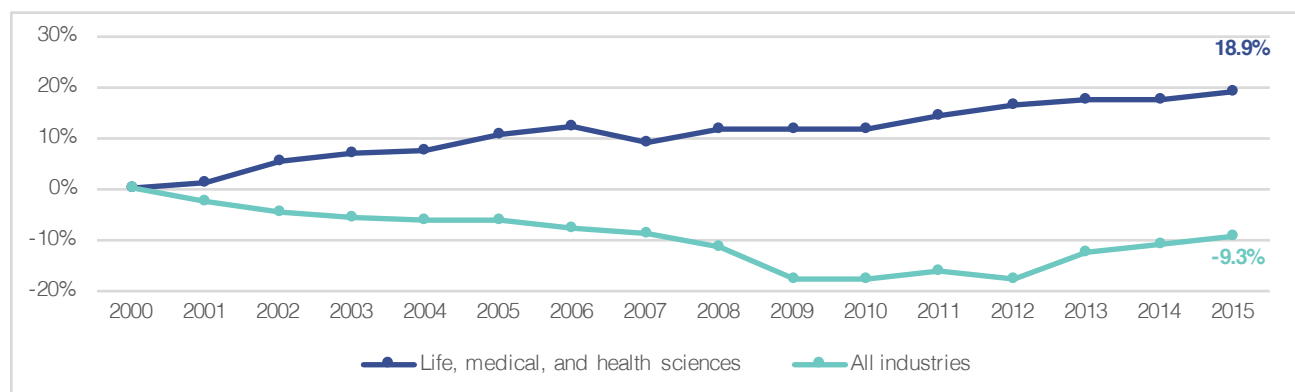
Recent Trends

The life, medical, and health science sector is extremely valuable to Michigan. This sector attracts federal research dollars and venture capital and creates technology companies with high-paying jobs. The average bioscience job pays 74 percent more than the average private sector job in Michigan. With the inclusion of jobs relating to the delivery of healthcare services, the sector represents an important economic stabilizer and major source of employment. It was one of the only sectors that grew during Michigan's long economic downturn of the 2000s, and workers in the medical and health sectors provide essential care and treatment to the people of Michigan.

In 2015, approximately 533,000 Michiganders were employed in the life, medical, and health sciences, representing one in eight jobs, and the importance of this sector is growing. Between 2011 and 2015, Michigan added over 21,000 jobs in the life, medical, and health sciences—growth of 4.2 percent. While this growth is slower than that of employment in the overall economy over this period, this slower growth is deceptive. Michigan's overall

economy is still recovering from the sharp employment decline that occurred in the 2000s, a decline the life, medical, and health sciences did not experience. Michigan's economy steadily shed jobs between 2000 and 2009, while employment in the life, medical, and health sciences continued to grow, as is clearly illustrated in Exhibit 1.⁴ The steady growth of this sector helped stabilize Michigan's economy during a very difficult period.

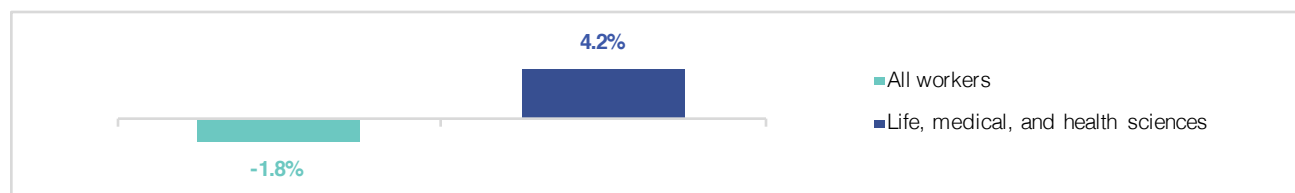
Exhibit 1. Cumulative Change in Employment from 2000-2015, Life, Medical, and Health Sciences Compared to All Industries



Source: PSC calculations using data from the U.S. Department of Labor Statistics n.d.

The life, medical, and health sciences also exhibited stronger wage growth than the overall economy. Between 2000 and 2015, the average wage in this sector grew 4.2 percent after adjusting for inflation, from \$52,068 to \$54,246. Over this same period, the average inflation-adjusted wage in Michigan fell by 1.8 percent from \$50,963 to \$50,063 (see Exhibit 2).

Exhibit 2. Inflation-adjusted Change in Average Wage for All Workers and Life, Medical, and Health Science Workers, 2000–2015



Source: PSC calculations using data from the U.S. Department of Labor Statistics n.d.

Michigan's Bioscience Industry

A recent study published by TEconomy Partners LLC and Biotechnology Innovation Organization (2016) provides a 50-state look at the bioscience industry. The bioscience industry is a subset of the life, medical, and health sciences that does not include the delivery of healthcare services to patients. Instead, the bioscience sector is focused on export industries, which are important drivers of economic growth.

The bioscience industry is defined by TEconomy as companies engaged in advanced manufacturing, research activities, and technology relating to the application of knowledge in the life sciences. The biosciences can be divided into five key components: agricultural feedstock and chemicals; bioscience-related distribution; drugs and pharmaceuticals; medical devices and equipment; and research, testing, and medical laboratories.

⁴ PSC calculations using data published by the U.S. Department of Labor's Quarterly Census of Employment and Wages (QCEW).

Exhibit 3 presents some of the key statistics for Michigan's bioscience sector. The sector directly employs 44,277 people and has 1,833 business establishments. Michigan ranks 13th highest among states for both metrics. Jobs in this sector pay particularly well, with an average annual wage of \$83,482, 74 percent more than the average private sector job in Michigan. Michigan ranks 10th highest among the states for bioscience R&D dollars at \$1.2 billion, or \$122 per capita. From 2012 to 2015, there were 2,333 bioscience-related patents issued in Michigan, and venture capital investment in Michigan totaled \$666 million over this time (see Exhibit 4).

The Role of the URC

Working individually and collaboratively, the URC is a key driver of the life, medical, and health sciences in Michigan.

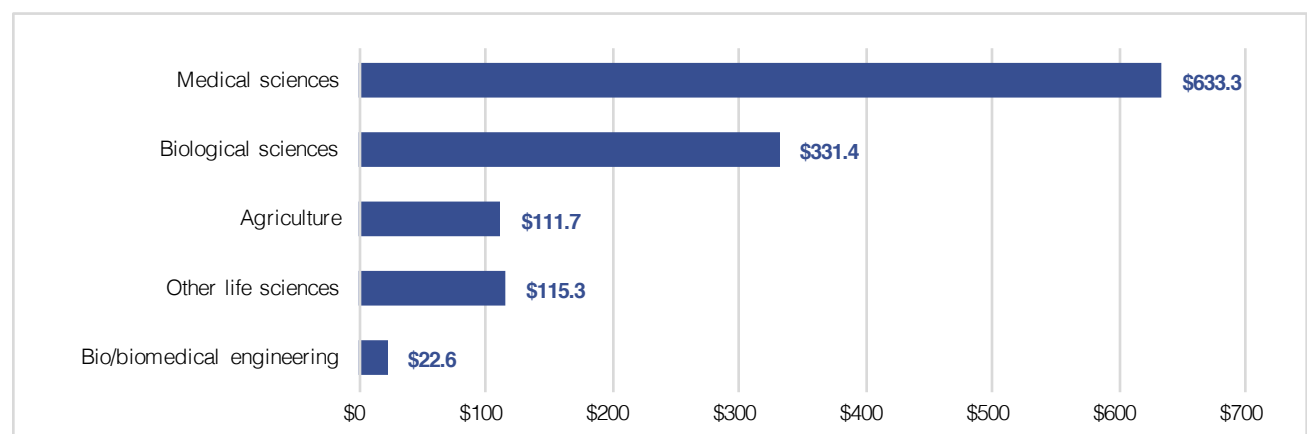
The URC conducts research, trains members of the workforce, provides care, and helps create new companies in the field. The URC is responsible for 94 percent of all academic R&D expenditures in Michigan and 95 percent of R&D expenditures relating to the life, medical, and health sciences. The URC universities award 43 percent of the degrees in Michigan in the life, medical and health sciences, and the vast majority of PhDs and medical doctor degrees.⁵ The URC institutions deliver lifesaving medical care to hundreds of thousands of Michiganders each year at medical centers and community hospitals. It is researching new cures to devastating diseases. Finally, it serves as an important engine of economic growth by training the skilled workforce, generating research dollars, and successfully transferring academic research into the private sector through licensing agreements and startup companies.

Exhibit 3. Michigan Bioscience Statistics

Bioscience Metric	Michigan Total	State Rank
Industry employment, 2014	44,277	13
Industry establishments, 2014	1,833	13
Academic research and development expenditures (\$ thousands), FY 2014	\$1,214,255	10
Share of total research and development, FY 2014	57%	29
Venture capital investments, 2012 to 2015 (millions of \$)	\$666.5	16
Bioscience and related patents, 2012 to 2015	2,333	18

Source: TEconomy Partners LLC and Biotechnology Innovation Organization (2016).

Exhibit 4. Michigan Bioscience Academic R&D Spending, FY 2014 (in millions)



Source: TEconomy Partners LLC and Biotechnology Innovation Organization (2016).

⁵ Degree total is for bachelor's degrees or higher.



Caring in Crisis: How URC Universities are Helping Flint

In 2015, a substantial public health emergency emerged from the discovery of lead in the city of Flint's water. When tests revealed toxic levels of lead content in the drinking water of Flint homes, URC universities quickly responded to assess and support the crisis.

On-site MSU researchers were the first to correlate elevated lead levels in children's blood with contamination of municipal water, and to physically map the extent of the problem. In partnership with Hurley Children's Hospital, where MSU physician Mona Hanna-Attisha leads the pediatric residency program, MSU formed the Pediatric Public Health Initiative to develop approaches to long-term well-being of Flint children. That initiative brings together experts in pediatrics, child development, psychology, epidemiology, nutrition, toxicology, geography, education, and community and workforce development. The swift response was facilitated by MSU's embedding in the Flint community for more than 100 years through MSU Extension, partnerships with local hospitals and expansion of the MSU College of Human Medicine's public health program there and addition of a campus downtown in 2014.

At WSU, the Flint Area Community Health and Environment Partnership (FACHEP) was formed to conduct an independent study to evaluate the possible association between changes in Flint's water system and public health, specifically the recent Legionnaires' disease outbreak.

"With input from the community and a number of healthcare partners in Flint and Genesee County, we developed a three-pronged approach to investigating the cause of these outbreaks and reducing the community risk of more illness in the future," said Shawn McElmurry, Ph.D., FACHEP's lead principal investigator and professor of Civil and Environmental Engineering in WSU's College of Engineering.

At the U-M Flint and Ann Arbor campuses, researchers partnered with Google to develop a mobile app and website that allows residents and city employees to see information about lead-testing results, water testing, where pipes have been replaced, and the location of distribution centers for water and filters.

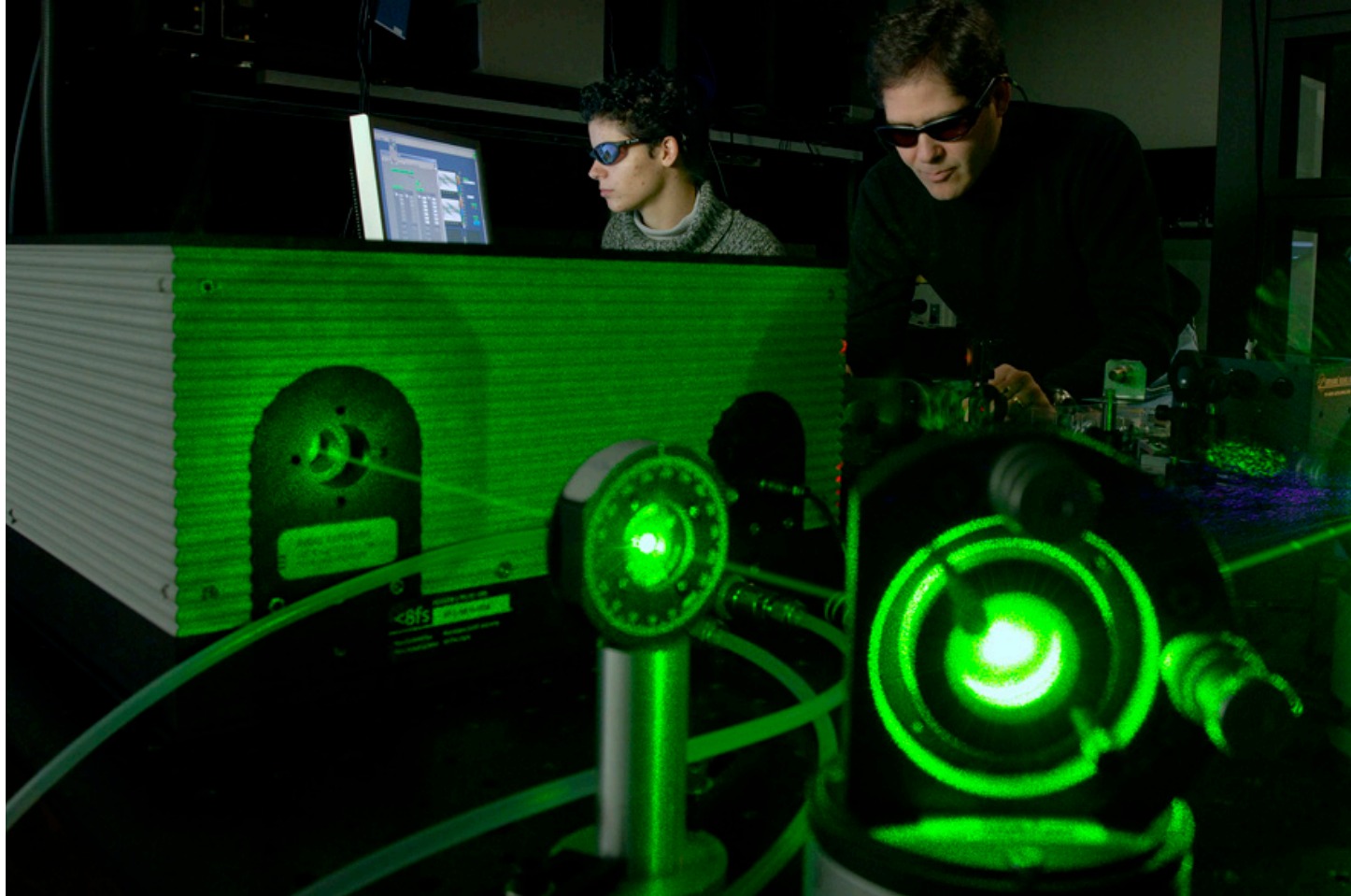
"We've developed an essential resource," said Jake Abernethy, assistant professor of computer science and engineering at U-M Ann Arbor. "It's an independent platform that gives people information they need and want to know as they navigate this complex situation. There's no playbook for it."

Additionally, recent federal grants will support collaborative research involving all three URC universities to determine the best ways to manage the point-of-use water filters being used by Flint residents. Manufacturers typically recommend replacing filters after they process approximately 100 gallons of water. This research will examine if this replacement schedule is best for the Flint water distribution system.



"Based on the results we have gathered thus far, the filters are doing a good job removing lead and disinfection by-products," Susan Masten, professor of civil and environmental engineering at MSU said. "These by-products are the chemical compounds that occur after water has been disinfected and are measured as total trihalomethanes. So far, after filtration, these chemicals are typically at concentrations below what we can measure."

While Michigan universities have helped Flint make positive strides, the journey to recovery is far from over. The URC will continue to lead at the community level to increase resources, strengthen research discoveries, and fully support the residents in the city of Flint.



PEER UNIVERSITY CLUSTERS

Overview

An economic cluster is a region with a high density of economically related organizations. Southeast Michigan is known for its automotive cluster. The URC represents a cluster of high-power research universities. The URC frequently benchmarks its performance against clusters consisting of the best public and private universities from around the nation, and the URC has identified the nation's top seven university clusters for comparison purposes: Northern California, Southern California, Illinois, Massachusetts, North Carolina, Pennsylvania, and Texas (see Exhibit 5).

Exhibit 5. University Clusters

Cluster	University
University Research Corridor	Michigan State University University of Michigan, Ann Arbor, Dearborn and Flint Campuses Wayne State University
Northern California	Stanford University University of California, Berkeley University of California, San Francisco
Southern California	University of California, Los Angeles University of California, San Diego University of Southern California
Illinois	University of Chicago University of Illinois, Champaign Urbana Northwestern University
Massachusetts	Boston University Harvard University Massachusetts Institute of Technology
North Carolina	Duke University North Carolina State University University of North Carolina, Chapel Hill
Pennsylvania	Carnegie Mellon University Pennsylvania State University University of Pittsburgh
Texas	Rice University Texas A&M, College Station and Commerce University of Texas, Austin

Source: Rosaen and Taylor 2016.

R&D Spending

Exhibit 6 shows R&D spending on the life, medical, and health sciences by academic cluster.⁶ The URC ranked fourth among its peer university clusters in academic R&D spending in 2015. The URC's spending was slightly below the average spending of the nation's top university clusters and slightly above the median spending. URC research spending grew 1.4 percent from 2011 to 2015.

Virtually all of Michigan's academic R&D expenditures occur at the URC institutions, which contrasts sharply with other states. In 2015, 95 percent of Michigan's academic R&D expenditures in the life, medical, and health sciences took place at the URC, ranking its cluster of research universities first among peer clusters in terms of the state share (see

Exhibit 7). Therefore, the URC is essential to Michigan's competitiveness in this important sector, and plays a more important role in Michigan than other university clusters do in their respective states.

Exhibit 6. Academic R&D Spending in the Life, Medical, and Health Sciences by University Cluster, 2011 and 2015 (in thousands)

Cluster	2011	2015	2015 Rank
Northern California	\$1,794,356	\$1,983,794	1
North Carolina	\$1,775,189	\$1,881,332	2
Southern California	\$1,751,011	\$1,871,332	3
URC	\$1,235,518	\$1,252,481	4
Massachusetts	\$843,879	\$1,066,741	5
Pennsylvania	\$1,129,843	\$1,057,724	6
Illinois	\$987,355	\$1,001,171	7
Texas	\$329,525	\$462,601	8
Cluster average	\$1,230,835	\$1,322,147	
Cluster median	\$1,182,681	\$1,159,611	

Source: PSC analysis of NSF n.d.b

Exhibit 7. Percentage of Total State Academic R&D Expenditures in the Life, Medical, and Health Sciences Occurring at University Clusters, 2011 and 2015

Cluster	2011	2015	2015 Rank
URC	98%	95%	1
North Carolina	86%	89%	2
Northern California*	69%	73%	3
Southern California*	68%	69%	4
Illinois	64%	67%	5
Massachusetts	59%	64%	6
Pennsylvania	52%	48%	7
Texas	11%	15%	8
Cluster average	64%	65%	
Cluster median	66%	68%	

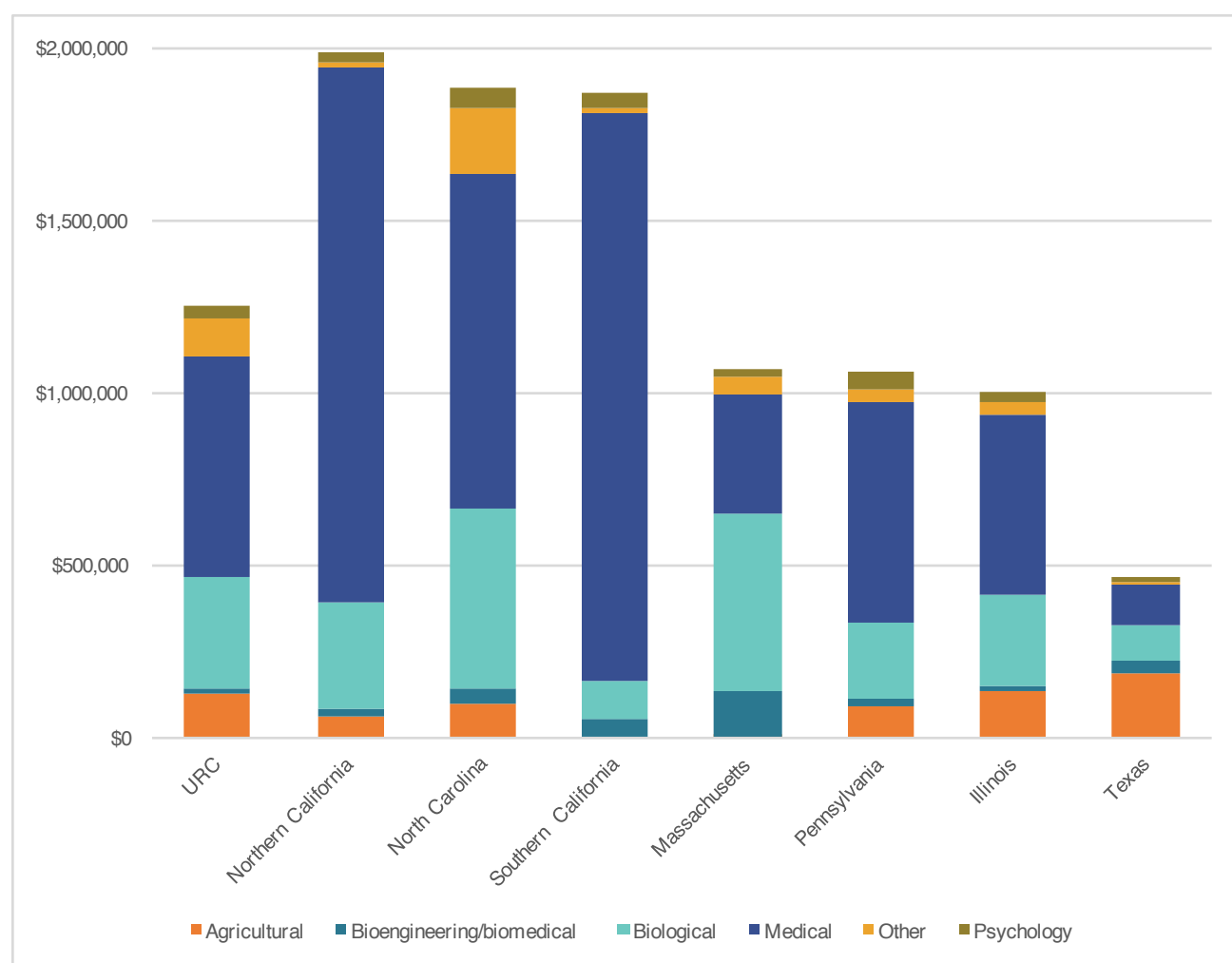
*Total California expenditures are divided by two when performing the calculations, since the state has two strong academic clusters.

Source: PSC analysis of NSF n.d.b

⁶ The expenditure data are from the National Science Foundation's (NSF) Higher Education R&D Survey (HERD).

Within the NSF-defined disciplinary fields in the life, medical, and health science sector, the URC ranks in the top three for agricultural sciences (3), biological sciences (3), and other life sciences (2). The URC ranks in the middle of the top university clusters for medical sciences (5) and psychology (4). One area in which the URC has room to grow in the cluster ranks is in bioengineering and biomedical engineering (8). Recent institutional investments in bioengineering and biomedical engineering are positioning the URC to increase its R&D activity and improve the URC's rankings in years to come. Academic R&D expenditures by life, medical, and health science subfield for each cluster are presented in Exhibit 8.⁷

Exhibit 8. Academic R&D Expenditures in the Life, Medical, and Health Sciences by Subsector, 2015



Source: PSC analysis of NSF n.d.b.

Among the 50 states, Michigan has the 11th highest academic R&D spending in the life, medical, and health sciences (see Exhibit 9). Michigan's 2015 spending of \$1.3 billion is 64 percent more than the average state and almost triple the median spending nationwide. Over the past five years, academic R&D expenditures in the life, medical, and health sciences grew 4.8 percent in Michigan.

⁷ The detailed figures supporting Exhibit 8 can be found in Appendix A.

Exhibit 9. Top 15 States for Academic R&D Spending in the Life, Medical, and Health Sciences, 2011 and 2015 (in thousands)

State	2011	2015	2015 Rank
California	\$5,166,120	\$5,426,725	1
New York	\$3,657,226	\$3,838,668	2
Texas	\$2,902,704	\$3,170,725	3
Pennsylvania	\$2,180,594	\$2,186,998	4
North Carolina	\$2,056,883	\$2,124,955	5
Maryland	\$1,583,480	\$1,802,230	6
Massachusetts	\$1,419,246	\$1,665,738	7
Illinois	\$1,533,560	\$1,499,580	8
Florida	\$1,239,329	\$1,361,383	9
Ohio	\$1,419,246	\$1,342,978	10
Michigan	\$1,258,496	\$1,319,242	11
Georgia	\$902,101	\$1,020,283	12
Washington	\$931,607	\$976,928	13
Missouri	\$854,503	\$888,386	14
Connecticut	\$752,029	\$857,957	15
50-state and D.C. average	\$768,555	\$802,187	
50-state and D.C. median	\$454,679	\$433,118	

Source: PSC analysis of NSF n.d.b

Talent

The URC is a major producer of talent in the life, medical, and health sciences, and Michigan is competitive nationally in these fields due to the talent generated by the URC. The URC ranks first in degrees awarded in these fields among the nation's top university clusters (see Exhibit 10). From 2011 to 2015, the URC awarded 44,422 degrees in these fields, 14 percent more than the second-ranked cluster. The URC also ranks highly in almost every subfield. The URC awards the most degrees in the medical sciences, psychology, and other life sciences. It ranks second in the biological sciences, third in the agricultural sciences, and fifth in bioengineering and biomedical engineering.

The URC also ranks highly when looking at advanced degrees. Among the top university clusters, the URC ranks fourth in the number of PhDs awarded in the life, medical, and health sciences. It ranks first in the number of medical doctor degrees awarded, as well as the number of master's and bachelor's degrees awarded. From 2011 to 2015, the URC universities awarded 26,408 bachelor's degrees in the

life, medical, and health sciences, 9,008 master's degrees, 6,881 doctors of medicine degrees, and 2,125 PhDs.⁸

Talent In Michigan

The URC is a major source of talent within Michigan, awarding one-third of the state's degrees in the life, medical, and health sciences, and 44 percent of bachelor's degrees or higher (excluding associate degrees, which are usually awarded by two-year community colleges). The URC is especially important with respect to advanced degrees. The URC awarded 37 percent of bachelor's degrees, 50 percent of master's degrees, and 75 percent of the PhDs earned in Michigan in the life, medical, and health sciences from 2011 to 2015 (see Exhibit 12). The URC also awarded 75 percent of the professional medical doctorates, which include physicians, nurses, pharmacists, and veterinarians. The URC universities are critically important in the development of specialized life, medical and health sciences talent by providing the vast majority of advanced degrees, which speaks to unique role the URC plays in the state and sector as research universities.

⁸ Doctors of medicine here includes physicians, pharmacists, and veterinarians.



Collaborating to Study and Improve Children's Health

Children's brains develop very quickly in their early years, and this development is influenced by their environment. Understanding exactly how mothers' and children's exposure to adverse environmental factors (such as lead and organic pollutants) affects child development, however, can make a world of difference. This knowledge has the potential to help drive environmental and public health policy, lead to better, early interventions, and improve the health and lives of tens of thousands of children across the nation.

The National Institutes for Health (NIH) is leading the Environmental Influences of Child Health and Outcomes (ECHO) study, which focuses on this issue. ECHO, which has enrolled more than 50,000 children from diverse backgrounds, promises a better understanding of the interaction between the environment and child development. As part of this work, the NIH recently awarded a \$4.8 million grant to a Michigan team comprising representatives from MSU, UM, WSU, the Henry Ford Health System, and the Michigan Department of Health and Human Services to support collaborative research.

This team will be working with ten hospitals and 20 clinics throughout the state. ECHO will examine how environment affects children's health outcomes over time and build on research in areas that the three URC institutions jointly worked on for the National Children's Study—such as autism spectrum disorders, low birth weight, and childhood obesity.

"The results should provide critical information about prenatal environmental influences and the health of children, contributing to public policy formations in maternal and child health and ultimately improving the public health of mothers and children," said Nigel Paneth, M.D., M.P.H., university distinguished professor of epidemiology and biostatistics in the MSU College of Human Medicine.

As part of this work, Douglas Ruden, Ph.D., codirector of the Exposures Signatures Core Facility in the Center for Urban Responses to Environmental Stressors at WSU, leads a team working to determine whether environmental pollutants change the epigenome of the DNA in children.

"My research team has studied lead toxicity in Detroit for over ten years and published a research paper last year that showed that maternal exposure to lead can alter the DNA in the grandchildren," Ruden said. "This was the first demonstration of multigenerational effects of lead poisoning."

The ECHO study uses innovative blood spot techniques that were developed in part through research supported

by URC seed funding. "Innovative to our approach is the use of newborn dried blood spots from the Michigan Neonatal Biobank, a unique resource for the assessment of both perinatal exposures and epigenetic markers," said Dana Dolinoy, Ph.D., associate professor for environmental health sciences and nutritional sciences at U-M's School of Public Health.

The ECHO study is a good example of how the URC institutions collaborate to deliver powerful research.



As noted, for bachelor's degrees and higher, the URC universities awarded 44 percent of all degrees in the life, medical and health sciences in Michigan. With respect to the subfields, the URC universities awarded 69 percent of the state's bachelor's degrees and higher in the agricultural sciences, 78 percent of the state's degrees in bioengineering and biomedical engineering, 56 percent in the biological sciences, 45 percent in the medical sciences (including doctors, pharmacists, nurses, and other medical science professions), 45 percent in psychology, and 26 percent in the other life sciences (see Exhibit 13).

The URC is a vitally important source of talent for medical care for both people and animals. Among Michigan

colleges and universities, from 2011 to 2015, the URC institutions awarded 54 percent of all dentistry degrees, 99 percent of all Doctor of Medicine degrees, and 100 percent of all degrees in osteopathic and veterinary medicine (see Exhibit 14). The URC awarded 29 percent of all nursing degrees at the bachelor's level or higher. This includes 74 percent of all Doctor of Nursing degrees, 35 percent of all PhDs, 52 percent of all master's degrees, and 23 percent of all nursing bachelor's degrees.⁹ From 2011 to 2015, the URC universities awarded 559 dentistry degrees, 3,046 Doctor of Medicine degrees, 1,277 osteopathic medicine/osteopathy degrees, and 529 Doctor of Medicine degrees.¹⁰

Exhibit 10. Research Cluster Medical, Health, and Life Science Degrees by Level of Degree, 2011-2015

Cluster	Bachelor's		Master's	
	Degrees	Rank	Degrees	Rank
URC	26,408	1	9,008	1
Illinois	12,442	6	3,479	6
Massachusetts	7,680	8	7,133	3
Northern California	9,691	7	3,168	7
North Carolina	16,001	5	6,433	4
Pennsylvania	18,509	4	4,637	5
Southern California	23,912	2	7,167	2
Texas	21,451	3	2,861	8

Cluster	Doctor (medical)		PhD	
	Degrees	Rank	Degrees	Rank
URC	6,881	1	2,125	4
Illinois	2,258	7	1,811	7
Massachusetts	3,232	4	2,344	3
Northern California	3,008	5	2,048	5
North Carolina	3,350	3	2,674	1
Pennsylvania	2,777	6	1,823	6
Southern California	5,395	2	2,574	2
Texas	1,960	8	1,795	8

Source: PSC analysis using data from National Center for Education Statistics n.d.

⁹ A Doctor of Nursing degree is clinically focused while a PhD in nursing is a research focused degree.

¹⁰ The earlier classification of professional medical doctorates included physicians, pharmacists, and veterinarians. Doctor of Medicine degree used here refers specifically to physicians earning an MD.

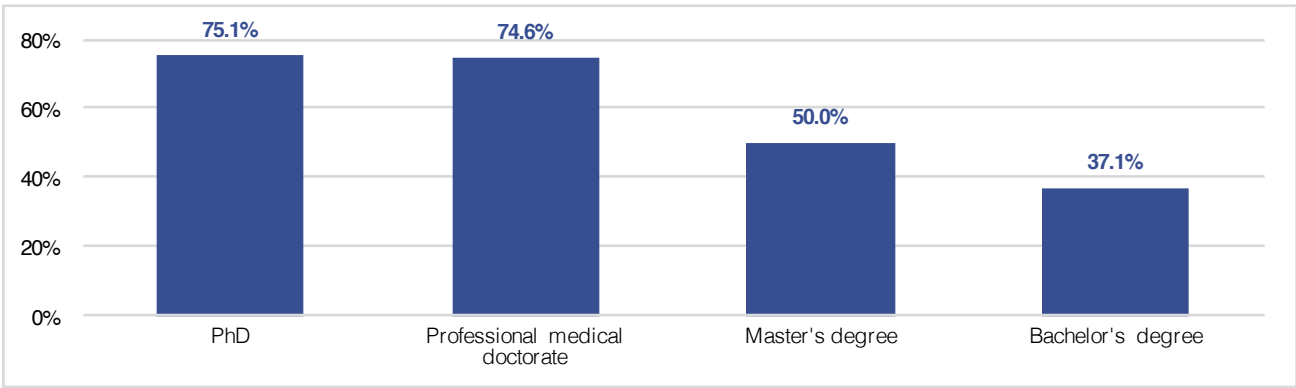


"The URC is an incredible asset for our industry, state, and citizens in terms of the scale of R&D conducted at its universities in critically important areas, such as biomedical engineering, bio-agriculture, veterinary medicine, pharmacology and health disparities. Medical and healthcare discoveries with the potential to improve and save lives position Michigan as a top state for innovation in the life, medical and health sciences."

Mike Jandernoa

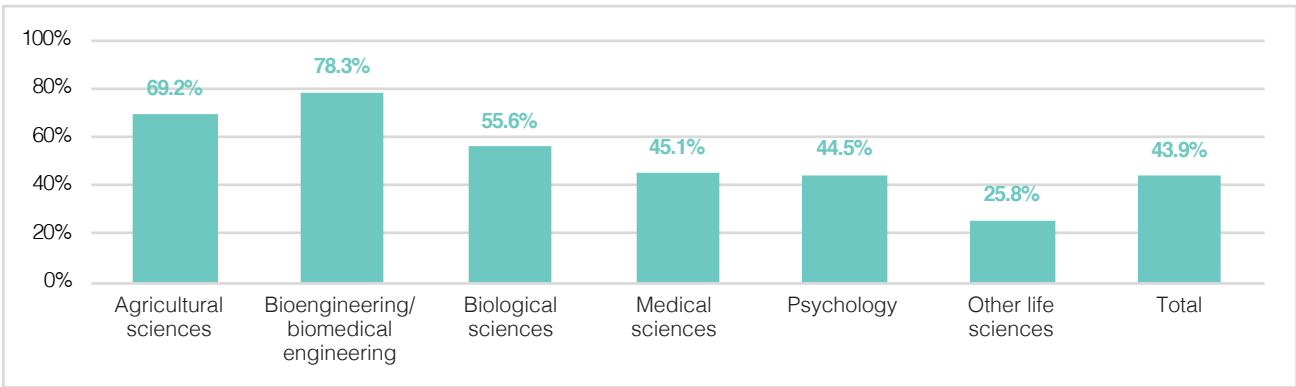
Former Chairman of the Board and CEO of Perrigo Company

Exhibit 12. Percent of Michigan Degrees in the Life, Medical, and Health Sciences Awarded by the URC, 2011-2015



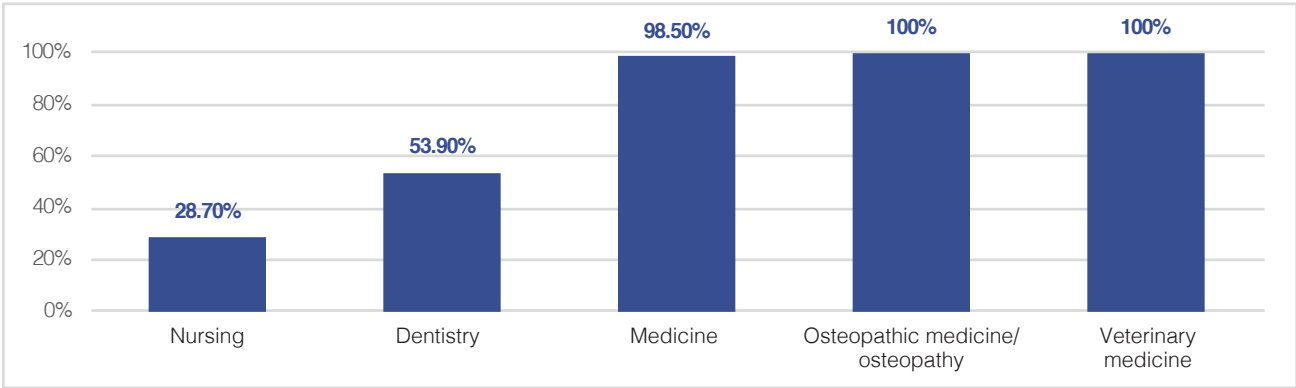
Source: PSC analysis using data from National Center for Education Statistics n.d.

Exhibit 13. Percent of Michigan Life, Medical, and Health Science Degrees Awarded by the URC by Subfield, 2011-2015



Source: PSC analysis using data from National Center for Education Statistics n.d. Percentages exclude associate degrees.

Exhibit 14. Percent of Michigan Doctor of Dentistry, Medicine, Osteopathic Medicine, and Veterinary Medicine Degrees Awarded by the URC, 2011-2015



Source: PSC analysis using data from National Center for Education Statistics n.d.



TECHNOLOGY COMMERCIALIZATION

Overview

Technology commercialization is an important outcome of the research process, and the life, medical, and health sciences make up a significant share of URC institutions' technology commercialization. Technology commercialization—taking discoveries and inventions out of the lab and bringing them into the marketplace—is often what ensures that a new pharmaceutical, vaccine, surgical tool, or other invention makes it from the research lab to becoming a widely used treatment. Moving a new drug from the lab through FDA approval can take years of additional expensive research and clinical trials. Corporate partners can provide the resources needed to extend research and ensure that important discoveries make it to market.

Discoveries that are successfully brought into the marketplace can bring universities licensing fees, and can lead to the formation of new companies creating jobs in Michigan. Licensing fees earned by the universities can be significant, and these fees can be used to support further research and technology commercialization.

The commercialization process works similarly at each of the URC institutions, with functions that can be divided into technology commercialization, business formation, and corporate

engagement. During technology commercialization, the universities work with their researchers to ensure that inventions are disclosed and evaluated for market potential. Intellectual property is protected with copyrights and patents, and the universities identify potential partners. Partners can license technology or help extend the research, since in some cases expensive additional research (such as clinical trials) is needed before a product can be brought to market. The universities can connect their researchers with the partners who have the knowledge and capacity to guide the research through the next steps.

The universities also assist in business formation. Where appropriate, the universities can provide the education and financial support needed to turn inventions and discoveries into successful startup businesses. Corporate engagement offices provide an access point for corporations seeking to access university resources including inventions, researchers, and laboratories. These connections can help ensure the successful commercialization of university discoveries.

Neurable, a company founded by former U-M student researchers, is a good example of a successful technology commercialization effort. The company is at the cutting edge of efforts to produce software guided by the users' thoughts rather than through a controller. The technology can detect and interpret subconscious processing to rapidly detect the user's intentions. The noninvasive brain interface allows users to control objects through software. This technology can help revolutionize how people with disabilities communicate, and might even have applications in video gaming (Schmid Stevenson 2016). The company recently received \$2 million in seed funding (Techcrunch 2016).

WSU recently issued a patent for a targeted drug delivery nanodevice for spinal cord injury. After more than 20 years of research, WSU researchers have found a way to use pharmaceuticals to activate "alternative pathways" found in the non-damaged regions of the spinal cord that

connect the breathing cells in the brain with the spinal cord cells that control breathing muscles. Paralysis of the breathing muscles is one of the most serious and life-threatening consequences of spinal-cord injury. The new drug combination resulted in an 80 percent recovery in an injured rat. This new drug is effective at dramatically lower doses than previously developed drugs, reducing the risks of serious side effects (Dunbar 2017).

Retia Medical is an MSU spinoff located in East Lansing. The company makes cardiac monitors for high-risk heart patients. Dr. Ramakrishna Mukkamala, an associate professor at MSU, is the principal inventor of the cardiovascular monitoring technology. The company won the People's Choice Award in the Accelerate Michigan Business Plan competition in 2012 and has since successfully raised more than \$7 million in venture capital (Retia Medical 2017, Crunchbase 2012). The technology monitors the flow rate of blood pumped from the heart, and the initial target markets for the technology are operating rooms and intensive care units.

Between FY 2012 and FY 2016, 1,348 life, medical, and health science inventions were reported by researchers at the URC to the universities technology commercialization offices, a pace of 22 new inventions each month. Forty percent of all inventions reported at the URC over this time period were in the life, medical, and health sciences. The URC institutions issued 380 patents in the life, medical, and health sciences, and reached 433 license agreements, representing an average of six patent awards and seven license agreements every month for five years.

URC technology commercialization efforts in the life, medical, and health sciences resulted in 32 new companies between FY 2012 and FY 2016, a pace of one new company every other month. Life, medical, and health science startups accounted for 40 percent of the URC institution startups over this period. These efforts also resulted in \$142 million in licensing revenues across this period.

Exhibit 15. URC Life, Medical, and Health Sciences Technology Commercialization Outcomes, FY 2012–FY 2016

Metric	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2012 to FY 2016 Total
Invention reports	235	256	238	313	306	1,348
U.S. patents issued	64	78	72	90	76	380
License agreements	69	59	96	92	117	433
New startup companies	4	2	2	14	10	32
Royalties (in millions)	\$13.5	\$13.5	\$14.1	\$78.1	\$22.7	\$141.9

Source: PSC calculations using institutional data, 2017.

The life, medical, and health sciences represent a significant share of technology commercialization activity. Approximately four in ten inventions reported by faculty and staff at the URC institutions are related to the life, medical, and health sciences. The life, medical, and health sciences generated over 80 percent of the royalty revenue received by the URC over this period.

Michigan Translational Research and Commercialization

Established in 2012, the Michigan Translational Research and Commercialization Statewide Program (MTRAC) is a partnership between the state and public universities to identify commercial potential in advanced technologies developed at universities. The program works to help move the research and discoveries from universities to the marketplace by way of a startup or license to industry. U-M, MSU, and WSU are all homes to MTRACs. U-M and MSU host MTRAC Innovation Hubs, which are statewide in scope.

WSU's MTRAC is focused on medical devices, biomaterials, and healthcare information technology. The program includes research funding for proof-of-concept and late-stage translational studies, regulatory guidance, business plan development, and mentorship from industry and investment experts from outside the university (WSU 2017). Recent WSU MTRAC grants include a research project involving continuous heart rate monitoring for endurance athletes and a biomedical engineering project focusing

on novel bone graft substitutes for orthopedic applications (WSU 2016).

U-M's MTRAC, the Life Sciences Innovation Hub, is aimed at supporting translational life science research projects with high commercial potential. The Life Science Innovation Hub is co-managed by U-M Medical School's Fast Forward Medical Innovation Program and the university's technology commercialization office (MEDC 2016). Past grants from U-M's MTRAC include the Cryo-Anesthesia Device, which provides quicker, less painful anesthesia for those needing eye surgery, a treatment for influenza with a broad-spectrum antiviral agent, and smartphone-based retinal imaging for the screening of eye disease (U-M Medical School Office of Research 2016). Earlier this year, the newly established Life Sciences Innovation Hub announced its first set of project awards to 11 project teams with grants totaling over \$2 million. The awards included collaborative projects that included researchers from the Henry Ford Health System, Beaumont Surgery, U-M, MSU, and Michigan Technological University.

MSU's MTRAC is the state's innovation hub for AgBio. AgBio projects eligible for grant funding fit the broad range of the U.S. Department of Agriculture's definition of food, fuel, and fiber or anything relating to these areas. The AgBio definition also includes bioderived/biobased materials and companion animal veterinary medicine. MSU's grants help develop projects that have shown promise in the laboratory, but need assistance to be successful in the competitive market (MSU Innovation Center 2016). Recent AgBio awards include technologies that enhance the drought resistance of crops, improvements in the fermentation process for shikimic acid, which is commonly used in the manufacture of Tamiflu, an antiviral medicine for treating the flu, and an electrochemical reactor that can produce ethanol without the waste byproducts that typically build up in similar processes (MSU Innovation Center 2015).

Technology commercialization in the life, medical, and health sciences is also enhanced by the Technology Transfer Network (T3N), an MEDC program supported with state funds matched by participating universities. Each of the URC schools participate, along with Grand Valley State University, Michigan Technological University, Oakland University, and Western Michigan University. T3N supports graduate student fellows who help assess the market potential of new investments, mentors-in-residence who are experienced entrepreneurs who bring expertise and connections to help assess opportunities, and post-doctoral fellowships for students who can work on technology or startup development (U-M Tech Transfer 2017). While T3N's focus is broader than simply the life, medical, and health sciences, it is an important asset in commercializing the URC institutions' discoveries in these areas.



"As a serial entrepreneur and venture investor based in Michigan since 2000, I've experienced first-hand the innovation-rich environment provided by the presence and accessibility of the URC that enables Michigan's life sciences sector to thrive, attract venture investment, and create opportunities for business and job growth. Apjohn Ventures has made investments in a number of companies founded on a university technology licensed from a URC institution or that were university startups, including RenaMed Biologics, CytoPherx, and ProNAi Therapeutics."

Mina Sooch

President, CEO, and board member of Gemphire Therapeutics



URC Innovation

Some of the research emerging from URC universities can seem like science fiction, but it has practical, real-world applications to improve the health and quality of life of people around the world. These discoveries can increase the efficiency of healthcare efforts, reduce costs to patients, and—in some cases—serve as the basis for successful startup companies.

At MSU, a team led by university distinguished professor Marcos Dantus has developed a laser with a pulse duration shorter than one millionth of a second. Using these ultra-fast smart lasers, doctors can identify molecules that indicate disease quickly and noninvasively—an “optical biopsy.” Currently, tests for skin cancer involve cutting away a sliver of skin and sending it off to a lab, creating long wait times. This new technology allows doctors to conduct a biopsy as early as the patient’s first appointment, and review the results immediately, which can greatly increase chances of recovery. It is also more accurate and cheaper to use—it can see twice as deep, define margins more accurately, use much less energy, and salvage more tissue.

“In the case of melanoma, which is a fast, progressive cancer, it can literally mean a life or death difference,” Dantus said. “Melanoma usually starts from the very top layers, so if it’s detected on time and removed on time, the prognosis is usually good.”

Safe drug dosages are determined by measuring the toxicity of drugs in animals, but results can often be skewed because animals process medications much more quickly than humans. U-M researchers are using a microfluidic chip to deliver a precise flow of medication across kidney cells as an alternative testing option that may be the beginning of improvements in dosing, reducing instances of kidney damage in patients.

“When you administer a drug, its concentration goes up quickly, and its gradually filtered out as it flows through the kidneys,” said Shuichi Takayama, U-M professor of biomedical engineering. “A kidney on a chip enables us to simulate that filtering process, providing a much more accurate way to study how medications behave in the body.”

WSU spin-off RetroSense Therapeutics is a success story on several fronts. They are helping restore vision in patients suffering from blindness due to retinitis pigmentosa and



advanced dry age-related macular degeneration, for which there are no FDA-approved therapies. RetroSense also represents the strong innovation ecosystem of the URC institutions. “The world-leading research conducted at Wayne State University formed the bedrock on which RetroSense was founded. It was a great experience working with the university, which was supportive at the research level, in tech transfer, and beyond,” Said Sean Ainsworth, CEO and founder of RetroSense Therapeutics. In June 2016, RetroSense was named one of the 50 smartest companies by *MIT Technology Review*, and in the fall of 2016 it was acquired by Allergan plc, a leading global pharmaceutical company.



CONCLUSION

For more than 150 years, the URC universities have been at the forefront of discovery, innovation, and talent development in the life, medical and health sciences, through research and development, teaching and learning, service and outreach. They have made an impact on the lives and livelihoods of people in Michigan, from contributing to a robust, recession-resistant industry that provides consistent job growth and relatively high median wages, to the health and well-being of residents throughout the state through the delivery of basic and specialized medical care. The URC has also made its mark on the world in the life, medical and health sciences through pioneering research and discovery, from life-saving technologies that eradicate devastating illness like polio or enable complicated medical procedures like heart bypass, to innovative processes that increase the stability and safety of our food supply.

The universities of the URC continue to push the boundaries of possibility in the life, medical and health sciences, tackling some of the biggest challenges facing the world, and Michigan. URC researchers are conducting research

to uncover the mysteries of devastating illnesses like Alzheimer's and Parkinson's Disease, discover how to better heal individuals through precision medicine that utilizes a person's unique genetics in developing treatments, identify threats challenging our agricultural systems, and addressing the factors that contribute to health disparities across populations to achieve greater equity in health outcomes.

Tackling these big challenges requires diverse perspectives and expertise, harnessed through partnerships and collaborations. The URC universities are sought-after partners for leading universities and hospitals across the country. Often, the best partners are the ones in your backyard. The URC universities have engaged in a number of important collaborations with each other. Some of these collaborations have spanned multiple projects over many years, such as the ECHO project, while others are forged through a common cause and will to contribute, such as in Flint. In the aggregate, the URC's contribution to the life, medical and health sciences is significant, and its role in research, innovation and talent production in an important and stable state industry is vital to the health – economic and physical – of Michigan.

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APPENDIX A:

DETAILED TABLES

This appendix contains additional detail on some of the life, medical, and health science statistics reported in the text.

Exhibit A1. State Academic R&D Expenditures in the Life, Medical, and Health Sciences by Subsector

	AGRICULTURAL SCIENCES		BIOENGINEERING AND BIOMEDICAL ENGINEERING		BIOLOGICAL SCIENCES	
Cluster	(thousands of \$)	Rank	(thousands of \$)	Rank	(thousands of \$)	Rank
URC	\$123,216	3	\$19,106	8	\$324,479	3
Massachusetts	\$21	7	\$130,834	1	\$519,552	2
Northern California	\$62,493	6	\$22,667	5	\$305,453	4
Southern California	\$ -		\$52,244	2	\$107,021	7
North Carolina	\$99,041	4	\$41,448	3	\$520,403	1
Pennsylvania	\$86,968	5	\$22,288	6	\$220,533	6
Illinois	\$130,410	2	\$20,686	7	\$260,648	5
Texas	\$182,199	1	\$40,811	4	\$103,424	8
Cluster average	\$85,544		\$43,761		\$295,189	
URC median	\$93,005		\$31,739		\$283,051	

	MEDICAL SCIENCES		OTHER LIFE SCIENCES		PSYCHOLOGY	
Cluster	(thousands of \$)	Rank	(thousands of \$)	Rank	(thousands of \$)	Rank
URC	\$637,167	5	\$112,057	2	\$36,456	4
Massachusetts	\$340,368	7	\$54,280	3	\$21,686	7
Northern California	\$1,548,411	2	\$18,365	6	\$26,405	6
Southern California	\$1,649,842	1	\$16,156	7	\$46,069	3
North Carolina	\$973,868	3	\$188,228	1	\$58,344	1
Pennsylvania	\$644,381	4	\$34,471	5	\$49,083	2
Illinois	\$518,839	6	\$38,207	4	\$32,381	5
Texas	\$118,520	8	\$2,752	8	\$14,895	8
Cluster average	\$803,925		\$58,065		\$35,665	
URC median						

Source: URC and PSC analysis of NSF n.d.b

Exhibit A2. Research Cluster Medical, Health, and Life Science Graduates by Field, 2011-2015

	ALL LMHS FIELDS		AGRICULTURE SCIENCES	
Cluster	Graduates	Rank	Graduates	Rank
URC	44,422	1	2,256	3
Illinois	19,990	7	1,188	5
Massachusetts	20,389	6	0	7
Northern California	17,915	8	671	6
North Carolina	28,930	3	3,678	2
Pennsylvania	27,780	5	1,851	4
Southern California	39,048	2	0	7
Texas	28,067	4	3,750	1

	BIO AND BIOMEDICAL ENGINEERING		BIOLOGICAL SCIENCES	
Cluster	Graduates	Rank	Graduates	Rank
URC	1,236	5	11,406	2
Illinois	857	8	6,862	7
Massachusetts	1,361	3	6,598	8
Northern California	944	7	7,373	5
North Carolina	1,300	4	8,763	4
Pennsylvania	1,210	6	6,902	6
Southern California	2,303	1	14,891	1
Texas	1,401	2	10,004	3

	MEDICAL SCIENCES		PSYCHOLOGY	
Cluster	Graduates	Rank	Graduates	Rank
URC	13,808	1	9,641	1
Illinois	3,846	8	5,183	5
Massachusetts	6,042	6	2,465	7
Northern California	6,091	5	2,437	8
North Carolina	7,541	4	4,908	6
Pennsylvania	7,947	3	5,272	4
Southern California	10,321	2	8,539	2
Texas	3,885	7	5,979	3

	OTHER LIFE SCIENCES	
Cluster	Graduates	Rank
URC	6,075	1
Illinois	2,054	7
Massachusetts	3,923	3
Northern California	399	8
North Carolina	2,740	6
Pennsylvania	4,598	2
Southern California	2,994	5
Texas	3,048	4

Source: PSC analysis using data from National Center for Education Statistics n.d.

APPENDIX B:

URC SECTOR REPORTS

Over the past seven years, Michigan's University Research Corridor—an alliance between Michigan State University, the University of Michigan, and Wayne State University—has commissioned a series of reports examining the contributions of the URC to key sectors of Michigan's economy. Key findings include:

Engaging Detroit: URC's Contribution to Resurgence in the Motor City (2016)

- The URC's Detroit economic impact is \$958 million (FY2014)
- The URC accounts for one in 20 jobs in Detroit.
- The URC is engaged in more than 340 programs, projects, activities and events in Detroit focused on community building, economic revitalization, public education, and public health.

Talent for the Global Economy (2015)

- Among top research university clusters, the URC ranks first in medical degrees, total degrees awarded and enrollment, and second in advanced degrees in high-tech fields such as engineering and sciences.
- Of the 32,000 URC graduates each year, more than a third earn degrees in high-demand fields, such as medicine and engineering.
- Ann Arbor, East Lansing, and Midtown Detroit residents 25 and older are three times more likely to have a degree compared to other Michigan communities.

Blue Economy (2014)

- From 2009 to 2013, URC universities received 2,100 awards totaling nearly \$300 million and supporting 341 researchers from dozens of departments for water-related research and outreach.
- Each year, URC universities produce more than 3,400 graduates prepared to analyze and find solutions to water-related issues in academia, government, and the private sector.
- One in five Michigan jobs (718,700) is associated with water-enabled or water-related industries.

Alumni Entrepreneurship (2013)

- A 2013 survey of URC alumni found 19.1 percent of respondents had founded or cofounded a business.
- Nearly half of the businesses started by URC alumni entrepreneurs began in Michigan.
- URC alumni-started firms were nearly 1.5 times more likely to stay in business versus the national average.
- URC alumni entrepreneurs started or acquired businesses at double the national average rate among college graduates between 1996 and 2012, and many of these companies were in fields outside their major area of study.
- URC alumni entrepreneurs have started businesses in every U.S. state and more than 100 countries.

Automotive Innovation (2012)

- The URC universities confer more than 3,600 degrees annually in auto-ready disciplines, supplying the industry with talent.
- Between FY 2007 and 2011, the URC universities spent \$300 million on more than 1,400 auto projects. More than 28 percent of the research was funded by private industry—nine times the average share of industry funding for all university R&D at these institutions.
- URC researchers have helped automakers improve vehicle quality and safety, improve engine efficiency and performance, and reduce fossil fuel use.

Information and Communication Technology (2011)

- URC universities spent nearly \$74 million on research projects with a strong IT focus in FY 2010.
- Nearly 40 percent of the approximately 150 URC-assisted startups between 2001 to 2011 had an Information and Communication Technology component.
- Information technology employs about 3.5 percent of the state's workforce (135,000 workers)—a significant standalone sector and the underpinning for much of the major industry activity and growth represented in previous sector reports.

Advanced Manufacturing (2010)

- URC universities spent \$101 million on advanced manufacturing R&D in 2009.
- URC universities are educating more than 14,000 students in engineering.
- In 2007, Michigan's advanced manufacturing industry employed 381,351 workers, accounting for 10.3 percent of all employment. One-third of the Midwest's advanced manufacturing jobs were in Michigan, paying an average wage of \$64,122.

Life Sciences (2009)

- In 2008, URC universities spent \$887 million on life sciences R&D.
- R&D expenditures grew 69 percent since the founding of the Life Sciences Corridor in 1999.
- Michigan's life sciences industry employed more than 79,000 workers, (2.1 percent of all employment in 2006).
- Between 1999 and 2006, life sciences industry employment grew by 10.7 percent while manufacturing employment dropped by 24 percent.
- Life sciences wages averaged \$83,494 in 2006.

Alternative Energy R&D (2008)

- Michigan has a comparative advantage in biomass and wind compared to the energy potential in the other 49 states.
- URC universities spent more than \$79.5 million on R&D related to alternative energy in 2007.
- More than half of all alternative energy R&D supported the auto industry.



**A Report Commissioned by the
University Research Corridor**

Michigan State University
University of Michigan
Wayne State University

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